

**DEPARTMENT OF DEFENSE
SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
SBIR 22.1 Program Broad Agency Announcement (BAA)**

December 1, 2021: DoD BAA issued for pre-release

January 12, 2022: DoD begins accepting proposals

February 10, 2022: Deadline for receipt of proposals no later than **12:00 p.m. ET**

Participating DoD Components:

- Department of Navy (Navy)
- Department of Air Force (Air Force)
- Defense Health Agency (DHA)
- Defense Logistics Agency (DLA)
- Defense Microelectronics Agency (DMEA)
- Missile Defense Agency (MDA)
- Office of the Secretary of Defense – National Geospatial-Intelligence Agency (OSD – NGA)
- Office of the Secretary of Defense – Quantum Science (OSD – Quantum Science)
- United States Special Operations Command (USSOCOM)

IMPORTANT

Deadline for Receipt: Complete proposals must be certified and submitted in DSIP no later than **12:00 PM** ET on **February 10, 2022**. Proposals submitted after 12:00 p.m. ET will not be evaluated. The final proposal submission includes successful completion of all firm level forms, all required volumes, and electronic corporate official certification. Please plan to submit proposals as early as possible in order to avoid unexpected delays due to high volume of traffic during the final hours before the BAA close. DoD is not responsible for missed proposal submission due to system latency.

Classified proposals will not be accepted under the DoD SBIR Program.

This BAA and the Defense SBIR/STTR Innovation Portal (DSIP) sites are designed to reduce the time and cost required to prepare a formal proposal. DSIP is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Proposers submitting through this site for the first time will be asked to register. Firms are required to register for a Login.gov account and link it to their DSIP account. See section 4.14 for more information regarding registration.

The Small Business Administration (SBA), through its SBIR/STTR Policy Directive, purposely departs from normal Government solicitation formats and requirements, thus authorizing agencies to simplify the SBIR/STTR award process and minimize the regulatory burden on small business. Therefore, consistent with the SBA SBIR/STTR Policy Directive, the Department of Defense is soliciting proposals as a Broad Agency Announcement.

SBIR/STTR Updates and Notices: To be notified of SBIR/STTR opportunities and to receive e-mail updates on the DoD SBIR and STTR Programs, you are invited to subscribe to our Listserv by visiting <https://www.dodsbirsttr.mil/submissions/login> and clicking “DSIP Listserv” located under Quick Links.

Questions: Visit the Learning & Support section of DSIP at <https://www.dodsbirsttr.mil/submissions/learning-support/faqs> for DoD SBIR or STTR program-related information. Email the DSIP Help Desk at DoDSBIRSupport@reisystems.com only for assistance with using DSIP. Questions regarding DSIP may be emailed to the DSIP Help Desk and will be addressed in the order received during normal operating hours (Monday through Friday, 9:00 a.m. to 5:00 p.m. ET). See section 4.13 for information on where to direct other BAA and topic-related questions.

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1.0 INTRODUCTION

Navy, Air Force, DHA, DLA, DMEA, OSD-NGA, OSD-Quantum Science, and USSOCOM, hereafter referred to as DoD Components, invite small business firms to submit proposals under this BAA for the Small Business Innovation Research (SBIR) Program. Firms with the capability to conduct research and development (R&D) in any of the defense-related topic areas described in this BAA and to commercialize the results of that R&D are encouraged to participate.

This BAA is for Phase I proposals only unless the Component is participating in the **Direct to Phase II Program**. Navy, Air Force, DMEA, OSD-NGA, OSD-Quantum, and USSOCOM are offering Direct to Phase II topics for this BAA – see the Component-specific instructions for more information.

A separate BAA will not be issued requesting Phase II proposals, and unsolicited proposals will not be accepted. All firms that receive a Phase I award originating from this BAA will be eligible to participate in Phase II competitions and potential Phase III awards. DoD Components will notify Phase I awardees of the Phase II proposal submission requirements. Submission of Phase II proposals will be in accordance with instructions provided by individual Components. The details on the due date, content, and submission requirements of the Phase II proposal will be provided by the awarding DoD Component either in the Phase I award or by subsequent notification. If a firm submits their Phase II proposal prior to the dates provided by the individual Components, it may be rejected without evaluation.

DoD is not obligated to make any awards under Phase I, Phase II, or Phase III, and all awards are subject to the availability of funds. DoD is not responsible for any monies expended by the proposer before the issuance of any award.

2.0 PROGRAM DESCRIPTION

2.1 Objectives

The objectives of the DoD SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DoD research and development needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing the commercial application of DoD-supported research or research and development results.

2.2 Technology and Program Protection to Maintain Technological Advantage

In accordance with DoD Instruction 5000.83, Technology and Program Protection to Maintain Technological Advantage, dated July 20, 2020, and as a means to counter the threat from strategic competitor nations, the DoD will employ risk-based measures to protect systems and technologies from adversarial exploitation and compromise of U.S. military vulnerabilities and weaknesses in: (1) systems, (2) components, (3) software, (4) hardware, and (5) supply chains. Any offeror submitting a proposal under this BAA will be required to disclose via self-report any foreign ownership or control. Offerors shall also require any proposed subcontractors included in their proposal under this BAA to disclose via self-report any foreign ownership or control. Reporting and disclosing such information will enable the DoD to identify national security risks posed by foreign participation, through investment, ownership, or influence, in the defense industrial base. This information will be used by DoD program offices to determine risks posed by SBIR contract awardees and their subcontractors to the DoD and the defense industrial base.

OUSD(R&E) Modernization Priorities

Focus Area	Description
5G	Technologies enabling the 5G spectrum to increase speed over current networks, to be more resilient and less susceptible to attacks, and to improve military communication and situational awareness.
Artificial Intelligence (AI)/ Machine Learning (ML)	Systems that perceive, learn, decide, and act on their own. Machine-learning systems with the ability to explain their rationale, characterize their strengths and weaknesses, and convey understanding of how they will behave in the future.
Autonomy	Technology that can deliver value by mitigating operational challenges such as: rapid decision making; high heterogeneity and/or volume of data; intermittent communications; high complexity of coordinated action; danger to mission; and high persistence and endurance.
Biotechnology	Biotechnology is any technological application that harnesses cellular and biomolecular processes. Most current biotech research focuses on agent detection, vaccines, and treatment. Future advances in biotechnology will improve the protection of both the general public and military personnel from biological agents, among numerous other potential applications.
Cybersecurity	Prevention of damage to, protection of, and restoration of computers, electronic communications systems, electronic communications services, wire communication, and electronic communications, including information contained therein, to ensure its availability, integrity, authentication, confidentiality, and nonrepudiation.
Directed Energy (DE)	Technologies related to production of a beam of concentrated electromagnetic energy, atomic, or subatomic particles.
Hypersonics	Innovative concepts or technologies that enable, or directly support, weapons or aircraft that fly at or near hypersonic speeds and/or innovation that allows for enhancing defensive capability against such systems.
Microelectronics	Critical microcircuits used in covered systems, custom-designed, custom-manufactured, or tailored for specific military application, system, or environment.
Networked Command, Control, and Communications (C3)	Fully networked command control and communications including: command and control (C2) interfaces, architectures, and techniques (e.g., common software interfaces and functional architectures and improved C2 processing/decision making techniques); communications terminals (e.g., software-defined radio (SDRs)/apertures with multiple networks on the same band and multi-functional systems); and apertures and networking technologies (e.g., leveraging/managing a diverse set of links across multiple band and software defined networking/ network slicing).
Nuclear	Technologies supporting the nuclear triad-including nuclear command, control, and communications, and supporting infrastructure. Modernization of the nuclear force includes developing options to counter competitors' coercive strategies, predicated on the threatened use of nuclear or strategic non-nuclear attacks.
Quantum Science	Technologies related to matter and energy on the atomic and subatomic level. Areas of interest: clocks and sensors; networks; computing enabling technologies (e.g., low temperature amplifiers, cryogenics, superconducting circuits, photon detectors); communications (i.e., sending/receiving individual photons); and manufacturing improvements.
Space	Technologies supporting space, or applied to a space environment.
General Warfighting Requirements (GWR)	Warfighting requirements not meeting the descriptions above; may be categorized into Reliance 21 areas of interest.

The DoD SBIR/STTR Programs follow the policies and practices of the Small Business Administration (SBA) SBIR/STTR Policy Directive updated on October 1, 2020. The guidelines presented in this BAA incorporate and make use of the flexibility of the SBA SBIR/STTR Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to the DoD and the private sector. The SBIR/STTR Policy Directive is available at: https://www.sbir.gov/sites/default/files/SBA_SBIR_STTR_POLICY_DIRECTIVE_OCT_2020_0.pdf.

2.3 Three Phase Program

The SBIR Program is a three-phase program. Phase I is to determine, to the extent possible, the scientific, technical, and commercial merit and feasibility of ideas submitted under the SBIR Program. Phase I awards are made in accordance with the SBA Policy Directive guidelines, current version. The period of performance is generally between six to twelve months with twelve months being the maximum period allowable. Proposals should concentrate on research or research and development which will significantly contribute to proving the scientific and technical feasibility, and commercialization potential of the proposed effort, the successful completion of which is a prerequisite for further DoD support in Phase II. Proposers are encouraged to consider whether the research or research and development being proposed to DoD Components also has private sector potential, either for the proposed application or as a base for other applications.

Phase II awards will be made to firms on the basis of results of their Phase I effort and/or the scientific merit, technical merit, and commercialization potential of the Phase II proposal. Phase II awards are made in accordance with the SBA Policy Directive guidelines, current version. The period of performance is generally 24 months. Phase II is the principal research or research and development effort and is expected to produce a well-defined deliverable prototype. A Phase II contractor may receive up to one additional, sequential Phase II award for continued work on the project.

Under Phase III, the Proposer is required to obtain funding from either the private sector, a non-SBIR Government source, or both, to develop the prototype into a viable product or non-R&D service for sale in military or private sector markets. SBIR Phase III refers to work that derives from, extends, or completes an effort made under prior SBIR funding agreements, but is funded by sources other than the SBIR Program. Phase III work is typically oriented towards commercialization of SBIR research or technology.

3.0 DEFINITIONS

The following definitions from the SBA SBIR/STTR Policy Directive, the Federal Acquisition Regulation (FAR), and other cited regulations apply for the purposes of this BAA:

Commercialization

The process of developing products, processes, technologies, or services and the production and delivery (whether by the originating party or others) of the products, processes, technologies, or services for sale to or use by the Federal government or commercial markets.

Cooperative Research and Development

Research and development conducted jointly by a small business concern and a research institution. For purposes of the STTR Program, 40% of the work is performed by the small business concern, and not less than 30% of the work is performed by the single research institution. For purposes of the SBIR Program, this refers to work conducted by a research institution as a subcontractor to the small business concern. At

least two-thirds of the research and/or analytical work in Phase I must be conducted by the proposing firm.

Essentially Equivalent Work

Work that is substantially the same research, which is proposed for funding in more than one contract proposal or grant application submitted to the same Federal agency or submitted to two or more different Federal agencies for review and funding consideration; or work where a specific research objective and the research design for accomplishing the objective are the same or closely related to another proposal or award, regardless of the funding source.

Export Control

The International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, will apply to all projects with military or dual-use applications that develop beyond fundamental research, which is basic and applied research ordinarily published and shared broadly within the scientific community. More information is available at https://www.pmddtc.state.gov/ddtc_public.

NOTE: Export control compliance statements found in the individual Component-specific proposal instructions are not meant to be all inclusive. They do not remove any liability from the submitter to comply with applicable ITAR or EAR export control restrictions or from informing the Government of any potential export restriction as fundamental research and development efforts proceed.

Federal Laboratory

As defined in 15 U.S.C. §3703, means any laboratory, any federally funded research and development center (FFRDC), or any center established under 15 U.S.C. §§ 3705 & 3707 that is owned, leased, or otherwise used by a Federal agency and funded by the Federal Government, whether operated by the Government or by a contractor.

Foreign Entity

Foreign entity means any branch, partnership, group or sub-group, association, estate, trust, corporation or division of a corporation, non-profit, academic institution, research center, or organization established, directed, or controlled by foreign owners, foreign investors, foreign management, or a foreign government.

Foreign Government

Foreign government means any government or governmental body, organization, or instrumentality, including government owned-corporations, other than the United States Government or United States state, territorial, tribal, or jurisdictional governments or governmental bodies. The term includes, but is not limited to, non-United States national and subnational governments, including their respective departments, agencies, and instrumentalities.

Foreign Nationals

Foreign Nationals (also known as Foreign Persons) as defined by 22 CFR 120.16 means any natural person who is not a lawful permanent resident as defined by 8 U.S.C. § 1101(a)(20) or who is not a protected individual as defined by 8 U.S.C. § 1324b(a)(3). It also means any foreign corporation, business

association, partnership, trust, society or any other entity or group that is not incorporated or organized to do business in the United States, as well as international organizations, foreign governments and any agency or subdivision of foreign governments (e.g., diplomatic missions).

“Lawfully admitted for permanent residence” means the status of having been lawfully accorded the privilege of residing permanently in the United States as an immigrant in accordance with the immigration laws, such status not having changed.

"Protected individual" means an individual who (A) is a citizen or national of the United States, or (B) is an alien who is lawfully admitted for permanent residence, is granted the status of an alien lawfully admitted for temporary residence under 8 U.S.C. § 1160(a) or 8 U.S.C. § 1255a(a)(1), is admitted as a refugee under 8 U.S.C. § 1157, or is granted asylum under Section 8 U.S.C. § 1158; but does not include (i) an alien who fails to apply for naturalization within six months of the date the alien first becomes eligible (by virtue of period of lawful permanent residence) to apply for naturalization or, if later, within six months after November 6, 1986, and (ii) an alien who has applied on a timely basis, but has not been naturalized as a citizen within 2 years after the date of the application, unless the alien can establish that the alien is actively pursuing naturalization, except that time consumed in the Service's processing the application shall not be counted toward the 2-year period.

Fraud, Waste and Abuse

- a. **Fraud** includes any false representation about a material fact or any intentional deception designed to deprive the United States unlawfully of something of value or to secure from the United States a benefit, privilege, allowance, or consideration to which an individual or business is not entitled.
- b. **Waste** includes extravagant, careless or needless expenditure of Government funds, or the consumption of Government property, that results from deficient practices, systems, controls, or decisions.
- c. **Abuse** includes any intentional or improper use of Government resources, such as misuse of rank, position, or authority or resources.
- d. The SBIR Program training related to Fraud, Waste and Abuse is available at: <https://www.sbir.gov/tutorials/fraud-waste-abuse/tutorial-1>. See Section 4.17 for reporting Fraud, Waste and Abuse.

Funding Agreement

Any contract, grant, or cooperative agreement entered into between any Federal Agency and any small business concern for the performance of experimental, developmental, or research work, including products or services, funded in whole or in part by the Federal Government. Only the contract method will be used by DoD Components for all SBIR awards.

Historically Black Colleges and Universities and Minority Institutions (HBCU/MI)

Listings for the Historically Black Colleges and Universities (HBCU) and Minority Institutions (MI) are available through the Department of Education Web site, <http://www.ed.gov/about/offices/list/ocr/edlite-minorityinst.html>.

Certified HUBZone Small Business Concern

An SBC that has been certified by SBA under the Historically Underutilized Business Zones (HUBZone) Program (13 C.F.R. § 126) as a HUBZone firm listed in the Dynamic Small Business Search (DSBS).

Performance Benchmark Requirements for Phase I

Companies with multiple SBIR/STTR awards must meet minimum performance requirements to be eligible to apply for a new Phase I or Direct-to-Phase II award. The purpose of these requirements is to ensure that Phase I applicants that have won multiple prior SBIR/STTR awards are making progress towards commercializing the work done under those awards. The Phase I to Phase II Transition Rate addresses the extent to which an awardee progresses a project from Phase I to Phase II. The Commercialization Benchmark addresses the extent to which an awardee has moved past Phase II work towards commercialization. Additional information on performance benchmarking for Phase I applicants can be found at <https://www.sbir.gov/performance-benchmarks>.

Principal Investigator

The principal investigator/project manager is the one individual designated by the applicant to provide the scientific and technical direction to a project supported by the funding agreement.

For both Phase I and Phase II, the primary employment of the principal investigator must be with the small business firm at the time of award and during the conduct of the proposed project. Primary employment means that more than one-half of the principal investigator's time is spent in the employ of the small business. This precludes full-time employment with another organization. Occasionally, deviations from this requirement may occur, and must be approved in writing by the contracting officer after consultation with the agency SBIR/STTR Program Manager/Coordinator. Further, a small business firm or research institution may replace the principal investigator on an SBIR/STTR Phase I or Phase II award, subject to approval in writing by the contracting officer.

Proprietary Information

Proprietary information is information that you provide which constitutes a trade secret, proprietary commercial or financial information, confidential personal information or data affecting the national security.

Research Institution

Any organization located in the United States that is:

- a. A university.
- b. A nonprofit institution as defined in Section 4(5) of the Stevenson-Wydler Technology Innovation Act of 1980.
- c. A contractor-operated federally funded research and development center, as identified by the National Science Foundation in accordance with the government-wide Federal Acquisition Regulation issued in accordance with Section 35(c)(1) of the Office of Federal Procurement Policy Act. A list of eligible FFRDCs is available at: <https://www.nsf.gov/statistics/ffrdclist/>.

Research or Research and Development

Any activity that is:

- a. A systematic, intensive study directed toward greater knowledge or understanding of the subject studied.
- b. A systematic study directed specifically toward applying new knowledge to meet a recognized need; or

- c. A systematic application of knowledge toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements.

Research Involving Animal Subjects

All activities involving animal subjects shall be conducted in accordance with DoDI 3216.01 “Use of Animals in DoD Programs,” 9 C.F.R. parts 1-4 “Animal Welfare Regulations,” National Academy of Sciences Publication “Guide for the Care & Use of Laboratory Animals,” as amended, and the Department of Agriculture rules implementing the Animal Welfare Act (7 U.S.C. §§ 2131-2159), as well as other applicable federal and state law and regulation and DoD instructions.

“Animal use” protocols apply to all activities that meet any of the following criteria:

- a. Any research, development, test, evaluation or training, (including experimentation) involving an animal or animals.
- b. An animal is defined as any living or dead, vertebrate organism (non-human) that is being used or is intended for use in research, development, test, evaluation or training.
- c. A vertebrate is a member of the subphylum Vertebrata (within the phylum Chordata), including birds and cold-blooded animals.

See DoDI 3216.01 for definitions of these terms and more information about the applicability of DoDI 3216.01 to work involving animals.

Research Involving Human Subjects

All research involving human subjects shall be conducted in accordance with 32 C.F.R. § 219 “The Common Rule,” 10 U.S.C. § 980 “Limitation on Use of Humans as Experimental Subjects,” and DoDI 3216.02 “Protection of Human Subjects and Adherence to Ethical Standards in DoD-Supported Research,” as well as other applicable federal and state law and regulations, and DoD component guidance. Proposers must be cognizant of and abide by the additional restrictions and limitations imposed on the DoD regarding research involving human subjects, specifically as they regard vulnerable populations (DoDI 3216.02), recruitment of military research subjects (DoDI 3216.02), and informed consent and surrogate consent (10 U.S.C. § 980) and chemical and biological agent research (DoDI 3216.02). Food and Drug Administration regulation and policies may also apply.

“Human use” protocols apply to all research that meets any of the following criteria:

- a. Any research involving an intervention or an interaction with a living person that would not be occurring or would be occurring in some other fashion but for this research.
- b. Any research involving identifiable private information. This may include data/information/specimens collected originally from living individuals (broadcast video, web-use logs, tissue, blood, medical or personnel records, health data repositories, etc.) in which the identity of the subject is known, or the identity may be readily ascertained by the investigator or associated with the data/information/specimens.

See DoDI 3216.02 for definitions of these terms and more information about the applicability of DoDI 3216.02 to research involving human subjects.

Research Involving Recombinant DNA Molecules

Any recipient performing research involving recombinant DNA molecules and/or organisms and viruses containing recombinant DNA molecules shall comply with the National Institutes of Health Guidelines for Research Involving Recombinant DNA Molecules, dated January 2011, as amended. The guidelines can be found at: https://osp.od.nih.gov/wp-content/uploads/2016/05/NIH_Guidelines.pdf. Recombinant DNA is defined as (i) molecules that are constructed outside living cells by joining natural or synthetic DNA segments to DNA molecules that can replicate in living cells or (ii) molecules that result from the replication of those described in (i) above.

Service-Disabled Veteran-Owned Small Business (SDVOSB)

A small business concern owned and controlled by a Service-Disabled Veteran or Service-Disabled Veterans, as defined in Small Business Act 15 USC § 632(q)(2) and SBA's implementing SDVOSB regulations (13 CFR 125).

Small Business Concern (SBC)

A concern that meets the requirements set forth in 13 C.F.R. § 121.702 (available [here](#)).

An SBC must satisfy the following conditions on the date of award:

- a. Is organized for profit, with a place of business located in the United States, which operates primarily within the United States or which makes a significant contribution to the United States economy through payment of taxes or use of American products, materials or labor;
- b. Is in the legal form of an individual proprietorship, partnership, limited liability company, corporation, joint venture, association, trust or cooperative, except that if the concern is a joint venture, each entity to the venture must meet the requirements set forth in paragraph (c) below;
- c. Is more than 50% directly owned and controlled by one or more individuals (who are citizens or permanent resident aliens of the United States), other small business concerns (each of which is more than 50% directly owned and controlled by individuals who are citizens or permanent resident aliens of the United States), or any combination of these; and
- d. Has, including its affiliates, not more than 500 employees. (For explanation of affiliate, see www.sba.gov/size.)

Subcontract

A subcontract is any agreement, other than one involving an employer-employee relationship, entered into by an awardee of a funding agreement calling for supplies or services for the performance of the original funding agreement. This includes consultants.

Subcontractor

Subcontractor means any supplier, distributor, vendor, firm, academic institution, research center, or other person or entity that furnishes supplies or services pursuant to a subcontract, at any tier.

United States

"United States" means the fifty states, the territories and possessions of the Federal Government, the Commonwealth of Puerto Rico, the Republic of the Marshall Islands, the Federated States of Micronesia, the Republic of Palau, and the District of Columbia.

Women-Owned Small Business Concern

An SBC that is at least 51% owned by one or more women, or in the case of any publicly owned business, at least 51% of the stock is owned by women, and women control the management and daily business operations.

4.0 PROPOSAL FUNDAMENTALS

4.1 Introduction

The proposal must provide sufficient information to demonstrate to the evaluator(s) that the proposed work represents an innovative approach to the investigation of an important scientific or engineering problem and is worthy of support under the stated criteria. The proposed research or research and development must be responsive to the chosen topic, although it need not use the exact approach specified in the topic. Anyone contemplating a proposal for work on any specific topic should determine:

- a. The technical approach has a reasonable chance of meeting the topic objective,
- b. This approach is innovative, not routine, with potential for commercialization and
- c. The proposing firm has the capability to implement the technical approach, i.e., has or can obtain people and equipment suitable to the task.

Please note, **this BAA is for Phase I proposals only** unless the Component is participating in the **Direct to Phase II Program**.

a. Direct to Phase II

15 U.S.C. §638 (cc), as amended by NDAA FY2012, Sec. 5106, and further amended by NDAA FY2019, Sec. 854, PILOT TO ALLOW PHASE FLEXIBILITY, allows DoD to make a SBIR Phase II award to a small business concern with respect to a project, without regard to whether the small business concern was provided an award under Phase I of the SBIR program with respect to such project. Missile Defense Agency (MDA), Joint Service Small Arms Program (OSD-JSSAP), SCO, and USSOCOM are conducting a "Direct to Phase II" implementation of this authority for select topics under this BAA. DoD does not guarantee Direct to Phase II opportunities will be offered in future BAAs.

Each eligible topic requires that proposers provide documentation to demonstrate feasibility described in the Phase I section of the topic has been met. **Feasibility documentation cannot be based upon or logically extend from any prior or ongoing federally funded SBIR or STTR work.** Work submitted within the feasibility documentation must have been substantially performed by the proposer and/or the PI. If technology in the feasibility documentation is subject to Intellectual Property (IP), the proposer must either own the IP, or must have obtained license rights to such technology prior to proposal submission, to enable it and its subcontractors to legally carry out the proposed work.

If the proposer fails to demonstrate technical merit and feasibility equivalent to the Phase I level as described in the associated topic, the related Phase II proposal will not be accepted or evaluated, in accordance with the Component-specific Direct to Phase II instructions.

Please refer to the Component-specific Direct to Phase II instructions for full details regarding Component Direct to Phase II processes and proposal preparation requirements.

4.2 Proposer Eligibility and Performance Requirements

- a. Each proposer must qualify as a small business concern as defined by 13 C.F.R §§ 701-705 at time of award and certify to this in the Cover Sheet section of the proposal. The eligibility

requirements for the SBIR/STTR programs are unique and do not correspond to those of other small business programs (see Section 3 of this BAA). Proposers must meet eligibility requirements for Small Business Ownership and Control (see 13 CFR § 121.702 and Section 4.4 of this BAA).

- b. A minimum of two-thirds of the research and/or analytical work in Phase I must be conducted by the proposing firm. For Phase II, a minimum of one-half (50%) of the research and/or analytical work must be performed by the proposing firm. The percentage of work is measured by both direct and indirect costs.
- c. For both Phase I and II, the primary employment of the principal investigator must be with the small business firm at the time of the award and during the conduct of the proposed effort. Primary employment means that more than one-half of the principal investigator's time is spent with the small business. Primary employment with a small business concern precludes full-time employment at another organization.
- d. For both Phase I and Phase II, all research or research and development work must be performed by the small business concern and its subcontractors in the United States.
- e. **Benchmarks.** Proposers with prior SBIR/STTR awards must meet two benchmark requirements for Progress towards Commercialization as determined by the Small Business Administration (SBA) on June 1 each year.

- (1) Phase I to Phase II Transition Rate: For all proposers with greater than 20 Phase I awards over the past five fiscal years excluding the most recent year, the ratio of Phase II awards to Phase I awards must be at least 0.25.
- (2) Commercialization Benchmark: For all proposers with greater than 15 Phase II awards over the last ten fiscal years excluding the last two years, the proposer must have received, to date, an average of at least \$100,000 of sales and/or investments per Phase II award received or have received a number of patents resulting from the SBIR work equal to or greater than 15% of the number of Phase II awards received during the period.

Consequence of failure to meet the benchmarks:

- SBA will identify and notify Agencies on June 1st of each year the list of companies which fail to meet minimum performance requirements. These companies will not be eligible to submit a proposal for a Phase I or Direct to Phase II award for a period of one year from that date.
- Because this requirement only affects a company's eligibility for new Phase I or Direct to Phase II awards, a company that fails to meet minimum performance requirements may continue working on its current ongoing SBIR/STTR awards and may apply for and receive new Phase II and Phase III awards.
- To provide companies with advance warning, SBA notifies companies on April 1st if they are failing the benchmarks. If a company believes that the information used was not complete or accurate, it may provide feedback through the SBA Company Registry at www.sbir.gov.
- In addition, SBA has posted a [Guide to SBIR/STTR Program Eligibility](#) to help small businesses understand program eligibility requirements, determine if they will be eligible at the time of award, and accurately complete necessary certifications.
- The benchmark information on the companies will not be available to the public.
- More detail is available at <https://www.sbir.gov/performance-benchmarks>.

4.3 Joint Ventures

Joint ventures and limited partnerships are permitted, provided that the entity created qualifies as a small business in accordance with the Small Business Act, 13 U.S.C. § 121.701. Proposers must disclose joint ventures with existing (or planned) relationships/partnerships with any foreign entity or any foreign government-controlled companies.

4.4 Majority Ownership in Part by Multiple Venture Capital, Hedge Fund, and Private Equity Firms

Unless otherwise noted in the participating Component instructions, small businesses that are owned in majority part by multiple venture capital operating companies (VCOs), hedge funds, or private equity funds are ineligible to submit applications or receive awards for opportunities in this BAA. Component instructions will specify if participation by a small business majority owned in part by VCOs, hedge funds, or private equity funds is allowable for a specific topic in the BAA. If a Component authorizes such participation, any proposer that is owned, in whole in or in part, by any VCO, hedge fund, and/or private equity fund must identify each foreign national, foreign entity, or foreign government holding or controlling greater than a 5% equity stake in the proposer, whether such equity stake is directly or indirectly held. The proposer must also identify any and all of its ultimate parent owner(s) and any other entities and/or individuals owning more than a 5% equity stake in its chain of ownership.

4.5 Conflicts of Interest

Contract awards to firms owned by or employing current or previous Federal Government employees could create conflicts of interest for those employees, which may be a violation of federal law.

4.6 Organizational Conflicts of Interest

FAR 9.5 Requirements

In accordance with FAR 9.5, proposers are required to identify and disclose all facts relevant to potential OCIs involving the proposer's organization and any proposed team member (sub-awardee, consultant). Under this Section, the proposer is responsible for providing this disclosure with each proposal submitted to the BAA. The disclosure must include the proposer's, and as applicable, proposed team member's OCI mitigation plan. The OCI mitigation plan must include a description of the actions the proposer has taken, or intends to take, to prevent the existence of conflicting roles that might bias the proposer's judgment and to prevent the proposer from having unfair competitive advantage. The OCI mitigation plan will specifically discuss the disclosed OCI in the context of each of the OCI limitations outlined in FAR 9.505-1 through FAR 9.505-4.

Agency Supplemental OCI Policy

In addition, DoD Components may have a supplemental OCI policy that prohibits contractors/performers from concurrently providing Scientific Engineering Technical Assistance (SETA), Advisory and Assistance Services (A&AS) or similar support services and being a technical performer. Therefore, as part of the FAR 9.5 disclosure requirement above, a proposer must affirm whether the proposer or any proposed team member (sub-awardee, consultant) is providing SETA, A&AS, or similar support to any DoD Component office(s) under: (a) a current award or sub-award; or (b) a past award or sub-award that ended within one calendar year prior to the proposal's submission date.

If SETA, A&AS, or similar support is being or was provided to any DoD Component office(s), the proposal must include:

- The name of the DoD Component office receiving the support;
- The prime contract number;

- Identification of proposed team member (sub-awardee, consultant) providing the support; and
- An OCI mitigation plan in accordance with FAR 9.5.

Government Procedures

In accordance with FAR 9.503, 9.504 and 9.506, the Government will evaluate OCI mitigation plans to avoid, neutralize or mitigate potential OCI issues before award and to determine whether it is in the Government's interest to grant a waiver. The Government will only evaluate OCI mitigation plans for proposals that are determined selectable under the BAA evaluation criteria and funding availability.

The Government may require proposers to provide additional information to assist the Government in evaluating the proposer's OCI mitigation plan.

If the Government determines that a proposer failed to fully disclose an OCI; or failed to provide the affirmation of Government support as described above; or failed to reasonably provide additional information requested by the Government to assist in evaluating the proposer's OCI mitigation plan, the Government may reject the proposal and withdraw it from consideration for award.

4.7 Classified Proposals

Classified proposals will not be accepted under the DoD SBIR Program. If topics will require classified work during Phase II, the proposing firm must have a facility clearance in order to perform the Phase II work. For more information on facility and personnel clearance procedures and requirements, please visit the Defense Counterintelligence and Security Agency (DCSA) website at:

<https://www.dcsa.mil/mc/ctp/fc/>.

4.8 Research Involving Human Subjects

All research involving human subjects, to include use of human biological specimens and human data, shall comply with the applicable federal and state laws and agency policy/guidelines for human subject protection (see Section 3).

Institutions to be awarded funding for research involving human subjects must provide documentation of a current Federal Assurance of Compliance with Federal regulations for human subject protection, for example a Department of Health and Human Services, Office for Human Research Protections Federal-wide Assurance (<http://www.hhs.gov/ohrp>). Additional Federal Assurance documentation may also be requested by the awarding DoD Component. All institutions engaged in human subject research, to include subcontractors, must also have a valid Assurance. In addition, personnel involved in human subjects research must provide documentation of completing appropriate training for the protection of human subjects. Institutions proposing to conduct human subject research that meets one of the exemption criteria in 32 CFR 219.101 are not required to have a Federal Assurance of Compliance. Proposers should clearly segregate research activities involving human subjects from other research and development activities in their proposal.

If selected, institutions must also provide documentation of Institutional Review Board (IRB) approval or a determination from an appropriate official in the institution that the work meets one of the exemption criteria with 32 CFR 219. As part of the IRB review process, evidence of appropriate training for all investigators should accompany the protocol. The protocol, separate from the proposal, must include a detailed description of the research plan, study population, risks and benefits of study participation, recruitment and consent process, data collection and data analysis.

The amount of time required for the IRB to review and approve the protocol will vary depending on such things as the IRB's procedures, the complexity of the research, the level of risk to study participants and the responsiveness of the Investigator. The average IRB approval process can last between one and three months. Once the IRB has approved the research, the awarding DoD Component will review the protocol and the IRB's determination to ensure that the research will be conducted in compliance with DoD and DoD Component policies. The DoD review process can last between three to six months. Ample time should be allotted to complete both the IRB and DoD approval processes prior to recruiting subjects. **No funding can be used towards human subject research until ALL approvals are granted. Submitters proposing research involving human and/or animal use are encouraged to separate these tasks in the technical proposal and cost proposal in order to avoid potential delay of contract award.**

4.9 Research Involving Animal Subjects

All research, development, testing, experimentation, education or training involving the use of animals shall comply with the applicable federal and agency rules on animal acquisition, transport, care, handling, and use (see Section 3).

For submissions containing animal use, proposals should briefly describe plans for their Institutional Animal Care and Use Committee (IACUC) review and approval.

All Recipients must receive their IACUC's approval as well as secondary or headquarters-level approval by a DoD veterinarian who is trained or experienced in laboratory animal medicine and science. **No animal research may be conducted using DoD funding until all the appropriate DoD office(s) grant approval. Submitters proposing research involving human and/or animal use are encouraged to separate these tasks in the technical proposal and cost proposal in order to avoid potential delay of contract award.**

4.10 Research Involving Recombinant DNA Molecules

All research involving recombinant DNA molecules shall comply with the applicable federal and state law, regulation and any additional agency guidance. Research shall be approved by an Institutional Biosafety Committee.

4.11 Debriefing/Technical Evaluation Narrative

After final award decisions have been announced, the technical evaluations of the submitter's proposal may be provided to the submitter. Please refer to the Component-specific instructions of your topics of interest for Component debriefing processes.

4.12 Pre-Award and Post Award BAA Protests

Interested parties have the right to protest as prescribed in FAR 33.106(b) and FAR 52.233-2. For purposes of pre-award protests related to the terms of this BAA, protests should be served to the Contracting Officer (listed below).

Ms. Chrissandra Smith
DoD SBIR/STTR BAA Contracting Officer
E-mail: chrissandra.smith.civ@mail.mil

NOTE: CONTACT FOR PROTESTS ONLY. All other inquiries will not be answered or considered.

Washington Headquarters Services (WHS)
Acquisition Directorate
1155 Defense Pentagon
Washington, DC 20301-1155

For the purposes of a protest related to a selection or award decision, protests should be served to the point-of-contact (POC) listed in the instructions of the DoD Component that authored the topic.

For protests filed with the Government Accountability Office (GAO), a copy of the protest shall be submitted to the Contracting Officer listed above (pre-award ONLY) or DoD Component POC (selection/award decision ONLY) within one day of filing with the GAO. Protests of small business status of a selected firm may also be made to the Small Business Administration.

4.13 Phase I Award Information

All Phase I proposals will be evaluated and judged on a competitive basis. Proposals will be initially screened to determine responsiveness. Proposals passing this initial screening will be technically evaluated by engineers or scientists to determine the most promising technical and scientific approaches. Each proposal will be judged on its own merit. DoD is under no obligation to fund any proposal or any specific number of proposals in a given topic. It also may elect to fund several or none of the proposed approaches to the same topic.

- a. **Number of Phase I Awards.** The number of Phase I awards will be consistent with the Component's RDT&E budget. No Phase I contracts will be awarded until evaluation of all qualified proposals for a specific topic is completed.
- b. **Type of Funding Agreement.** Each Phase I proposal selected for award will be funded under negotiated contracts or purchase orders and will include a reasonable fee or profit consistent with normal profit margins provided to profit-making firms for R/R&D work. Firm-Fixed-Price, Firm-Fixed-Price Level of Effort, Labor Hour, Time & Material, or Cost-Plus-Fixed-Fee type contracts can be negotiated and are at the discretion of the Component Contracting Officer.
- c. **Dollar Value.** The Phase I contract value varies among the DoD Components; it is therefore important for proposing firms to review Component-specific instructions regarding award size.
- d. **Timing.** Proposing firms will be notified of selection or non-selection status for a Phase I award by the DoD Component that originated the topic within 90 days of the closing date for this BAA. Please refer to the Component-specific instructions for details.

The SBA SBIR/STTR Policy Directive, Section 7(c)(1)(ii), states that agencies should issue the Phase I award no more than 180 days after the closing date of the BAA. However, across DoD, the median time between the date that the SBIR BAA closes and the award of a Phase I contract is approximately four months.

This information in this section is applicable to Phase I proposals only. If the Component is participating in the **Direct to Phase II Program**, refer to the Component-specific Direct to Phase II instructions for award information.

4.14 Questions about this BAA and BAA Topics

a. General SBIR Questions/Information.

(1) DSIP Help Desk:

Email the DSIP Help Desk at DoDSBIRSupport@reisystems.com for assistance with using DSIP. Questions regarding DSIP can be emailed to the DSIP Help Desk and will be addressed in the order received, during normal operating hours (Monday through Friday, 9:00 a.m. to 5:00 p.m. ET).

The DSIP Help Desk cannot provide updates to proposal status after submission, such as proposal selection/non-selection status or contract award status. Contact the DoD Component that originated the topic in accordance with the Component-specific instructions given at the beginning of that Component's topics.

(2) Websites:

The Defense SBIR/STTR Innovation Portal (DSIP) at <https://www.dodsbirsttr.mil/submissions/login>, which provides the following resources:

- SBIR and STTR Program Opportunities
- Topics Search Engine
- Topic Q&A
- All Electronic Proposal Submission for Phase I and Phase II Proposals. Firms submitting through this site for the first time will be asked to register on <https://www.dodsbirsttr.mil/submissions>.

DoD SBIR/STTR website at <https://rt.cto.mil/rtl-small-business-resources/sbir-sttr/>, which provides the following resources:

- SBIR and STTR Program Opportunities
- Dates for Current and Upcoming Opportunities
- Past SBIR and STTR Program Opportunities

(3) SBIR/STTR Updates and Notices:

To be notified of SBIR/STTR opportunities and to receive e-mail updates on the DoD SBIR and STTR Programs, subscribe to the Listserv by selecting “DSIP Listserv” under Quick Links on the DSIP login page.

- b. **General Questions about a DoD Component.** General questions pertaining to a particular DoD Component and the Component-specific BAA instructions should be submitted in accordance with the instructions given at the beginning of that Component's topics, in Section 12.0 of this BAA.
- c. **Direct Contact with Topic Authors.** From **December 1, 2021 to January 12, 2022**, this BAA is issued for pre-release with the names of the topic authors and their phone numbers and e-mail addresses. During the pre-release period, proposing firms have an opportunity to contact topic authors by telephone or e-mail to ask technical questions about specific BAA topics. Questions should be limited to specific information related to improving the understanding of a particular topic's requirements. Proposing firms may not ask for advice or guidance on solution approach and you may not submit additional material to the topic author. If information provided during an exchange with the topic author is deemed necessary for proposal preparation, that information will be made available

to all parties through Topic Q&A. After this period questions must be asked through Topic Q&A as described below.

- d. **Topic Q&A.** Once DoD begins accepting proposals on **January 12, 2022**, no further direct contact between proposers and topic authors is allowed unless the Topic Author is responding to a question submitted during the pre-release period. However, proposers may submit written questions through Topic Q&A at <https://www.dodsbirsttr.mil/submissions/login>. In Topic Q&A, all questions and answers are posted electronically for general viewing. Identifying information for the questioner and respondent is not posted.

Questions submitted through the Topic Q&A are limited to technical information related to improving the understanding of a topic's requirements. Any other questions, such as those asking for advice or guidance on solution approach, or administrative questions, such as SBIR or STTR program eligibility, technical proposal/cost proposal structure and page count, budget and duration limitations, or proposal due date WILL NOT receive a response. Refer to the Component-specific instructions given at the beginning of that Component's topics for help with an administrative question.

Proposing firms may use the Topic Search feature on DSIP to locate a topic of interest. Then, using the form at the bottom of the topic description, enter and submit the question. Answers are generally posted within seven (7) business days of question submission (answers will also be e-mailed directly to the inquirer).

The Topic Q&A for this BAA opens on **December 1, 2021** and closes to new questions on **January 27, 2022 at 12:00 PM ET**. Once the BAA closes to proposal submission, no communication of any kind with the topic author or through Topic Q&A regarding your submitted proposal is allowed.

Proposing firms are advised to monitor Topic Q&A during the BAA period for questions and answers. Proposing firms should also frequently monitor DSIP for updates and amendments to the topics.

4.15 Registrations and Certifications

Proposing firms must be registered in the Defense SBIR/STTR Innovation Portal (DSIP) in order to prepare and submit proposals. All users will be required to register for a login.gov account and link it to their DSIP account. To register in Login.gov, click the Login/Register button in the top right corner on the DSIP Submissions homepage and follow the steps to register. If you already have a Login.gov account, you can link your existing Login.gov account with your DSIP account. Job Aids and Help Videos to walk you through the process are in the Learning & Support section of DSIP, here: <https://www.dodsbirsttr.mil/submissions/learning-support/training-materials>.

Please note that the email address you use for Login.gov should match the email address associated with your existing DSIP account. If you do not recall the email address associated with your DSIP account, or if you already have an existing Login.gov account using a different email address, you will need your Firm's DUNS number and your Firm PIN in order to link your Login.gov account with your DSIP account. If the email address associated with your existing DSIP account has been used for multiple DSIP accounts within your Firm, you will also need your Firm's DUNS number and your Firm PIN in order to link your Login.gov account with your DSIP account. The Firm PIN can be obtained from your Firm Admin. You can view the Firm Admin's contact information by entering your Firm's DUNS number when prompted. If you are the Firm Admin, please ensure that you contact all DSIP users in your Firm and provide them with the Firm PIN.

It is recommended that you complete your Login.gov setup as soon as possible to avoid any delays in your proposal submissions.

Before the DoD Components can award a contract, proposing firms must be registered in the System for Award Management (SAM). SAM allows firms interested in conducting business with the federal government to provide basic information on business structure and capabilities as well as financial and payment information. To register, visit www.sam.gov. It is in the firm's interest to visit SAM and ensure the firm's registration is active and representations and certifications are up-to-date to avoid delay in award.

SAM.gov merged into the modernized beta.SAM.gov environment on May 24, 2021. Legacy SAM.gov has been decommissioned and the new environment has retired the "beta" and is renamed SAM.gov. The system provides a modern portal for entities to register, update, renew, and check the status of their registration in the rebranded SAM.gov. Core functions of SAM and core data has not changed. Entities with an active registration do not need to take action and the process to register to do business with the government has not changed.

Follow instructions found during SAM registration on how to obtain a Commercial and Government Entry (CAGE) code and Data Universal Numbering System (DUNS) number. Once a CAGE code and DUNS number are obtained, update the firm's profile on the Defense SBIR/STTR Innovation Portal (DSIP) at <https://www.dodsbirsttr.mil/submissions/>.

In addition to the standard federal and DoD procurement certifications, the SBA SBIR Policy Directive requires the collection of certain information from firms at time of award and during the award life cycle. Each firm must provide this additional information at the time of the Phase I and Phase II award, prior to final payment on the Phase I award, prior to receiving 50% of the total award amount for a Phase II award, and prior to final payment on the Phase II award.

4.16 Promotional Materials

Promotional and non-project related discussion is discouraged, and additional information provided via Universal Resource Locator (URL) links or on computer disks, CDs, DVDs, video tapes or any other medium will not be accepted or considered in the proposal evaluation.

4.17 Prior, Current, or Pending Support of Similar Proposals or Awards

IMPORTANT -- While it is permissible, with proposal notification, to submit identical proposals or proposals containing a significant amount of essentially equivalent work (see Section 3) for consideration under numerous federal program BAAs or solicitations, it is unlawful to enter into contracts or grants requiring essentially equivalent effort. If there is any question concerning prior, current, or pending support of similar proposals or awards, it must be disclosed to the soliciting agency or agencies as early as possible. See Section 5.4.c(11).

4.18 Fraud and Fraud Reporting

Knowingly and willfully making any false, fictitious, or fraudulent statements or representations may be a felony under the Federal Criminal False Statement Act (18 U.S.C. Sec 1001), punishable by a fine of up to \$10,000, up to five years in prison, or both.

The Department of Defense, Office of Inspector General Hotline (“Defense Hotline”) is an important avenue for reporting fraud, waste, abuse, and mismanagement within the Department of Defense. The Office of Inspector General operates this hotline to receive and investigate complaints or information from contractor employees, DoD civilians, military service members and public citizens. Individuals who wish to report fraud, waste or abuse may contact the Defense Hotline at (800) 424-9098 between 8:00 a.m. and 5:00 p.m. Eastern Time or visit <https://www.dodig.mil/Components/Administrative-Investigations/DoD-Hotline/Hotline-Complaint/> to submit a complaint. Mailed correspondence should be addressed to the Defense Hotline, The Pentagon, Washington, DC 20301-1900, or e-mail addressed to hotline@dodig.mil.

4.19 State and Other Assistance Available

Many states have established programs to provide services to those small business firms and individuals wishing to participate in the Federal SBIR Program. These services vary from state to state, but may include:

- Information and technical assistance;
- Matching funds to SBIR recipients;
- Assistance in obtaining Phase III funding.

Contact your State SBIR/STTR Support office at https://www.sbir.gov/state_services?state=105813# for further information. Small Businesses may seek general administrative guidance from small and disadvantaged business utilization specialists located in various Defense Contract Management activities throughout the continental United States.

4.20 Discretionary Technical and Business Assistance (TAB A)

DoD has not mandated the use of TAB A pending further SBA guidance and establishment of a limit on the amount of technical and business assistance services that may be received or purchased by a small business concern that has received multiple Phase II SBIR or STTR awards for a fiscal year. However, proposers should carefully review individual component instructions to determine if TAB A is being offered and follow specific proposal requirements for requesting TAB A funding.

5.0 PHASE I PROPOSAL

5.1 Introduction

This BAA and the Defense SBIR/STTR Innovation Portal (DSIP) sites are designed to reduce the time and cost required to prepare a formal proposal. DSIP is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Proposers submitting through this site for the first time will be asked to register. It is recommended that firms register as soon as possible upon identification of a proposal opportunity to avoid delays in the proposal submission process.

This information in this section is applicable to Phase I proposals only. If the Component is participating in the **Direct to Phase II Program**, refer to the Component-specific Direct to Phase II instructions for more information on proposal preparation.

Guidance on allowable proposal content may vary by Component. Accordingly, it is the proposing firm’s responsibility to consult the Component-specific instructions for detailed guidance, including

required proposal documentation, cost and duration limitations, budget structure, TABA allowance and proposal page limits.

DSIP provides a structure for providing the following proposal volumes:

- Volume 1: Proposal Cover Sheet
- Volume 2: Technical Volume
- Volume 3: Cost Volume
- Volume 4: Company Commercialization Report
- Volume 5: Supporting Documents
 - a. Contractor Certification Regarding Provision of Prohibition on Contracting for Certain Telecommunications and Video Surveillance Services or Equipment (Attachment 1)
 - b. Foreign Ownership or Control Disclosure (Proposers must review Attachment 2: Foreign Ownership or Control Disclosure to determine applicability.)
 - c. Other supporting documentation (Refer to Component-specific instructions for additional Volume 5 requirements)
- Volume 6: Fraud, Waste and Abuse Training

All proposers must complete the following:

- Volume 4: Company Commercialization Report (upload of CCR from SBIR.gov to DSIP is required for proposers with prior Federal SBIR or STTR awards)
- Volume 5(a): Contractor Certification Regarding Provision of Prohibition on Contracting for Certain Telecommunications and Video Surveillance Services or Equipment (Attachment 1)
- Volume 5(b): Foreign Ownership or Control Disclosure (Proposers must review Attachment 2: Foreign Ownership or Control Disclosure to determine applicability)
- Volume 6: Fraud, Waste and Abuse training.

Refer to Section 5.3 below for full details on these proposal requirements.

A Phase I Proposal Template is available to provide helpful guidelines for completing each section of your Phase I technical proposal. This can be found at <https://www.dodsbirsttr.mil/submissions/learning-support/firm-templates>.

Detailed guidance on registering in DSIP and using DSIP to submit a proposal can be found at <https://www.dodsbirsttr.mil/submissions/learning-support/training-materials>. If the proposal status is “In Progress” or “Ready to Certify” it will NOT be considered submitted, even if all volumes are added prior to the BAA close date. The proposer may modify all proposal volumes prior to the BAA close date.

Although signatures are not required on the electronic forms at the time of submission the proposal must be certified electronically by the corporate official for it to be considered submitted. If the proposal is selected for award, the DoD Component program will contact the proposer for signatures at the time of award.

5.2 Marking Proprietary Proposal Information

Proposers that include in their proposals data that they do not want disclosed to the public for any purpose, or used by the Government except for evaluation purposes, shall:

(1) Mark the first page of each Volume of the proposal submission with the following legend:

"This proposal includes data that shall not be disclosed outside the Government and shall not be duplicated, used, or disclosed-in whole or in part-for any purpose other than to evaluate this proposal. If, however, a contract is awarded to this proposer as a result of-or in connection with-the submission of this data, the Government shall have the right to duplicate, use, or disclose the data to the extent provided in the resulting contract. This restriction does not limit the Government's right to use information contained in this data if it is obtained from another source without restriction. The data subject to this restriction are contained in pages [insert numbers or other identification of sheets]"; and

(2) Mark each sheet of data it wishes to restrict with the following legend:

"Use or disclosure of data contained on this page is subject to the restriction on the first page of this volume."

The DoD assumes no liability for disclosure or use of unmarked data and may use or disclose such data for any purpose.

Restrictive notices notwithstanding, proposals and final reports submitted through the Defense SBIR/STTR Innovation Portal (DSIP) may be handled, for administrative purposes only, by support contractors. All support contractors are bound by appropriate non-disclosure agreements.

5.3 Phase I Proposal Instructions

a. Proposal Cover Sheet (Volume 1)

On the Defense SBIR/STTR Innovation Portal (DSIP) at <https://www.dodsbirsttr.mil/submissions/>, prepare the Proposal Cover Sheet.

The Cover Sheet must include a brief technical abstract that describes the proposed R&D project and a discussion of anticipated benefits and potential commercial applications. Each section should be no more than 200 words. **Do not include proprietary or classified information in the Proposal Cover Sheet.** If your proposal is selected for award, the technical abstract and discussion of anticipated benefits may be publicly released on the Internet. Once the Cover Sheet is saved, the system will assign a proposal number. You may modify the cover sheet as often as necessary until the BAA closes.

b. Format of Technical Volume (Volume 2)

- (1) **Type of file:** The Technical Volume must be a single Portable Document Format (PDF) file, including graphics. Perform a virus check before uploading the Technical Volume file. If a virus is detected, it may cause rejection of the proposal. **Do not lock or encrypt the uploaded file. Do not include or embed active graphics such as videos, moving pictures, or other similar media in the document.**
- (2) **Length:** It is the proposing firm's responsibility to verify that the Technical Volume does not exceed the page limit after upload to DSIP. Please refer to Component-specific instructions for how a technical volume is handled if the stated page count is exceeded. Some Components will reject the entire technical proposal if the proposal exceeds the stated page count.
- (3) **Layout:** Number all pages of your proposal consecutively. Those who wish to respond must submit a direct, concise, and informative research or research and development proposal (no type smaller than 10-point on standard 8-1/2" x 11" paper with one-inch

margins). The header on each page of the Technical Volume should contain your company name, topic number, and proposal number assigned by the Defense SBIR/STTR Innovation Portal (DSIP) when the Cover Sheet was created. The header may be included in the one-inch margin.

c. **Content of the Technical Volume (Volume 2)**

The Technical Volume should cover the following items in the order given below:

- (1) **Identification and Significance of the Problem or Opportunity.** Define the specific technical problem or opportunity addressed and its importance.
- (2) **Phase I Technical Objectives.** Enumerate the specific objectives of the Phase I work, including the questions the research and development effort will try to answer to determine the feasibility of the proposed approach.
- (3) **Phase I Statement of Work (including Subcontractors' Efforts)**
 - a. Provide an explicit, detailed description of the Phase I approach. If a Phase I option is required or allowed by the Component, describe appropriate research activities which would commence at the end of Phase I base period should the Component elect to exercise the option. The Statement of Work should indicate what tasks are planned, how and where the work will be conducted, a schedule of major events, and the final product(s) to be delivered. The Phase I effort should attempt to determine the technical feasibility of the proposed concept. The methods planned to achieve each objective or task should be discussed explicitly and in detail. This section should be a substantial portion of the Technical Volume section.
 - b. This BAA may contain topics that have been identified by the Program Manager as research or activities involving Human/Animal Subjects and/or Recombinant DNA. In the event that Phase I performance includes performance of these kinds of research or activities, please identify the applicable protocols and how those protocols will be followed during Phase I. Please note that funds cannot be released or used on any portion of the project involving human/animal subjects or recombinant DNA research or activities until all of the proper approvals have been obtained (see Sections 4.7 - 4.9). **Submitters proposing research involving human and/or animal use are encouraged to separate these tasks in the technical proposal and cost proposal in order to avoid potential delay of contract award.**
- (4) **Related Work.** Describe significant activities directly related to the proposed effort, including any conducted by the principal investigator, the proposing firm, consultants, or others. Describe how these activities interface with the proposed project and discuss any planned coordination with outside sources. The technical volume must persuade reviewers of the proposer's awareness of the state-of-the-art in the specific topic. Describe previous work not directly related to the proposed effort but similar. Provide the following:
 - a. Short description,
 - b. Client for which work was performed (including individual to be contacted and phone number), and
 - c. Date of completion.
- (5) **Relationship with Future Research or Research and Development**
 - a. State the anticipated results of the proposed approach if the project is successful.

- b. Discuss the significance of the Phase I effort in providing a foundation for Phase II research or research and development effort.
 - c. Identify the applicable clearances, certifications and approvals required to conduct Phase II testing and outline the plan for ensuring timely completion of said authorizations in support of Phase II research or research and development effort.
- (6) **Commercialization Strategy.** Describe in approximately one page your company's strategy for commercializing this technology in DoD, other Federal Agencies, and/or private sector markets. Provide specific information on the market need the technology will address and the size of the market. Also include a schedule showing the quantitative commercialization results from this SBIR project that your company expects to achieve.
- (7) **Key Personnel.** Identify key personnel who will be involved in the Phase I effort including information on directly related education and experience. A concise technical resume of the principal investigator, including a list of relevant publications (if any), must be included (Please do not include Privacy Act Information). All resumes will count toward the page limitations for Volume 2.
- (8) **Foreign Citizens.** Identify any foreign citizens or individuals holding dual citizenship expected to be involved on this project as a direct employee, subcontractor, or consultant. For these individuals, please specify their country of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project. Proposers frequently assume that individuals with dual citizenship or a work permit will be permitted to work on an SBIR project and do not report them. This is not necessarily the case and a proposal will be rejected if the requested information is not provided. Therefore, firms should report any and all individuals expected to be involved on this project that are considered a foreign national as defined in Section 3 of the BAA. You may be asked to provide additional information during negotiations in order to verify the foreign citizen's eligibility to participate on a SBIR contract. Supplemental information provided in response to this paragraph will be protected in accordance with the Privacy Act (5 U.S.C. 552a), if applicable, and the Freedom of Information Act (5 U.S.C. 552(b)(6)).
- (9) **Facilities/Equipment.** Describe available instrumentation and physical facilities necessary to carry out the Phase I effort. Justify equipment purchases in this section and include detailed pricing information in the Cost Volume. State whether or not the facilities where the proposed work will be performed meet environmental laws and regulations of federal, state (name), and local Governments for, but not limited to, the following groupings: airborne emissions, waterborne effluents, external radiation levels, outdoor noise, solid and bulk waste disposal practices, and handling and storage of toxic and hazardous materials.
- (10) **Subcontractors/Consultants.** Involvement of a university or other subcontractors or consultants in the project may be appropriate. If such involvement is intended, it should be identified and described to the same level of detail as the prime contractor costs. A minimum of two-thirds of the research and/or analytical work in Phase I, as measured by direct and indirect costs, must be conducted by the proposing firm, unless otherwise approved in writing by the Contracting Officer. SBIR efforts may include subcontracts with Federal Laboratories and Federally Funded Research and Development Centers (FFRDCs). A waiver is no longer required for the use of federal laboratories and FFRDCs;

however, proposers must certify their use of such facilities on the Cover Sheet of the proposal.

- (11) **Prior, Current, or Pending Support of Similar Proposals or Awards.** If a proposal submitted in response to this BAA is substantially the same as another proposal that was funded, is now being funded, or is pending with another Federal Agency, or another or the same DoD Component, you must reveal this on the Proposal Cover Sheet and provide the following information:
- Name and address of the Federal Agency(s) or DoD Component to which a proposal was submitted, will be submitted, or from which an award is expected or has been received.
 - Date of proposal submission or date of award.
 - Title of proposal.
 - Name and title of principal investigator for each proposal submitted or award received.
 - Title, number, and date of BAA(s) or solicitation(s) under which the proposal was submitted, will be submitted, or under which award is expected or has been received.
 - If award was received, state contract number.
 - Specify the applicable topics for each SBIR proposal submitted or award received.

Note: If this does not apply, state in the proposal "No prior, current, or pending support for proposed work."

d. Content of the Cost Volume (Volume 3)

Complete the Cost Volume by using the on-line cost volume form on the Defense SBIR/STTR Innovation Portal (DSIP). Some items in the cost breakdown may not apply to the proposed project. If that is the case, there is no need to provide information on each and every item. What matters is that enough information be provided to allow us to understand how you plan to use the requested funds if a contract is awarded.

- List all key personnel by name as well as by number of hours dedicated to the project as direct labor.
- While special tooling and test equipment and material cost may be included under Phases I, the inclusion of equipment and material will be carefully reviewed relative to need and appropriateness for the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Component Contracting Officer, be advantageous to the Government and should be related directly to the specific topic. These may include such items as innovative instrumentation or automatic test equipment. Title to property furnished by the Government or acquired with Government funds will be vested with the DoD Component, unless it is determined that transfer of title to the contractor would be more cost effective than recovery of the equipment by the DoD Component.
- Cost for travel funds must be justified and related to the needs of the project.
- Cost sharing is permitted for proposals under this BAA; however, cost sharing is not required nor will it be an evaluation factor in the consideration of a Phase I proposal.
- A Phase I Option (if applicable) should be fully costed separately from the Phase I (base) approach.

- (6) All subcontractor costs and consultant costs, such as labor, travel, equipment, materials, must be detailed at the same level as prime contractor costs. Provide detailed substantiation of subcontractor costs in your cost proposal. Volume 5, Supporting Documents, may be used if additional space is needed.

When a proposal is selected for award, you must be prepared to submit further documentation to the Component Contracting Officer to substantiate costs (e.g., an explanation of cost estimates for equipment, materials, and consultants or subcontractors). For more information about cost proposals and accounting standards, see <https://www.dcaa.mil/Guidance/Audit-Process-Overview/>.

e. **Company Commercialization Report (Volume 4)**

The Company Commercialization Report (CCR) allows companies to report funding outcomes resulting from prior SBIR and STTR awards. SBIR and STTR awardees are required by SBA to update and maintain their organization's CCR on SBIR.gov. Commercialization information is required upon completion of the last deliverable under the funding agreement. Thereafter, SBIR and STTR awardees are requested to voluntarily update the information in the database annually for a minimum period of 5 years.

If the proposing firm has prior DoD and/or non-DoD Phase I and/or Phase II SBIR/STTR awards, regardless of whether the project has any commercialization to date, a PDF of the CCR must be downloaded from SBIR.gov and uploaded to the Firm Forms section of DSIP by the Firm Admin. Firm Forms are completed by the DSIP Firm Admin and are applied across all proposals the firm submits. The DSIP CCR requirement is fulfilled by completing the following:

1. Log into the firm account at <https://www.sbir.gov/>.
2. Navigate to My Dashboard > My Documents to view or print the information currently contained in the Company Registry Commercialization Report.
3. Create or update the commercialization record, from the company dashboard, by scrolling to the "My Commercialization" section, and clicking the create/update Commercialization tab under "Current Report Version". Please refer to the "Instructions" and "Guide" documents contained in this section of the Dashboard for more detail on completing and updating the CCR. **Ensure the report is certified and submitted.**
4. Click the "Company Commercialization Report" PDF under the My Documents section of the dashboard to download a PDF of the CCR.
5. Upload the PDF of the CCR (downloaded from SBIR.gov in previous step) to the Company Commercialization Report in the Firm Forms section of DSIP. This upload action must be completed by the Firm Admin.

This version of the CCR, uploaded to DSIP from SBIR.gov, is inserted into all proposal submissions as Volume 4.

During proposal submission, the proposer will be prompted with the question: "Do you have a new or revised Company Commercialization Report to upload?". There are three possible courses of action:

- a. If the proposing firm has prior DoD and/or non-DoD Phase I and/or Phase II SBIR/STTR awards, and **DOES have a new or revised CCR from SBIR.gov to upload to DSIP**, select YES.

- If the user is the Firm Admin, they can upload the PDF of the CCR from SBIR.gov directly on this page. It will also be updated in the Firm Forms and be associated with all new or in-progress proposals submitted by the firm. If the user is not the Firm Admin, they will receive a message that they do not have access and must contact the Firm Admin to complete this action.
 - **WARNING:** Uploading a new CCR under the Firm Forms section of DSIP or clicking “Save” or “Submit” in Volume 4 of one proposal submission is considered a change for ALL proposals under any open BAAs or CSOs. If a proposing firm has previously certified and submitted any Phase I or Direct to Phase II proposals under *any* BAA or CSO *that is still open*, those proposals will be automatically reopened. Proposing firms will have to recertify and resubmit such proposals. If a proposing firm does not recertify or resubmit such proposals, they will not be considered fully submitted and will not be evaluated.
- b. If the proposing firm has prior DoD and/or non-DoD Phase I and/or Phase II SBIR/STTR awards, and **DOES NOT have a new or revised CCR from SBIR.gov to upload to DSIP**, select NO.
- If a prior CCR was uploaded to the Firm Forms, the proposer will see a file dialog box at the bottom of the page and can view the previously uploaded CCR. This read-only access allows the proposer to confirm that the CCR has been uploaded by the Firm Admin.
 - If no file dialog box is present at the bottom of the page that is an indication that **there is no previously uploaded CCR in the DSIP Firm Forms**. To fulfill the DSIP CCR requirement the Firm Admin must follow steps 1-5 listed above to download a PDF of the CCR from SBIR.gov and upload it to the DSIP Firm Forms to be included with all proposal submissions.
- c. If the proposing firm has **NO** prior DoD and/or non-DoD Phase I and/or Phase II SBIR/STTR awards, the upload of the CCR from SBIR.gov is not required and firm will select NO. The CCR section of the proposal will be marked complete.

While all proposing firms with prior DoD and/or non-DoD Phase I and/or Phase II SBIR/STTR awards must report funding outcomes resulting from these awards through the CCR from SBIR.gov and upload a copy of this report to their Firm Forms in DSIP, **please refer to the Component-specific instructions for details on how this information will be considered during proposal evaluations.**

f. **Supporting Documents (Volume 5)**

Volume 5 is provided for proposers to submit additional documentation to support the Coversheet (Volume 1), Technical Volume (Volume 2), and the Cost Volume (Volume 3).

All proposers are REQUIRED to submit the following documents to Volume 5:

1. Contractor Certification Regarding Provision of Prohibition on Contracting for Certain Telecommunications and Video Surveillance Services or Equipment (Attachment 1) (REQUIRED)
2. Foreign Ownership or Control Disclosure (BAA Attachment 2) (Proposers must review Attachment 2: Foreign Ownership or Control Disclosure to determine applicability)

Any of the following documents may be included in Volume 5 if applicable to the proposal. Refer to Component-specific instructions for additional Volume 5 requirements.

1. Letters of Support
2. Additional Cost Information
3. Funding Agreement Certification
4. Technical Data Rights (Assertions)
5. Lifecycle Certification
6. Allocation of Rights
7. Other

g. **Contractor Certification Regarding Provision of Prohibition on Contracting for Certain Telecommunications and Video Surveillance Services or Equipment**

The DoD must comply with Section 889(a)(1)(B) of the National Defense Authorization Act (NDAA) for Fiscal Year 2019, and is working to reduce or eliminate contracts with entities that use any equipment, system, or service that uses covered telecommunications equipment or services (as defined in BAA Attachment 1) as a substantial or essential component of any system, or as critical technology as part of any system.

All proposals must include certifications in Defense Federal Acquisition Regulation Supplement (DFARS) provisions 252.204-7016, 252.204-7017, and clause 252.204-7018, executed by the proposer's authorized company representative. The DFARS provisions and clause may be found in BAA Attachment 1. **These certifications must be signed by the authorized company representative and uploaded as a separate PDF file in the supporting documents sections of Volume 5 for all proposal submissions.**

The effort to complete the required certification clauses includes due diligence on the part of the proposer and for any contractors that may be proposed as a part of the submission including research partners and suppliers. Therefore, proposers are strongly encouraged to review the requirements of these certifications early in the proposal development process. Failure to submit or complete the required certifications as a part of the proposal submission process may be cause for rejection of the proposal submission without evaluation.

h. **Foreign Ownership or Control Disclosure**

Proposers must review Attachment 2: Foreign Ownership or Control Disclosure to determine applicability. If applicable, an authorized firm representative must complete the Foreign Ownership or Control Disclosure (BAA Attachment 2). The completed and signed disclosure must be uploaded to Volume 5 of the proposal submission.

i. **Fraud, Waste and Abuse Training (Volume 6)**

The Fraud, Waste and Abuse (FWA) training is **required** for Phase I and Direct to Phase II proposals. FWA training provides information on what represents FWA in the SBIR/STTR program, the most common mistakes that lead to FWA, as well as the penalties and ways to prevent FWA in your firm. This training material can be found in the Volume 6 section of the proposal submission module in DSIP and must be thoroughly reviewed once per year. Plan ahead and leave ample time to complete this training based on the proposal submission deadline. FWA training must be completed by one DSIP firm user with read/write access (Proposal Owner, Corporate Official or Firm Admin) on behalf of the firm.

6.0 PHASE I EVALUATION CRITERIA

Proposals will be evaluated based on the criteria outlined below, unless otherwise specified in the Component-specific instructions. Selections will be based on best value to the Government considering the following factors which are listed in descending order of importance:

- a. The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.
- b. The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.
- c. The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.

Cost or budget data submitted with the proposals will be considered during evaluation.

Technical reviewers will base their conclusions only on information contained in the proposal. It cannot be assumed that reviewers are acquainted with the firm or key individuals or any referenced experiments. Relevant supporting data such as journal articles, literature, including Government publications, etc., should be included based on requirements provided in Component-specific instructions.

7.0 PHASE II PROPOSAL INFORMATION

7.1 Introduction

Unless the Component is participating in Direct to Phase II, Phase II proposals may only be submitted by Phase I awardees. Submission of Phase II proposals are not permitted at this time, and if submitted, may be rejected without evaluation. Phase II proposal preparation and submission instructions will be provided by the DoD Components to Phase I awardees. See Component-specific instructions for more information on Direct to Phase II Program preparation and submission instructions.

7.2 Proposal Provisions

IMPORTANT -- While it is permissible, with proposal notification, to submit identical proposals or proposals containing a significant amount of essentially equivalent work for consideration under numerous federal program BAAs and solicitations, it is unlawful to enter into contracts or grants requiring essentially equivalent effort. If there is any question concerning this, it must be disclosed to the soliciting agency or agencies as early as possible. If a proposal submitted for a Phase II effort is substantially the same as another proposal that was funded, is now being funded, or is pending with another Federal Agency, or another or the same DoD Component, you must reveal this on the Cover Sheet and provide the information required in Section 5.4.c(11).

Due to specific limitations on the amount of funding and number of awards that may be awarded to a particular firm per topic using SBIR/STTR program funds, Head of Agency Determinations are now required before a different agency may make an award using another agency's topic. This limitation does not apply to Phase III funding. Please contact your original sponsoring agency before submitting a Phase II proposal to an agency other than the one who sponsored the original topic.

Section 4(b)(1)(i) of the SBIR/STTR Policy Directive provides that, at the agency's discretion, projects awarded a Phase I under a solicitation for SBIR may transition in Phase II to STTR and vice versa. A firm

wishing to transfer from one program to another must contact their designated technical monitor to discuss the reasons for the request and the agency's ability to support the request. The transition may be proposed prior to award or during the performance of the Phase II effort. Agency disapproval of a request to change programs shall not be grounds for granting relief from any contractual performance requirement. All approved transitions between programs must be noted in the Phase II award or award modification signed by the contracting officer that indicates the removal or addition of the research institution and the revised percentage of work requirements.

7.3 Commercialization Strategy

At a minimum, your commercialization strategy must address the following five questions:

- (1) What is the first product that this technology will go into?
- (2) Who will be the customers, and what is the estimated market size?
- (3) How much money will be needed to bring the technology to market, and how will that money be raised?
- (4) Does the company contain marketing expertise and, if not, how will that expertise be brought into the company?
- (5) Who are the proposing firm's competitors, and what is the price and/or quality advantage over those competitors?

The commercialization strategy must also include a schedule showing the anticipated quantitative commercialization results from the Phase II project at one year after the start of Phase II, at the completion of Phase II, and after the completion of Phase II (i.e., amount of additional investment, sales revenue, etc.). After Phase II award, the company is required to report actual sales and investment data in its SBA Company Commercialization Report via "My Dashboard" on SBIR.gov at least annually. For information on formatting, page count and other details, please refer to the Component-specific instructions.

7.4 Phase II Evaluation Criteria

Phase II proposals will be evaluated based on the criteria outlined above in section 6.0, unless otherwise specified in the Component-specific instructions.

7.5 Phase II Award Information

DoD Components will notify Phase I awardees of the Phase II proposal submission requirements. Submission of Phase II proposals will be in accordance with instructions provided by individual Components. The details on the due date, content, and submission requirements of the Phase II proposal will be provided by the awarding DoD Component either in the Phase I award or by subsequent notification.

7.6 Adequate Accounting System

In order to reduce risk to the small business and avoid potential contracting delays, it is suggested that companies interested in pursuing Phase II SBIR contracts and other contracts of similar size with the Department of Defense (DoD), have an adequate accounting system per General Accepted Accounting Principles (GAAP), Generally Accepted Government Auditing Standards (GAGAS), Federal Acquisition Regulation (FAR) and Cost Accounting Standards (CAS) in place. The accounting system will be audited by the Defense Contract Audit Agency (DCAA). DCAA's requirements and standards are available on their Website at <https://www.dcaa.mil/Guidance/Audit-Process-Overview/> and <https://www.dcaa.mil/Checklists-Tools/Pre-award-Accounting-System-Adequacy-Checklist/>.

7.7 Phase II Enhancement Policy

To further encourage the transition of SBIR research into DoD acquisition programs as well as the private sector, certain DoD Components have developed their own Phase II Enhancement policy. Under this policy, the Component will provide a Phase II awardee with additional Phase II SBIR funding if the company can match the additional SBIR funds with non-SBIR funds from DoD acquisition programs or the private sector.

See component instructions for more details on Phase II Enhancement opportunities.

7.8 Commercialization Readiness Program (CRP)

The SBIR/STTR Reauthorization Act of 2011 established the Commercialization Pilot Program (CPP) as a long-term program titled the Commercialization Readiness Program (CRP).

Each Military Department (Army, Navy, and Air Force) has established a Commercialization Readiness Program. Please check the Component instructions for further information.

The Small Business and Technology Partnerships Office has established the OSD Transitions SBIR Technology (OTST) Pilot Program. The OTST pilot program is an interim technology maturity phase (Phase II), inserted into the SBIR development.

For more information contact osd.ncr.ousd-r-e.mbx.sbir-sttr@mail.mil.

8.0 CONTRACTUAL REQUIREMENTS

8.1 Additional Contract Requirements

Small Business Concerns (SBCs) are strongly encouraged to engage with their Contracting/Agreements Office to determine what measures can be taken in the event contract performance is affected due to the COVID-19 situation. SBCs are encouraged to monitor the CDC Website, engage with your employees to share information and discuss COVID-19 concerns employees may have. Please identify to your Contracting/Agreements Officer potential impacts to the welfare and safety of your workforce and any contract/OT performance issues. Most importantly, keep in mind that only your Contracting/Agreements Officer can affect changes to your contract/OT.

Upon award of a contract, the contractor will be required to make certain legal commitments through acceptance of Government contract clauses in the Phase I contract. The outline that follows is illustrative of the types of provisions required by the Federal Acquisition Regulation that will be included in the Phase I contract. This is not a complete list of provisions to be included in Phase I contracts, nor does it contain specific wording of these clauses. Copies of complete general provisions will be made available prior to award.

Examples of general provisions:

- a. **Standards of Work.** Work performed under the contract must conform to high professional standards.
- b. **Inspection.** Work performed under the contract is subject to Government inspection and evaluation at all reasonable times.

- c. **Examination of Records.** The Comptroller General (or a fully authorized representative) shall have the right to examine any directly pertinent records of the contractor involving transactions related to this contract.
- d. **Default.** The Government may terminate the contract if the contractor fails to perform the work contracted.
- e. **Termination for Convenience.** The contract may be terminated at any time by the Government if it deems termination to be in its best interest, in which case the contractor will be compensated for work performed and for reasonable termination costs.
- f. **Disputes.** Any dispute concerning the contract which cannot be resolved by agreement shall be decided by the contracting officer with right of appeal.
- g. **Contract Work Hours.** The contractor may not require an employee to work more than eight hours a day or forty hours a week unless the employee is compensated accordingly (that is, receives overtime pay).
- h. **Equal Opportunity.** The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.
- i. **Affirmative Action for Veterans.** The contractor will not discriminate against any employee or applicant for employment because he or she is a disabled veteran.
- j. **Affirmative Action for Handicapped.** The contractor will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.
- k. **Officials Not to Benefit.** No member of or delegate to Congress shall benefit from the contract.
- l. **Covenant Against Contingent Fees.** No person or agency has been employed to solicit or secure the contract upon an understanding for compensation except bona fide employees or commercial agencies maintained by the contractor for the purpose of securing business.
- m. **Gratuities.** The contract may be terminated by the Government if any gratuities have been offered to any representative of the Government to secure the contract.
- n. **Patent Infringement.** The contractor shall report each notice or claim of patent infringement based on the performance of the contract.
- o. **Military Security Requirements.** The contractor shall safeguard any classified information associated with the contracted work in accordance with applicable regulations.
- p. **American Made Equipment and Products.** When purchasing equipment or a product under the SBIR funding agreement, purchase only American-made items whenever possible.

Applicable Federal Acquisition Regulation (FAR) and/or Defense Federal Acquisition Regulation Supplement (DFARS) Clauses:

- q. **Unique Identification (UID).** If your proposal identifies hardware that will be delivered to the government, be aware of the possible requirement for unique item identification in accordance with DFARS 252.211-7003.
- r. **Disclosure of Information.** In accordance with FAR 252.204-7000, Government review and approval will be required prior to any dissemination or publication, regardless of medium (e.g., film, tape, document), pertaining to any part of this contract or any program related to this contract except within and between the Contractor and any subcontractors, of unclassified and non-fundamental information developed under this contract or contained in the reports to be furnished pursuant to this contract.
- s. **Animal Welfare.** Contracts involving research, development, test, evaluation, or training on vertebrate animals will incorporate DFARS clause 252.235-7002.
- t. **Protection of Human Subjects.** Effective 29 July 2009, contracts that include or may include research involving human subjects in accordance with 32 CFR Part 219, DoD Directive 3216.02 and 10 U.S.C. 980, including research that meets exemption criteria under 32 CFR 219.101(b), will incorporate DFARS clause 252.235-7004.

- u. **E-Verify.** Contracts exceeding the simplified acquisition threshold may include the FAR clause 52.222-54 “Employment Eligibility Verification” unless exempted by the conditions listed at FAR 22.1803.
- v. **ITAR.** In accordance with DFARS 225.7901-4, Export Control Contract Clauses, the clause found at DFARS 252.225-7048, Export-Controlled Items (June 2013), must be included in all BAAs/solicitations and contracts. Therefore, all awards resulting from this BAA will include DFARS 252.225-7048. Full text of the clause may be found at <https://www.govinfo.gov/content/pkg/CFR-2013-title48-vol3/pdf/CFR-2013-title48-vol3-sec252-225-7048.pdf>.
- w. **Cybersecurity.** Any SBC receiving an SBIR/STTR award is required to provide adequate security on all covered contractor information systems. Specific security requirements and cyber incident reporting requirements are listed in DFARS 252.204.7012. Compliance is mandatory.
- x. **Safeguarding Covered Defense Information Controls.** As prescribed in DFARS 252.204-7008, for covered contractor information systems that are not part of an information technology service or system operated on behalf of the Government, the SBC represents that it will implement the security requirements specified by National Institute of Standards and Technology (NIST) Special Publication (SP) 800-171, “Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations”.
- y. **Limitations on the Use or Disclosure of Third- Party Contractor Reported Cyber Incident Information.** As required in DFARS 252.204-7009, the Contractor must agree that certain conditions apply to any information it receives or creates in the performance of a resulting contract that is information obtained from a third-party's reporting of a cyber incident pursuant to DFARS clause 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting (or derived from such information obtained under that clause).
- z. **Notice of NIST SP 800-171 DoD Assessment Requirements.** As prescribed by DFARS 252.204-7019, in order to be considered for award, the SBC is required to implement NIST SP 800-171. The SBC shall have a current assessment (see 252.204-7020) for each covered contractor information system that is relevant to the offer, contract, task order, or delivery order. The Basic, Medium, and High NIST SP 800-171 DoD Assessments are described in the NIST SP 800-171 DoD Assessment Methodology located at https://www.acq.osd.mil/dpap/pdi/cyber/strategically_assessing_contractor_implementation_of_NIST_SP_800-171.html. In accordance with DFARS 252.204-7020, the SBC shall provide access to its facilities, systems, and personnel necessary for the Government to conduct a Medium or High NIST SP 800-171 DoD Assessment, as described in NIST SP 800-171 DoD Assessment Methodology, linked above. Notification of specific requirements for NIST SP 800-171 DoD assessments and assessment level will be provided as part of the component instructions, topic, or award.
- aa. **Contractor Certification Regarding Provision of Prohibition on Contracting for Certain Telecommunications and Video Surveillance Services or Equipment.** In accordance with DFARS Subpart 204.21, DFARS provisions 252.204-7016, 252.204-7017, and clause 252.204-7018 are incorporated into this solicitation. This subpart implements section 1656 of the National Defense Authorization Act for Fiscal Year 2018 (Pub. L. 115-91) and section 889(a)(1)(A) of the National Defense Authorization Act for Fiscal Year 2019 (Pub. L. 115-232). Full text of the provisions and clause and required offeror representations can be found in Attachment 1 of this BAA.
- bb. **Disclosure of Ownership or Control by a Foreign Government.** DFARS 252.209-7002, Disclosure of Ownership or Control by a Foreign Government (JUN 2010), is incorporated into this solicitation. In accordance with DFARS 252.209-7002, any SBC submitting a proposal in response to this solicitation is required to disclose, by completing Attachment 2 to this solicitation, Foreign Ownership or Control Disclosure, any interest a foreign government has in

the SBC when that interest constitutes control by a foreign government, as defined in DFARS provision 252.209-7002. If the SBC is a subsidiary, it is also required to disclose any reportable interest a foreign government has in any entity that owns or controls the subsidiary, including reportable interest concerning the SBC's immediate parent, intermediate parents, and the ultimate parent.

8.2 Ensuring Adequate COVID-19 Safety Protocols for Federal Contractors

In accordance with Class Deviation 2021-O0009 implementing the direction provided by Executive Order 14042, the following clause 252.223-7999 will be incorporated into awards that: (a) exceed the simplified acquisition threshold of \$250,000; and, (b) have been identified by the awarding DoD Component as meeting the applicability requirements as outlined in E.O. 14042 to ensure that contractors comply with all guidance for contractor and subcontractor workplace locations published by the Safer Federal Workforce Task Force at: <https://www.saferfederalworkforce.gov/contractors/>.

Covered contractors are cautioned to pay particular attention to "COVID 19 Workplace Safety: Guidance for Federal Contractors and Subcontractors" dated 24 September 2021 as promulgated by the Safer Federal Workforce Task Force.

252.223-7999 Ensuring Adequate COVID-19 Safety Protocols for Federal Contractors (Deviation 2021-O0009)

(a) *Definition.* As used in this clause –

United States or its outlying areas means—

- (1) The fifty States;
- (2) The District of Columbia;
- (3) The commonwealths of Puerto Rico and the Northern Mariana Islands;
- (4) The territories of American Samoa, Guam, and the United States Virgin Islands; and
- (5) The minor outlying islands of Baker Island, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Midway Islands, Navassa Island, Palmyra Atoll, and Wake Atoll.

(b) *Authority.* This clause implements Executive Order 14042, Ensuring Adequate COVID Safety Protocols for Federal Contractors, dated September 9, 2021 (published in the *Federal Register* on September 14, 2021, 86 FR 50985).

(c) *Compliance.* The Contractor shall comply with all guidance, including guidance conveyed through Frequently Asked Questions, as amended during the performance of this contract, for contractor or subcontractor workplace locations published by the Safer Federal Workforce Task Force (Task Force Guidance) at <https://www.saferfederalworkforce.gov/contractors/>.

(d) *Subcontracts.* The Contractor shall include the substance of this clause, including this paragraph (d), in subcontracts at any tier that exceed the simplified acquisition threshold, as defined in Federal Acquisition Regulation 2.101 on the date of subcontract award, and are for services, including construction, performed in whole or in part within the United States or its outlying areas.

8.3 Basic Safeguarding of Covered Contractor Information Systems

FAR 52.204-21, Basic Safeguarding of Covered Contractor Information Systems, is incorporated into this solicitation. In accordance with FAR 52.204-21, the contractor shall apply basic safeguarding requirements and procedures when the contractor or a subcontractor at any tier may have Federal contract information residing in or transiting through its information system.

FAR 52.204-21 Basic Safeguarding of Covered Contractor Information Systems (JUN 2016)

(a) Definitions. As used in this clause -

Covered contractor information system means an information system that is owned or operated by a contractor that processes, stores, or transmits Federal contract information.

Federal contract information means information, not intended for public release, that is provided by or generated for the Government under a contract to develop or deliver a product or service to the Government, but not including information provided by the Government to the public (such as on public Web sites) or simple transactional information, such as necessary to process payments.

Information means any communication or representation of knowledge such as facts, data, or opinions, in any medium or form, including textual, numerical, graphic, cartographic, narrative, or audiovisual (Committee on National Security Systems Instruction (CNSSI) 4009).

Information system means a discrete set of information resources organized for the collection, processing, maintenance, use, sharing, dissemination, or disposition of information (44 U.S.C. 3502).

Safeguarding means measures or controls that are prescribed to protect information systems.

(b) Safeguarding requirements and procedures.

(1) The Contractor shall apply the following basic safeguarding requirements and procedures to protect covered contractor information systems. Requirements and procedures for basic safeguarding of covered contractor information systems shall include, at a minimum, the following security controls:

- (i) Limit information system access to authorized users, processes acting on behalf of authorized users, or devices (including other information systems).
- (ii) Limit information system access to the types of transactions and functions that authorized users are permitted to execute.
- (iii) Verify and control/limit connections to and use of external information systems.
- (iv) Control information posted or processed on publicly accessible information systems.
- (v) Identify information system users, processes acting on behalf of users, or devices.
- (vi) Authenticate (or verify) the identities of those users, processes, or devices, as a prerequisite to allowing access to organizational information systems.
- (vii) Sanitize or destroy information system media containing Federal Contract Information before disposal or release for reuse.
- (viii) Limit physical access to organizational information systems, equipment, and the respective operating environments to authorized individuals.

(ix) Escort visitors and monitor visitor activity; maintain audit logs of physical access; and control and manage physical access devices.

(x) Monitor, control, and protect organizational communications (i.e., information transmitted or received by organizational information systems) at the external boundaries and key internal boundaries of the information systems.

(xi) Implement subnetworks for publicly accessible system components that are physically or logically separated from internal networks.

(xii) Identify, report, and correct information and information system flaws in a timely manner.

(xiii) Provide protection from malicious code at appropriate locations within organizational information systems.

(xiv) Update malicious code protection mechanisms when new releases are available.

(xv) Perform periodic scans of the information system and real-time scans of files from external sources as files are downloaded, opened, or executed.

(2) **Other requirements.** This clause does not relieve the Contractor of any other specific safeguarding requirements specified by Federal agencies and departments relating to covered contractor information systems generally or other Federal safeguarding requirements for controlled unclassified information (CUI) as established by Executive Order 13556.

(c) **Subcontracts.** The Contractor shall include the substance of this clause, including this paragraph (c), in subcontracts under this contract (including subcontracts for the acquisition of commercial items, other than commercially available off-the-shelf items), in which the subcontractor may have Federal contract information residing in or transiting through its information system.

8.4 Prohibition on Contracting with Persons that have Business Operations with the Maduro Regime

Section 890 of the National Defense Authorization Act (NDAA) for Fiscal Year (FY) 2020 prohibits entering into a contract for the procurement of products or services with any person that has business operations with an authority of the government of Venezuela that is not recognized as the legitimate government of Venezuela by the United States Government, unless an exception applies. See [provision 252.225-7974 Class Deviation 2020-O0005](#) “Prohibition on Contracting with Persons that have Business Operations with the Maduro Regime.

8.5 Copyrights

With prior written permission of the Contracting Officer, the awardee may copyright (consistent with appropriate national security considerations, if any) material developed with DoD support. DoD receives a royalty-free license for the Federal Government and requires that each publication contain an appropriate acknowledgment and disclaimer statement.

8.6 Patents

Small business firms normally may retain the principal worldwide patent rights to any invention developed with Government support. The Government receives a royalty-free license for its use, reserves the right to require the patent holder to license others in certain limited circumstances, and requires that anyone exclusively licensed to sell the invention in the United States must normally manufacture it domestically. To the extent authorized by 35 USC 205, the Government will not make public any information disclosing a Government-supported invention for a period of five years to allow the awardee to pursue a patent. See also Invention Reporting in Section 8.6.

8.7 Technical Data Rights

Rights in technical data, including software, developed under the terms of any contract resulting from proposals submitted in response to this BAA generally remain with the contractor, except that the Government obtains a royalty-free license to use such technical data only for Government purposes during the period commencing with contract award and ending twenty years after completion of the project under which the data were generated. This data should be marked with the restrictive legend specified in DFARS 252.227-7018 Class Deviation 2020-O0007. Upon expiration of the twenty-year restrictive license, the Government has unlimited rights in the SBIR data. During the license period, the Government may not release or disclose SBIR data to any person other than its support services contractors except: (1) For evaluation purposes; (2) As expressly permitted by the contractor; or (3) A use, release, or disclosure that is necessary for emergency repair or overhaul of items operated by the Government. See [DFARS clause 252.227-7018 Class Deviation 2020-O0007](#) "Rights in Noncommercial Technical Data and Computer Software – Small Business Innovation Research (SBIR) Program."

If a proposer plans to submit assertions in accordance with DFARS 252.227-7017 Class Deviation 2020-O0007, those assertions must be identified and assertion of use, release, or disclosure restriction **MUST** be included with your proposal submission, at the end of the technical volume. The contract cannot be awarded until assertions have been approved.

8.8 Invention Reporting

SBIR awardees must report inventions to the Component within two months of the inventor's report to the awardee. The reporting of inventions may be accomplished by submitting paper documentation, including fax, or through the Edison Invention Reporting System at www.iedison.gov for those agencies participating in iEdison.

8.9 Final Technical Reports - Phase I through Phase III

- a. **Content:** A final report is required for each project phase. The reports must contain in detail the project objectives, work performed, results obtained, and estimates of technical feasibility. A completed SF 298, "Report Documentation Page," will be used as the first page of the report. submission resources at <https://discover.dtic.mil/submit-documents/>. In addition, monthly status and progress reports may be required by the DoD Component.
- b. **SF 298 Form "Report Documentation Page" Preparation:**
 - (1) If desirable, language used by the company in its Phase II proposal to report Phase I progress may also be used in the final report.
 - (2) For each unclassified report, the company submitting the report should fill in Block 12 (Distribution/Availability Statement) of the SF 298, "Report Documentation Page," with the following statement: "Distribution authorized to U.S. Government only; Proprietary"

Information, (Date of Determination). Other requests for this document shall be referred to the Component SBIR Program Office.”

Note: Data developed under a SBIR contract is subject to SBIR Data Rights which allow for protection under DFARS 252.227-7018 Class Deviation 2020-O0007 (see Section 8.5, Technical Data Rights). The sponsoring DoD activity, after reviewing the company's entry in Block 12, has final responsibility for assigning a distribution statement.

For additional information on distribution statements see the following Defense Technical Information Center (DTIC) Web site: https://discover.dtic.mil/wp-content/uploads/2018/09/distribution_statements_and_reasonsSept2018.pdf

- (3) Block 14 (Abstract) of the SF 298, "Report Documentation Page" must include as the first sentence, "Report developed under SBIR contract for topic [insert BAA topic number. [Follow with the topic title, if possible.]]" The abstract must identify the purpose of the work and briefly describe the work conducted, the findings or results and the potential applications of the effort. **Since the abstract will be published by the DoD, it must not contain any proprietary or classified data and type "UU" in Block 17.**
- (4) Block 15 (Subject Terms) of the SF 298 must include the term "SBIR Report".
- c. **Submission:** In accordance with DoD Directive 3200.12 and DFARS clause 252.235-7011, a copy of the final report shall be submitted (electronically or on disc) to:
Defense Technical Information Center
ATTN: DTIC-OA (SBIR)
8725 John J Kingman Road, Suite 0944
Ft. Belvoir, VA 22060-6218

Delivery will normally be within 30 days after completion of the Phase I technical effort.

Other requirements regarding submission of reports and/or other deliverables will be defined in the Contract Data Requirements List (CDRL) of each contract. Special instructions for the submission of CLASSIFIED reports will be defined in the delivery schedule of the contract.

DO NOT E-MAIL Classified or controlled unclassified reports, or reports containing SBIR Data Rights protected under DFARS 252.227-7018 Class Deviation 2020-O0007.

ATTACHMENT 1

**Department of Defense (DoD)
Small Business Innovation Research (SBIR) Program
Small Business Technology Transfer (STTR) Program**

**CONTRACTOR CERTIFICATION REGARDING
PROVISION OF PROHIBITION ON CONTRACTING FOR CERTAIN
TELECOMMUNICATIONS AND VIDEO SURVEILLANCE SERVICES OR
EQUIPMENT (DFARS SUBPART 204.21)**

Contractor's Name	
Company Name	
Office Tel #	
Mobile #	
Email	

Name of person authorized to sign: _____

Signature of person authorized: _____

Date: _____

The penalty for making false statements is prescribed in the U.S. Criminal Code, 18 U.S.C. 1001.

DFARS PROVISIONS INCORPORATED IN FULL TEXT:

252.204-7016 Covered Defense Telecommunications Equipment or Services— Representation

**COVERED DEFENSE TELECOMMUNICATIONS EQUIPMENT OR SERVICES—
REPRESENTATION (DEC 2019)**

(a) *Definitions.* As used in this provision, “covered defense telecommunications equipment or services” has the meaning provided in the clause [252.204-7018](#) , Prohibition on the Acquisition of Covered Defense Telecommunications Equipment or Services.

(b) *Procedures*. The Offeror shall review the list of excluded parties in the System for Award Management (SAM) (<https://www.sam.gov/>) for entities excluded from receiving federal awards for “covered defense telecommunications equipment or services”.

(c) Representation. The Offeror represents that it ☐ does, ☐ does not provide covered defense telecommunications equipment or services as a part of its offered products or services to the Government in the performance of any contract, subcontract, or other contractual instrument.

252.204-7017 Prohibition on the Acquisition of Covered Defense Telecommunications Equipment or Services—Representation

PROHIBITION ON THE ACQUISITION OF COVERED DEFENSE TELECOMMUNICATIONS EQUIPMENT OR SERVICES—REPRESENTATION (MAY 2021)

*The Offeror is not required to complete the representation in this provision if the Offeror has represented in the provision at [252.204-7016](#), Covered Defense Telecommunications Equipment or Services—Representation, that it “**does not** provide covered defense telecommunications equipment or services as a part of its offered products or services to the Government in the performance of any contract, subcontract, or other contractual instrument.”*

(a) *Definitions*. “Covered defense telecommunications equipment or services,” “covered mission,” “critical technology,” and “substantial or essential component,” as used in this provision, have the meanings given in the [252.204-7018](#) clause, Prohibition on the Acquisition of Covered Defense Telecommunications Equipment or Services, of this solicitation.

(b) *Prohibition*. Section 1656 of the National Defense Authorization Act for Fiscal Year 2018 (Pub. L. 115-91) prohibits agencies from procuring or obtaining, or extending or renewing a contract to procure or obtain, any equipment, system, or service to carry out covered missions that uses covered defense telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system.

(c) *Procedures*. The Offeror shall review the list of excluded parties in the System for Award Management (SAM) at <https://www.sam.gov> for entities that are excluded when providing any equipment, system, or service to carry out covered missions that uses covered defense telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system, unless a waiver is granted.

Representation. If in its annual representations and certifications in SAM the Offeror has represented in paragraph (c) of the provision at [252.204-7016](#), Covered Defense Telecommunications Equipment or Services—Representation, that it “does” provide covered defense telecommunications equipment or services as a part of its offered products or services to the Government in the performance of any contract, subcontract, or other contractual instrument, then the Offeror shall complete the following additional representation:

The Offeror represents that it ☐ will ☐ will not provide covered defense telecommunications equipment or services as a part of its offered products or services to DoD in the performance of any award resulting from this solicitation.

(e) Disclosures. If the Offeror has represented in paragraph (d) of this provision that it “will provide covered defense telecommunications equipment or services,” the Offeror shall provide the following information as part of the offer:

(1) A description of all covered defense telecommunications equipment and services offered (include brand or manufacturer; product, such as model number, original equipment manufacturer (OEM) number, manufacturer part number, or wholesaler number; and item description, as applicable).

(2) An explanation of the proposed use of covered defense telecommunications equipment and services and any factors relevant to determining if such use would be permissible under the prohibition referenced in paragraph (b) of this provision.

(3) For services, the entity providing the covered defense telecommunications services (include entity name, unique entity identifier, and Commercial and Government Entity (CAGE) code, if known).

(4) For equipment, the entity that produced or provided the covered defense telecommunications equipment (include entity name, unique entity identifier, CAGE code, and whether the entity was the OEM or a distributor, if known).

(End of provision)

252.204-7018 Prohibition on the Acquisition of Covered Defense Telecommunications Equipment or Services

PROHIBITION ON THE ACQUISITION OF COVERED DEFENSE TELECOMMUNICATIONS EQUIPMENT OR SERVICES (JAN 2021)

Definitions. As used in this clause—

“Covered defense telecommunications equipment or services” means—

(1) Telecommunications equipment produced by Huawei Technologies Company or ZTE Corporation, or any subsidiary or affiliate of such entities;

(2) Telecommunications services provided by such entities or using such equipment; or

(3) Telecommunications equipment or services produced or provided by an entity that the Secretary of Defense reasonably believes to be an entity owned or controlled by, or otherwise connected to, the government of a covered foreign country.

“Covered foreign country” means—

- (1) The People’s Republic of China; or
- (2) The Russian Federation.

“Covered missions” means—

- (1) The nuclear deterrence mission of DoD, including with respect to nuclear command, control, and communications, integrated tactical warning and attack assessment, and continuity of Government; or
- (2) The homeland defense mission of DoD, including with respect to ballistic missile defense.

“Critical technology” means—

- (1) Defense articles or defense services included on the United States Munitions List set forth in the International Traffic in Arms Regulations under subchapter M of chapter I of title 22, Code of Federal Regulations;
- (2) Items included on the Commerce Control List set forth in Supplement No. 1 to part 774 of the Export Administration Regulations under subchapter C of chapter VII of title 15, Code of Federal Regulations, and controlled—
 - (i) Pursuant to multilateral regimes, including for reasons relating to national security, chemical and biological weapons proliferation, nuclear nonproliferation, or missile technology; or
 - (ii) For reasons relating to regional stability or surreptitious listening;
- (3) Specially designed and prepared nuclear equipment, parts and components, materials, software, and technology covered by part 810 of title 10, Code of Federal Regulations (relating to assistance to foreign atomic energy activities);
- (4) Nuclear facilities, equipment, and material covered by part 110 of title 10, Code of Federal Regulations (relating to export and import of nuclear equipment and material);
- (5) Select agents and toxins covered by part 331 of title 7, Code of Federal Regulations, part 121 of title 9 of such Code, or part 73 of title 42 of such Code; or
- (6) Emerging and foundational technologies controlled pursuant to section 1758 of the Export Control Reform Act of 2018 (50 U.S.C. 4817).

“Substantial or essential component” means any component necessary for the proper function or performance of a piece of equipment, system, or service.

(b) Prohibition. In accordance with section 1656 of the National Defense Authorization Act for Fiscal Year 2018 (Pub. L. 115-91), the contractor shall not provide to the Government any equipment, system, or service to carry out covered missions that uses covered defense telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system, unless the covered defense telecommunication equipment or services are covered by a waiver described in Defense Federal Acquisition Regulation Supplement [204.2104](#).

(c) Procedures. The Contractor shall review the list of excluded parties in the System for Award Management (SAM) at <https://www.sam.gov> for entities that are excluded when providing any equipment, system, or service, to carry out covered missions, that uses covered defense telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system, unless a waiver is granted.

(d) Reporting.

(1) In the event the Contractor identifies covered defense telecommunications equipment or services used as a substantial or essential component of any system, or as critical technology as part of any system, during contract performance, the Contractor shall report at <https://dibnet.dod.mil> the information in paragraph (d)(2) of this clause.

(2) The Contractor shall report the following information pursuant to paragraph (d)(1) of this clause:

(i) Within 3 business days from the date of such identification or notification: the contract number; the order number(s), if applicable; supplier name; brand; model number (original equipment manufacturer number, manufacturer part number, or wholesaler number); item description; and any readily available information about mitigation actions undertaken or recommended.

(ii) Within 30 business days of submitting the information in paragraph (d)(2)(i) of this clause: any further available information about mitigation actions undertaken or recommended. In addition, the Contractor shall describe the efforts it undertook to prevent use or submission of a covered defense telecommunications equipment or services, and any additional efforts that will be incorporated to prevent future use or submission of covered telecommunications equipment or services.

(e) Subcontracts. The Contractor shall insert the substance of this clause, including this paragraph (e), in all subcontracts and other contractual instruments, including subcontracts for the acquisition of commercial items.

(End of clause)

ATTACHMENT 2

Department of Defense (DoD)
Small Business Innovation Research (SBIR) Program
Small Business Technology Transfer (STTR) Program

OMB No. 0704-0187 OMB approval expires October 31, 2024

**DISCLOSURE OF OFFEROR'S OWNERSHIP OR CONTROL BY A
FOREIGN GOVERNMENT**

In accordance with DFARS provision 252.209-7002, an offeror is required to disclose, by completing this form (and adding additional pages, as necessary), any interest a foreign government has in the offeror when that interest constitutes control by a foreign government, as defined in DFARS provision 252.209-7002. If the offeror is a subsidiary, it is also required to disclose any reportable interest a foreign government has in any entity that owns or controls the subsidiary, including reportable interest concerning the offeror's immediate parent, intermediate parents, and the ultimate parent.

DISCLOSURE		
Offeror's Point of Contact for Questions about Disclosure	Name:	
	Phone Number:	
Offeror	Name:	
	Address:	
Entity Controlled by a Foreign Government	Name:	
	Address:	
Description of Foreign Government's Interest in the Offeror		
Foreign Government's Ownership Percentage in Offeror		
Identification of Foreign Government(s) with Ownership or Control		

DFARS 252.209-7002 Disclosure of Ownership or Control by a Foreign Government (JUN 2010)

(a) Definitions. As used in this provision—

(1) “Effectively owned or controlled” means that a foreign government or any entity controlled by a foreign government has the power, either directly or indirectly, whether exercised or exercisable, to control the election, appointment, or tenure of the Offeror’s officers or a majority of the Offeror’s board of directors by any means, e.g., ownership, contract, or operation of law (or equivalent power for unincorporated organizations).

(2) “Entity controlled by a foreign government”—

(i) Means—

(A) Any domestic or foreign organization or corporation that is effectively owned or controlled by a foreign government; or

(B) Any individual acting on behalf of a foreign government.

(ii) Does not include an organization or corporation that is owned, but is not controlled, either directly or indirectly, by a foreign government if the ownership of that organization or corporation by that foreign government was effective before October 23, 1992.

(3) “Foreign government” includes the state and the government of any country (other than the United States and its outlying areas) as well as any political subdivision, agency, or instrumentality thereof.

(4) “Proscribed information” means—

(i) Top Secret information;

(ii) Communications security (COMSEC) material, excluding controlled cryptographic items when unkeyed or utilized with unclassified keys;

(iii) Restricted Data as defined in the U.S. Atomic Energy Act of 1954, as amended;

(iv) Special Access Program (SAP) information; or

(v) Sensitive Compartmented Information (SCI).

(b) Prohibition on award. No contract under a national security program may be awarded to an entity controlled by a foreign government if that entity requires access to proscribed information to perform the contract, unless the Secretary of Defense or a designee has waived application of 10 U.S.C. 2536(a).

(c) Disclosure. The Offeror shall disclose any interest a foreign government has in the Offeror when that interest constitutes control by a foreign government as defined in this provision. If the Offeror is a subsidiary, it shall also disclose any reportable interest a foreign government has in any entity that owns or controls the subsidiary, including reportable interest concerning the Offeror’s immediate parent, intermediate parents, and the ultimate parent. Use separate paper as needed, and provide the information

in the following format:

Offeror's Point of Contact for Questions about Disclosure

(Name and Phone Number with Country Code, City Code and Area Code, as applicable)

Name and Address of Offeror

Name and Address of Entity Controlled by a Foreign Government

Description of Interest, Ownership Percentage, and Identification of Foreign Government

(End of provision)

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DEPARTMENT OF THE NAVY (DON) 22.1 Small Business Innovation Research (SBIR) Proposal Submission Instructions

IMPORTANT

- The following instructions apply to SBIR topics only:
 - N221-001 through N221-086
- The information provided in the DON Proposal Submission Instructions document takes precedence over the DoD Instructions posted for this Broad Agency Announcement (BAA).
- DON Phase I Technical Volume (Volume 2) page limit is not to exceed 10 pages.
- Proposers that are more than 50% owned by multiple venture capital operating companies (VCOC), hedge funds (HF), private equity firms (PEF) or any combination of these are eligible to submit proposals in response to DON topics advertised in this BAA. Information on Majority Ownership in Part and certification requirements at time of submission for these proposers are detailed in the section titled ADDITIONAL SUBMISSION CONSIDERATIONS.
- Phase I Technical Volume (Volume 2) and Supporting Documents (Volume 5) templates, specific to DON topics, are available at https://www.navysbir.com/links_forms.htm.
- The DON provides notice that Basic Ordering Agreements (BOAs) may be used for Phase I awards, and BOAs or Other Transaction Agreements (OTAs) may be used for Phase II awards.

INTRODUCTION

The DON SBIR/STTR Programs are mission-oriented programs that integrate the needs and requirements of the DON's Fleet through research and development (R&D) topics that have dual-use potential, but primarily address the needs of the DON. More information on the programs can be found on the DON SBIR/STTR website at www.navysbir.com. Additional information on DON's mission can be found on the DON website at www.navy.mil.

Digital Engineering. DON desires the ability to design, integrate, and test naval products by using authoritative sources of system data, which enables the creation of virtual or digital models for learning and experimentation, to fully integrate and test actual systems or components of systems across disciplines to support lifecycle activities from concept through disposal. To achieve this, digital engineering innovations will be sought in topics with titles leading with DIGITAL ENGINEERING.

The Director of the DON SBIR/STTR Programs is Mr. Robert Smith. For questions regarding this BAA, use the information in Table 1 to determine who to contact for what types of questions.

TABLE 1: POINTS OF CONTACT FOR QUESTIONS REGARDING THIS BAA

Type of Question	When	Contact Information
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Program and administrative	Always	Program Managers list in Table 2 (below)
Topic-specific technical questions	BAA Pre-release	Technical Point of Contact (TPOC) listed in each topic. Refer to the Proposal Fundamentals section of the DoD SBIR/STTR Program BAA for details.
	BAA Open	DoD SBIR/STTR Topic Q&A platform (https://www.dodsbirsttr.mil/submissions) Refer to the Proposal Fundamentals section of the DoD SBIR/STTR Program BAA for details.
Electronic submission to the DoD SBIR/STTR Innovation Portal (DSIP)	Always	DoD Help Desk via email at dodsbirsupport@reisystems.com
Navy-specific BAA instructions and forms	Always	Navy-sbir-sttr.fct@navy.mil

TABLE 2: DON SYSTEMS COMMANDS (SYSCOM) SBIR PROGRAM MANAGERS

<u>Topic Numbers</u>	<u>Point of Contact</u>	<u>SYSCOM</u>	<u>Email</u>
N221-001 to N221-003	Mr. Jeffrey Kent	Marine Corps Systems Command (MCSC)	sbir.admin@usmc.mil
N221-004 to N221-024	Mr. Shawn Slade (Acting)	Naval Air Systems Command (NAVAIR)	navair.sbir@navy.mil
N221-025 to N221-066	Mr. Jason Schroepfer	Naval Sea Systems Command (NAVSEA)	NSSC_SBIR.fct@navy.mil
N221-067 to N221-076	Ms. Lore-Anne Ponirakis	Office of Naval Research (ONR)	onr-sbir-sttr.fct@navy.mil
N221-077 to N221-086	Mr. Michael Pyryt	Strategic Systems Programs (SSP)	ssp.sbir@ssp.navy.mil

PHASE I SUBMISSION INSTRUCTIONS

The following section details what is required for a Phase I proposal submission to the DoD SBIR/STTR Programs.

(NOTE: Proposers are advised that support contract personnel will be used to carry out administrative functions and may have access to proposals, contract award documents, contract deliverables, and reports. All support contract personnel are bound by appropriate non-disclosure agreements.)

DoD SBIR/STTR Innovation Portal (DSIP). Proposers are required to submit proposals via the DoD SBIR/STTR Innovation Portal (DSIP); follow proposal submission instructions in the DoD SBIR/STTR Program BAA on the DSIP at <https://www.dodsbirsttr.mil/submissions>. Proposals submitted by any other

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means will be disregarded. Proposers submitting through DSIP for the first time will be asked to register. It is recommended that firms register as soon as possible upon identification of a proposal opportunity to avoid delays in the proposal submission process. Proposals that are not successfully certified electronically in DSIP by the Corporate Official prior to BAA Close will NOT be considered submitted and will not be evaluated by DON. Please refer to the DoD SBIR/STTR Program BAA for further information.

Proposal Volumes. The following six volumes are required.

- **Proposal Cover Sheet (Volume 1).** As specified in DoD SBIR/STTR Program BAA.
- **Technical Proposal (Volume 2)**
 - Technical Proposal (Volume 2) must meet the following requirements or it will be REJECTED:
 - Not to exceed 10 pages, regardless of page content
 - Single column format, single-spaced typed lines
 - Standard 8 ½" x 11" paper
 - Page margins one inch on all sides. A header and footer may be included in the one-inch margin.
 - No font size smaller than 10-point
 - Include, within the 10-page limit of Volume 2, an Option that furthers the effort in preparation for Phase II and will bridge the funding gap between the end of Phase I and the start of Phase II. Tasks for both the Phase I Base and the Phase I Option must be clearly identified. Phase I Options are exercised upon selection for Phase II.
 - Phase I Base Period of Performance must be exactly six (6) months.
 - Phase I Option Period of Performance must be exactly six (6) months.
 - Additional information:
 - It is highly recommended that proposers use the Phase I proposal template, specific to DON topics, at https://navysbir.com/links_forms.htm to meet Phase I Technical Volume (Volume 2) requirements.
 - A font size smaller than 10-point is allowable for headers, footers, imbedded tables, figures, images, or graphics that include text. However, proposers are cautioned that if the text is too small to be legible it will not be evaluated.
- **Cost Volume (Volume 3).**
 - Cost Volume (Volume 3) must meet the following requirements or it will be REJECTED:
 - The Phase I Base amount must not exceed \$140,000.
 - Phase I Option amount must not exceed \$100,000.
 - Costs for the Base and Option must be separated and clearly identified on the Proposal Cover Sheet (Volume 1) and in Volume 3.
 - Additional information:
 - Provide sufficient detail for subcontractor, material, and travel costs. Subcontractor costs must be detailed to the same level as the prime contractor. Material costs must include a listing of items and cost per item. Travel costs must include the purpose of the trip, number of trips, location, length of trip, and number of personnel.
 - Inclusion of cost estimates for travel to the sponsoring SYSCOM's facility for one day of meetings is recommended for all proposals.
 - The "Additional Cost Information" of Supporting Documents (Volume 5) may be used to provide supporting cost details for Volume 3. When a proposal is selected for award, be prepared to submit further documentation to the SYSCOM Contracting Officer to substantiate costs (e.g., an explanation of cost estimates for equipment, materials, and consultants or subcontractors).

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- **Company Commercialization Report (Volume 4).** DoD collects and uses Volume 4 and DSIP requires Volume 4 for proposal submission. Please refer to the Phase I Proposal section of the DoD SBIR/STTR Program BAA for details to ensure compliance with DSIP Volume 4 requirements.
- **Supporting Documents (Volume 5).** Volume 5 is for the submission of administrative material that DON may or will require to process a proposal, if selected, for contract award. All proposers must review and submit the following items, as applicable:
 - **Telecommunications Equipment Certification.** Required for all proposers. The DoD must comply with Section 889(a)(1)(B) of the FY2019 National Defense Authorization Act (NDAA) and is working to reduce or eliminate contracts, or extending or renewing a contract with an entity that uses any equipment, system, or service that uses covered telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system. As such, all proposers must include as a part of their submission a written certification in response to the clauses (DFAR clauses 252.204-7016, 252.204-7018, and subpart 204.21). The written certification can be found in Attachment 1 of the DoD SBIR/STTR Program BAA. This certification must be signed by the authorized company representative and is to be uploaded as a separate PDF file in Volume 5. Failure to submit the required certification as a part of the proposal submission process will be cause for rejection of the proposal submission without evaluation. Please refer to the instructions provided in the Phase I Proposal section of the DoD SBIR/STTR Program BAA.
 - **Disclosure of Offeror's Ownership or Control by a Foreign Government.** All proposers must review to determine applicability. In accordance with DFARS provision 252.209-7002, a proposer is required to disclose any interest a foreign government has in the proposer when that interest constitutes control by foreign government. All proposers must review the Foreign Ownership or Control Disclosure information to determine applicability. If applicable, an authorized firm representative must complete the Disclosure of Offeror's Ownership or Control by a Foreign Government (found in Attachment 2 of the DoD SBIR/STTR Program BAA) and upload as a separate PDF file in Volume 5. Please refer to instructions provided in the Phase I Proposal section of the DoD SBIR/STTR Program BAA.
 - **Majority Ownership in Part.** Proposers which are more than 50% owned by multiple venture capital operating companies (VCOC), hedge funds (HF), private equity firms (PEF), or any combination of these as set forth in 13 C.F.R. § 121.702, are eligible to submit proposals in response to DON topics advertised within this BAA. Complete certification as detailed under ADDITIONAL SUBMISSION CONSIDERATIONS.
- Additional information:
 - Proposers may include the following administrative materials in Supporting Documents (Volume 5); a template is available at https://navysbir.com/links_forms.htm to provide guidance on optional material the proposer may want to include in Volume 5:
 - Additional Cost Information to support the Cost Volume (Volume 3)
 - SBIR/STTR Funding Agreement Certification
 - Data Rights Assertion
 - Allocation of Rights between Prime and Subcontractor
 - Disclosure of Information (DFARS 252.204-7000)
 - Prior, Current, or Pending Support of Similar Proposals or Awards
 - Foreign Citizens

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- Do not include documents or information to substantiate the Technical Volume (Volume 2) (e.g., resumes, test data, technical reports, or publications). Such documents or information will not be considered.
- A font size smaller than 10-point is allowable for documents in Volume 5; however, proposers are cautioned that the text may be unreadable.
- **Fraud, Waste and Abuse Training Certification (Volume 6).** DoD requires Volume 6 for submission. Please refer to the Phase I Proposal section of the DoD SBIR/STTR Program BAA for details.

PHASE I EVALUATION AND SELECTION

The following section details how the DON SBIR/STTR Programs will evaluate Phase I proposals.

Proposals meeting DoD SBIR/STTR submission requirements will be forwarded to the DON SBIR/STTR Programs for evaluation. Prior to evaluation, all proposals will undergo a compliance review to verify compliance with DoD and DON SBIR/STTR submission requirements. Proposals not meeting submission requirements will be REJECTED and not evaluated.

- **Proposal Cover Sheet (Volume 1).** Not evaluated. The Cover Sheet (Volume 1) will undergo a compliance review (prior to evaluation) to verify the proposer has met eligibility requirements.
- **Technical Volume (Volume 2).** The DON will evaluate and select Phase I proposals using the evaluation criteria specified in the Phase I Proposal Evaluation Criteria section of the DoD SBIR/STTR Program BAA, with technical merit being most important, followed by qualifications of key personnel and commercialization potential of equal importance. “Best value” is defined as approaches containing innovative technology solutions to the Navy’s technical challenges for meeting its mission needs as reflected in the SBIR/STTR topics. This is not a FAR Part 15 evaluation and proposals will not be compared to one another. Cost is not an evaluation criteria and will not be considered during the evaluation process. Due to limited funding, the DON reserves the right to limit the number of awards under any topic.

The Technical Volume (Volume 2) will undergo a compliance review (prior to evaluation) to verify the proposer has met the following requirements or it will be REJECTED:

- Not to exceed 10 pages, regardless of page content
- Single column format, single-spaced typed lines
- Standard 8 ½” x 11” paper
- Page margins one inch on all sides. A header and footer may be included in the one-inch margin.
- No font size smaller than 10-point, except as permitted in the instructions above.
- Include, within the 10-page limit of Volume 2, an Option that furthers the effort in preparation for Phase II and will bridge the funding gap between the end of Phase I and the start of Phase II. Tasks for both the Phase I Base and the Phase I Option must be clearly identified.
- Phase I Base Period of Performance must be exactly six (6) months.
- Phase I Option Period of Performance must be exactly six (6) months.
- **Cost Volume (Volume 3).** Not evaluated. The Cost Volume (Volume 3) will undergo a compliance review (prior to the proposal evaluation) to verify the proposer has complied with not

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to exceed values for the Base (\$140,000) and Option (\$100,000). Proposals exceeding either the Base or Option not to exceed values will be REJECTED without further consideration.

- **Company Commercialization Report (Volume 4).** Not evaluated.
- **Supporting Documents (Volume 5).** Not evaluated. Supporting Documents (Volume 5) will undergo a compliance review to ensure the proposer has included items in accordance with the PHASE I SUBMISSION INSTRUCTIONS section above.
- **Fraud, Waste, and Abuse Training Certificate (Volume 6).** Not evaluated.

ADDITIONAL SUBMISSION CONSIDERATIONS

This section details additional items for proposers to consider during proposal preparation and submission process.

Discretionary Technical and Business Assistance (TABA). The SBIR and STTR Policy Directive section 9(b) allows the DON to provide TABA (formerly referred to as DTA) to its awardees. The purpose of TABA is to assist awardees in making better technical decisions on SBIR/STTR projects; solving technical problems that arise during SBIR/STTR projects; minimizing technical risks associated with SBIR/STTR projects; and commercializing the SBIR/STTR product or process, including intellectual property protections. Firms may request, in their Phase I Cost Volume (Volume 3) and Phase II Cost Volume, to contract these services themselves through one or more TABA providers in an amount not to exceed the values specified below. The Phase I TABA amount is up to \$6,500 and is in addition to the award amount. The Phase II TABA amount is up to \$25,000 per award. The TABA amount, of up to \$25,000, is to be included as part of the award amount and is limited by the established award values for Phase II by the SYSCOM (i.e. within the \$1,700,000 or lower limit specified by the SYSCOM). As with Phase I, the amount proposed for TABA cannot include any profit/fee by the proposer and must be inclusive of all applicable indirect costs. A Phase II project may receive up to an additional \$25,000 for TABA as part of one additional (sequential) Phase II award under the project for a total TABA award of up to \$50,000 per project. A TABA Report, detailing the results and benefits of the service received, will be required annually by October 30.

Request for TABA funding will be reviewed by the DON SBIR/STTR Program Office.

If the TABA request does not include the following items the TABA request will be denied.

- TABA provider(s) (firm name)
- TABA provider(s) point of contact, email address, and phone number
- An explanation of why the TABA provider(s) is uniquely qualified to provide the service
- Tasks the TABA provider(s) will perform
- Total TABA provider(s) cost, number of hours, and labor rates (average/blended rate is acceptable)

TABA must **NOT**:

- Be subject to any profit or fee by the SBIR proposer
- Propose a TABA provider that is the SBIR proposer
- Propose a TABA provider that is an affiliate of the SBIR proposer
- Propose a TABA provider that is an investor of the SBIR proposer
- Propose a TABA provider that is a subcontractor or consultant of the requesting firm otherwise required as part of the paid portion of the research effort (e.g., research partner, consultant, tester, or administrative service provider)

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TABA requests must be included in the proposal as follows:

- Phase I:
 - Online DoD Cost Volume (Volume 3) – the value of the TABA request.
 - Supporting Documents Volume (Volume 5) – a detailed request for TABA (as specified above) specifically identified as “Discretionary Technical and Business Assistance” in the section titled Additional Cost Information.
- Phase II:
 - DON Phase II Cost Volume (provided by the DON SYSCOM) - the value of the TABA request.
 - Supporting Documents (Volume 5) – a detailed request for TABA (as specified above) specifically identified as “Discretionary Technical and Business Assistance” in the section titled Additional Cost Information.

Proposed values for TABA must NOT exceed:

- Phase I: A total of \$6,500
- Phase II: A total of \$25,000 per award, not to exceed \$50,000 per Phase II project

If a proposer requests and is awarded TABA in a Phase II contract, the proposer will be eliminated from participating in the DON SBIR/STTR Transition Program (STP), the DON Forum for SBIR/STTR Transition (FST), and any other Phase II assistance the DON provides directly to awardees.

All Phase II awardees not receiving funds for TABA in their awards must attend a one-day DON STP meeting during the first or second year of the Phase II contract. This meeting is typically held in the spring/summer in the Washington, D.C. area. STP information can be obtained at: <https://navystp.com>. Phase II awardees will be contacted separately regarding this program. It is recommended that Phase II cost estimates include travel to Washington, D.C. for this event.

Disclosure of Information (DFARS 252.204-7000). In order to eliminate the requirements for prior approval of public disclosure of information (in accordance with DFARS 252.204-7000) under this award, the proposer shall identify and describe all fundamental research to be performed under its proposal, including subcontracted work, with sufficient specificity to demonstrate that the work qualifies as fundamental research. Fundamental research means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons (defined by National Security Decision Directive 189). A firm whose proposed work will include fundamental research and requests to eliminate the requirement for prior approval of public disclosure of information must complete the DON Fundamental Research Disclosure and upload as a separate PDF file to the Supporting Documents (Volume 5) in DSIP as part of their proposal submission. The DON Fundamental Research Disclosure is available on https://navysbir.com/links_forms.htm and includes instructions on how to complete and upload the completed Disclosure. Simply identifying fundamental research in the Disclosure does **NOT** constitute acceptance of the exclusion. All exclusions will be reviewed and, if approved by the government Contracting Officer, noted in the contract.

Majority Ownership in Part. Proposers that are more than 50% owned by multiple venture capital operating companies (VCO), hedge funds (HF), private equity firms (PEF), or any combination of these as set forth in 13 C.F.R. § 121.702, **are eligible** to submit proposals in response to DON topics advertised within this BAA.

For proposers that are a member of this ownership class the following must be satisfied for proposals to

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be accepted and evaluated:

- a. Prior to submitting a proposal, firms must register with the SBA Company Registry Database.
- b. The proposer within its submission must submit the Majority-Owned VCOC, HF, and PEF Certification. A copy of the SBIR VC Certification can be found on https://navysbir.com/links_forms.htm. Include the SBIR VC Certification in the Supporting Documents (Volume 5).
- c. Should a proposer become a member of this ownership class after submitting its proposal and prior to any receipt of a funding agreement, the proposer must immediately notify the Contracting Officer, register in the appropriate SBA database, and submit the required certification which can be found on https://navysbir.com/links_forms.htm.

System for Award Management (SAM). It is strongly encouraged that proposers register in SAM, <https://sam.gov>, by the Close date of this BAA, or verify their registrations are still active and will not expire within 60 days of BAA Close. Additionally, proposers should confirm that they are registered to receive contracts (not just grants) and the address in SAM matches the address on the proposal.

Notice of NIST SP 800-171 Assessment Database Requirement. The purpose of the National Institute of Standards and Technology (NIST) Special Publication (SP) 800-171 is to protect Controlled Unclassified Information (CUI) in Nonfederal Systems and Organizations. As prescribed by DFARS 252.204-7019, in order to be considered for award, a firm is required to implement NIST SP 800-171 and shall have a current assessment uploaded to the Supplier Performance Risk System (SPRS) which provides storage and retrieval capabilities for this assessment. The platform Procurement Integrated Enterprise Environment (PIEE) will be used for secure login and verification to access SPRS. For brief instructions on NIST SP 800-171 assessment, SPRS, and PIEE please visit <https://www.sprs.csd.disa.mil/nistsp.htm>. For in-depth tutorials on these items please visit <https://www.sprs.csd.disa.mil/webtrain.htm>.

Human Subjects, Animal Testing, and Recombinant DNA. Due to the short timeframe associated with Phase I of the SBIR/STTR process, the DON does not recommend the submission of Phase I proposals that require the use of Human Subjects, Animal Testing, or Recombinant DNA. For example, the ability to obtain Institutional Review Board (IRB) approval for proposals that involve human subjects can take 6-12 months, and that lengthy process can be at odds with the Phase I goal for time-to-award. Before the DON makes any award that involves an IRB or similar approval requirement, the proposer must demonstrate compliance with relevant regulatory approval requirements that pertain to proposals involving human, animal, or recombinant DNA protocols. It will not impact the DON's evaluation, but requiring IRB approval may delay the start time of the Phase I award and if approvals are not obtained within two months of notification of selection, the decision to award may be terminated. If the use of human, animal, and recombinant DNA is included under a Phase I or Phase II proposal, please carefully review the requirements at: <https://www.onr.navy.mil/work-with-us/how-to-apply/compliance-protections/Research-Protections/Human-Subject-Research.aspx>. This webpage provides guidance and lists approvals that may be required before contract/work can begin.

Government Furnished Equipment (GFE). Due to the typical lengthy time for approval to obtain GFE, it is recommended that GFE is not proposed as part of the Phase I proposal. If GFE is proposed, and it is determined during the proposal evaluation process to be unavailable, proposed GFE may be considered a weakness in the technical merit of the proposal.

International Traffic in Arms Regulation (ITAR). For topics indicating ITAR restrictions or the potential for classified work, limitations are generally placed on disclosure of information involving topics of a classified nature or those involving export control restrictions, which may curtail or preclude the involvement of universities and certain non-profit institutions beyond the basic research level. Small businesses must structure their proposals to clearly identify the work that will be performed that is of a

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basic research nature and how it can be segregated from work that falls under the classification and export control restrictions. As a result, information must also be provided on how efforts can be performed in later phases if the university/research institution is the source of critical knowledge, effort, or infrastructure (facilities and equipment).

SELECTION, AWARD, AND POST-AWARD INFORMATION

Notifications. Email notifications for proposal receipt (approximately one week after the Phase I BAA Close) and selection are sent based on the information received on the proposal Cover Sheet (Volume 1). Consequently, the e-mail address on the proposal Cover Sheet must be correct.

Debriefs. Requests for a debrief must be made within 15 calendar days of select/non-select notification via email as specified in the select/non-select notification. Please note debriefs are typically provided in writing via email to the Corporate Official identified in the firm proposal within 60 days of receipt of the request. Requests for oral debriefs may not be accommodated. If contact information for the Corporate Official has changed since proposal submission, a notice of the change on company letterhead signed by the Corporate Official must accompany the debrief request.

Protests. Protests of Phase I and II selections and awards must be directed to the cognizant Contracting Officer for the DON Topic Number, or filed with the Government Accountability Office (GAO). Contact information for Contracting Officers may be obtained from the DON SYSCOM Program Managers listed in Table 2. If the protest is to be filed with the GAO, please refer to instructions provided in the Proposal Fundamentals section of the DoD SBIR/STTR Program BAA.

Protests to this BAA and proposal submission must be directed to the DoD SBIR/STTR Program BAA Contracting Officer, or filed with the GAO. Contact information for the DoD SBIR/STTR Program BAA Contracting Officer can be found in the Proposal Fundamentals section of the DoD SBIR/STTR Program BAA.

Awards. Due to limited funding, the DON reserves the right to limit the number of awards under any topic. Any notification received from the DON that indicates the proposal has been selected does not ultimately guarantee an award will be made. This notification indicates that the proposal has been selected in accordance with the evaluation criteria and has been sent to the Contracting Officer to conduct cost analysis, confirm eligibility of proposer, and to take other relevant steps necessary prior to making an award.

Contract Types. The DON typically awards a Firm Fixed Price (FFP) contract or a small purchase agreement for Phase I. In addition to the negotiated contract award types listed in the section of the DoD SBIR/STTR Program BAA titled Proposal Fundamentals, for Phase II awards the DON may (under appropriate circumstances) propose the use of an Other Transaction Agreement (OTA) as specified in 10 U.S.C. 2371/10 U.S.C. 2371b and related implementing policies and regulations. The DON may choose to use a Basic Ordering Agreement (BOA) for Phase I and Phase II awards.

Funding Limitations. In accordance with the SBIR and STTR Policy Directive section 4(b)(5), there is a limit of one sequential Phase II award per firm per topic. Additionally, to adjust for inflation DON has raised Phase I and Phase II award amounts. The maximum Phase I proposal/award amount including all options (less TABA) is \$240,000. The Phase I Base amount must not exceed \$140,000 and the Phase I Option amount must not exceed \$100,000. The maximum Phase II proposal/award amount including all options (including TABA) is \$1,700,000 (unless non-SBIR/STTR funding is being added). Individual SYSCOMs may award amounts, including Base and all Options, of less than \$1,700,000 based on available funding. The structure of the Phase II proposal/award, including maximum amounts as well as breakdown

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between Base and Option amounts will be provided to all Phase I awardees either in their Phase I award or a minimum of 30 days prior to the due date for submission of their Initial Phase II proposal.

Contract Deliverables. Contract deliverables for Phase I are typically a kick-off brief, progress reports, and a final report. Required contract deliverables (as stated in the contract) must be uploaded to <https://www.navysbirprogram.com/navydeliverables/>.

Payments. The DON makes three payments from the start of the Phase I Base period, and from the start of the Phase I Option period, if exercised. Payment amounts represent a set percentage of the Base or Option value as follows:

Days From Start of Base Award or Option	Payment Amount
15 Days	50% of Total Base or Option
90 Days	35% of Total Base or Option
180 Days	15% of Total Base or Option

Transfer Between SBIR and STTR Programs. Section 4(b)(1)(i) of the SBIR and STTR Policy Directive provides that, at the agency's discretion, projects awarded a Phase I under a BAA for SBIR may transition in Phase II to STTR and vice versa.

PHASE II GUIDELINES

Evaluation and Selection. All Phase I awardees may submit an **Initial** Phase II proposal for evaluation and selection. The evaluation criteria for Phase II is the same as Phase I. The Phase I Final Report, Initial Phase II Proposal, and Transition Outbrief (as applicable) will be used to evaluate the proposer's potential to progress to a workable prototype in Phase II and transition technology to Phase III. Details on the due date, content, and submission requirements of the Initial Phase II Proposal will be provided by the awarding SYSCOM either in the Phase I contract or by subsequent notification.

NOTE: All SBIR/STTR Phase II awards made on topics from BAAs prior to FY13 will be conducted in accordance with the procedures specified in those BAAs (for all DON topics, this means by invitation only).

Awards. The DON typically awards a Cost Plus Fixed Fee contract for Phase II; but, may consider other types of agreement vehicles. Phase II awards can be structured in a way that allows for increased funding levels based on the project's transition potential. To accelerate the transition of SBIR/STTR-funded technologies to Phase III, especially those that lead to Programs of Record and fielded systems, the Commercialization Readiness Program was authorized and created as part of section 5122 of the National Defense Authorization Act of Fiscal Year 2012. The statute set-aside is 1% of the available SBIR/STTR funding to be used for administrative support to accelerate transition of SBIR/STTR-developed technologies and provide non-financial resources for the firms (e.g., the DON STP).

PHASE III GUIDELINES

A Phase III SBIR/STTR award is any work that derives from, extends, or completes effort(s) performed under prior SBIR/STTR funding agreements, but is funded by sources other than the SBIR/STTR programs. This covers any contract, grant, or agreement issued as a follow-on Phase III award or any contract, grant, or agreement award issued as a result of a competitive process where the awardee was an SBIR/STTR firm that developed the technology as a result of a Phase I or Phase II award. The DON will give Phase III status to any award that falls within the above-mentioned description. Consequently, DON will assign SBIR/STTR Data Rights to any noncommercial technical data and noncommercial computer software

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delivered in Phase III that were developed under SBIR/STTR Phase I/II effort(s). Government prime contractors and their subcontractors must follow the same guidelines as above and ensure that companies operating on behalf of the DON protect the rights of the SBIR/STTR firm.

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N221-070	Acoustic Vector Sensors that Achieve Affordable Array Directivity
N221-071	Forensic Memory for Self-Cued, Data-Thinning Receivers
N221-072	Low-Cost Deployable Structures for Sonobuoy Arrays
N221-073	Radio Frequency Spectrum Patterns of Life
N221-074	Turbine Engine Efficiency improvements by Additive Manufacturing
N221-075	Enhanced Lethality Warhead
N221-076	Lightweight, Compact, and Cost-effective Gaseous Hydrogen Storage System
N221-077	DIGITAL ENGINEERING - Semantically-Driven Data Integration Software Solutions
N221-078	Split Ratio Fine-Tuning Feature for Integrated Optical Circuits in Interferometric Fiber-Optic Gyroscopes
N221-079	Low-Loss, Low-Aberration, Numerical Aperture-Matched Microlens Arrays to Improve Coupling Efficiency onto Photonic Imaging Devices.
N221-080	Development of a Time-Triggered Ethernet Intellectual Property Block
N221-081	Development of an Aerothermal Modeling and Simulation Code for Hypersonic Applications
N221-082	Integrated Complementary Metal Oxide Semiconductor Nuclear Event Detector for System on a Chip Applications
N221-083	Variable Conductance Thermal Management Technology
N221-084	[Navy has removed topic N221-084 from the 22.1 SBIR BAA]
N221-085	Integration Strategy for Complementary Metal Oxide Semiconductor-based Terahertz Spectroscopy Systems
N221-086	[Navy has removed topic N221-086 from the 22.1 SBIR BAA]

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N221-001 TITLE: DIGITAL ENGINEERING - Civilian Behavior Conceptual Models for Wargaming

OUSD (R&E) MODERNIZATION PRIORITY: Networked C3

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop Civilian Pattern of Life models, sufficient to withstand review board scrutiny to support model verification, validation, and accreditation, as required. Focus on developing and implementing the models referenced herein, not on the underlying mechanics of the Program Manager Wargaming Capability (PM WGC) materiel solution simulation framework.

DESCRIPTION: This SBIR topic addresses two parametrics of interest for future inclusion in the Marine Corps Wargaming and Analysis Center (MCWAC), both related to modeling civilian populations. In the table below, the two major parametrics considered are “Civilian Pattern of Life” and “Civilian Populations.” The specific conceptual model requirements are listed for each parametric.

ID	Parametric	Parametric Description	Conceptual Model Requirements
Info1	Civilian pattern of life (traffic patterns on the air, land, and sea)	Basic needs (food, water, shelter); basic economic behaviors (work locations, work activities); basic religious behaviors (worship times, locations, behaviors); basic reactions to military activities (bombs, blue forces presence, red forces presence); etc.	Identify geographic locations of homes, places of business, schools, religious activities, and social activities.
Info2			Represent opening hours for places of business, schools, religious activities, and social activities.
Info3			Represent statistical demographics based on age, gender, and social role.
Info4			Represent aggregate daily civilian location based on geographic locations, opening hours, and statistical demographics.
Info5			Identify recurring, large-scale activities impacting civilian activities.
Info6			Simulate changes to daily civilian location based on recurring, large-scale activities.
Info7			Identify anomalous circumstances impacting daily civilian activities.
Info8			Simulate changes to daily civilian location based on anomalous circumstances.

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Info9			Identify aggregate daily land vehicle traffic.
Info10			Identify aggregate daily foot traffic.
Info13			Identify aggregate daily civilian resource requirements
Info16			Simulate daily civilian movements between locations based on LOCE CoD requirements.
Info17			Identify minimum daily civilian resource requirements.
Info18			Simulate individual civilian daily traffic based on geographic locations, opening hours, statistical demographics, and all forms of daily traffic.
Info19			Simulate changes to individual daily traffic based on recurring, large-scale activities.
Info20			Simulate changes to individual daily traffic based on anomalous circumstances impacting daily civilian activities.
Info22	Civil populations have atmospherics (culture, society, economic, technology, and density); personal intent and perceptions; and human dynamics for both domestic and foreign groups. The collection affects the political and military environments based upon the knowledge and perceptions of the collection.	This is just the representation of civilian representations. There is a parallel effort to look at the data and validity of the data.	Identify political parties, religions (sects), families, social / cultural organizations, professional organizations, and prominent figures with which individuals may have affiliations.
Info23			Identify sentiments, positions / beliefs, and goals associated with all affiliations.
Info24			Represent civilian affiliations in the aggregate based on age, gender, and social role.
Info25			Simulate changes in sentiments, positions / beliefs, and goals associated with all affiliations based

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			on changes in the physical environment.
Info26			Simulate changes in sentiments, positions / beliefs, and goals associated with all affiliations based on changes in the social, political, economic, and cultural environment.

Some examples under the above headings include, but are not limited to:

- Model civil infrastructure networks for Food, Water, Sewage, Power, Fuel, Communications.
- Model key civil infrastructure facilities to include religious centers, medical treatment, civil supply, law enforcement.
- Model displacement of civilians due to military activity (or disasters) that causes them to require shelter, medical attention, and food.
- Model the relationship between various civil factions including level of violence.
- Model incidents of violence (fully automated). Military action (or lack of) can suppress these incidents.
- Model the positive or negative "influence" of one faction versus another, a key metric for Stability and Support Operations (SASO).

Full satisfaction of each conceptual model requirement is the end goal; however, partial solutions will be considered. This topic specifically focuses on developing the mathematical, algorithmic, and data aspects of the conceptual models. The mechanism by which these conceptual models would be implemented within the MCWAC is not the focus. Documentation of the conceptual models with Cameo/SysML is desirable, but not necessarily a strict requirement, if another representation is more suitable [Ref 2].

PHASE I: Develop concepts for an improved representation of civilian populations in wargaming Modeling and Simulation (M&S) that meets the requirements described above. Demonstrate the feasibility of the concepts in meeting Marine Corps needs and establish that the concepts can be developed into a useful product for the Marine Corps. Feasibility will be established by evaluation of the plan of attack for the development effort including data availability. Provide a Phase II development plan with performance goals and key technical milestones, and that will address technical risk reduction.

PHASE II: Develop prototype conceptual models to be evaluated to determine its capability in meeting the performance goals defined in the Phase II development plan and the Marine Corps requirements for civilian populations M&S. System performance will be demonstrated through prototype evaluation over the required range of parameters. Evaluation results will be used to refine the prototype into an initial design that will meet Marine Corps requirements. Prepare a Phase III development plan to transition the technology to Marine Corps use.

PHASE III DUAL USE APPLICATIONS: Support the Marine Corps in transitioning the technology for Marine Corps use. Develop civilian population conceptual model implementations for evaluation to determine their effectiveness in an operationally relevant environment within the MCWAC. Support the Marine Corps for M&S Verification, Validation, and Accreditation (VV&A) to certify and qualify the system for Marine Corps use.

The conceptual models described herein are not only a high priority within the Marine Corps [Ref 1], but are equally applicable across the Services, to support not only wargaming, but also analysis, training, and experimentation. Successfully developed conceptual models would likely be of great interest across these

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communities. Outside DoD, marketing firms would be a natural customer, looking to understand patterns of civilian behavior from which to develop market segmentation strategies and ultimately advertisement campaigns.

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<https://www.sisostds.org/StandardsActivities/SupportGroups/DSEPDMAOPSG-DistributedSimulationEngineer.in.aspx>.

KEYWORDS: Wargaming; Modeling and Simulation; M&S; Civilian Pattern of Life; Conceptual Model; Marine Corps Wargaming and Analysis Center; MCWAC; Program Manager Wargaming Capability; PM WGC; Information modeling

VERSION 8

N221-002 TITLE: Ultra Lightweight Tactical Vehicle Power Generation

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop a compact, lightweight, and engine driven power generation system for energy export power with high specific power (kilowatts per kilogram) that fits within the confines of the chassis of recreational off-highway vehicles (ROVs) to meet expected power and energy demands and allow for future mission growth.

DESCRIPTION: Currently available vehicles capable of being internally transported in rotary wing aircraft have insufficient export power capabilities to meet power and energy demands of current Counter-Unmanned Aerial Systems (C-UASs) and allow for future mission growth. The current Light Marine Air Defense Integrated System (LMADIS) uses a 5 kilowatts (kW) diesel generator weighing 300 lbs. that results in the vehicle weighing 15 lbs. over the maximum gross vehicle weight (GVW) of the current Ultra Lightweight Tactical Vehicle (ULTV). Future mission growth to add additional communications equipment to LMADIS is expected to increase the power demands to 10 kW. Currently available diesel generators that meet the higher power requirements weigh close to 500 lbs. and would result in the vehicle weighing 100 to 150 lbs. over maximum Gross Vehicle Weight (GVW). Compact and lightweight power generation systems are needed to power C-UAS and C2 systems and keep the vehicle safely within its allowable GVW. System requirements are:

- Integrated system using the existing Polaris MRZR-ALPHA 118hp 1.5L Ford diesel engine
- Export power output of 10 kW at idle Threshold (T); 15 kW at idle Objective (O) at 28 volts direct current (VDC)
- Reduced physical size of export power system (same approximate size as an alternator, 8 inches wide x 10 inches long x 8 inches high)
- Physical weight of export power system less than 125 lbs.
- Compatible with typical 28VDC tactical electrical systems and 14VDC vehicle electrical systems while conforming to the necessary requirements within MIL-STD-1275E, MIL-STD-1332B, and MIL-STD-705D
- Electrical component and connections with an ingress protection rating of Ingress Protection (IP67) or higher in accordance with (IAW) American National Standards Institute (ANSI) / International Electrotechnical Commission (IEC) 60529-2004
- Modular design that can be inspected, serviced, and repaired in the field
- Full power output across the range of engine speeds, ~750-4,500 Revolutions Per Minute (RPM)
- Operate at temperatures between 0°F to 125°F (T); -25°F to 125°F (O)

PHASE I: Develop concept(s) for a generator technology and its supporting control equipment that can meet the requirements described above. Demonstrate the feasibility of the concept(s) in meeting the Marine Corps needs and establish that the concepts can be developed into a useful product for the Marine Corps. Feasibility will be established by material testing and/or analytical modeling, as appropriate. Provide a Phase II development plan with performance goals, key technical milestones, and address technical risk reduction.

PHASE II: Develop a full-scale prototype for evaluation. The prototype shall be evaluated through bench or lab testing to determine its capability in meeting the performance goals defined in the Phase II development plan and the Marine Corps requirement for the integrated power generation system. System performance shall be demonstrated through prototype evaluation and modeling or analytical methods over the required range of parameters including numerous deployment cycles. Evaluate the results and refine the design as necessary. Conduct on-vehicle testing in a relevant environment. Evaluate and compare the

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results to Marine Corps requirements. Prepare a Phase III development plan to transition the technology for Marine Corps and commercial use.

PHASE III DUAL USE APPLICATIONS: Provide support to the Marine Corps in transitioning the technology for Marine Corps use. Refine a power generation system for further evaluation and determine its effectiveness in an operationally relevant environment. Support the Marine Corps test and evaluation program to qualify the system for the Marine Corps use.

Commercial applications include law enforcement vehicles, search and rescue vehicles, tractor trailers, and general automotive platforms to provide integrated power capability reducing both weight and space claim supporting a more demanding future mobile power environment.

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1. "MIL-STD-1275E Characteristics of 28 Volt DC Input Power to Utilization Equipment in Military Vehicles." U.S. Army Tank automotive and Armaments Command, March 22, 2013. https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=36186.
2. "MIL-STD-1332B Tactical, Prime. Precise, and Utility Terminologies For Classification of the DoD Mobile Electric Power Engine Generator Set Family." Naval Facilities Engineering Command, Naval Construction Battalion Center, March 13, 1973. https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=36687.
3. "MIL-STD-705D Mobile Electric Power Systems." Communications Electronics Research Development Engineering Center (CERDEC) Product Realization Directorate (PRD), November 22, 2016. https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=35902.
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KEYWORDS: Tactical vehicle; power generation; weight reduction; size reduction; ultra lightweight tactical vehicle; ULTV; Light Marine Air Defense Integrated System; LMADIS; Exportable power; Power

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N221-003 TITLE: Remote Expeditionary Autonomous Pioneer System

OUSD (R&E) MODERNIZATION PRIORITY: Autonomy; General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop an expeditionary system that integrates a multiplicity of capabilities currently provided by several separate and distinct systems that provide material handling, construction, path/trail clearance, explosive hazard defeat capabilities, and refueling into a single system; and would utilize separate “attachments” or end-effectors to perform the various missions.

DESCRIPTION: The intent of this SBIR topic is to develop a system that integrates material handling, construction, path/trail clearance, and explosive hazard defeat capabilities into a single system. The system may be configured as a “base” and incorporate various attachments for each specific application. It is desired that the system require a minimum amount of operational input from personnel, including the changing of attachments. The system must be transportable by Marine Corps ground and air assets. Proposals should specifically describe the technology that will be applied to solve the problem, how it will be developed, what estimated benefits will be, and how it might be transitioned to the Marine Corps.

Definitions:

- Systems must meet Threshold requirements = (T)
 - It is highly desirable for the system meets Objective requirements = (O)
1. Ability to meet the requirements of the Marine Corps in all of its operating environments (MIL-STD-810) (T=O)
 2. Capable of repair in the field with plug-and-play line replaceable units or parts produced by expeditionary advanced manufacturing (additive manufactured 3D printed/subtractive manufactured Computer Numerical Control (CNC) milling or lathing parts) (T=O)
 3. Able to be deployed and operational by 1 person within 30 minutes (T), less than 5 minutes (O), starting from its transport configuration
 4. Retrievable and ready for transport within 30 minutes (T), less than 5 minutes (O)
 5. Operated with little or no human intervention. Single-person wireless remote operation (T); Fully Autonomous operation (O)
 6. Base system weight: 5,000 lbs (T), 4,000 lbs (O)
 7. Transportability:
 - a. Aircraft: CH-53 (T), MV-22 (O)
 - b. Ground: MTRV (T), JLTV Trailer (O)
 8. Propulsion: diesel, electric, or hybrid
 9. Run Time: 4 hours (T), 8 hours (O)
 10. Operable in rivers or streams with a depth of 1 m (T=O)
 11. Capable of operation in fresh and brackish water (T=O)
 12. Mission Attachments
 - a. The base system will connect to attachments with limited human intervention (T), or no human intervention (O). A universal skid steer adapter is an example of a tool that may facilitate this function.
 - b. The time to connect/disconnect attachments will be 30 min (T), or 5 min (O).
 13. Examples of desired Mission Capabilities that may require separate, distinct attachments to perform each task identified below:
 - a. The base system may use commercial off-the-shelf (COTS) attachments. As an example, the Airfield Damage Repair Kit with the following attachments:

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- i. Compactor, Vibratory (NSN 3805-01-553-7850, PN 231-8601, CAGE 11083)
 - ii. Hydraulic Hammer (PN 435-5318 CAGE 11083)
 - iii. Angle Broom Attachment (PN 448-5670 CAGE 11083)
 - iv. Fork Attachment (NSN 3930-01-561-7981, PN 353-1697, CAGE 11083)
 - v. Bucket Attachment (PN 426-6947 CAGE 11083)
 - b. Material Handling
 - i. Payload: 11,200 lbs (T=O)
 - ii. Lift Capacity: 5,000 lbs (T), 11,200 lbs (O)
 - iii. Lift Height: 60" (T), 72" (O)
 - iv. Adjustable forks and mast
 - c. Explosive Hazard Defeat
 - i. Flail
 - ii. Mine Roller
 - iii. Breaching
 - iv. Marking
 - d. Counter Mobility
 - i. Create man-made obstacles
 - ii. Emplacement of lethal area denial capabilities
 - e. Fueling
 - i. Remote/Autonomous refueling of ground vehicles; e.g, JLTV, MTRV, LVSr (T)
 - ii. Remote/Autonomous refueling of aviation assets (O)
 - f. Fire Suppression
 - g. Auxiliary Power Generation: 1,500W (T), 5,000W (O)
14. The system software will employ an open architecture; e.g., Robotic and Operating Systems – Modular (ROS-M) or Robotic Operating System (ROS) (T=O)
15. Cost, Base System: cost < \$50,000 (O)

PHASE I: Develop concepts for a REAPr that meets the requirements described above. Demonstrate the feasibility of the concepts in meeting the Marine Corps requirements. Establish that the concepts can be developed into a useful product for the Marine Corps. Feasibility will be established by material testing and analytical modeling, as appropriate. Provide a Phase II development plan with performance goals and key technical milestones, and that will address technical risk reduction.

PHASE II: Develop a scaled prototype for evaluation to determine its capability in meeting the performance goals defined in the Phase II development plan and the Marine Corps requirements for REAPr. Demonstrate system performance through prototype evaluation and modeling or analytical methods over the required range of parameters including numerous deployment cycles. Evaluation results will be used to refine the prototype into an initial design that will meet Marine Corps and REAPr requirements; and for evaluation to determine its effectiveness in an operationally relevant environment approved by the Government. Prepare a Phase III development plan to transition the technology to Marine Corps use.

PHASE III DUAL USE APPLICATIONS: Support the Marine Corps in transitioning the technology for Marine Corps use. Support the Marine Corps for test and validation to certify and qualify the system for Marine Corps use.

Commercial applications may include, but not be limited to: material handling in finished and austere environments; forestry and logging; public safety; demining and clearance; construction and earth

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movement; aviation (material handling and fueling). Additionally, the system lends itself to operations in remote locations that may not be accessible by traditional construction equipment.

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KEYWORDS: autonomous; robot; material handling; expeditionary; maneuver; construction; explosive hazard; mine; mobility; Remote Expeditionary Autonomous Pioneer System; REAPr

VERSION 8

N221-004 TITLE: DIGITAL ENGINEERING - Embedded Aircraft Design Geometry in Multidisciplinary Design Optimization Frameworks

OUSD (R&E) MODERNIZATION PRIORITY: Hypersonics

TECHNOLOGY AREA(S): Air Platforms

OBJECTIVE: Develop and demonstrate a conceptual design geometry tool capable of embedding in fixed- and rotary-wing multidisciplinary optimization frameworks to enable improved estimates of cost and technical feasibility during requirements development and concept refinement of new manned aircraft, unmanned aircraft systems, and weapons.

DESCRIPTION: Early in the acquisition lifecycle of a new air vehicle—Pre-milestone A—the Department of Defense (DoD) conducts aircraft conceptual design studies to determine the technical feasibility of potential requirements sets. The DoD uses these conceptual designs to estimate the development, production, and operating cost of the aircraft program. They also use the designs as inputs to virtual and constructive modeling and simulation (M & S) tools. The DoD uses M & S to quantify the military effectiveness of the aircraft design. Finally, the DoD uses this combination of cost vs. effectiveness data as the basis for decisions setting the requirements for the new aircraft development program.

This process can be used for all sizes and types of air vehicles, from manned tactical aircraft like strike fighters, to rotary-wing vehicles like helicopters and tilt-rotors, to small unmanned aircraft and weapons. This forms the start of the Model-Based System Engineering (MBSE) process. At Naval Air Warfare Center Aircraft Division (NAWCAD), this process is conducted by the Mission Engineering and Analysis Department (MEAD). MEAD engineers use multidisciplinary analysis and optimization (MDAO) software frameworks to find the best possible design for each potential requirement set under evaluation.

This current process is significantly hampered by the lack of a 3D aircraft geometry modeling tool that can be embedded within MDAO frameworks. MEAD engineers need an ability to visualize the geometry they are entering into the MDAO framework in order to support program offices as they look at new and innovative air vehicles, from hypersonic weapons to manned rotary-wing platforms to Unmanned Aerial Vehicles (UAVs) designed specifically for manned-unmanned-teaming. They also need the ability to generate 3D models of the aircraft results produced by the MDAO framework. Currently, commercial CAD packages are not flexible enough to handle the large variations in geometry produced during an MDAO run. Some open source parametric geometry tools are flexible enough, but do not allow the Application Programming Interface (API) to be used while the Graphical User Interface (GUI) is open.

This geometry modeling tool must allow parametric modeling of a wide variety of classes of aircraft and nonconventional arrangements. It should include an aircraft conceptual design specific geometry parametrization, and provide a fully documented, fully unit tested API that allows communication with MDAO software while the geometry tool GUI is open. It must include a GUI that enables MEAD and program office engineers to visualize geometry as they input it to MDAO software, and as the MDAO software returns results. The geometry tool should provide the flexibility to easily generate new aircraft configurations, with the capability for an engineer to start from a blank file and create all major aircraft components in less than one hour. All features available in the API should be available in the GUI, and all features available in the GUI should be available in the API. It must be capable of generating multiple geometry models for analysis from a single authoritative model, including the ability to generate geometry input data for Vortex Lattice aerodynamic analysis. It should be capable of modeling both fixed- and rotary-wing vehicle geometries. It must be capable of exporting 3D watertight trimmed geometry models in both IGES and STEP formats. It must be capable of modeling internal component

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layouts and outer mold line geometry shapes. It should be capable of providing geometry measurements including surface areas, volumes, cross sectional areas, and projected areas. It should be capable of running on both Windows and Linux operating systems.

PHASE I: Demonstrate the feasibility of an aircraft geometry modeling tool that can be embedded in an MDAO framework. This demonstration will test integration with both the Aircraft Design, Analysis, Performance, and Tradespace (ADAPT) framework produced by the DoD High Performance Computing Modernization Program (HPCMP), and with An Integrated Design Environment for NASA Design and Analysis of Rotorcraft (AIDEN/NDARC). The government will provide access to both ADAPT and AIDEN for development and demonstration. The demonstration of at least one feature in the API working while the GUI is open, providing two-way communication between the geometry tool and ADAPT is a critical goal of Phase I. The demonstration of two-way communication between the geometry tool and both AIDEN is also a critical goal of Phase I. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a prototype fully featured geometry tool, with all capabilities available within the API while the GUI is running. Direct integration with both ADAPT and AIDEN frameworks should be completed. Several classes of military aircraft should be demonstrated (fighters, helicopters, hypersonic weapons, small unmanned aircraft, etc.). GUI updates to support integration with MDAO frameworks must be completed. Documentation and unit testing of the full API will be completed.

PHASE III DUAL USE APPLICATIONS: Final integration tests with MDAO frameworks will be completed, and the geometry tool will transition into use with NAWCAD MEAD engineers, and other design groups in government and industry.

Geometry modeling for aircraft conceptual design is needed across industry for both defense and commercial applications. A geometry tool capable of direct integration with MDAO frameworks could be valuable to many private sector design groups.

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KEYWORDS: Aircraft Design; Geometry; Optimization; MDAO; Software; Open Vehicle Sketch Pad; OpenVSP

VERSION 8

N221-005 TITLE: DIGITAL ENGINEERING - Photonics Integration for Modular Open Systems
Approach Avionics Plug-in Modules

OUSD (R&E) MODERNIZATION PRIORITY: Networked C3

TECHNOLOGY AREA(S): Air Platforms;Electronics;Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop photonic plug-in module technology and a modeling approach for designing and packaging air platform digital and analog optical communication avionics.

DESCRIPTION: Current airborne military (mil-aero) core avionics, electro-optic (EO), communications and electronic warfare systems require ever-increasing bandwidths while simultaneously demanding reductions in space, weight, and power. The replacement of shielded twisted pair wire and coaxial cable with earlier generation length-bandwidth product, multimode optical fiber has given increased immunity to electromagnetic interference, bandwidth, throughput, and a reduction in size and weight on aircraft. The effectiveness of these systems hinges on optical communication components that realize large link budget, high dynamic range, and are compatible with the harsh avionic environment [Refs 1, 5-7].

Future avionics digital and analog/radio-frequency (RF) signal transmission rates and frequencies are expected to increase to the point where fiber optics is the only medium with the capacity and low loss for maintaining communications signal integrity. Substantial work has been done in the digital domain to realize 100 Gbps data rates based on shortwave wavelength division multiplexing (SWDM) and coarse wavelength division multiplexing (CWDM) technologies [Refs 8-9]. Generally, SWDM utilizes 50 micrometer core multimode optical fiber and CWDM utilizes single-mode optical fiber for optical interconnection. Optical Multimode 4 (OM4) and Optical Multimode 5 (OM5) optical fiber has been optimized for 100 Gbps and higher SWDM links. Digital links generally use physical contact and non-contact connectors, with no angle polish. In the analog/RF domain there is interest in realizing higher performance intensity modulation with direct detection photonic links based on improvements in fiber pigtailed laser and photodetector, and electro-optic modulator performance [Ref 12]. Phase modulation with interferometric detection type links continues to be of interest for avionics as well [Ref 13]. Analog/RF photonic links generally utilize single-mode fiber (both polarization maintaining and single-core) and physical contact connectors [Refs 14-15]. Dual-core fiber connector and analog/RF photonic link technology is in the early stage of development for balanced photonic links [Refs 16-17].

The ANSI/VITA 46 base standard defines physical features that enable high-speed communication in 3U or 6U backplane-based critical and intelligent embedded computing systems [Ref 18]. The ANSI/VITA 65 OpenVPX System standard uses module mechanical, connectors, thermal, communications protocols, utility, and power definitions provided by specific VPX standards and then describes a series of standard profiles that define slots, backplanes, modules, and standard development chassis [Ref 19]. The ANSI/VITA 66.0 Optical Interconnect on VPX base standard defines a family of blind mate fiber optic interconnects for use with VITA 46 backplanes and plug-in modules [Ref 20]. The ANSI/VITA 67 Coaxial Interconnect on VPXbase standard establishes a structure for implementing blind mate analog

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coaxial interconnects with VPX backplanes and plug-in module, and to define a specific family of interconnects and configurations within that structure [Ref 21].

Photonics integration on plug-in module innovation is needed to implement 100 Gbps and higher digital fiber optic technology. 100 Gbps fiber optic transceivers generally transmit and receive multi-wavelength optical signals with four wavelengths of light, each operating at 25 Gbps to achieve an aggregate bandwidth of =100 Gbps. Typically, the transceivers are interfaced with differential current mode logic signaling and either single-mode or OM4/OM5 multimode fiber. Analog/RF photonics integration on plug-in module innovation is also needed. Analog/RF photonic links generally include a laser with power supply and electro-optic modulator with bias control circuitry and RF connection transmitter, and a high-speed fiber pigtailed photodetector receiver. The proposed digital and analog/RF photonic plug-in modules must operate over a -40 °C to +95 °C temperature range, and maintain performance upon exposure to typical naval air platform vibration, humidity, temperature, altitude, thermal shock, mechanical shock, and temperature cycling environments [Refs 22-27].

Integrating the disparate interfaces associated with digital and analog/RF photonic components on 3U or 6U plug-in modules will require significant digital engineering research and innovation. Not all of the required connections and interfaces are specified in the ANSI/VITA specifications. Field programmable gate array integration and electro-optic modulator RF and optical signal connections for moving digital and analog signals onto and off of plug-in modules between chassis and through chassis backplanes is required. The developed models should include digital and analog/RF loss budget calculations and the ability to perform analysis of system designs up to 100 Gbps and 100 GHz, respectively. Approaches to fill identified digital and analog/RF photonics technology gaps including packaging and connectors is also needed. Digital engineering research is required to understand how to best utilize the existing CAMEO Systems Modeler tool [Ref 28] and Systems Modeling Language (SysML) [Ref 29] for avionics hardware integration.

PHASE I: Using SysML, create the handoff between development board level electrical layouts and photonic component packaging concepts for digital and analog/RF photonic components mounted on the plug-in module level, and the module to backplane and external backplane levels. Identify key risk areas for tracing lower level module design to higher level module level design to realize desired performance and packaging for chassis integration, and mitigate these risks using digital engineering research concepts and modeling tools. Demonstrate computer aided designs of 3U and 6U photonic plug-in modules. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Collect research data on plug-in module photonics integration concepts including plug-in module to backplane digital and RF connections. Using digital engineering-based software, model photonic plug-in module and chassis backplane integration of digital and analog/RF components. Optimize the plug-in module designs. Build and test photonic module prototypes to meet avionics digital and analog/RF link performance requirements. Characterize the photonic module prototypes over temperature, and perform highly accelerated life testing. If necessary, perform root cause analysis and remediate circuit and/or packaged transmitter failures. Deliver two 100 Gbps digital modules, one intensity modulated with direct detection analog/RF module, and one phase modulated with interferometric detection module. Deliver the SysML model and the CAD model.

PHASE III DUAL USE APPLICATIONS: Finalize the prototype. Verify and validate that the plug-in module operates from -40 °C to +95 °C. Transition to applicable naval platforms.

Commercial avionics and general network Infrastructure sectors could benefit from high-speed fiber optic plug-in modules.

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KEYWORDS: Digital Engineering; Fiber Optics; Photonics; Modular Open Systems Approach; Plug-in Module; 100 Gigabits per second

VERSION 8

N221-006 TITLE: Room-Temperature Filler for Honeycomb Repairs

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Air Platforms;Materials / Processes

OBJECTIVE: Develop and demonstrate a lightweight honeycomb core filler for repairs with a short, room room-temperature cure.

DESCRIPTION: Current composite honeycomb repairs rely on either epoxy fill, higher temperature cure (150-160° F; 65.56–71.11 °C) syntactic foams, or 7-day room-temperature cures of syntactic foam. These options have drawbacks, including long times to complete the repair, additional required equipment for controlling/monitoring the cure, and increased resultant weight for epoxy fill repairs. In addition, syntactic foams were designed for battlefield or non-aviation applications and lack the target room-temperature cure duration and required mechanical performance. Composite honeycomb repairs need to be simplified and streamlined to reduce repair turnaround time and necessary support equipment. Reducing the time to cure can drastically improve the rate at which repairs are completed, increasing fleet readiness. As an added benefit, development and qualification of a new repair material will offer an additional solution for repairs.

A new lightweight, streamlined composite honeycomb repair material and process using a novel lightweight, structural filler formulation is sought to reduce the time required for honeycomb repairs. The proposed material can take advantage of various matrix chemistries and fillers [Ref 1]. The repair material would be expected to meet threshold requirements, threshold mechanical properties, and target requirements.

Threshold requirements include, but are not limited to:

- Maximum of 24 hour cure at room temperature 70 °F (27 °C)
- Compatibility with aluminum, Nomex, and polyurethane foam cores
- Maximum exothermic temperature during cure not to exceed 200 °F (93.3 °C)
- Minimum 15 minute pot life
- Maximum density of 0.8 g/cc
- Shelf life of 12 months at 77 °F (25 °C)

Threshold mechanical properties include, but are not limited to:

- Compressive strength of 8 ksi at 77 °F (25 °C) by ASTM D695 [Ref 2]
- Lap shear of 700 psi at 77 °F (25 °C) by ASTM D1002 [Ref 3]
- Retention of 50 % of compressive strength at 180 °F (83 °C)

Target requirements include, but are not limited to:

- 1 hr cure before sanding at room temperature 70 °F (27 °C)
- Retention of greater than 15% compressive strength at 350 °F (177 °C)
- Ability to cure at temperatures down to 32 °F (0 °C) without added heat
- Greater than 15 min pot life
- Density 0.5 g/cc or lower

PHASE I: Develop novel composite honeycomb filler formulations and screen candidate formulations for feasibility. This assessment can include cure kinetics (maximum exothermic temperature, cure time, pot life) and density to identify the most promising candidate formulations. The Phase I effort will include prototype plans to be developed under Phase II.

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PHASE II: Develop and provide a prototype repair process (suitable for a Depot or I Level repair) using the developed repair material in Phase I. Complete a repair with a minimum size of 3 inches in diameter and 1.5 inches in thickness on a representative part with the developed honeycomb filler. Conduct, in coordination with the Government, mechanical and physical testing that includes a limited set of screening tests sufficient to ensure acceptable properties. Demonstrate reduction in overall cure time and compatibility with common naval aviation honeycomb materials.

PHASE III DUAL USE APPLICATIONS: Generate data for full qualification and validate the repair filler material and the repair technique. Repair instructions for Depot or I Level honeycomb repairs will be developed and provided. Transition the technology to applicable Navy Depot.

Honeycomb repair is applicable to composites outside of the aerospace industry. The automotive, as well as the marine industry, use honeycomb or filled-composite structures. A repair material that is effective across multiple industries is possible.

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KEYWORDS: Composites; Honeycomb; Repair; Lightweight; Room temperature; Filler

VERSION 8

N221-007 TITLE: Data-Driven Physics-Based Modeling Tools to Determine Effective Mechanical Properties of As-Built Composite Structures

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence (AI)/Machine Learning (ML)

TECHNOLOGY AREA(S): Air Platforms;Materials / Processes

OBJECTIVE: Develop a software toolkit to automate the generation of nonlinear, anisotropic mechanical properties for as-built composite structures, including the effects of defects, to accelerate finite element (FE) analysis for fleet repairs and aircraft production non-conformal dispositions.

DESCRIPTION: Advanced rotors for vertical lift aircraft and wings on many U.S. Navy fixed-wing aircraft are complex assemblies made primarily from thermoset composites (e.g., IM7/977-3). Full-scale fatigue tests are frequently required to qualify and certify these critical safety items for a calculated number of flight hours. The selected part chosen for testing may have deliberate seeded flaws and/or severe manufacturing defects to capture the worst damage/condition expected in service. After these weakened parts survive the full-scale fatigue tests, applied knockdown factors further reduce the risk of fatigue failure. Even though the strength safety margin for a given part could be sufficiently high, when service damage occurs, engineers have very tight repair limits, and few options, due to the fatigue life constraint. Local stress distributions, and in-situ mechanical properties of the composite parts, have a significant influence on fatigue life and residual strength, and are very complex to predict, especially for the thick (0.5 in./1.27 cm or greater) laminate composites.

A potential remedy to establish additional cost-effective repair options is to implement a data-driven, physics-based, modeling approach by analyzing the parts in the as-built condition with their own unique configuration, including manufacturing defects and in-service damages. Examples of manufacturing defects are wrinkles, marcols, foreign object debris, porosities/voids, and delamination. In-service damages could include impact, maintenance induced, and heat or ballistic damage.

In addition to an accurate FE mesh representation of the as-built component, the other crucial analysis requirement is the assignment of accurate in-situ (nonlinear) mechanical properties to the FEs. Typical mechanical properties for laminate composite FE analyses (FEAs) use linear orthotropic values based on coupon testing (versus as-built structures). As a result, strain gauge values monitored during full-scale tests can differ substantially from FEA results. These differences between strain gauge results and strain/stress analysis predictions deserve scrutiny when considering repair options. Innovative advancements in computerized tomography (CT) scan image processing coupled with advanced micro-meso-macro mechanics modeling can be utilized to yield not only more representative anisotropic mechanical properties, but also a more accurate stress/residual strength analysis of the real structures.

The Navy seeks to develop a software toolkit that can automate the process to generate in-situ, nonlinear, anisotropic effective mechanical properties using CT scans of as-built composite parts. The critical size and boundary conditions of the representative volume element (RVE) must be consistent with the material system's inhomogeneity, scan resolution, and fidelity of the intended FE mesh. The scan resolution should be sufficiently high enough to capture the appropriate length scale(s) associated with material system components (e.g., ply thickness/orientation, fiber path/bundle/volume, fiber/resin, and adhesive interfaces) and manufacturing defects (e.g., porosities/voids, wrinkles, delamination, and fiber waviness). The most critical defects include combinations of wrinkles, porosities/voids, and resin-rich or adhesive-rich zones, which should be captured by the model with an effective relationship to the FE mesh and intended analysis. The proposed toolkit must also account for material degradation due to repeated loadings and Hot/Wet (H/W) operating environments. The generated quasi-static and dynamic-effective mechanical properties (stiffness, strength, and strain energy release rate) must be compatible with

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different 2-D and 3-D FE types including shell/plate and tetra-/hexahedral elements. Since the data volume of the CT scans could be very huge (larger than one terabyte) for a full-scale component, speed and accuracy issues relating to data acquisition, image processing, and data storage and retrieval must also be addressed, including the use of machine learning (ML) and computer vision techniques.

PHASE I: Demonstrate technical feasibility of the proposed concept to develop a computationally efficient, multiscale, physics-based, modeling toolkit coupled with CT-scanned data, ML, and computer vision techniques to generate in-situ, quasi-static, and dynamic effective mechanical properties (stiffness, strength, and strain energy release rate) for as-built, thick laminate composite structures, including effects of defects, repeated loadings, and expected H/W operating environments. Demonstrate the proposed workflow to auto-populate the input data for different 2-D and 3-D FE meshes, including various element sizes and types to support progressive damage analysis of thick laminate composite structures. Develop a verification and validation (V & V) test plan for the proposed concept, including, at a minimum, the use of Digital Image Correlation (DIC).

PHASE II: Perform CT scan of test coupons/components representative of a structural component with manufacturing defects (e.g., L-shape). Develop algorithms for fast CT image processing, automated feature extraction, and identification/classification with ML techniques, and data storage and retrieval. Demonstrate the generation of a localized FE mesh from CT scan data capturing ply orientations and manufacturing defects. Demonstrate the integrated process utilizing the developed multiscale, physics-based, modeling toolkit and CT-scanned data to predict the in-situ, quasi-static, and dynamic effective mechanical properties (stiffness, strength, and strain energy release rate) for a structural representative thick laminate composite test component including effects of defects and operating environments. Demonstrate the auto-populated input data functionality for different 2-D and 3-D meshes. Conduct testing in accordance with the V & V test plan developed in Phase I to correlate with the predicted results.

PHASE III DUAL USE APPLICATIONS: Finalize the prototype modeling-toolkit and ensure usability for the end user. Perform final testing to demonstrate the toolkit's ability to support analysis of a fleet repair or solve a production issue on a large-scale and relevant platform part.

Commercial aviation uses similar structures and has a similar need for more capable analysis toolkits to analyze repairs and production issues. This capability might also find use in the wind turbine industry, as the blades are large composite structures.

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KEYWORDS: Composites; Finite Element Analysis; Damage Progression; Material Characterization; Manufacturing Defects; Composite Repairs; Computed Tomography

VERSION 8

N221-008 TITLE: Innovative Approaches to Reducing the Complexity and Increasing Sustainability of Linkless Ammunition Loading System III

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Weapons

OBJECTIVE: Identify and demonstrate system innovative approaches to the Linkless Ammunition Loading System III (LALS III) to increase the system's reliability and availability.

DESCRIPTION: The M61A1 and M61A2 gun systems installed on the legacy and super Hornet F/A-18 are loaded using the LALS III, consisting of a system of gears and conveyors that are complicated to utilize and maintain. There have been several attempts to increase the Mean Time Between Failure (MTBF). However, with the incorporated changes the system still has a high-failure rate for several components (e.g., the conveyor assembly, aircraft interchange unit, and chain ladder assembly) as identified by Conventional Ordnance Discrepancy Reports (CODR). This high-failure rate causes mission delays and an increase to the maintenance workload for the fleet. These components are all complex parts of the overall conveyor system that moves ammunition throughout the LALS III. When connected to the aircraft or the ammunition transfer system to load or download ammunition in and out of the LALS III, there are several sequential steps necessary for the system to function properly. Severe damage and timing issues occur to these components if one step is missed or done out of order. Potential improvements include: (a) an internal timing and tension function to remove human error from the equation, and (b) improvements to the conveyor assembly, aircraft interchange unit, and chain ladder assembly to make them more robust to handle the rigors of the aircraft carrier environment, Forward Operating Bases, and decrease maintenance complexity. Any materials considered should be all-weather, corrosion resistant, suffer no adverse effects from contact with solvents, lubricants, or oils, and be compatible in a Hazards of Electromagnetic Radiation to Ordnance (HERO) environment. The overall goal is to increase the overall availability, sustainability, and readiness.

PHASE I: Define, develop, and demonstrate the feasibility of innovative concepts and procedures increasing the reliability of failed components of the LALS III. Use CODR data to analyze high-failure areas and evaluate failed components of the LALS III. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Refine the conceptual design and develop a prototype. Perform testing of prototype to demonstrate their effectiveness.

PHASE III DUAL USE APPLICATIONS: Integrate solutions in a LALS III. Support operational assessment of the prototype design solutions by a squadron prior to full-scale fielding.

The improvements to the LALS III could potentially be modified to fit other ammunition conveyor units or commercial conveyor assemblies. The improved solutions could be sold to manufacturing processes to increase their reliability and decrease maintenance requirements.

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KEYWORDS: Linkless Ammunition Loading System III (LALS III); 20mm Ammunition; Weapons Unloading; Weapons Loading; Weapons Handling; Linkless System

VERSION 8

N221-009 TITLE: Automated System to Assist in Gauge Block Calibration

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence (AI)/Machine Learning (ML);Autonomy

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Design and develop an automated system to assist in the gauge block calibration process.

DESCRIPTION: The Navy Primary Standards Laboratory (NPSL) and the Navy Calibration Laboratory Lakehurst (LAL) provide specialized calibration support throughout the Navy. One of the primary calibration procedures they perform is gauge block calibration. This process involves calibrating a precise length measurement machine using calibrated gauge blocks. The block, or blocks, being used must be placed on a precise position on the measuring machine. Measuring machines currently in use at the facilities include the Labmaster Universal Measuring System Model 175, and the Precimar Models 130B-24 and 130B-16. As the task is currently performed by hand, the operators regularly run into an issue where the heat from their hands causes the blocks to expand, and affects the blocks' dimensions. The operators handle the gauge blocks with gloves in order to mitigate this effect, but enough heat is still transferred to affect the measurements. When this occurs, blocks have to be left sitting untouched for up to a few hours to return to normal dimensions. This can introduce delays and increased costs.

This SBIR topic seeks to develop an automated system that can perform some or all of this calibration process. This would greatly reduce required operator time, freeing up resources for alternate tasks. This would also reduce any delays, as tasks using the system could be run consecutively.

In particular, the system must meet the following block and measurement device specifications:

- Block sizes range from < 1 in. (< 2.54 cm) to approximately 24 in. (60.96 cm) in length.
- Blocks are stored in several standard containers near the measurement device.
- Blocks must be placed on a planar surface in a designated position with a minimum accuracy of 0.03125 in. (0.07937 cm) and an ideal accuracy of 0.01 in. (0.0254 cm).
- The measurement device has a free working dimension of 1.5 in. by 3 in. (3.81 cm by 7.62 cm). The solution must not make contact with the measurement device outside of this area.
- The system should capture the output from the measurement device.
- Total thermal output of the system should prevent raising the temperature of the room more than 0.2 °F (-17.66 °C) to maintain repeatable calibrations.

While there are precision robotic systems in other domains such as medical robotics [Ref 4], none have been evaluated for use in this type of situation, including the accuracy requirements and the ability to handle the wide range of gauge block sizes. This calibration procedure requires precise manipulation and placement of these blocks within the test stand. The key barrier is ensuring that the process is repeatable and reliable to operate without user supervision while still meeting all calibration process requirements. If successful, this solution could be adapted to additional calibration labs or other similar processes.

PHASE I: Design and develop an initial concept that can meet the stated requirements for the calibration system. Demonstrate feasibility of the system concept to perform the calibration procedure subject to those requirements. The system concept does not have to perform all steps in the procedure, it must only demonstrate that the steps are likely to work and meet the acceptance criteria through benchtop tests. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a working prototype. Integrate the functions demonstrated in Phase I into a working system that meets all performance requirements. Demonstrate the prototype in a lab or live environment.

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PHASE III DUAL USE APPLICATIONS: Perform final testing for verification of requirements by the calibration stakeholders. Following success in final tests, the system will be transitioned into use at naval calibration facilities.

Companies that develop complex mechanical systems, such as defense contractors, and university research laboratories utilize metrology facilities to accurately measure mechanical components. As gauge blocks are a commonly utilized method of calibrating measurement equipment, an automated system that can perform the calibration task would be a valuable acquisition for any of those companies and groups. In addition, though the goal of this topic is to develop a system targeted at the requirements of the described calibration task, the precise manipulation and repeatability requirements would have potential use in many applications where an automated system needs to precisely manipulate small objects, such as pick-and-place operations and assembly portions of manufacturing processes.

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KEYWORDS: Automation; Metrology; Robotics; Calibration; Robotic Manipulation; Robotic Grasping

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N221-010 TITLE: Magnetometer Classification of Underwater Objects

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Air Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Design and develop a system using existing sensors and real-time signal-processing algorithms for classification of underwater objects.

DESCRIPTION: Modern frontline submarines pose a threat to maritime strategy and naval operations. The proliferation of acoustic quieting techniques has severely decreased the detection range of passive acoustic sensors. Active acoustic sensors can provide longer range, however they do not provide classification of the target.

New compact sensors provide an opportunity to develop improved real-time detection, target parameter extraction, target localization, prosecution/tracking, and classification of underwater objects. Advanced signal processing techniques may generate classification from a variety of sources, including magnetometers; magnetic dipoles; and extremely low frequency (ELF), ultralow frequency (ULF), electric fields (E-Fields); or other sources of opportunity, such as magnetotelluric or very low frequency radio wave sources. The desired end-product is a system for classification of underwater objects consisting of the magnetometers (< 4) and an open architecture, software module with the necessary algorithms to process sensor data and conduct data fusion for classification. It will be requested for the software to process the data in real time, that is, capable of providing a result analysis and display of the data while data is being taken. The magnetometer will be an onboard system vice a towed magnetometer. Developed software must be compatible with platform architecture, i.e., Joint Mission Planning System (JMPS).

Examples of features the system should account for include, but are not limited to:

- geo-location coordinates
- date and time stamp
- platform altitude
- graphical user interface
- probability of detection
- false alarm rate
- geologic, geo-atmospheric, oceanic, and platform noise characteristics
- data fusion

If the target is identified as a mobile submerged target, the following features should be identified:

- target course, speed, and depth parameters
- target length
- target diameter
- target screw turn rate

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- target screw configuration (i.e., 5-bladed screw)

If the target is determined to be a submarine, the following features should be identified:

- submarine sail length and location
- submarine type

Magnetic Anomaly Detection (MAD) sensor metrics include, but are not limited to:

- noise floor: $< 0.35 \text{ pT/rt Hz}$ from 0.01–100 Hz
- magnetometer: able to operate in all of Earth's field orientations and magnitudes
- magnetometer: not sensitive to motion-induced measurement errors or the MAD system must be able to compensate for motion-induced measurement errors
- cost per system: Objective $< \$2,000$, Threshold $< \$10,000$
- volume: $< 100 \text{ cc}$ (sensor Head), $< 500 \text{ cc}$ (electronic module)
- power: Objective $< 1 \text{ W}$, Threshold $< 5 \text{ W}$

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Demonstrate a conceptual design of real-time, open architecture software signal processing algorithms to achieve classification of underwater objects using commercial off-the-shelf magnetometer sensors onboard rotorcraft. The Phase I effort will include prototype plans to be developed under Phase II. Awardees should provide NAVAIR a white paper of the developed or implemented theory.

PHASE II: Develop a candidate prototype for real-time magnetometer sensor and signal processing for classification of underwater objects using an open architecture software. Perform algorithm testing and performance validation using simulated processed signals and actual data. Refine the software, integrate it with the proposed sensors and a commercial magnetometer in the laboratory (or other location), and demonstrate the system classification performance. Use of fictitious classification data is acceptable.) Conduct a flight test to demonstrate the prototype magnetometer sensor and signal processing for classification of underwater objects against a target of opportunity (surface ship if the target of opportunity is not available). Demonstration parameters should be approved by the Technical Point of Contact (TPOC). Deliver the classification of underwater objects prototype to the Government for use as a laboratory demonstration model.

Work in Phase II may become classified. Please see note in Description paragraph.

PHASE III DUAL USE APPLICATIONS: Final transition of this project will involve implementation of the software to JMPS or other hardware architecture specific to the platform. In addition, noise models tailored to the requested platform should be developed. Final testing will involve compilation of real data in the platform, processing of the data in the software, analysis of software results with those simulated with probability models created by software, and measurement of software effectiveness. End results should provide detection, localization, and classification of a target with a signal of around 100 to 101 pT/rt Hz.

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Development of a magnetic detection capability that can be implemented and, potentially, sold to different airborne platforms for the detection of unknown magnetic targets hidden underground or at sea. Possible industries include military, security, atmospheric, and surveillance.

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KEYWORDS: Electromagnetic Detection; Underwater Object Classification; Signal Processing; Rotorcraft; Magnetometer; Object Vector Characterization

VERSION 8

N221-011 TITLE: Low-Cost, Large, Multidimensional, High-Sensor-Density, Collapsible Arrays

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop large, multidimensional, high-sensor-density, collapsible arrays compatible with A-size sonobuoy dimensions and applications.

DESCRIPTION: The Navy requires high-gain arrays for both passive and active sonar due to continued submarine quieting. Technically, this implies designs with increased apertures, dimensionality, and numbers of elements. However, the fundamental constraint of an A-size sonobuoy will remain in place for the foreseeable future. Traditional sonobuoys have evolved from single-line, multi-element arrays to more complex two-dimensional planar arrays (e.g., the Air-Deployable Acoustic Receiver (ADAR)). Rather than seeking an incremental path of increasing the efficiency of discrete element foldable structures, this SBIR topic seeks radical new solutions for achieving high-gain, three-dimensional, multi-element array structures capable of fitting within an 18 in. length and 4.75 in diameter section of an A-size sonobuoy. Of interest, but not required, is the use of collapsible, water-inflatable structures or novel material methods to create a structural framework. The solution should then enlist techniques to maximize use of the array's structure to support stable sensing elements of high density. The over-sampled volumetric array should increase array gain, increase flexibility in controlling sidelobes, and increase adaptivity across operating bands. Efficiency in electrical connectivity (if needed), power use, stability of the structure when deployed, sensitivity of the elements, and overall weight are important design factors to consider as well. The overall goal of this topic is to identify and implement technology that incorporates novel mechanical and sensor designs to exploit as much of the array's structure as possible to greatly increase sonobuoy sensing capability.

The performance objectives:

- Packaged size: < 18 in. (45.72 cm) of the A-size canister
- Numbers of elements: > 100
- Element frequency response: up to 7.5 kHz
- Sensitivity—Noise: limited sea -state zero (SS0) noise
- Weight: < 20 lb (9.07 kg)

PHASE I: Develop a conceptual design for a volumetric array. Since there is no physical aperture requirement, demonstrate the feasibility of the design relative to an existing A-size sonobuoy aperture and expected performance estimated from open sources. Identify technological and reliability challenges of the design and propose viable risk mitigation strategies. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a specific set of sonobuoy array requirements satisfying critical mission(s) needs. Adapt the Phase I conceptual design to satisfy those requirements. Then design, fabricate, and deliver an

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array subsystem prototype capable of meeting the requirements. Test and fully characterize the system prototype.

PHASE III DUAL USE APPLICATIONS: Adapt the Phase II design into existing A-size sonobuoy architecture(s); designing, fabricating, and delivering a sonobuoy prototype capable of meeting the requirements; test and fully characterize the system prototype.

The development of this technology will have application to the oceanographic community and oil exploration industry.

REFERENCES:

1. Suhey, J. D., Kim, N. H., & Niezrecki, C. (2005). Numerical modeling and design of inflatable structures—application to open-ocean-aquaculture cages. *Aquacultural Engineering*, 33(4), 285-303. <https://doi.org/10.1016/j.aquaeng.2005.03.001>.
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KEYWORDS: Sonobuoy; Array; ASW; Collapsible; A-size; Structure

VERSION 8

N221-012 TITLE: Advanced Jam-Resistant Radar Waveforms

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop radar waveform design approaches that are robust in the presence of barrage noise and deceptive jamming techniques.

DESCRIPTION: Radar electronic protection systems employing traditional static, table-based threat recognition have increasingly limited efficacy against modern electronic warfare systems. However, the software control of many modern radar systems enables dynamic waveform generation and scheduling that significantly expands the available signal use and processing domain. Here we seek to take advantage of that flexibility to design a class of jam-resistant waveforms suitable for surface and air target detection, tracking, and imaging from an airborne radar system. The selection of a particular waveform would be determined by a cognitive, engine-based, radar resource manager and counter electronic attack system using knowledge gained from its perception-action, real-time feedback loop. Among the candidate approaches to be considered are coded waveforms, chaotic waveforms, and noise waveforms. Other techniques optimizing the waveform for target, clutter, and jamming conditions should be considered.

The cognitive control element in this approach should assess the efficacy of waveform choices and capture this information as part of a data record agent that leverages that information to support a jammer technique recognition and inference process. This also should serve as the means of accumulating new knowledge for future model aggregation. The streaming record is envisioned as an object database/ontology that maintains a signal record and linkage-based affiliation of signals and their inferred emitter attributes. The layers should leverage a common data structure to define and maintain a model of each unique jammer response as an evolving knowledge base, support relational assessment of them and their behaviors, support model extensions to accommodate new and anomalous signals, and support constrained collection and dissemination of this information.

Work produced in Phase II may be classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

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PHASE I: Develop approaches and demonstrate feasibility of multiple jam-resistant radar waveforms for maritime surveillance and imaging modes, and/or airborne all-aspect search or airborne early warning horizon search. Assess performance impacts of use of these waveforms relative to traditional waveforms in both quiescent and jamming environments. Identify the critical cognitive control elements including the nature of efficacy metrics to be collected and models generated. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop prototype modes for demonstration on a Navy test asset. Based on these results, select and further mature the most promising approaches. Significantly increase the fidelity of the cognitive control element by fully identifying end-to-end functions, and develop a prototype implementation.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Complete development, perform final testing, integrate, and transition the final solution to naval airborne radar system.

Civilian uses for both radar and communication system in the presence of unintentional and intentional jamming is possible with this technology. Those potential applications include law enforcement and emergency services communication systems as well as civil aviation communication and radar systems.

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KEYWORDS: Radar; Waveforms; Anti-Jam; Adaptive; Coding; Interference

VERSION 8

N221-013 TITLE: Development of High-Viscosity Pre-Penetrant Etching Materials

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop high-viscosity pre-penetrant etchant materials for aluminum alloys.

DESCRIPTION: Fluorescent penetrant nondestructive inspection (NDI) processes are utilized to detect surface-breaking cracks and corrosion in aircraft structures. Most military aircraft structures are made of 7000 series aluminum alloys (with 7075/7050/7085 being most common). The parts are primed and painted to provide protection from corrosion. Removal of paint schemes or corrosion is often performed through mechanically abrasive processes such as sanding, grinding, or machining, which smear small amounts of material over fine cracks and corrosion, making them less detectable with the penetrant inspection method. Chemical etching is used throughout the NDI industry as a method to remove approximately 0.0002 in. (0.00508 mm) of smeared metal prior to penetrant inspections [Refs 1 & 2]. The etching process typically requires multiple steps, which include precleaning the area, applying an etchant, applying a neutralizer, and applying a desmutting agent [Refs 1–3]. The etchant, neutralizer, and desmutting agents are typically acidic or alkaline and pose some safety hazards, as well as hazards to the aircraft when used in the field. The low-viscosity chemicals (similar to water) are prone to spilling and migrating into crevices in the structures (faying surfaces and fastener holes) near the inspection zone.

This SBIR topic seeks to develop paste forms of viable etchant materials with viscosities similar to toothpaste (70,000 to 100,000 cP) to reduce the hazards of using these chemicals during inspections of parts while they are still installed in the aircraft.

Various chemicals are currently used for these tasks and may be suitable for viscosity tailoring. The most common chemical mixtures used by NAVAIR are:

- Etchant: 0.705 oz (20 g) sodium hydroxide in 3.38 oz (100 ml) water
- De-smutting agent: 1.69 oz (50 ml) nitric acid added to 1.69 oz (50 ml) water
- Neutralizer: 0.353 oz (10mg) sodium bicarbonate in 3.38 oz (100 ml) water

Alternate combinations of chemicals, or other nonchemical processes that can evenly remove 0.0002 in. (0.00508 mm) of aluminum without smearing, are viable alternate approaches.

Etchant, neutralizer, and de-smut materials should have:

- Viscosity of 70,000 to 100,000 cP
- Shelf life of 6 months minimum (single-use needs for areas up to 16 in.² (40.64cm²))
- Useable temperature range of 50F (10C) to 120F (49C)
- Etch rates of 0.00002–0.0001 in. (0.00508–0.00254 mm)/min (removes 0.0002 in. (0.00508 mm) in 2–10 min)
- Etch rate should be uniform
- Chemicals should not require the user to mix components.

PHASE I: Develop, design, and demonstrate feasibility of etchant, neutralizer, and de-smut materials as described in the Description.

Phase I should include laboratory measurements of the viscosities of the chemicals and tests to demonstrate etch rates. Etch rates and uniformity of etching should be substantiated by laboratory testing and microscopy.

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If a nonchemical approach is proposed, Phase I tasking should focus on demonstrating the proper etch rates and uniformity requirements are achieved. If the process poses safety hazards or other potential hazards to the aircraft, those hazards should be assessed and mitigated. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Phase II should focus on refining the proposed solution, demonstrating minimum shelf-life requirements, and optimizing packaging/storage concepts for single-use needs for areas up to 16 in.² (40.64 cm²).

PHASE III DUAL USE APPLICATIONS: Verify, validate, and finalize the prototype. Transition to applicable naval platforms and depots.

Pre-penetrant etch is required before penetrant inspection processes when any mechanical working (sanding, grinding, blasting, machining, etc.) of the part's metal surface during manufacturing or reworking is done. Penetrant inspections cannot be performed on painted parts, so mechanical paint stripping in-service parts requires etching before penetrant inspection can be performed. Penetrant nondestructive testing (NDT) is commonly used in a multitude of industries including infrastructure (buildings/bridges), transportation (auto/rail/ship), energy (oil and gas/hydrodynamic/wind), and space (rockets/payloads). Users of the penetrant NDT process could benefit from a safer etching process.

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KEYWORDS: Penetrant; etchant; metal; smear; nondestructive; non-destructive

VERSION 8

N221-014 TITLE: Synthetic Aperture Radar High Resolution Imaging when Performing Random Nonrepeating Radar Orbits

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR);Networked C3

TECHNOLOGY AREA(S): Air Platforms; Battlespace Environments; Information Systems

OBJECTIVE: Develop innovative Synthetic Aperture Radar (SAR) image formation/detections techniques for aerial vehicles performing Coherent Change Detection (CCD) that permits randomized radar orbits.

DESCRIPTION: Modern synthetic aperture radar signal processing algorithms retrieve accurate and subtle information regarding a scene that is being interrogated by an airborne radar. An important application of “continuous-stare” SAR systems involves detecting changes in an imaged scene. Current CCD radar techniques require flying the same orbit path repeatedly in order to look for changes in the scene. While this is acceptable in a benign threat environment, this predictable flight profile will be lethal to the air vehicle in a high-threat environment.

Achieving the alignment necessary between images (especially for CCD) is often difficult due to many factors beyond the control of the platform and sensor, including imaging geometry issues, air vehicle motion, errors in motion compensation, difficult clutter environments, clutter motion, and meteorological issues. Even when good alignment is obtained, weaker stationary target signature may be overcome by the surrounding clutter or masked by false alarms, requiring more sophisticated alignment algorithms and change metrics to extract the relevant image change information. Also, the steep depression angles required for urban imagery aggravate the effects of mismatched imaging geometry on change detection. These effects can be considerable, especially for CCD. Noncoherent change detection (NCCD) is often difficult in urban areas, for example, because large cultural object scatterers and their side lobes may be difficult to align (especially when imaging geometries are different) and may overwhelm weaker stationary target signatures. High-frequency CCD is potentially capable of detecting extremely subtle terrain disturbances, but is even more sensitive to alignment issues, typically producing an overwhelming number of naturally occurring false alarms, even in relatively benign cases. Inability to perform change detection (CD) may result in missed opportunities for extraction of significant information.

This SBIR topic seeks to develop and demonstrate techniques and transforms enabling CCD to be conducted with orbits that are randomized and nonrepeating. These techniques and transforms will be applicable to any aerial vehicle that is conducting SAR CCD missions under degraded conditions and various deployment environments. These techniques and transforms will be able to compare the coherent and/or noncoherent reference and test SAR images: (a) to detect image changes in randomized CCD radar orbits; (b) to extract automatic features such as stationary-vehicle Doppler “smears” embedded in urban clutter and other alternative change detection metrics; (c) sensitivity to various image formation techniques, including wavefront reconstruction (WR) and the polar format algorithm (PFA); and (d) sensitivity to phase history processing and conditioning methods.

Developed algorithms, techniques, transforms, and a simulation tool to estimate the SAR performance producing high-resolution radar imagery of stationary objects being performed by various aerial vehicles performing randomized CCD radar orbits will be tested during one, or possibly two, Government Rapid Prototype Experimentation Demonstration (RPED).

The offeror’s proposal must clearly explain how an aerial vehicle flight path variation SAR imagery collection will be accounted for with respect to:

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1. Spatial registration of the reference SAR image with respect to the test SAR image using the available air vehicle platform motion data (e.g., Global Positioning System (GPS), Inertial Measurement Unit (IMU), etc.).
2. Spatially varying motion compensation (on points on ground plane and elevation) in a three-dimensional spatial domain using GPS denied navigation filtering software and simulation to assess SAR randomized and nonrepeating orbits imagery quality when the GPS is available or denied.
3. Spectral registration of both the test SAR image and the georegistered reference SAR image to extract the common Doppler data in the two images using the available air vehicle platform motion data.
4. Blind calibration of variations of the Image Point Responses (IPR) of the resultant (spatially and spectrally registered) reference and test SAR images using applicable adaptive filtering methods.

Air vehicles equipped with multichannel along-track monopulse/displaced phase center antenna-SAR (ATM-SAR) and high-Pulse Repetition Frequency AzScan-SAR Doppler Beam Sharpening-SAR (DBS-SAR) may be included in but are not required to be part of this SBIR topic.

Air vehicles performing Ground Moving Target Indicator (GMTI) using SAR imagery are not to be considered and are not part of this topic.

PHASE I: Develop and demonstrate techniques and transforms that exploit fundamental mathematical and physical properties of SAR signals to detect changes in imagery of a scene that are acquired via randomized CCD radar orbits of a SAR aerial platform using a single channel radio frequency (RF) sensor. Develop and provide techniques and transforms to retrieve the common spatial spectral information in randomized and nonrepeating orbits SAR imagery for coherent and noncoherent change detection (NCD). Develop and provide signal models for the effects of measured randomized and nonrepeating orbits SAR data calibration errors as related to radar electronics phase errors, and unknown motion errors. Deliver an analytical study of the randomized and nonrepeating orbits SAR signal, and identify its information contents in the spatial and spectral domains. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Further study, develop, and improve analytical principles developed in Phase I. Validate and mature the mathematical modeling and processing trade-analysis using an Integrated Fly-out Simulation (IFS) testbed to exploit randomized and nonrepeating orbits SAR imagery. Demonstrate, with minimal additional data processing in the image formation process, in a relevant flight environment the developed signal processing techniques and transforms that exploit randomized and nonrepeating single-channel SAR data acquired at different time points for high-resolution imagery of stationary objects during a Government sponsored RPED. Furthermore, real-time simultaneous imaging, as well as CCD/NCD, are to be demonstrated while the SAR data is being collected over a full aperture (slow-time).

PHASE III DUAL USE APPLICATIONS: Further research and development will be directed toward refining final Synthetic Aperture Radar (SAR) image formation/detections techniques. Incorporate these techniques based on results from tests conducted during Phase II.

Deploy Synthetic Aperture Radar Image (SAR) formation/detections techniques, in relevant environment aerial test environments, to validate techniques. Document lessons learned (what worked, what did not, areas of improvement). Identify gaps in SAR image formation/detections techniques and propose a solution to the identified gap to the Government working groups.

The completion of this phase would result in a mature capability, which would undergo an appropriate operational demonstration, such as surveillance and reconnaissance. These SAR image formation/detections techniques should prove the ability to provide high-resolution imagery of stationary objects by various aerial vehicles performing randomized CCD radar orbits.

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Continue relationships with radar manufacturers with the objective of placing these Synthetic Aperture Radar Image (SAR) formation/detections techniques in major defense and commercial radars.

From a military application, these Synthetic Aperture Radar I (SAR) image formation/detections techniques would enable hypersonic air vehicles to have high-speed radar target detection, identification, and discrimination capability of stationary objects. From a commercial application, homeland security and commercial applications include guidance and control for robotic systems used in hazardous environments, and materials handling applications involving cranes; and loading equipment, and industrial equipment used in assembly, welding, inspection, and other similar operations. These algorithms could be used to support commercial ground mapping applications and current radar system performance for border patrol, drug traffic monitoring, perimeter surveillance, and air traffic control applications.

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KEYWORDS: Radar; SAR; imagery; detection; orbit; target

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N221-015 TITLE: Electromagnetic Interactions Between Cables, Antennas, and Their Environments

OUSD (R&E) MODERNIZATION PRIORITY: Networked C3

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop a multifidelity simulation tool for analyzing electromagnetic interactions between cables, antennas, and their environments for Navy aircraft.

DESCRIPTION: Modern Navy aircraft are replete with cable harnesses that carry sensitive information and provide power to avionics, weapons, sensors, control surfaces, and landing gear. The internal arrangement and layout of cable bundles in aircraft is a critical part of the design of new and existing platforms. Rules of thumb for cable harness separation, shielding, and layout exist, but they often result in over-engineering the solution and are not always effective.

A need exists for a multifidelity cable harness tool that can be used during all phases of an aircraft's life cycle to assess potential for self-interference, as well as disruption due to external sources such as EMP, HIRF, and lightning. NAVAIR analysts often need to provide rapid feedback regarding a design trade study or changes to a piece of avionics and its associated cables on an existing aircraft. As aircraft designs mature and more information about the structure of the platform, avionics, and cable harnesses becomes available, analysts want to work in the same tool leveraging the investment made in the previous analyses, all the way through to the simulation of the full aircraft for certification purposes.

The design process needs to consider cross-talk between cables within a harness or between cables in different harnesses. It must also include coupling to and from antennas located on the aircraft. There must be consideration for the electromagnetic compatibility of systems connected to the power bus, which becomes complicated as the number of systems on the same bus increases. Finally, a cable harness design should account for the impact of coupling from the external electromagnetic environment, including Electromagnetic Pulse (EMP), High Intensity Radiated Fields (HIRF) and lightning. All these interactions must be considered for cable harnesses in aircraft to understand the impact on the devices attached to the cables.

Multifidelity analysis tools exist that predict electromagnetic interference (EMI) between RF systems where the dominant coupling path is from a transmitting antenna to a receiving antenna. Such tools are extremely powerful for NAVAIR analysts because the same software tool can be used for quick, as well as rigorous analyses, and the models developed for a platform can be maintained throughout the lifecycle of that platform. However, a similar multifidelity solution for the cable harness analysis problem does not exist in a single software package. There are existing spreadsheet-based approaches for analyzing power buses. There are existing high-fidelity, full-wave solvers for analyzing the various modes of aircraft cable harness coupling. However, there are several limitations with existing approaches and tools. Spreadsheet-based solutions do not scale well with problem size, they are prone to errors, and make configuration control a challenge. Hybrid solvers, that include full-wave simulations of structures with transmission line modeling of cable harnesses, work well when all the necessary details are available to the analyst and there is enough time to build up the complex models of the platform with all the details of the various cable harnesses. However, this level of detail is usually not available until the design of the aircraft is almost complete. Medium-fidelity cable harness simulation tools based on modified transmission line theory are available. However, there is not a common platform to allow the medium-fidelity simulations to evolve as the design changes, and eventually incorporate the aircraft structure in a hybrid simulation. The compatibility problem must be set up for each environment individually, and they have, thus far, not been automated to consider multiple self-interference and external environments automatically.

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PHASE I: Demonstrate solutions for low-, medium-, and high-fidelity approaches to the cable harness analysis problem considering both self-interference and external interference scenarios, such as those addressed in MIL-STD-461 and 464. Review approaches with NAVAIR technical staff to ensure that they fit the current and future workflow for NAVAIR programs. Develop a detailed software architecture plan for Phase II implementation that includes a user-friendly graphical user interface (GUI) and configuration control that allows for sharing of projects between groups working on different problems for the same platform (e.g., cross talk analysis, power bus analysis, and external field analyses). The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop and demonstrate a robust, multifidelity software solution that allows NAVAIR analysts to consider very simple problems when there is limited information, all the way through full aircraft models with all the geometric, material, and cable harness details. Provide interfaces for reading common CAD formats. Demonstrate the accuracy, robustness, and speed of the tool. Develop a Phase III commercialization plan.

PHASE III DUAL USE APPLICATIONS: Complete development, and perform final testing and validation of a commercial grade application.

The tool is suitable for electromagnetic compatibility evaluation of any civilian or military electronic system, including within the commercial aviation and automobile industries.

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KEYWORDS: Cable harness; cross talk; lightning; Electromagnetic Pulse; EMP; electronic vulnerability; electromagnetic interference

VERSION 8

N221-016 TITLE: Autonomous Onboard Processing Hostile Fire Sensor System

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR);Microelectronics

TECHNOLOGY AREA(S): Electronics;Materials / Processes;Weapons

OBJECTIVE: Develop and deliver chip-scale multifunction midwave infrared (MWIR) metasurface optics sensor system for detecting and geolocating hostile fire to be mounted on, or installed within, small battery operated Group 1 unmanned air vehicles (UAV) and self-guiding target munitions.

DESCRIPTION: Especially when first engaged, it is often difficult for a soldier, UAV operator, or autonomous self-guiding target munitions to quickly ascertain from where hostile fire has originated. This confusion prevents a quick geolocation and effective auto target coordinates handoff to counter and eliminate hostile fire.

Traditional uncooled microbolometer technologies for small arms bullet detection do not have the potential performance on small battery operated Group 1 UAVs and self-guiding target munitions mainly due to the bullet's large thermal time constants. Fast detector response times are required to detect fast moving objects at peak energy.

This SBIR topic seeks to improve upon the detection and geolocation capabilities of standard broadband optics sensors such as uncooled microbolometer heat detectors by distinguishing between a hostile fire signal and self-emitting blackbody radiation.

To this end, a chip-scale multifunction MWIR metasurface optics hostile fire sensor system for hostile fire detection and geolocation is needed. Demonstrate a thorough understanding of the computational targeting cue algorithms embedded with optics models that minimize calibration and computational processing of spectra needed to make the chip-scale multifunction MWIR metasurface optics hostile fire sensor system successful. As part of the effort, a sensor system design concept should be developed using available existing chip-scale optical components.

Because this topic sensor system is meant to be carried/installed on battery operated Group 1 UAVs (e.g., UVision Hero-20, Teledyne FLIR R80D SkyRaider) and self-guiding target munitions, it must be extremely light weight, low power, and possess an appropriate form factor: this is of primary importance in not degrading other Group 1 UAV and self-guiding target munitions' performance. Additionally, it should be compatible and not interfere with other sensing systems such as acoustic, electro-optical and infrared sensors.

The sensor system need not be imaging, but must provide at least angular direction to the origin of the hostile fire event. In order to provide the user with the best chance of quickly identifying and engaging the threat, the sensor system should minimally be capable of identifying the angle to the threat with $< 30^\circ$ resolution and $< \pm 15^\circ$ error, but ideally $< 5^\circ$ resolution with $< \pm 2.5^\circ$ error. This must be balanced against Size, Weight, Power, and Cost (SWAP-C); horizontal angular (azimuth) resolution is more important than vertical (zenith).

The time lag between the shot and geolocating origin data to the user/or other UAV/self-guiding target munitions system components should be minimal, ideally < 50 ms. Of course, probability of detection at tactically relevant ranges for small arms (500–600 m), such as common assault rifles and carbines, and medium arms (1–1.5 km), such as large rifles and machine guns, should be maximized ($> 90\%$ minimum, ideally $> 95\%$) and false alarms close to zero. Other features, such as weapons identification, the ability to

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squelch alerts generated from friendly fire, and range to target, are desirable. The system must minimally operate within the entire UAV and self-guiding target munitions flight/performance envelope.

Appropriate algorithms to be incorporated into the design are to provide, at a minimum: (a) angular direction to the origin of hostile fire event in all-weather day/night conditions; (b) a least probability of detection versus range; (c) angular resolution and error; (d) time to detect; (e) geo-location; and (f) sources of false alarms and potential mediation.

Testing during later stages of development must include valuation of brass board system using live fire and controlled motion studies over a wide range of relevant background environments.

PHASE I: Demonstrate the feasibility of a complete chip-scale multifunction MWIR metasurface optics hostile fire sensor system design using only components which are commercial off-the-shelf (COTS) or those that could reasonably be designed and fabricated within the time and budget constraints. The sensor design need not be optimized for SWAP-C at this stage, but it must show extensibility to small battery operated UAVs and self-guiding target munitions systems. A complete and thorough understanding of the algorithms necessary to make the sensor system successful must be demonstrated. Rigorous modeling should be performed to estimate sensor system performance, including at least probability of detection versus range, angular resolution and error, time to detect, geolocation, and any other features. Sources of false alarms and potential mediation should be well thought out and incorporated into the design. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Using the results of Phase I, fabricate and deliver a prototype chip scale multifunction MWIR metasurface optics hostile fire sensor system. Prototype should minimally meet requirements for a minimum of TRL 4: component and/or breadboard validation operating in a laboratory environment. All required sensors must be carried or installed small battery operated UAVs, but processing and power may be external at this stage, so long as a detailed design path is provided to show that it can all be integrated into the small battery operated UAVs and self-guiding target munitions (full integration is preferred). Probability of detection, angular resolution and error, and time to detect shall be measured through live-fire testing at close-to-moderate distance, at least 50–1000 m. False alarm mitigation techniques should also be laboratory or field tested when possible.

Perform data collection for the purposes of evaluating sensor and system performance at appropriate program intervals, to include live fire testing. Cameras and sensors must be appropriately calibrated and characterized including sensor pose. Live fire testing shall occur at relevant system ranges and locations relative to system or sensor. Testing during later stages of development must include valuation of brass board system using live fire and controlled motion studies over a wide range of relevant background environments.

Algorithms must minimally include detection, tracking, spatiotemporal registration, motion stabilization. Algorithms shall be capable of running in real time in SWAP-C appropriate hardware as in a postprocessing mode (e.g., on a desktop computer for analysis and precollected data).

PHASE III DUAL USE APPLICATIONS: Transition applicable techniques and processes to a production environment with the support of an industry partner. Finalize a sensor design with appropriate SWAP-C and form factor based on human factors testing. Determine the best integration path as a capability upgrade to existing or future systems, including firmware and interfaces required to meet sensor interoperability protocols for integration into candidate systems as identified by the Navy.

From a military application, this system gives small battery operated UAVs and self-guiding target munitions the capability to provide accurate azimuth, elevation, and range information about hostile fire

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shot line as well as the geolocation of the hostile fire origin to blue forces and if equipped encounter and eliminate hostile fire sources.

From the commercial application, this systems capability will be able to detect smoke and fire at speeds comparable to or faster than conventional detection systems. This makes them a good choice in settings like laboratories, chemical plants, refineries, and boiler rooms where it is critical to detect smallest temperature changes or hidden pockets of embers at an early stage.

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KEYWORDS: Hostile Fire; chip-scale; metasurface; unmanned air vehicle; UAV; optics; munitions

VERSION 8

N221-017 TITLE: Manned-Unmanned Teaming Survival in an Adaptive World

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence (AI)/Machine Learning (ML);Autonomy;General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Battlespace Environments;Electronics;Information Systems

OBJECTIVE: Develop and demonstrate an innovative, mission effective Unmanned Air Vehicle (UAV) capability to assist manned-unmanned teaming (MUM-T) to challenge and/or negate radars and radar networks by enabling UAVs to automatically sense and communicate weaknesses in a radar and/or radar networks.

DESCRIPTION: Current airborne electronic warfare (EW) systems must first identify a threat radar to determine the appropriate preprogrammed electronic countermeasure (ECM) technique. This approach loses effectiveness as radars evolve from fixed analog systems to programmable digital variants with unknown behaviors and agile waveforms. Future radars will likely present an even greater challenge as they will be capable of sensing the environment and adapting transmissions and signal processing to maximize performance and mitigate interference effects.

A growing concept in the field of MUM-T is the idea of using a team of cooperating unmanned and manned air vehicles to significantly challenge and/or negate existing and/or new, unknown, and adaptive radar networks in real time. Some MUM-T strategies to challenge radar networks may include using either jamming techniques, deception techniques, or a combination of the two, to assist in completing MUM-T mission objectives. A UAV may be tasked to engage a radar or radar network using noise jamming to mask its radar return or that of another vehicle. Similarly, a UAV may be assigned to deceive a radar by directing a delayed signal toward the victim radar, which has the effect of producing a radar phantom perceived by the radar as an object at a false range and/or bearing. Depending on the number of UAVs in the MUM-T and the number of radars in the radar network, the UAVs may be able to employ different strategies simultaneously.

A characteristic of these MUM-T strategies is that they require the UAVs to follow time-critical, directionally dependent trajectories with tight constraints in order to be successful, from the start of the defensive task to the very end. It is absolutely necessary that UAVs are able to control their own movements during defensive tasks, as well as navigate in a coordinated fashion enroute to the subsequent tasking. A valid configuration for a UAV is a position in the three-dimensional space environment, which is collision free. At any given trajectory, the algorithm generates a random node and, subsequently, inspects the trajectory path from the generated node to closest previously expanded node for collisions. If collisions exist along the trajectory path, the generated node is discarded and a new random node is generated; otherwise, the generated node is added to the set of expanded nodes. The goal state is reached and ultimately a collision-free path from start to goal state in the three-dimensional environment. UAVs participating in MUM-T missions will need to have local analysis and action capabilities, as well as the ability to speak with and update each other.

The successful completion of this SBIR effort will culminate in demonstrations of the MUM-T challenge and/or negate capabilities being able to:

- Isolate unknown radar signals in the presence of other hostile, friendly, and neutral signals.
- Deduce the threat posed by a radar and/or a radar network.
- Synthesize and transmit signals to achieve a desired effect on the radar and/or a radar network.
- Assess the effectiveness of strategies based on radar and radar network behaviors.

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Simulation-based demonstrations of the effectiveness of small UAV sensor suites in performing various challenging and/or negating missions will help planners and decision makers determine the appropriate mix of UAVs and sensors that will be required to support MUM-T missions, and will show performance as a function of system cost. The flexibility of distributing the sensors across several Group 1-5 UAV platforms enables customized sensor suite solutions that both meet various mission needs and minimize cost. Therefore, a MUM-T member will not have to pay for sensing capabilities that they do not want or require.

This SBIR topic seeks to develop a MUM-T challenging and/or negating product(s), which includes the following features and functions:

- High-Level Decision Maker—adaptive allocation to each payload manager
- Director—multifunction optimization and conflict resolution
- Multiobjective Optimization and Learning Engine—dynamic, context-based learning
- Weight Adjuster—autonomously adapt to multiple UAV trajectories
- Compliant interfaces—seamless connection to external subsystems
- Multiobjective reasoning in dynamically changing environments
- Context-based consideration of long-term benefits and tradeoffs in effect option set selection
- Efficient resource allocations
- Reinforcement learning framework that overcomes uncertainty and avoids reliance on static models
- Adaptation across multiple timescales to accommodate dynamic contested environment
- Robust to different environments through contextual processing
- Integration with nonstandard platforms via translation with platform agnostic reasoning
- Vendor-agnostic integration with various Group 1-5 UAV platforms and their respective systems and subsystems
- Hybrid decentralized approach for local decisions to support multiplatform collaboration
- Near real-time mission feedback with reduced processing times
- Lightweight signaling in a hierarchical command and control (C2) structure supporting battlefield applications with multiple distributed platforms
- Negating radio frequency (RF), cyber takeover of unmanned air vehicles

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Research, develop, and propose a design concept with the potential of realizing the goals in the Description above. Describe and quantify how the proposed solution offers enhancement(s) over current technology approaches and/or how it augments other strategies/technologies. Conduct necessary investigation and simulation on the design and performance of the components to demonstrate the feasibility and practicality of the proposed system design, minimizing user input. Identify any technical challenges that may cause a performance parameter(s) not to be met, results of any modeling, safety issues, and estimated costs. The Phase I effort will include prototype plans to be developed under Phase II.

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PHASE II: Develop, optimize, demonstrate, and deliver the technology identified in Phase I. The technology derived designs will then be modified as necessary to produce final prototypes. Work with the Government team to test the algorithms against data collected from candidate sensors relevant to the Navy with Government furnished MUM-T air vehicles. The prototypes must be capable of demonstrating the performance goals stated in the Description above in a rapid prototype experiment demonstration (RPED) environment. Phase II will include MUM-T field testing against a radar of interest with at least 10 UAVs and one manned aircraft to validate performance claims. Document the design specifications, performance characterization, and any recommendations for future development.

Work in Phase II may become classified. Please see note in Description paragraph.

PHASE III DUAL USE APPLICATIONS: Incorporate the lessons learned from Phase II into the detailed design. Further, refine detailed design to address any unique requirements and to improve performance robustness and capability for manned-unmanned team operational scenarios. Develop preproduction and production components and subsystems for integration into manned and unmanned air and ground vehicles. Further miniaturization and low-cost manufacturability of the capability may be required. Develop relevant environment test methods and evaluate the final designed system performance in field or at sea demonstrations.

Integrate the technology using engineering model of proposed product/platform or software, along with full report of development, capabilities, and measurements (showing specific improvement metrics).

Military Application: Integration of the products and resulting capabilities with current and future manned and unmanned aircraft teams will enhance team survivability during electronic warfare engagements against layered defense systems.

Commercial Application: Potential low-cost development program for unmanned systems to autonomously, interoperate with other unmanned and manned systems in uncontrolled, unsupervised, underwater, ground, and airspace environments or operations safely, e.g., package delivery and photography.

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KEYWORDS: Unmanned Air Vehicle; UAV; Manned-Unmanned Team; MUM T; electronic warfare; EW; reinforcement learning; simulation; radar

VERSION 8

N221-018 TITLE: Smart Avionics Systems Environment for Automatic Test Systems

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence (AI)/Machine Learning (ML)

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Identify, characterize, and standardize the use of smart avionics systems' data-driven capabilities. Leverage Units Under Test (UUTs) health, environment, and performance data collection capabilities of these systems. Develop innovative technologies to streamline adoption of condition-based and predictive maintenance techniques in Test Program Sets (TPSs).

DESCRIPTION: Naval aviation maintenance is shifting course from reactive maintenance (after component failure) and is preparing to adopt new maintenance strategies that rely upon Condition-Based Maintenance (CBM) and Prognostics and Health Management (PHM) techniques. Recently, new technologies have allowed for avionics systems to collect "Smart" data related to system health, performance, and environmental factors. This will allow for advanced automated analyses to better diagnose avionics systems, and even help predict failures, and provide preventative maintenance actions before the system actually fails. These maintenance strategies require monitoring, managing, and predicting the condition of avionics systems to enable informed action by maintenance staff. Efficient diagnostics and repairs serve to avoid disruptions in flight operations due to equipment downtime.

The primary impacts of the implementation of the proposed technology would be reduced cost of avionics maintenance and increased availability of aircraft platforms. Transitioning to CBM/PHM strategies requires the integration and application of smart avionics systems health, environment, and performance data into the naval enterprise sustainment operations, spanning Automated Logistics Environment (ALE), Automatic Test Equipment (ATE), and TPS usage. Characterizing the data collection capability of smart aircraft systems (components with embedded computer systems to collect and interpret system data) will facilitate this integration and application, but no standard format currently exists for the compilation of all available data.

Further technology development must enable the use of such a standardized data set to inform diagnostics and repair of avionics modules and components. Current maintenance methodologies (as defined in the Naval Aviation Maintenance Program COMNAVAIRFORINST 4790.2 [Ref 4]) and environments do not provide the flexibility and interoperability to implement new techniques and industry standards for characterizing design-time and run-time data specification and information exchange. Therefore, in order to address these shortfalls, the Navy is seeking innovative technologies and application development methodologies through this topic.

The advanced technologies and techniques implementing the smart avionics systems environment should be based on open standards and support both legacy and new naval aviation weapon systems and Automatic Test Systems (ATS). In addition, through the use of open system standards that have been developed and are currently being developed, the resulting environment and tools should be more easily transported to the electronics maintenance environments of other Military Services.

PHASE I: Demonstrate the feasibility of developing innovative software technologies, methodologies, and tools for health, environment, and performance data sharing between weapon system UUTs and ATS systems to enable improvements in weapon system availability, and advance the application of smart systems capabilities and open standards. Develop a plan for integrating the advanced technologies, tools, and methodologies required to achieve the stated objective. The Phase I effort will include prototype plans to be developed under Phase II.

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PHASE II: Build and integrate a prototype environment to validate the technology and characterization methodology. Work with Navy to produce, test, and demonstrate a new capability that satisfies the objectives of this topic.

PHASE III DUAL USE APPLICATIONS: Build, certify, and deploy a production toolset at a Navy organization. Commercialize the resulting technology.

There is significant potential for commercialization of the technology. For example, the technology can be applied in other Defense and commercial industries where failures in critical assets have a great economic or safety impact (e.g., automotive, aviation, or power). Similar to naval aviation, the health, environment, and performance data for the assets in these other areas are being integrated and are moving more toward CBM and PHM concepts.

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KEYWORDS: Automatic Test Equipment; Condition-Based Maintenance; Prognostics; Avionics Maintenance; Health Management; Diagnostics

VERSION 8

N221-019 TITLE: Long-Range Passive Surveillance in Anti-Access/Area-Denial Environments

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Air Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop passive surveillance techniques that utilize the wideband signal processing and direction of arrival measurement capabilities of modern signals intelligence/electronic intelligence (SIGINT/ELINT) systems to act as a passive radar system leveraging opportunistic emitters in the operational area to develop and maintain the tactical surface picture in Anti-Access/Area-Denial (A2/AD) environments.

DESCRIPTION: Operations in high-threat environments drive both our own forces, as well as our adversaries, to effectively go dark by limiting detectable emissions. In such situations, long-range situational awareness provided by radar and SIGINT/ELINT systems is lost. However, in most of these environments, particularly those in littoral regions, many other electromagnetic emissions are present from other sources, including commercial ships, land-based emitters, and even satellites. In principle, an airborne platform's mission radar could use these emissions to maintain situational awareness by processing the reflections of these emissions from surrounding ships. However, this requires that not only the opportunistic emission is in the operating band of the mission radar (typically x-band), but also be suitable for the particular radar function (detection/tracking or imaging). This requirement is highly restrictive. On the other hand, modern SIGINT/ELINT collection systems operate over a very wide-frequency range and have wide-instantaneous bandwidth processing capabilities, making them an excellent passive radar system in A2/AD environments where opportunistic emissions may be the only means to develop and maintain a long-range surface picture. The nature of the available emissions should be considered and their suitability for use in vessel detection, tracking, and inverse synthetic aperture imaging over frequency ranges typical of modern SIGINT/ELINT systems.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Develop passive radar concepts suitable for opportunistic emission exploitation by conceptual modern airborne SIGINT/ELINT systems. Supporting analyses should include the presence of potential opportunistic emissions in littoral and blue water oceanic regions. Hypothetical coverage maps should be

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developed for operations in peace time, heightened tensions, and during conflicts. The concepts should consider the relatively modest antenna gain (0-3 dBi) of typical SIGINT/ELINT systems. The feasibility of coherent signal processing approaches of these opportunistic emissions should be considered. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Based on Phase I results, candidate concept(s) will be matured through more detailed high-fidelity analyses with a focus on a particular SIGINT/ELINT system identified by the Navy sponsor. Examine integration concepts. Working with the Navy sponsor, assess software and possible firmware impacts to accommodate the candidate techniques. Identify critical technical challenges and perform necessary analysis and as required experimentation to understand the associated risk. The Phase II deliverable should provide a detailed conceptual approach with supporting analyses of sufficient detail to support follow-on design and integration in the candidate airborne platform system. A prototype system should be developed and demonstrated to assess feasibility of the proposed approach.

Work in Phase II may become classified. Please see note in Description paragraph.

PHASE III DUAL USE APPLICATIONS: Complete development, perform final testing, integrate, and transition the final solution to naval airborne SIGINT/ELINT systems.

The technology can support a variety of passive RF surveillance system for air surveillance, facility monitoring, or coastal navigation.

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KEYWORDS: Passive radar; anti access/area denial; A2/AD; signal processing; parasitic radar; wideband

VERSION 8

N221-020 TITLE: Heat Tolerant Decoy Towline for Towed Decoy

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Air Platforms; Battlespace Environments; Electronics

OBJECTIVE: Develop an advanced heat tolerant towline for towed decoy with an operating temperature limit of at least 700 °C with a goal operating temperature limit of 1000 °C.

DESCRIPTION: The current Navy towed decoy deployment system location places the trailing towline in a position where hot engine exhaust encroaches on it during high Angle of Attack (AOA) maneuvers that use engine afterburners. The hot engine exhaust encroachment causes material failure of the towline that can cause towline separation or prevent operation of the decoy. A towline typically contains from two to five high-voltage wires and a single-mode optical fiber. Zylon fibers provide towline tensile strength in excess of 200 lb (90.72 kg). The towline diameter is restricted by available spool volume to about 0.062 in. (1.57 mm), and a bend radius of approximately 0.25 in. (6.35 mm) is required to meet unspooling functionality. The towline must remain flexible over a storage temperature range between -60 °C to +85 °C. The current decoy insulated wire consists of the polyimide EKJ (DuPont) that is tape-wrapped around a fine-gauge conductor. Studies and material analysis have shown that the EKJ insulation tends to electrically break down on exposure to temperatures above 550 °C for more than 30 seconds (s) at the high voltages (> 2,500 V) necessary to properly energize the decoy electronics. The electrical breakdown of the insulation leads to arcing and current leakage between conductors, which causes the decoy power supply to shut down due to overcurrent. The Zylon fibers that provide tensile strength also fail rapidly above 650 °C, resulting in parting of the towline and loss of the decoy. Ideally, as a near-term goal, a towline operating temperature of 700 °C for six towline exposures of > 30 s each is sought, and as a longer term goal, an operating temperature as high as 1000 °C with the same or greater exposure times is desired. This can possibly be achieved by perfecting the existing science in the towline systems, and/or devising novel towline systems, e.g., the conducting and strength members may ultimately be a single entity. Such advanced tow cables may also require materials that are not entirely organic in nature as they will most likely not survive extreme conditions up to 1000 °C. In this regard, innovative research involving inorganic/ceramic and other hybrid material systems may be useful and such innovative ideas are sought in this SBIR topic.

PHASE I: Demonstrate the feasibility of an advanced heat tolerant tow cable concept, including addressing in detail how each component of the proposed tow cable will meet the material and structural demand with regard to the sought requirements. Preliminary component level testing results supporting the design, i.e., proof-of-concept results are highly desirable although not a must. Propose Phase II cable fabrication and test effort that will fully demonstrate the sought requirements. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a prototype tow cable. Perform component level testing supporting the design to demonstrate the sought parameters of both near-term and long-term goals. Fabricate and test multiple lengths, i.e., from 10–100 ft (3.05–30.48 m) of tow cables.

PHASE III DUAL USE APPLICATIONS: Once an effective, affordable, and improved temperature towed decoy cable design has been demonstrated, the Navy can reflect the new capability in performance specifications. The Navy and the small business can negotiate to provide that improved performance to the Navy.

Improved high temperature cables would be useful for commercial aircraft wiring around hot engines and for cables for sensors in deep earth drilling operations.

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REFERENCES:

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5. Reference added 01/12/2022 – Towline Cable Design - https://navysbir.com/n22_1/N221-020_Reference_5_Towline_Cable_Design.pdf

KEYWORDS: Towline; high temperature; HT; HT wire insulation; HT fibers with tensile strength; decoy; HT fibers

VERSION 8

N221-021 TITLE: Modeling and Process Planning Tool for Hybrid Metal Additive/Subtractive Manufacturing to Control Residual Stress and Reduce Distortion

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop a modeling and process planning tool for hybrid metal additive manufacturing processes to predict and minimize the residual stress and distortion of a part.

DESCRIPTION: Additive Manufacturing (AM) technologies have become increasingly important for the rapid production of industrial products. However, AM processes also pose challenges with associated features such as residual stress. Many AM process parameters and post-processes may affect the final residual stress of the part. Laser scanning patterns during AM processing can significantly affect distortion and residual stress distribution in an AM process [Ref 1]. Residual stress caused by the thermal cycles in AM processing is a critical issue for the fabricated metal parts since the steep residual stress gradients generate part distortion which dramatically deteriorates the functionality of the end-use parts. Thus, the residual stress can degrade the AM part's quality, service life, precision, and fatigue performance. For example, after AM processing, a considerable amount of chip curl out of the cutting plane was observed, which was not observed when cutting wrought parts of the same material. This out-of-plane curl was attributed to the residual stress distribution in the part from an AM process, and indicated that residual stresses from the AM process can impact chip formation during machining [Ref 2].

Hybrid additive/subtractive manufacturing is a process that combines both AM and subtractive manufacturing, such as machining, to create parts with high complexity, tight tolerances, and good surface finish. The hybrid process integrates the AM capability of fabricating almost any complex geometry and the machining capability of offering high part quality and short processing times. Properly chosen tooling and cutting conditions may induce stresses along the outer surface to counteract those imposed from the preceding AM process [Ref 3]. Thus, if well planned, a hybrid process can potentially be used to produce a part with controlled stresses and minimum distortion.

Due to the complexity of the residual stresses, some researchers have investigated the modeling of dual processes or hybrid processes. For example, finite element modeling was used to predict the residual stresses developed during heat treatment processes and the distortion during machining operations [Ref 4]. Another finite element method, utilizing the level set method to define the cutting tool path, was able to predict results such as residual stresses and part distortion [Ref 5]. The results show that machining can partially eliminate the residual stresses and distortion caused by laser cladding. However, the entire part needs to be modelled to predict residual stress, making the analysis computationally very expensive. The challenge increases when using a modeling tool to plan and benchmark between different tool paths and deposition strategies. Thus, an efficient and effective modeling and planning tool for AM processes is needed.

The Navy requires a modeling and process planning system for a hybrid metal additive manufacturing process. The tool will integrate the effects of additive and subtractive processes. These results will be the basis for hybrid process planning in order to control the residual stress and minimize the distortion of the resulting parts. This modeling and planning system should also be computationally efficient.

PHASE I: Demonstrate the feasibility of a modeling and planning tool to predict the residual stress and distortion of an AM part based on key hybrid process parameters for both the additive and subtractive steps. This tool should be capable of predicting the residual stress in a Ti-6Al-4 coupon, which is repaired

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using a hybrid process. This coupon should be developed independently. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a full-scale modeling and process planning tool prototype to efficiently predict the residual stress and distortion of hybrid additive/subtractive parts based on various process parameters, including, but not limited to, energy density, build orientation, build tool path, material properties, scan speed, layer thickness, part geometry, machining conditions, sequence between additive (conventional AM, cold spray, and welding) and subtractive processes, and post processing (stress relieving, normalization, etc.). Compare the predicted residual stress of the test cases by printing and machining Ti-6Al-4V samples to show the effectiveness of the model's prediction capability and the computational efficiency of the planning capability. Demonstrate the solution(s) in a real-world AM processing scenario and its possible transition into both military and commercial applications. Note: No Government test facility should be needed.

PHASE III DUAL USE APPLICATIONS: Validate and demonstrate an aircraft ready AM part using a hybrid process. This part should conform to all design tolerances and strength requirements predicted by the physics-based modeling solution created in Phase II.

Metal AM component studies are being conducted in both the private and public sector for parts that might benefit from a hybrid additive/subtractive construction using AM. AM components can reduce weight, tooling costs, and material waste. By understanding the distortions and internal stresses of as-built and post-processed parts, a manufacturer can reduce material waste and time required to redesign components to meet requirements.

REFERENCES:

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5. Salonitis, K., D'Alvise, L., Schoinochoritis, B., & Chantzis, D. (2016). Additive manufacturing and post-processing simulation: laser cladding followed by high speed machining. *The International Journal of Advanced Manufacturing Technology*, 85(9), 2401-2411. <https://doi.org/10.1007/s00170-015-7989-y>.

KEYWORDS: Additive Manufacturing; Design; Distortion; Hybrid Process; Residual Stress; Subtractive Manufacturing

VERSION 8

N221-022 TITLE: Compact Thermal Energy Storage

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR);Hypersonics

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a compact thermal energy storage device.

DESCRIPTION: The latest version of the Department of Defense's Anti-Radiation Homing Missile (AARGM-ER) must store the thermal energy generated by its electronics on board during its mission. The current energy storage device concept utilizes wax in an aluminum container. This concept consumes a lot of space within the guidance section and the control section of the missile. The current Thermal Protection System in the Guidance Section requires 267 in.³ (4350 cm³) and in the Control Section requires 119 in.³ (1950 cm³). The Navy requires that the space consumed by these devices be reduced by no less than one half. These devices are configured to surround the electronics packages and may require an asymmetric shape. Prior to captive carry the device will be at 71°C due to potential worst case storage condition and experience a temperature rise up to 76°C. The devices together must be able to absorb a constant 156 Btu/min while maintaining an electronic package's temperature at no more than 85 °C, with an initial starting temperature of 76 °C (captive carry end temperature). Thermal absorption performance will be evaluated for durations of 5, 15, and 30 minutes. The devices must be reusable and rapidly regenerated within 1 hour after absorbing energy during captive carriage of the missile with temperature conditions decreasing from 76°C to 71°C. The combined weight of the devices cannot exceed 21.75 lb. (9.86 kg). Further the device shall provide secondary structure to support approximately 4-5 Circuit Card Assemblies (CCA) with associated cabling. It is desired that the devices require no consumables, and do not require preventative maintenance. The Navy is looking for a unique and innovative approach to reduce the size of the current energy storage device in the guidance and control sections while maintaining the identified temperature and weight parameters. Analysis and/or modeling are approaches that may be used to validate the ability of this unique/innovative approach to achieve the size reduction while maintaining the temperature and weight parameters.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

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PHASE I: Develop, design, and demonstrate the feasibility, through analysis and/or modeling, of a device to absorb the required thermal energy within the required size. For additional information please refer to MIL-STD-810 for fighter aircraft environments. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Design, test and demonstrate a device that will work within a missile guidance and control type structure, environment, and mission profile.

Work in Phase II may become classified. Please see note in Description paragraph.

PHASE III DUAL USE APPLICATIONS: Design and demonstrate a device that will work within a missile guidance and control type structure, environment, mission profile and different asymmetric designs while adapting and accommodating different electronic packages. Transition the technology to applicable naval platforms.

The technology could be used within any electronic enclosure exposed or generating high temperatures to reduce its thermal footprint.

REFERENCES:

1. Greene, E. E. (2013, July 29). Thermal protection and control [Internship Final Report, University of Nebraska-Lincoln]. <https://ntrs.nasa.gov/api/citations/20140002341/downloads/20140002341.pdf>.
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KEYWORDS: Thermal management; Reduced Footprint; No preventative maintenance; Missile; Thermal Energy; Thermal Protection

VERSION 8

N221-023 TITLE: Miniaturized Sonobuoy High-Data-Rate Tether

OUSD (R&E) MODERNIZATION PRIORITY: Autonomy

TECHNOLOGY AREA(S): Air Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop innovative miniaturized data tether deployment modules for use in a variety of sonobuoys for antisubmarine warfare (ASW).

DESCRIPTION: NATO A-size buoys have been produced in large quantities over many decades. The standardization of the A-size bare buoy form factor has supported a tremendous economy of scale to reduce unit production costs and has driven designs of compatible platform launchers and stores management, as well as logistics support. The advent of new sonobuoys requiring improved sensors requires miniaturization of components in the sonobuoys to allow for more space for sensor arrays. Additionally, deep and long-life sonobuoys have unique size and capacity constraints due to additional tether length and/or larger power supplies. With advances in miniaturization technologies, the Navy seeks new and innovative data tether deployment modules for use in multiple sonobuoys.

This SBIR topic addresses the need for new data tether modules to provide a strengthened, full-duplex communications datalink between the surface unit and the suspended payload. Following air launch and water entry, the data tether deploys the payload to a programmed depth and then suspends the payload for the duration of operations. The data tether module functionality includes: (a) the upper and lower mechanical, data, and power interfaces with the sonobuoy surface and payload units; (b) tether deployment; (c) full-duplex communications; (d) suspension of payload unit static and dynamic loads while providing for requisite acoustic isolation; and (e) packaging as an extractable sonobuoy module. Power for any interface electronics would come from either or both the surface and payload units.

The performance objectives address two miniaturized data tether deployment modules.

Module #1 Performance Objectives:

- deployed tether length threshold: a fixed, to-be-specified length ranging from 1,000 ft–12,000 ft (304.8 m–3,687.6 m); objective: command selectable with up to four to-be-specified lengths ranging from 1,000 ft–16,000 ft (304.8- m–4,876.8 m)
- static tensile load threshold: 5 lb (2. 27 kg); objective: 10 lb (4. 54 kg)
- full-duplex data rate threshold: up to 100 kb/s; objective: up to 1. 5 Gb/s
- diameter: threshold < 4.5 in. (11.43 cm)
- cylindrical stack height: threshold 8 in. (20.32 cm); objective 6 in. (15.24 cm)
- power consumption threshold: < 1. 5 W; objective: < 0. 5 W
- operational life threshold: 14 days; objective 180 days
- ability to be ruggedized and packaged to withstand the shock, vibration, pressure, temperature, humidity, electrical power conditions, etc., encountered in a system built for long-term, nonclimate- controlled storage, and for airborne use

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- reliably deployed in sea-state conditions 0 through 5 (international scale) with 90% two-dimensional current profile meantime between equipment failure threshold: 90 days; objective: 180 days
- full-rate production cost: threshold < \$1,000; objective < \$500 (based on 1000 units)

Module #2 Performance Objectives:

- deployed tether length threshold: a fixed, to-be-specified length ranging from 90 ft–1,500 ft (27.43 m–457.2 m); objective: command selectable with up to four to-be-specified lengths ranging from 90 ft–1,500 ft (27.43 m–457.2 m)
- static tensile load threshold: 4 lb (1.81 kg); objective: 8 lb (3.63 kg)
- full-duplex data rate threshold: up to 100 kb/s; objective: up to 1.5 Gb/s
- diameter: threshold < 3.5 in. (8.89 cm); objective: < 4.5 in. (11.43 cm)
- cylindrical stack height: threshold < 2 in. (5.08 cm); objective < 1.5 in. (3.81 cm)
- power consumption threshold: < 1.5 W; objective: < 0.5 W
- operational life threshold: 6 hr; objective 8 hr
- ability to be ruggedized and packaged to withstand the shock, vibration, pressure, temperature, humidity, electrical power conditions, etc., encountered in a system built for long-term nonclimate- controlled storage, and for airborne use
- reliably deployed in sea-state conditions 0 through 5 (international scale) with 90% two-dimensional current profile meantime between equipment failure threshold: 4 hr; objective: 8 hr
- full-rate production cost: threshold < \$500; objective < \$250 (based on 1,000 units)

Technology Innovation will include a sonobuoy high-data-rate tether deployment module that meets the performance objects and metrics below. Currently, there does not exist a small diameter fiber optic tether capable of supporting a deep sonobuoy deployment. Fiber optics have reduced volume per foot compared to existing sonobuoy tethers that will enable the development of a deep sonobuoy high-data-rate deployment module. In addition, fiber optics support a significantly higher data rate from the deep sensor to the surface. Successful sonobuoy high-data-tether deployment module development will result in a deep sonobuoy capability. Specific technology innovation is a small high-data-rate fiber deployment module with a high-strength member supporting deep depth. Details of this innovation include, but are not limited to:

1. High strength tether that is > 3 mi long and has the ability to support the weight of sensors at the bottom of the tether for up to six months.
2. High-strength tether diameter must be small enough to fit into the fiber-optic deployment module with a size of 4.5 in. (11.43 cm) in diameter and 6 in. (15.24 cm) in height. This further complicates the ability of the tether meeting the high strength necessary for a deep-deployed sonobuoy.
3. The tether needs to double as the communication link from depth to the surface. The use of fiber optics as the tether results in transmission of acoustic detection using a high-digital-data rate from depth to the surface that is required by this topic. Copper wire is not capable of providing the high-data rates required.
4. Module #2 requires a much smaller high-data-rate fiber-optic deployment module. This is due to the limited space in future tactical sonobuoys as a result of increased sensor space requirements, and for use in miniature sonobuoys (mBuoy). Miniature sonobuoys provide aircraft the capability to carry twice as many sonobuoys. Module #2 has the same innovations and challenges described in 1-3 above, but with a greatly reduced depth. The remaining innovations ? (a) small module, (b) high strength tether, and (c) small-diameter fiber optic ? are the same as above.

PHASE I: Develop, design, and demonstrate the feasibility of a viable and robust miniaturized data tether deployment module solutions consisting of a tether deployment canister packaged with the requisite length of tether and interface electronics, as required to pass uplink and downlink communications, to

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receive power from the upper and lower sonobuoy components, and with a compliant suspension, to isolate a notional acoustic payload from surface dynamics. Identify technological and reliability challenges of the design approach and propose viable risk mitigation strategies. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Design, fabricate, and deliver miniaturized data tether deployment module prototypes based on the design from Phase I. Test and fully characterize the system prototype. The interface electronics to the sonobuoy upper and lower units need not meet the miniature packaging requirements to allow use of discrete assemblies, in anticipation of tight integration of these interfaces with the sonobuoy's upper and lower units during Phase III.

PHASE III DUAL USE APPLICATIONS: Integrate the technologies into a logistically supportable sonobuoy package that is compatible with air carriage and air drop for existing and future Navy launch platforms.

The small size, low cost, and standardized form factor of mBuoys will expand market potential enabling new applications and greater use of sensors for ocean and climate research, marine mammal surveys, economic exclusion zone monitoring, and customs and border protection.

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KEYWORDS: Miniaturized; Tether; Sensors; Antisubmarine Warfare; ASW; Acoustics; Airborne

VERSION 8

N221-024 TITLE: Automated Air Traffic Control Communication Technology Enhancement

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence (AI)/Machine Learning (ML);Autonomy;General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Human Systems

OBJECTIVE: Provide an intelligent, realistic, and autonomous communications software tool intended to provide relevant radio and chat information exchanges within training systems and feedback to improve the fidelity and quality of communication-based training.

DESCRIPTION: The current Air Traffic Control (ATC) operational environment requires an operator to listen and filter through a large number of communications (voice and/or text) in order to complete their objectives. During training, the quality of the “non-target” communications, or “noise” is lacking, or does not exist, due to technological or instructor workload limitations. Calls that are replayed on a loop can alert the student to the normal pattern and allow them to pick out the target communications more easily than they would in an operational environment. This limitation decreases the training fidelity of the environment and can cause a lack of trainee skill.

This SBIR topic seeks to provide a software solution for enhancing communications-based training systems for the ATC community and others through development of a capability to deliver intelligent, autonomous, and realistic background calls and text chat (i.e., not scripted) to increase training fidelity. This communication-based training solution must allow students to interact with relevant entities (e.g., aircraft, personnel within tower, personnel of adjacent airspace towers, command and control agencies) via voice and text, and be provided responses (for target communication responses, as well as nontarget). The system should also provide diagnostic feedback to the student after the exercise—specifically targeted at whether or not the student is communicating with the correct entities or “target” communications—and whether or not the content of their messages is appropriate for the situation. Instructors must be able to modify the environment of the scenarios, to include certain amounts and types of aircraft (and other calls) in order to simulate different mission sets, and difficulty levels.

As part of this SBIR effort, development and demonstration of hardware and/or software technology prototype is desired that provides this capability stated above. The hardware and software must meet the DoD system accreditation and certification requirements to support processing approvals for use through the policy cited in Department of Defense Instruction (DoDI) 8510.01, Risk Management Framework (RMF) for DoD Information Technology (IT) [Ref 1], and comply with appropriate DoDI 8500.01, Cybersecurity [Ref 2]. This solution should require minimal operator guidance to modify and maintain.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Demonstrate feasibility of an autonomous voice- and text-based communications capability to support signal-to-noise ratio in training scenarios. The early system should demonstrate an initial

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autonomous capability to provide audio and text during training, with some type of performance feedback to users, such as text or graphics-based information on user performance. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop and prototype the proposed solution to integrate into a sample training environment. The prototype capability should be able to provide realistic, autonomous voice- and text-based communications from various types of aircraft for the appropriate set of training scenarios, and provide feedback to students.

Work in Phase II may become classified. Please see note in Description paragraph.

PHASE III DUAL USE APPLICATIONS: Obtain management framework certification for an authority to operate within operational/training systems. Finalize, refine, and integrate the solution within the training system environment. Transition the technology to a Naval Air Station via a Program Office. This solution can be used in the defense industry as a framework to provide higher fidelity settings for communications-based training.

Commercial industries that could benefit from this type of training system include commercial aviation and air traffic control, in similar ways to how the technology would benefit the listed platforms. Outside of air traffic control, 911 operators and first responder training could benefit from this type of communications-based training system. Any job that filters through a large amount of voice and text communications (e.g., 911 dispatcher) could be trained using such a solution.

REFERENCES:

1. Department of Defense. (2020, December 29). DoDI 8510.01: Risk Management Framework (RMF) for DoD Information Technology (IT), Incorporating Change 3. Department of Defense. https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/851001p.pdf?ver=qEE2HGN_HE4Blu7161t1TQ%3D%3D.
2. Department of Defense. (2019, October 7). DoDI 8500.01, Incorporating Change 1: Cybersecurity. Department of Defense. https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/850001_2014.pdf.
3. Defense Counterintelligence and Security Agency. (n.d.). <https://www.dcsa.mil/>.
4. Department of Defense. (2006, February 28). DoD 5220.22-M National Industrial Security Program Operating Manual (Incorporating Change 2, May 18, 2016). Department of Defense. <https://www.esd.whs.mil/portals/54/documents/dd/issuances/dodm/522022m.pdf>.
5. FREQUENTLY ASKED QUESTIONS https://navysbir.com/n22_1/N221-024_FAQs.pdf

KEYWORDS: Air Traffic Control; Training System; Communications-based Training; Training Fidelity; Diagnostic Feedback; Instructor Workload

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N221-025 TITLE: DIGITAL ENGINEERING - Advanced Technologies for Automated Replay and Reconstruction of Theater Undersea Warfare Mission Data

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence (AI)/Machine Learning (ML)

TECHNOLOGY AREA(S): Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop the capability to automate multi-platform Theater Undersea Warfare (TUSW) mission data collection and use for time-periods of up to 180 days.

DESCRIPTION: Current processes and tools to reconstruct TUSW mission data information are manually cumbersome, labor-intensive, and time-consuming. The existing state-of-practice is to (a) bring together data recordings from different tactical systems across multiple platforms, and (b) filter and edit the data files to get some level of synchronization and fidelity across time and space. The resulting collated data set is used for replay to provide a wide-area Theater view of events. The TUSW mission is sufficiently complex and unique that there is no analogous commercial state of the art from which to draw.

The Navy desires a TUSW mission capability to be fielded within the AN/UYQ-100 Undersea Warfare Decision Support System (USW-DSS) to provide rapid data recording and replay, and event reconstruction through automation, which provides minimal user pre-processing. The rapid replay solution must use a robust automated data recording and automated replay, storage, archival, and retrieval procedure that is built into the overall system architecture, along with a logically formulated user methodology supported by reliable software toolsets.

To enable in-depth operational analysis and assessment by subject matter experts, the ability to comprehensively reconstruct long-term TUSW events is essential. Additionally, reconstruction is expected to support system engineers in improving the usability of the system from a human-factors perspective. These require the capability to (a) capture user interactions with the system (like menu selections, mouse clicks, etc.), and (b) collect Theater team member interactions (for example, between watchfloor personnel, command site and subordinate tactical units).

Since TUSW events can extend over several weeks and possibly months, the solution will collect mission data over a 180-day time-period and manage the data without burdensome Information Technology (IT) administration and intervention. It is often that high-interest events cross over from one Theater to another requiring the solution to have a multi-Theater system synchronization capability. The solution will be analyzed by the Government to ensure it effectively provides the rapid replay and comprehensive reconstruction required to conduct operational analysis and assessment, and perform usability improvements. Once the prospective contractor(s) demonstrates that their technology is beneficial on data they provide, the Navy will evaluate the solution with relevant tactical data to assess how well the capability meets performance goals, with an eye to the feasibility of having the capability meet Navy information assurance specifications for classification security. Once the technology is deemed acceptable

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to integrate into USW-DSS, the capability will be integrated into a future USW-DSS build for metrics-based Independent Validation and Verification (IV&V) tests during the normal USW-DSS System Integration Test events to qualify and certify the updated USW-DSS system for Fleet use.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a concept for automated replay and reconstruction of TUSW Mission Data over extended time-periods of up to 180 days. Demonstrate the concept meets the parameters in the Description. Establish feasibility in meeting Navy needs by sample testing, modeling, simulation, and analysis. The Phase I Option, if exercised, will include the initial design specifications and a capabilities description to build a prototype solution in Phase II. State of the practice standards such as Google Protocol Buffers (protobuf) and Advanced Message Queuing Protocol (AMQP) are to be supported. Cybersecurity is to be in accordance with Navy Authorizing Official (NAO) policies and procedures. This information will be provided during Phase I.

PHASE II: Based on the results of the research in Phase I, develop and deliver the prototype solution architecture, methodology and toolsets for incorporating automated replay and reconstruction into the USW-DSS. Demonstrate the prototype meets the required range of desired performance attributes given in the Description. System performance will be demonstrated through installation and prototype testing on a testbed with the lead system integrator.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use as a software configuration item in the production USW-DSS. The performer will be expected to follow the Continuous Integration/Continuous Delivery (CI/CD) cycle as mandated by the Navy's DevSecOps processes and the transition Program Office (IWS 5). The Navy will conduct metrics-based Independent Validation and Verification (IV&V) tests during the normal USW-DSS System Integration Test events to qualify and certify the component for Fleet use.

Data replay and reconstruction are key components of engineering systems that support a variety of military applications involving aircraft and ground vehicles in tactical operations. Commercial applications where the technology could be used include the aircraft industry, land-based shipping operations, and maritime shipping, travel, and rescue operations.

REFERENCES:

1. Pollock Jr, James and Cembrola, Joan. "Method for the collection and replay of submarine operational data". US Patent 6,016,453, awarded 18 January 2000.
<https://patents.justia.com/patent/6016453>.
2. Aldinger, Tye and Kao, Jimmy. "Data Fusion and Theater undersea warfare – an oceanographer's perspective." IEEE Oceans '04 MTS/IEEE Techno-Ocean '04. 9-12 November 2004, Kobe, Japan.

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<https://ieeexplore.ieee.org/abstract/document/1406451> (Locate a local library with a copy of these proceedings at <https://www.worldcat.org/title/oceans-04-mtsieee-techno-ocean04-bridges-across-the-oceans-conference-proceedings-november-9-12-2004-kobe-japan/oclc/1109187758#borrow>).

3. “AN/UYQ-100 Undersea Warfare Decision Support System (USW-DSS).” Navy Fact File, at <https://www.navy.mil/Resources/Fact-Files/Display-FactFiles/Article/2166791/anuyq-100-undersea-warfare-decision-support-system-usw-dss/>.
4. Reference added 12/8/2021 – Undersea Warfare Decision Support System (USW DSS) Overview - https://navysbir.com/n22_1/N221-025_Reference_4_USW_DSS_Overview.pdf
5. Reference added 01/12/2022 – Software List – Distro A - https://navysbir.com/n22_1/N221-025_Reference_5_Software_List_Distro_A.xlsx

KEYWORDS: Theater Undersea Warfare; TUSW; TUSW Mission Data; Automated data recording; Multi-Theater; Automated Replay; Event Reconstruction

VERSION 8

N221-026 TITLE: DIGITAL ENGINEERING - Automated Network Cluster Generation

OUSD (R&E) MODERNIZATION PRIORITY: Networked C3

TECHNOLOGY AREA(S): Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop an algorithm that automatically identifies clusters of nodes that should participate in specific information flows based on a combination of geographic location information type needs.

DESCRIPTION: Navy command and control networks currently implement “mass delivery”, meaning data from each node is sent to all nodes. This method of delivery makes sense given the networks’ initial purpose of providing a common track picture on each node. Having all sensor data available on each node allows each node to generate the same track picture as all other nodes. Future Navy requirements will add additional data to existing networks, using the Communications as a Service (CaaS) concept, and will require existing command and control networks be expanded to a larger number of nodes. At some network size, the concept of mass delivery will drive the network to its throughput limit for a given point-to-point communication. A concept to separate network size from throughput is to prioritize sending specific data to certain clusters of nodes that need that specific data. The data need can be characterized by a combination of geographic proximity and data type. Currently no known solutions exist that can accomplish this task. The Navy seeks an algorithm that automatically identifies clusters of nodes that will participate in specific information flows based on a combination of geographic location information type needs.

The solution should automatically assign network nodes to clusters. The cluster generator will be implemented in a high-level language (such as Python, MATLAB, and so forth) to facilitate its evaluation in simulation. Metrics available in the reference by J. Yang can be used to assess the quality of the clusters [Ref 1]. The default metric will be a comparison of the network size achievable using the clusters to the network size achievable using mass delivery, assuming a constant maximum throughput. The clusters may be generated upon the node entering the network or discovered during network execution. The net entry approach is intended to avoid chokepoints (i.e., communications that exceed the point-to-point throughput limit). The discovery method is an ad-hoc method and is intended to detect and mitigate chokepoints. Both methods will be simulated. Each approach optimizes the use of the network throughput. The solution(s) will be tested in a testbed provided by the Government. Based on the cluster definitions, the scheduling concept will be demonstrated in a simulation showing increased fidelity.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the

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national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a concept for an automated network cluster generator that automatically assigns network nodes to clusters. Demonstrate the concept meets the parameters of the Description. Show feasibility through analysis, modelling, simulation, and testing. The Phase I Option, if exercised, will include the initial design specifications and a capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver the prototype automated network cluster generator based on the results of Phase I. Demonstrate the prototype meets the required range of desired performance attributes given in the Description. System performance will be demonstrated through installation and prototype testing in a testbed. The scheduling concept, based on the cluster definitions, will be demonstrated in simulation with increased fidelity.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. The automated clustering concept will be merged with existing command and control software to assist in generating the Time-Division Multiple Access (TDMA) transmit/receive schedule. Working prototype scheduling algorithms will be delivered to the Navy Program of Record for integration into the scheduling algorithm to be deployed. Assist the Government in integrating the suite of scheduling concepts that best support the requirements of the network capability to be deployed.

This technology will benefit the commercial industry for companies or universities that use large amounts of computers to control aspects or communications within their industry.

REFERENCES:

1. J. Yang, J. McAuley and J. Leskovec, "Community Detection in Networks with Node Attributes," 2013 IEEE 13th International Conference on Data Mining, Dallas, TX, USA, 2013, pp. 1151-1156, doi: 10.1109/ICDM.2013.167. <https://ieeexplore.ieee.org/document/6729613>; <https://www-cs.stanford.edu/~jure/pubs/cesna-icdm13.pdf>.
2. Emmons S, Kobourov S, Gallant M, Börner K (2016) Analysis of Network Clustering Algorithms and Cluster Quality Metrics at Scale. PLoS ONE 11(7): e0159161. <https://doi.org/10.1371/journal.pone.0159161>; <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0159161>.

KEYWORDS: Large networks; clusters of nodes; cluster generator; optimized throughput; information flows; ad-hoc network.

VERSION 8

N221-027 TITLE: DIGITAL ENGINEERING - Undersea Warfare Tactical Advantage Support Kit

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a capability that embeds prompts for system usage within the Anti-Submarine Warfare (ASW) system to support proficiency and mission success.

DESCRIPTION: The AN/SQQ-89A(V)15 Surface Ship Undersea Warfare system is used to conduct operations across the entire detect to engage spectrum, including active sonar, passive sonar, sonobuoy operations, and weapons targeting and firing. Mission success relies on operator proficiency during tactical operations.

ASW operations require a highly-perishable, complex skill set. While operator proficiency can be developed and maintained using training, the ultimate purpose of improved proficiency is effective use of the mission system during tactical operations. Providing individualized support in the midst of tactical operations will reduce the time to correctly perform the complex functions from target detection to target engagement, improving mission effectiveness.

The Navy seeks a technology that provide embedded individualized support as operators perform each ASW function. It should be able to extend across the range of support that might be needed, from the apprentice level to those who are masters of employment. The proposed technology will also extend to the full range of functions operators are required to perform. The Navy believes the technology associated with this SBIR topic will provide opportunities to implement artificial intelligence and machine learning (AI/ML) techniques.

The solution should demonstrate an improvement in operator performance for apprentice operators without degrading performance of journeyman and master operators, translating to latency reduction of 25% in end-to-end metrics relative to unassisted employment of the system. Testing of the solution will occur using the IWS 5.0 Advanced Capability Build (ACB) step testing process.

Initial testing of the proposed technology may be demonstrated at the contractor facility, but a more robust evaluation of a fully developed toolset will eventually be conducted using representative data gathered from a fleet test event, at a developer site such as the Lockheed Martin Anti-Submarine Warfare Laboratory in Manassas, VA, or from an appropriate Navy training facility such as Fleet Anti-Submarine Warfare Training Center San Diego, CA (FASW-TC). In order to properly evaluate the technology, the technology will be used with a range of sonar operators across the full functionality of the AN/SQQ-89A(V)15 tactical system. These interactions would include real-world or synthetic scenarios that span the detect-to-engage timeline. During Phase I we ask the offeror to propose a representative data set they

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feel will demonstrate the unclassified capability. During Phase II, the Navy will provide classified data sets to fully exercise the toolset during the detect-to-engage timeline.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a concept for a tactical advantage support kit (TASK) that provides individualized tactical support prompts across a range of proficiency levels and different tasks within a larger system of systems. Demonstrate the concept meets the parameters of the Description. Show feasibility through analysis, modelling, simulation, and testing. The Phase I Option, if exercised, will include the initial design specifications and a capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of the research in Phase I, develop and deliver the prototype solution with architecture and methodology for incorporating the TASK. Demonstrate the prototype meets the required range of desired performance attributes given in the Description. System performance will be demonstrated through installation and prototype testing on a testbed with the lead system integrator.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use as an embedded capability within a future build of AN/SQQ-89A(V)15. Support the Navy in transitioning the technology to Navy use in ASW. Demonstrate and report on performance during laboratory testing. The prototype will be integrated into the IWS 5.0 surface ship ASW combat system Advanced Capability Build (ACB) program, which is being used to update the AN/SQQ-89A(V)15 Program of Record.

This technology can be used in a wide range of complex systems of systems where AI/ML is used to characterize operator proficiency and just-in-time performance assistance is crucial to mission performance. The technology would be of greatest use in complex safety-critical systems where mistakes carry disproportionate risk of mission failure.

REFERENCES:

1. Richardson, John ADM. "A Design for Maintaining Maritime Superiority 2.0," 2018.
2. Kezunovic, Mladen, et al. "The role of big data in improving power system operation and protection." 2013 IREP Symposium Bulk Power System Dynamics and Control - IX Optimization, Security and Control of the Emerging Power Grid; 1-9; IEEE.
<https://ieeexplore.ieee.org/abstract/document/6629368>.
3. "AN/SQQ-89(V) Undersea Warfare / Anti-Submarine Warfare Combat System." United States Navy Fact File, 15 January 2019. <https://www.navy.mil/Resources/Fact-Files/Display-FactFiles/Article/2166784/ansqq-89v-undersea-warfare-anti-submarine-warfare-combat-system/>.

KEYWORDS: Operator proficiency; embedded individualized support; Anti-Submarine Warfare; ASW function; detect-to-engage timeline; tactical operations

VERSION 8

N221-028 TITLE: DIGITAL ENGINEERING - Unmanned Harbor Piloting

OUSD (R&E) MODERNIZATION PRIORITY: Autonomy

TECHNOLOGY AREA(S): Ground / Sea Vehicles

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop an autonomous precision harbor piloting system that allows unmanned surface vehicles (USVs) to navigate safely within a channel, harbor, or strait without human intervention.

DESCRIPTION: Harbor piloting requires precise understanding of a vessel's current and projected position to avoid running aground. Additionally, areas such as channels, harbors, and straits are typically congested with other vessels. The current state-of-the-art in harbor piloting uses a human to integrate numerous inputs including his or her own senses of sight and hearing. Some work is currently ongoing to allow a pilot to perform this function from an off-vessel site. Innovations in process and methods by which the Navy conducts harbor piloting are required to ensure USVs are capable of safe transit in congested, confined, and constrained waterways without human intervention. These innovations will enable autonomous operations for future USVs.

The Navy seeks to develop an autonomous harbor piloting system (HPS) that will enable a USV to transit a channel, harbor, or strait without human intervention while consistently operating within the established navigational rules such as U.S. Coast Guard Navigation Rules and Regulations Handbook (COLREGS) Rules 9 and 10 [Ref 1]. This includes sensing harbor hazards and features (bridges, marine traffic, buoys, etc.) and planning a recommended route containing, at a minimum, waypoints, leg speeds, leg cross track error, and leg-to-leg turn radii. Outputs from the HPS will inform the Maneuvering Operations autonomy segment that guides the vessel's movements. The Maneuvering Operations Autonomy segment is not being developed under this SBIR topic. Harbors may include traffic schemes, restricted areas, and congested, confined, cluttered or unimproved environments with limited water depth. The HPS shall follow the preferred traffic schemes and comply with the established navigational rules based on the USV's relative position to harbor features and obstacles.

HPS concepts shall be scalable for Medium and Large USVs (MUSV and LUSV respectively) and capable of sensing harbor hazards and features (bridges, marine traffic, buoys, etc.) with a precision of 6 m (~6.5 yds.) or less, at distances from 15-100m (~16-109 yds.) from the USV, and operating at speeds less than or equal to ~ 60 kts and testing to applicable military standards (IAW MIL-STD-810H). The sensing system may use a priori information such as charts to enhance the localization and classification of harbor hazards, but it cannot solely rely on charts for obstacle and hazard avoidance. MUSV Block I has a Length Overall of about 190 feet, a beam of about 33 feet, and a displacement of about 500 LT. LUSV is still in preliminary design, but it will be larger than MUSV.

It should be assumed that current USV platforms can determine their position to within 6 meters (~6.5 yds.) and have the capability to navigate in a forward direction at 5 m/s (~10 kts) or less with a track error

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of 6 meters (~6.5 yds.) or less. Additionally, the USV has a dynamic positioning system (DPS), capable of holding position within 10m (~11 yds.) and heading within 5°.

This SBIR topic seeks development of a solution that is Modular Open Systems Architecture (MOSA) compliant to allow for compatibility with future USVs. To ensure interoperability with planned and future USVs, solutions must also comply with the PMS 406's Unmanned Maritime Autonomy Architecture (UMAA). UMAA establishes a standard for common interfaces and software reuse among the mission autonomy and the various vehicle controllers, payloads, and Command and Control (C2) services in the PMS 406 portfolio of Unmanned Systems (UxS) vehicles. The UMAA common standard for Interface Control Documents (ICDs) mitigates the risk of unique autonomy solutions applicable to just a few vehicles allowing flexibility to incorporate vendor improvements as they are identified; affect cross-domain interoperability of UxS vehicles; and allow for open architecture (OA) modularity of autonomy solutions, control systems, C2, and payloads. UMAA standards and required ICDs will be provided during the Phase I effort.

Testing and certification of the route planning capability of the system will consist of autonomy simulation with a vessel of opportunity. The testing and certification of the overall performance of the system will consist of hardware-in-the-loop testing on a vessel of opportunity provided by the Government.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a concept design for an automated harbor transit system that meets the requirements in the Description. The concept design must define a system that can consistently operate within the established navigational rules, and include any modeling and simulation, studies, or prototypes in support of concept risk reduction. Demonstrate the feasibility of the proposed concept through modeling, analysis, and concept demonstrations.

The Phase I Option, if exercised, will deliver a preliminary design of the concept, identifying the baseline design (hardware, software, support systems) and underlying architectures to ensure that the concept has a reasonable expectation of satisfying the requirements.

PHASE II: Based on the Phase I results and the Phase II Statement of Work (SOW), develop and deliver a prototype harbor piloting system based on the requirements in the Description. Identify the necessary interfaces, dependencies, and risks. After a successful Critical Design Review (CDR), develop a prototype system. Testing and certification of the route planning capability of the system will consist of autonomy simulation with a vessel of opportunity. The testing and certification of the overall performance of the system will consist of hardware-in-the-loop testing on a vessel of opportunity provided by the government.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

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PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use through system integration and qualification testing for the Navy USV harbor piloting system. UMAA-compliant precise navigation, planning, and execution systems for Navy USVs would have applicability to the commercial unmanned surface vehicles already widely in use further expanding their ability to adapt to their operational environment and conduct autonomous operations.

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1. U.S. Department of Homeland Security, “United States Coast Guard Navigation Rules and Regulations Handbook.” Rule 9 - Narrow Channels and Rule 10 Traffic Separation Schemes, 2014: 18-21. https://www.navcen.uscg.gov/pdf/navRules/Handbook/CG_NAV_Rules_29Apr2020.pdf.
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KEYWORDS: UxV; Unmanned systems; Harbor pilot navigation; autonomous navigation; UMAA; perception sensors; datafusion; COLREGS; MOSA

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N221-029 TITLE: DIGITAL ENGINEERING - Artificial Intelligence /Machine Learning Applications to STANDARD Missile Maintenance Data

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence (AI)/Machine Learning (ML)

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Apply Artificial Intelligence (AI)/Machine Learning (ML) techniques to develop a decision aide that automates and modernizes STANDARD Missile (SM) maintenance processes and procedures with the goal of reducing life cycle costs and manpower while maintaining readiness.

DESCRIPTION: AI/ML has seen steady growth in the commercial market. Consumers see daily benefit in many areas; greater computing power as Intel, Apple, and other manufactures incorporate AI into computer processors; predictive analytics used for targeted marketing on Google and other platforms. A survey conducted by McKinsey Analytics in 2020 indicates, since 2018 greater adoption of AI principles in the manufacturing (e.g., yield, optimization, predictive maintenance) and supply chain management industries while simultaneously demonstrating 10-20% cost savings. PEO IWS and Naval Supply System Command (NAVSUP) are specifically interested in AI/ML applications in these areas, applied to the SM family.

The SM family are solid propellant, tail-controlled surface to air missiles. Variants of SM have been in production for over 20 years. For maintenance and recertification, missiles cycle through an Intermediate Level Maintenance Facility (ILMF) at NMC Seal Beach and a Depot Level Maintenance Facility (DLMF) at the Missile manufacturer, Raytheon Missiles and Defense. NSWC Corona collects missile and section level data through all maintenance and recertification periods on a Surface Missile Systems Maintenance Data System (SMSMDS) database. The SMSMDS collects, stores, and distributes missile life cycle data, including (for current and previous variants) All Up Round manufacturing and production baseline performance data, test data, re-certification reports, Trouble Reports, and Failure Reporting and Corrective Action System (FRACAS). The technology sought will enable the SM program office to optimize maintenance concepts and strategies. This in turn will allow for increased capability to the warfighter and has the potential to reduce life cycle costs by prioritizing maintenance activities at the ILMF and DLMF.

Due to the amount of SM maintenance data available, the amount of missile maintenance work required, and current fiscal constraints, the SM program office has a strong desire to use AI/ML to modernize and automate maintenance planning as well as procedures while reducing extensive man hours required to analyze SM readiness and prioritize sustainment activities. The output will serve as a decision aide for the SM program office and will assist in understanding any section level or piece part's failure's influence on the overall mission effectiveness of the system.

Currently efficiencies are dependent on personnel experience and reporting. This point of view of efficiency is very narrow and does not factor in other pieces of the entire process. Overarching aggregated

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views of the entire process is at its infancy. The tool needs to be compatible with SQL server to analyze the current logistical state and an optimized state.

The Navy needs a tool to optimize SM maintenance strategies. The preferred solution will be a tool that uses AI/ML concepts such as linear regression, Decision Tree, best suited to existing SM data, which allows the user to make quicker decisions, predict reliability related failures, and identify future maintenance issues. It should also provide recommended repair processes and procedures. The tool will serve to reduce planning requirements and actions and improve procurement of spares and depot level preparation required to maintain the Fleet required load out requirements and inventory posture. Operation of the tool must be extensible to UNCLASSIFIED U.S. Navy network infrastructure. System required to comply with NIST SP 800-37 standards to include ACAS vulnerability scans and system hardening utilizing relevant DISA STIG's (i.e., Application & Security STIG and applicable OS STIG). Awardees will be required to coordinate with Government representative for specific cyber requirements.

PHASE I: Develop a concept for a SM maintenance decision aide that meets the parameters of the Description. Demonstrate the concept feasibility through analysis, modelling, and simulation. The Phase I Option, if exercised, will include the initial design specifications and a capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype SM maintenance decision aide based on the results of Phase I. Demonstrate the prototype meets the required range of desired performance attributes given in the Description. System performance will be demonstrated through installation and prototype testing on a testbed with the lead system integrator. The system will be checked for data accuracy of recorded values versus stored/calculated values. The algorithm results of the training data set will be evaluated against new data. The system optimizing capabilities metrics will be used in practice to check for concurrence.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the AI/ML tools to Navy use in the SM maintenance program to improve repair processes, procurement of spares, and depot level preparation required to maintain the Fleet required load out requirements and inventory posture. Support employing the technology developed under this SBIR topic to the Navy SM field activities. Assist in the transition of the data analytics into actionable maintenance plans and strategies for the SM program. Explore the potential to transfer the optimizing algorithm to other military and commercial systems such as automotive, aerospace, shipping, and manufacturing where logistical planning is needed.

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KEYWORDS: Intermediate Level Maintenance Facility; Artificial Intelligence; Machine learning; STANDARD Missile; STANDARD Missile Maintenance; Decision Aide

VERSION 8

N221-030 TITLE: DIGITAL ENGINEERING - Design for Additive Manufacturing (DfAM) Risk Toolset

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop a Design for Additive Manufacturing (DfAM) toolset that will enable additive manufacturing (AM)-specific design and manufacturing-driven risk analysis within a single user interface.

DESCRIPTION: Existing DfAM tools, both for generative design and modeling and simulation, are generally employed in separate software packages. Similarly, certain aspects unique to AM are not included in many of the existing software tools currently available. Additionally, the calculation of risk due to changing the manufacturing method and materials, or utilizing a lower maturity manufacturing process, does not currently exist within many of the available design optimization software packages. Meanwhile, the AM Technical Warrant Holder (TWH) is establishing the specification and standards development for AM technology to promote process qualification and quality assurance of AM parts. This modeling toolset is needed in conjunction with these technical publications to minimize engineering risk of using AM as a replacement manufacturing method of a traditionally manufactured part.

This SBIR topic seeks a combined toolset accessible through a single user interface able to simulate the performance expectations and failure modes for various physics scenarios (e.g., static loading, thermal transfer, mass transfer, etc.) expected for a part when fabricated using AM. The desired DfAM toolset should be comprised of three modules: 1. Part specific performance modeling and simulation (M&S) as a result of manufacturing process constraints (i.e., anisotropic behavior) (henceforth “Part Performance M&S Module”), 2. Producibility, manufacturability, and manufacturing-driven generative design analysis to improve design for manufacturing, (henceforth “Optimization Module) and 3. Manufacturing process-driven risk analysis (henceforth “Risk Analysis Module”). These three modules should provide feedback to perform calculations across each module; however, each module should be able to stand independently and perform with only the minimum amount of provided inputs.

Within the Part Performance M&S Module, the orientation of the build, anisotropy of the part, and any additives/reinforcements within the build must be considered to provide an accurate expectation of part performance. The Part Performance M&S and Optimization Modules shall be able to inform the following, given the AM process, Manufacturing Readiness Level, and material being used: optimized geometry, optimized reinforcement locations and parameters, optimized infill geometry and fill percentage, and alternate additive materials/manufacturing processes.

Finally, the Risk Analysis Module shall calculate a risk analysis for using AM when compared to the original part manufacturing method, lower the risk of engineering change proposals, and inform Fleet AM designs in the deployed environment. The analysis and resulting capabilities will be used to inform technical authority and program offices on the expectation of performance comparisons between the traditional part and the AM version. In addition, part performance trade-off analyses should be able to be completed based on potential lead time and cost reduction of a design that may not achieve the same longevity or durability. The following attributes should be considered in the Risk Analysis Module (This is not an all-inclusive list. Additional attributes will be provided as Government Furnished Information (GFI) to the awarded contractors):

- Part complexity
- Traditional manufacturing method(s) if applicable
- Material performance requirements

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- Manufacturing Process maturity
- Existing material and process data available
- Part performance requirements
- Part criticality (probability and severity)
- Part performance trade-off analyses (for example, reduced longevity of a part for shorter lead time and lower cost)

This toolset must provide a summary report that outlines expected key performance parameters for the part(s) under analysis and establishes a level of risk as a result of using AM to fabricate the part when compared to traditional manufacturing. A demonstration of this output report must be provided, as well as attached to the AM Technical Data Packages (in accordance with MIL-STD 31000B [Ref 1]), as appropriate. The resultant parts shall be tested for performance in accordance with the part requirements provided by the Navy to demonstrate DfAM toolset part performance prediction accuracy.

If all modules are not included in the prototype, but the contractor expects to be able to develop them, an implementation plan to include the various elements of the capabilities must be provided. User manuals instructing toolset usage, troubleshooting, and any other required information/training material to sufficiently operate the toolset must also be developed. 25 licenses of the developed product will be provided for testing and evaluation to the Navy stakeholders — 10 for NAVSEA, 10 for NAVAIR, 5 for NAVSUP.

The solution must use a model-based systems engineering approach to establish a single User Interface (UI) that can communicate with the entirety of the solution set. Government Furnished Information (GFI) in the form of a standard or guidance document will be provided to performers to ensure Defense Information Systems Agency (DISA) compliance for unclassified Research, Development, Testing, and Evaluation (RDTE) networked machines. The developed solution must comply with the DISA guidance and operate in the Windows 10 or newer operating systems with an approved Security Technical Implementation Guide (STIG) with configurable controls to meet DISA compliance requirements [Ref 7]. The toolset should be able to provide a summary report of the results in a concise format (Text, Comma separated value (CSV), Microsoft Word, Excel, other and/or Portable Document Format (PDF)) that can be included for the technical authority reviews. Finally, as the Navy works towards migration into Product Lifecycle Management (PLM) platforms, data produced within this toolset should be able to communicate with the PLM platforms. These platforms will be based on Commercial Off the Shelf (COTS) PLM programs.

A toolset to optimize various parameters within the AM process, as well as provide accurate, AM-specific, part simulations, will reduce risk of adoption of the AM technology across the NAVSEA enterprise. AM has the potential to reduce the lead time on many parts within the supply system, as well as provide an alternate manufacturing source for other parts. This flexibility, coupled with the added engineering confidence that the part will perform to the technical requirements, could result in more AM parts within the supply chain, ultimately reducing lead time for parts and increasing readiness of the warfighter.

PHASE I: Develop a conceptual program architecture and description of supporting software required to meet DfAM modules described in the Description. Demonstrate the feasibility of the concept to address the three modules. Include a description of each of the proposed models and their expected inputs and outputs. If a solution cannot support all of the modules a detailed justification to meet the described parameters listed in the Description must be provided along with a roadmap projecting how the contractor would overcome the technological gaps prohibiting completion of all three modules.

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The Phase I Option, if exercised, will include the initial design specifications, capabilities description to build a prototype solution, and hardware requirements in Phase II.

PHASE II: Develop and deliver a prototype of the DfAM Risk-based toolset that demonstrates the usability of the three-module DfAM toolset. The prototype should demonstrate the intuitive user interface that supports all of the Phase I development, as well as all of the major elements listed in the Description section. The Navy will provide 1-3 use-cases to walk through the prototype solution.

The software should meet all the requirements of the Description and be able to interface with the Product Lifecycle Management (PLM) tools used by the Navy. In addition, the solution must consider hosting platforms to sustain the solution, such as enterprise software environments including the Agile Warfighter Analytics Readiness Environment (AWARE) and the Enterprise Risk Analysis & Management Tool (ERAMT) Integrated Development Environment (IDE).

PHASE III DUAL USE APPLICATIONS: Develop the final application package to include any road-mapped capabilities from Phase II. Support the Navy in transitioning the technology to Navy use. Develop a full user manual and training package. Additionally, connections to the NAVSEA method for storing and tracking material data should be possible. Application Program Interfaces (APIs) should be able to be established to make additional connections to Navy-specific databases in an effort to streamline data processing and minimize multiple sources of truth. The final transition and hosting platform, either standalone or Navy platform, will be finalized and software modified accordingly.

Additional considerations for the manufacturing location environmental variability (whether shipboard, land-based, expeditionary, or other) of the manufacturer should be able to be applied to inform a factor of safety adjustment to the simulation and design considerations. This could be used to improve robustness of AM parts manufactured in the shipboard environment, improve shipboard part certification confidence, and be leveraged by the Fleet community to inform designs of parts at-sea, as well as formalize the risk analysis procedures.

This software would be applicable to other manufacturing processes and could be leveraged by various program offices and engineering support sites. The risk analysis module could be used to inform engineering-related risk assessments that could be integrated into the Enterprise Risk Analysis & Management Tool (ERAMT).

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KEYWORDS: Additive manufacturing; AM; 3D printing; modeling and simulation; geometry optimization; risk analysis; failure modes; DfAM

VERSION 8

N221-031 TITLE: DIGITAL ENGINEERING - Distributed Mission Effectiveness and Readiness Management System

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a distributed mission effectiveness and readiness management system data analytics tool to integrate FFG 62 Model Based Systems Engineering (MBSE) and Model Based Product Support (MBPS) artifacts and/or data to present a mission effectiveness viewpoint of a single FFG 62 ship based on system readiness data.

DESCRIPTION: Within the framework of MBSE, models are developed to support system requirements, design, analysis, verification, and validation activities throughout the lifecycle. MBPS uses the same information along with information on support providers to optimize a platform's product support footprint, including supply chain, training, and maintenance strategy. MBSE can be leveraged to model fleet-wide effectiveness for performing missions based on technical performance characteristics, and MBPS can be leveraged to model the effectiveness of the product support footprint in supporting these missions, but the two are not often linked to optimize the decision space for the fleet. The Navy is modernizing its MBSE and MBPS toolkits, but current MBSE models do not accurately correlate product suitability data, system architecture, and Condition Based Maintenance (CBM+) data with overall mission effectiveness.

PEO USC platforms are built as an integrated System of Systems (SoS), usually comprising both Contractor Furnished Equipment (CFE) and Government Furnished Equipment (GFE) systems to deliver a complete platform architecture. PEO USC seeks to develop a methodology and a data analytics tool for analyzing, modeling, and optimizing our mission support capabilities in a proactive and predictive manner that could extend to unmanned integration or strike group operations. The solutions will facilitate performance predictions against platform mission needs of this diverse SoS architecture from an end-to-end perspective. The solution would result in a data-driven decision-making tool for FFG 62 sustainment and readiness planning, linking reliability, maintainability, and availability data with overall platform mission effectiveness and informing program Sustainment Key Performance Parameters (KPPs). The data analytics tool will aggregate MBSE data from disparate models and ontological structures to provide a platform-level view of the FFG 62's ability to meet its required missions in context of both own-ship and strike group ops.

Proposed concepts should address the ability to perform multi-platform-level and multi-mission analysis based on operational data, platform design, architecture, reliability, maintainability, and supply chain inputs. The tool should be able to handle complex functional redundancies at the platform and strike group level and provide outputs that support Program Office sustainment decisions for product support footprint, including maintenance and supply across multiple programs. Effective solutions would analyze data associated with individual systems and generate a model to predict overall performance. This would

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inform Program Offices early in the acquisition cycle regarding potential performance of the platform design, and also support the decision-making process to evaluate proposed system changes. Approaches could be based on commercial SoS and Quality of Service algorithms to predict system performance, human factors analysis for usability, and dynamic systems modeling techniques. Additionally, the tool should provide information on algorithms to analyze resource decisions across multiple platforms. The tool should also interface with existing Navy CBM+ suites to perform real-time tracking and analysis of platform effectiveness. The algorithms and tools would be verified and tested at the end of each phase of the project by Government Subject Matter Experts for adequate SoS modeling through failure modeling, probability of successful mission estimation, and Monte Carlo simulation.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) at <https://rmfks.osd.mil> (Information Assurance Technical Authority (IATA) Standards and Tools at <https://software.forge.mil/sf/projects/navy-iata>).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government's efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, "Safeguarding Covered Defense Information and Cyber Incident Reporting," and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept that can meet the design constraints listed in the Description section. Establish feasibility by developing models that show the system architecture and operational concept of the tool. Feasibility will also be established by computer-based simulations that show the tool's capabilities are suitable for the project needs. Example inputs for Phase I include system-of-systems diagrams in XML, reliability, maintainability, and cost information associated with the systems, and notional mission profiles as they apply to the systems. The output concept should link the inputs in an architecture that displays platform systems design characteristics and information on required

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functionality for mission effectiveness. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I and the Phase II Statement of Work (SOW), the company will develop, demonstrate, and deliver a comprehensive modeling tool prototype that can perform platform-level mission analysis based on system design, system architecture, and mission engineering concepts linking reliability, maintainability, and supply chain inputs. The tool should provide outputs that support program acquisition and sustainment decisions for product support logistics footprint, including maintenance and supply. The prototype solution shall be based on a data architecture that establishes relationships between individual systems, associated design characteristics, acquisition cost, and sustainment footprint. Evaluate the tool's effectiveness in linking disjointed and disparate data sources into a cohesive model for evaluation and its ability of the model to support decision-making and 'what-if' analysis to determine whether the models meet performance goals as defined. Demonstrate the tool's performance through prototype testing and detailed analysis, including mission thread analysis and failure mode analysis with verification through Monte Carlo simulations. Prepare a Phase III development plan to transition the technology to Navy use.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy to transition the multi-platform, multi-mission modeling capability tool from stand-alone application to application integrated with Department of Navy and PMS 515 MBSE and MBPS efforts, including CBM+ systems. Assist with integration aboard fielded platforms for real time analysis of mission effectiveness to support decision makers in the fleet. Program offices and Navy Type Commanders (TYCOMs) can use the tool to better understand impacts of lack of resources or to support reallocation of resources, or resources or assess to probability of mission success in a highly complex environment. Commercial applications of the tool would include other multi-use and/or multi-nodal systems, including air, ground, and maritime vehicles, computing infrastructure, and other uses where optimizing operational time across a wide array of assets is beneficial.

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KEYWORDS: Model Based Systems Engineering; Model Based Product Support; Mission Engineering; Operational Availability; Readiness, Sustainment; Product Support; Distributed; Mission Effectiveness; System Optimization

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N221-032 TITLE: DIGITAL ENGINEERING - 3D Operator Decision Aides for Ship Control Systems

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop an automated operator decision aide capability for ship control systems that improves situational understanding through the use of a single 3D visualization system to reduce cognitive burden; enable and provide an aggregate viewpoint of system and platform health; and enable data-driven decision making.

DESCRIPTION: As the Navy continues to reduce manpower requirements associated with operating ever-increasing technologically complex systems, new methods that enable natural and intuitive 3D interaction with ship control systems' data are desired to aid in reducing the overall operator burden and enhance watch stander situational awareness. Developing an optimized capability to engage and process a ship's information from multiple systems in a high-stress environment will allow the operators to increase task accuracy, reduce response time, and increase overall situational awareness.

This SBIR topic seeks an automated operator decision aide capability for ship control system logic that improves bridge watch stander situational understanding through the integration of data from multiple ship systems and use of 3D visualization techniques. New approaches are needed to reduce operator burden through the application of enhanced visualization methods and dynamic real-time, temporally accurate visualizations of ship systems. By presenting complex data in a user-friendly, yet informative, manner, the cognitive load on the operator can be decreased and the ability to make data-driven decisions based on complicated information is improved. Approaches are encouraged to apply Artificial Intelligence (AI) and Machine Learning (ML) as practicable.

Automated operator decision aides will convert various ship systems' data and sensor outputs into a human-readable and intuitive User Experience (UX) to provide an aggregate viewpoint of the overall ship system and platform health. This will enable operators to visualize the mission impact of ship control system status (e.g., up/down, failure mode, performance). The automated operator decision aides should categorize and prioritize information display with the goal of compiling, automating, and reducing burdens on the decision makers to assist them in understanding a component failure's influence on the overall mission effectiveness of the system. The automated operator decision aides will also display the integrated logic functions associated with the systems' permissive and alarms and inform operators of these failures to enable a data driven decision making process and allow for immediate corrective actions.

The automated operator decision aide system must be capable of collecting all ship control systems' data and must include an interface to support data export. This will enable data analysis by the Program Office, In-Service Engineering Agents (ISEAs), and subject matter experts. The data can be used to track failures, help find mitigation plans to avoid future failures, and inform maintenance and logistical requirements. Proposers should develop a solution that is Modular Open Systems Approach (MOSA)-compliant to allow for cross-platform compatibility and future capability improvements. Because of the unique and specific nature of the multiple FFG 62 subsystems, of which data will be collected, no commercial solutions to allow for subsystem data integration and/or data exportation currently exist. Testing will be iterative throughout the phases in order to test accurate data consolidation, user experience, and secure cyber footprint. Specifically, this solution must have the ability to achieve Navy accreditation and certification in order to be installed on an operational vessel in accordance with the latest guidance including, but not limited to, Authorization to Operate and Risk Management Framework policies.

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Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

All DoD Information Systems (IS) and Platform Information Technology (PIT) systems will be categorized in accordance with Committee on National Security Systems Instruction (CNSSI) 1253, implemented using a corresponding set of security controls from National Institute of Standards and Technology (NIST) Special Publication (SP) 800-53, and evaluated using assessment procedures from NIST SP 800-53A and DoD-specific (KS) at <https://rmfks.osd.mil> (Information Assurance Technical Authority (IATA) Standards and Tools at <https://software.forge.mil/sf/projects/navy-iata>).

The Contractor shall support the Assessment and Authorization (A&A) of the system. The Contractor shall support the government's efforts to obtain an Authorization to Operate (ATO) in accordance with DoDI 8500.01 Cybersecurity, DoDI 8510.01 Risk Management Framework (RMF) for DoD Information Technology (IT), NIST SP 800-53, NAVSEA 9400.2-M (October 2016), and business rules set by the NAVSEA Echelon II and the Functional Authorizing Official (FAO). The Contractor shall design the tool to their proposed RMF Security Controls necessary to obtain A&A. The Contractor shall provide technical support and design material for RMF assessment and authorization in accordance with NAVSEA Instruction 9400.2-M by delivering OQE and documentation to support assessment and authorization package development.

Contractor Information Systems Security Requirements. The Contractor shall implement the security requirements set forth in the clause entitled DFARS 252.204-7012, "Safeguarding Covered Defense Information and Cyber Incident Reporting," and National Institute of Standards and Technology (NIST) Special Publication 800-171.

PHASE I: Develop a concept for an automated operator decision aide that integrates data from multiple ship systems with a 3D visualization and export capability. The concept must show that it can feasibly meet the requirements of the Description. Establish feasibility through modeling and simulation of the concept.

The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Fabricate a comprehensive automated decision aide prototype that is capable of demonstrating the implementation and integration into the ship system environment for testing and evaluation. Demonstrate accuracy, repeatability, and functionality, adhering to the requirements outlined in the Description. Perform a system demonstration in a simulated environment.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

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PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use and support further refinement and testing of the automated operator decision aide's functionality following successful prototype development and demonstration. Testing will be accomplished by real-time demonstration of the developed capability with operational users in order to gauge successful metrics for accuracy, readability, and implementation of data feeds into a singular user interface. Upon capability demonstration and quantifiable test results, direct the focus toward the transition and integration of the technology into Bridge and Machinery Control Systems.

This solution has applicability across the Navy on other platforms with complex/automated ship control systems such as Unmanned Vehicles (UxVs) and could help to increase both mission effectiveness and readiness. This capability can be applied to commercial applications with diverse and complex human-in-the-loop interfaces, including aviation and commercial maritime operations.

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1. Scherer, Timothy and Cohen, Jeffrey. "The Evolution of Machinery Control Systems Support at the Naval Ship Systems Engineering Station". Naval Engineers Journal. 18 May 2011. Volume 2: 85-109.
2. Wright, R. Glenn. "Virtual Aids to Navigation". World Maritime University. 2017.
https://commons.wmu.se/phd_dissertations/14/.
3. Balogh, P., Kovacs, P. T., and Barsi, A. "Holovizio 3D Display System." 2007 3DTV Conference. 07-09 May 2007. DOI: 4379386

KEYWORDS: Ship control system; virtual environment; 3D visualization; interactive shipboard; system logic functions; virtual watchstander.

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N221-033 TITLE: DIGITAL ENGINEERING - Perception System for Situational Awareness and Contact Detection for Unmanned Underwater Vessels

OUSD (R&E) MODERNIZATION PRIORITY: Autonomy

TECHNOLOGY AREA(S): Ground / Sea Vehicles

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a sense and avoid perception system for unmanned underwater vessels (UUVs) to support the safe maneuvering and navigation in both the surface and the undersea domains.

DESCRIPTION: A UUV needs to surface periodically to get GPS fixes, charge batteries, or communicate with other vessels and buoys. Before surfacing a UUV must identify potential surface or near-surface contacts, obstacles or features to ascertain if the environment is safe for the vehicle to ascend and conduct operations.

The Navy is seeking to develop and demonstrate a sense and avoid perception processing system for small-class UUVs as categorized in the Navy's report to Congress on Autonomous Undersea Vehicle Requirement for 2025 [Ref 1]. The system will enable the UUV to detect, classify, track, and estimate risk of contact with surface and undersea vessels operating in proximity. The solution must be scalable for future adaptation on larger unmanned system platforms including medium-class and larger UUVs. No current commercial technologies exist that have the military applications that the Navy seeks.

The perception processing system will utilize onboard sensors to provide the UUV 360 degree situational awareness both on and near the water's surface to enable the vehicle to safely surface or avoid a collision. The system must be able to process the raw data and provide the contact attributes as an output to an onboard autonomous control system to support obstacle/collision avoidance.

Contacts may include all sizes of power and sailing vessels, buoys and other navigation markers, and structures. Attributes may include but are not limited to contact size, height to length ratio, range, bearing, and speed/direction. The perception processing system should be capable of measuring a contact's relative position information, rate of change of relative position, and/or the trajectory information to decide whether a risk of collision exists and if an avoidance maneuver is required. These measurements and projections of future movements include varying degrees of uncertainty. An estimate of the uncertainty is valuable in assessing when sufficient information is available to make a maneuver decision. The decision timeline is time-constrained but the reaction time to successfully evade. Maneuver decisions must be made early enough to ensure safe separation. Additionally the system should be capable of tracking surface or near-surface objects and their attributes to maintain awareness of potential surface contacts within 10 nautical miles of UUV objective areas that are closing on the location of UUV(s). Concepts proposing additional external sensors as a portion of their solution must do so without adversely impacting trim, balance, or hydrodynamic performance of the target host platform and should offer solutions requiring 50w or less power.

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The solution may be software or a combination of software, hardware processors, and sensors necessary to support operation of the developed perception algorithms. For the initial phase of this SBIR topic, prefer solutions suitable for with small-class (7.5” diameter) expeditionary UUVs, which are two-person carry in size and weight in accordance with MIL-STD 1472 section 5.8 [Ref 2]. Application of artificial intelligence/machine learning (AI/ML) and other digital engineering techniques are desired. As an element of the seminal transition event in Phase II, testing of the key performance parameters and key system attributes will be conducted in a relevant environment to verify that the capabilities of the system were satisfied.

To ensure interoperability with planned and future unmanned systems, solutions must also comply with DoN’s Unmanned Maritime Autonomy Architecture (UMAA) [Ref 3]. UMAA establishes a standard for common interfaces and software reuse among the mission autonomy and the various vehicle controllers, payloads, and Command and Control (C2) services for unmanned systems (UxS) vehicles. The UMAA common standard for Interface Control Documents (ICDs) mitigates the risk of unique autonomy solutions applicable to just a few vehicles allowing flexibility to incorporate vendor improvements as they are identified; effects cross-domain interoperability of UxS vehicles; and allows for open architecture (OA) modularity of autonomy solutions, control systems, C2, and payloads. UMAA standards and required ICDs will be provided during the Phase I effort.

PHASE I: Develop a concept design for the automated perception processing system that meets the requirements in the Description. The concept design must define a system that can consistently sense, perceive, and report surface objects and vessels and include any modeling and simulation, studies in support of concept risk reduction. Demonstrate the feasibility of the proposed concept through modeling, analysis, and concept demonstrations. Feasibility studies in Phase I will be oriented at solutions for small class UUVs, but should assess scalability for future medium-class UUVs and other expeditionary unmanned systems.

The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I efforts and the Phase II Statement of Work (SOW), develop, deliver, and integrate perception processing prototype system capabilities for demonstration and characterization of key performance parameters, key system attributes, and objectives. Based on lessons learned in Phase II through the prototype demonstration, integrate the perception processing system into unmanned surface vessel of opportunity, deliver the prototype solution, and demonstrate feasibility of the concept and functionality of the autonomy.

PHASE III DUAL USE APPLICATIONS: Incorporate design improvements from the Phase II demonstration efforts and assist the Navy in transitioning the technology to Navy use. Fabricate and deliver prototype software with integrated Navy provided UUV and USV. Independent testing and evaluation will be conducted by the Navy in cooperation with Fleet end user community to validate effectiveness and suitability for transition and fielding. Autonomy and products developed and demonstrated under this initiative provide potential solutions for other unmanned surface and undersea systems across the Navy portfolio and throughout commercial activities in including offshore oil and gas pipeline inspection and undersea survey, search, salvage and recovery, and port security companies; and in other Government agencies employing unmanned systems.

REFERENCES:

1. “Secretary of the Navy Report to Congress: Autonomous Undersea Vehicle Requirement for 2025.” dated 18 February 2016. <https://news.usni.org/wp-content/uploads/2016/03/18Feb16-Report-to-Congress-Autonomous-Undersea-Vehicle-Requirement-for-2025.pdf>.

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2. “Department of Defense Design Criteria Standard, Human Engineering (MIL-STD 1472F), 23 Aug 1999.” <http://chassis-plans.com/PDF/MIL-STD-1472F.pdf>.
3. PEO Unmanned and Small Combatants (PEO USC); Unmanned Maritime Autonomy Architecture (UMAA), Architecture Design Description (ADD); 29 Dec 2019.
4. DON Innovation. “The Expeditionary MCM (ExMCM) Company: The Newest Capability in U.S. Navy Explosive Ordnance Disposal (EOD) Community.” July 2017.
<https://www.secnav.navy.mil/innovation/Documents/2017/07/ExMCM.pdf>.

KEYWORDS: Underwater Unmanned Vehicle (UUV); Unmanned Surface Vehicle (USV); Autonomous Unmanned Vehicle (AUV); Perception; Autonomy

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N221-034 TITLE: DIGITAL ENGINEERING - Combatant Craft Autonomy-Enabling Sensors, Perception and Command & Control

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Ground / Sea Vehicles

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a sensor, perception, and Command and Control (C2) suite suitable and sufficient for enabling combatant craft mission-specific autonomous behaviors.

DESCRIPTION: The Navy's Maritime Expeditionary Security Force (MESF) provides port and harbor security, and high value asset security inland, on coastal waterways and ashore. Advanced unmanned autonomous patrol craft would help reduce risks to boat crews and enable unique new operational capabilities. The operating environments and mission requirements for these craft differ significantly from open ocean missions, which are the focus of many current Navy autonomous vessel development efforts. Specifically, the Navy needs a small form factor sensor, perception, and C2 suite to enable autonomy for combatant craft addressing the unique challenges of their mission sets. New proposed system must meet Size, Weight, Power and Cost (SWaP-C) of existing systems if applicable.

Current sensors and perception software for Unmanned Surface Vessels (USVs) lack the ability to conduct precision close-in tracking of small vessels for fine-tune and/or high relative speed maneuvering. They are also unable to sufficiently sense and characterize a potential threat vessel or individuals on it, or make a determination of a potential threat's intent, either for reporting to a human operator or triggering autonomous vessel responses.

Many potential sensor/perception technologies exist that may be suitable for these particular challenges. For the sake of example, but not to limit the scope of potential proposed solutions, a Light Detection and Ranging (LIDAR) system or radar system may be appropriate for close-in tracking to enable autonomous maneuvering near or in contact with another vessel, or an Electro Optical/Infra-Red (EO/IR) camera with advanced image recognition capabilities may be appropriate for characterizing contact vessels and establishing probable intent. Many candidate LIDAR and EO/IR camera systems are already commercially available for other applications (e.g., LIDAR for agricultural surveying, radars in use for car traffic detection and lane assist systems, or EO/IR cameras for fixed site security).

Analysis and development is also required to optimize a system to allow high level C2 of multiple varied types of combatant craft, both manned and unmanned, when equipped with autonomy software and controllers. This includes a mesh networking (or other suitable) communications system, a Common Operating Picture (COP), and C2 interface. The C2 interface must provide clear indications to human operators of the current threats perceived and high-level behaviors being executed by autonomous craft and allow dynamic tasking/re-tasking of high-level behaviors from human operators to the autonomous craft.

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These capabilities should be suitable for integration on a variety of small combatant craft. Size and weight should be minimized, notionally not to exceed one half a standard electronics rack, with smaller electronics solutions preferred. Similarly, deck space for integration of sensors is at a premium, so smaller and/or less-invasive options are preferred. Power consumption should also be minimized to the extent possible.

Target platforms for transition include the 40 PB (40 foot patrol boat), Rigid Inflatable Boats (RIBs), MK VI Patrol Boat, etc., and/or existing small autonomous vessels, e.g., the Common Unmanned Surface Vehicle (CUSV).

A variety of autonomous vehicles and autonomy software frameworks already exist, in various states of development and employment. Many of these are commercial proprietary and tied to specific autonomous vehicles, such as the Leidos autonomy developed for the SeaHunter program. While not prescriptive of any particular vessel or framework, it is the hope for this effort to leverage one or more existing capabilities to the maximum extent practical. This reduces the scope to focus specifically on the immature components of sensing, perception, and C2 as applied to combatant craft operations. One potential system is the Control Architecture for Robotic Agent Command and Sensing (CARACaS), originally developed by NASA's Jet Propulsion Laboratory for the Office of Naval Research (<https://www-robotics.jpl.nasa.gov/tasks/showTask.cfm?FuseAction=ShowTask&TaskID=271&tdaID=700075>).

PHASE I: Develop a concept for an advanced sensor, perception, and C2 suite suitable for integration on a variety of existing or future combatant craft and integration with an existing vessel autonomy framework. Demonstrate the viability of the concept in meeting Navy requirements, as described above, and will establish that the system can be feasibly developed into a useful product for the Navy. Feasibility will be established by engineering analysis, component and system level modeling and simulation, and component technology maturity assessments. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I and the Phase II Statement of Work (SOW), develop and deliver a prototype to the Navy for evaluation in meeting the performance goals defined in the Phase II SOW and the Navy requirements for a combatant craft sensor, perception, and C2 suite. Conduct on-water testing as well as modeling or analysis to demonstrate system performance over the required range of parameters. This will allow the government team to evaluate the system's ability to meet the performance goals defined in the Phase II SOW and the Navy requirements for the system. On-water testing location(s) will be negotiated between the small business and government team for reasons of proximity to both parties, weather/current conditions, availability of instrumented ranges, etc. Evaluation results will be used in collaboration with the Navy design team to refine the prototype into a design that will meet Navy needs. Conduct performance integration and risk assessments, and develop a cost benefit analysis and cost estimate for a naval shipboard system. Prepare a Phase III development plan to transition the technology to Navy and potential commercial use.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use and determine appropriate system components/variants for shore-side operation and installation on various craft. Support required modifications for integration, performance and environmental testing, and required certifications (e.g., electronic interference mitigation, battery safety, etc., as applicable). This includes providing component manufacturer information and specifications and/or testing components to verify regulations compliance. Target platforms for transition include the 40 PB (40 foot patrol boat), Rigid Inflatable Boats (RIBs), MK VI Patrol Boat, etc., and/or existing small autonomous vessels, e.g., the CUSV.

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Other potential targets for transition include U.S. Coast Guard patrol craft, which have similar mission sets, and commercial vendors for related applications, for example, pleasure or fishing boats. Additional potential transition targets include universities or research institutions studying and/or employing small autonomous craft.

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1. Ansary, Jamal, et al. "Swarms of Aquatic Unmanned Surface Vehicles (USV), a Review From Simulation to Field Implementation." Proceedings of the ASME 2020 International Design Engineering Technical Conference and Computers and Information Engineering Conference. Volume 2: 16th International Conference on Multibody Systems, Nonlinear Dynamics, and Control (MSNDC). Virtual, Online. August 17-19, 2020. V002T02A029. ASME. <https://doi.org/10.1115/DETC2020-22702>.
2. Halterman, Ryan and Bruch, Michael "Velodyne HDL-64E lidar for unmanned surface vehicle obstacle detection", Proc. SPIE 7692, Unmanned Systems Technology XII, 76920D. 7 May 2010; <https://doi.org/10.1117/12.850611>.
3. Schaus, Brian M. Improving maritime domain awareness using neural networks for target of interest classification. Naval Postgraduate School Thesis. Monterrey, CA. 2015. <http://hdl.handle.net/10945/45252>.
4. See, Hongze Alex. Coordinated guidance strategy for multiple USVs during maritime interdiction operations. Naval Postgraduate School Thesis. Monterrey, CA. 2017. <http://hdl.handle.net/10945/56175>.

KEYWORDS: Autonomy; image recognition; threat detection; Command and Control; Manned Unmanned Teaming; high value unit escort.

VERSION 8

N221-035 TITLE: DIGITAL ENGINEERING - Multi-Beam Antenna Scheduling Optimization

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop an algorithmic approach to optimally schedule transmit/receive communications in a command-and-control network using multi-beam antennas.

DESCRIPTION: Existing Navy command and control networks create a force-level track picture by fusing sensor measurements from all members of the deployed group. The measurements are sent from the sensing unit to all other units by a series of pairwise exchanges using directional, single-beam antennas. Command and control networks use time-division multiple access (TDMA) to create the pairwise, transmit/receive schedule to send measurements from each sensor to all other sensors in the network for fusion. Command and control networks also support the flow of sensor data to directly support Engage on Remote (EOR), which requires more dedicated information exchange to achieve required latencies.

New antenna technologies are being developed that permit multiple beams to be formed by the antenna array, providing the possibility to transmit or receive simultaneously in multiple beams. Creating such an antenna, compatible with the existing command and control networks, is a significant technological development. The development of a new transmit/receive scheduling method is required to derive operational benefit from this technological development. There are no known current solutions that addresses this developed technology need. A solution is needed to develop an algorithmic approach to optimally schedule transmit/receive communications in a command-and-control network using multi-beam antennas.

Several possible configurations are of interest. Configuration 1 contains one unit with a multi-beam antenna while the remaining units have single beam antennas. Configuration 2 contains a random mix single-beam and multi-beam antennas. Configuration 3 is composed entirely of multi-beam antennas. These configurations are representative of the evolution from an initial operational capability to a final operational capability of the new antenna technology. It is required that a single scheduling approach be able to support all configurations.

The term multi-beam can be interpreted to mean 2 beams, but the ability to scale the scheduling concept to a larger number of beams must be addressed. The intent is to demonstrate, in modeling and simulation, improved network performance using the multi-beam scheduling versus single-beam scheduling. Network performance metrics must be defined to quantify the performance improvement of the various multi-beam configurations relative to the single beam configuration.

Media Access Control (MAC) protocols for multi-beam antennas are discussed in the Wang and Kuperman references. These approaches may be relevant for the exchange of track measurements among

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units to produce the fused track picture. The Raviv reference discusses the inclusion of priorities and deadlines in the schedule creation, which may be relevant to scheduling transmission of EOR support data. A single scheduling approach that supports both track measurements and EOR data is required. The solution will be validated by testing in a laboratory environment which will be provided by the performer. The prototype solution will be delivered to the Navy for further testing and development assisted by the performer.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a concept for an algorithmic approach to optimally schedule transmit/receive communications and demonstrate the concept meets the parameters in the Description. Concept feasibility will be demonstrated through analysis, modelling, and simulation. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop, demonstrate, and deliver a prototype algorithmic approach to optimally schedule transmit/receive communications based on the results of Phase I. Demonstrate the prototype meets the parameters described in the Description through testing in a laboratory environment. The laboratory environment will be provided by the performer.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. The scheduling concept will be merged with existing command and control software to assist in generating the TDMA transmit/receive schedule. Working prototype scheduling algorithms, will be delivered to the Navy for testing and further development. Work with the program of record prime contractor for integration into the scheduling algorithm to be deployed. The prime contractor will be responsible for integrating the suite of scheduling concepts that best support the requirements of the network capability to be deployed in conjunction with the company assisting in the integration processes.

This technology will also benefit commercial radio industries that have a need to handle many transmissions at the same time over networks.

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1. Wang, Gang, Yanyuan, Qin. "MAC Protocols for Wireless Mesh Networks with Multi-beam Antennas: A Survey," Future of Information and Communication Conference 2019/02/02, doi: 10.1007/978-3-030-12388-8.
https://www.researchgate.net/publication/337774271_MAC_Protocols_for_Wireless_Mesh_Networks_with_Multi-beam_Antennas_A_Survey.
2. G. Kuperman, R. Margolies, N. M. Jones, B. Proulx and A. Narula-Tam, "Uncoordinated MAC for Adaptive Multi-Beam Directional Networks: Analysis and Evaluation," 2016 25th

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International Conference on Computer Communication and Networks (ICCCN), Waikoloa, HI, USA, 2016, pp. 1-10, doi: 10.1109/ICCCN.2016.7568593.

<https://ieeexplore.ieee.org/document/7568593>.

3. Raviv, Li-on, Leshem, Amir. "Scheduling for Multi-User Multi-Input Multi-Output Wireless Networks with Priorities and Deadlines," 2019/08/05, doi: 10.3390/fi11080172.

https://www.researchgate.net/publication/334979274_Scheduling_for_Multi-User_Multi-Input_Multi-Output_Wireless_Networks_with_Priorities_and_Deadlines.

KEYWORDS: Multi-beam antenna; transmit/receive scheduling; fused track picture; pairwise exchange; time-division multiple access (TDMA); media access control

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N221-036 TITLE: DIGITAL ENGINEERING - Exploitation of Ephemeral Features in Sonar Classification Algorithms

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop automated classification techniques that improve performance with ephemeral features in active and passive sonar systems.

DESCRIPTION: In active and passive sonar systems, automated processing can include classification algorithms to reject false alarms (that is, clutter) while retaining true target detections.

State of the art classification algorithms are, in general, multiple hypothesis tests that can be implemented by extracting features from the acoustic measurement associated with each detected "contact". The features distill different characteristics of the measured sound such as aural features or descriptive features, similar to how arches, loops, and whorls help classify fingerprints. In automated sonar systems, the features extracted from a sonar contact are typically combined using non-linear algorithms to identify the class to which the contact belongs. In most cases, these algorithms have parameters that must be learned (that is, the classifier is trained) through analysis of existing data that has already been labeled as to its class.

The availability of off-the-shelf classifiers such as multiple hypothesis testing and machine learning tools, has enabled the development and testing of numerous features. A limitation of most off-the-shelf algorithms is that they typically assume every feature is available all the time. However, not all features are viable in every contact. Some are missing only occasionally and some only occur rarely (that is, ephemeral features). An example of such an ephemeral feature in facial recognition would be the shape of the nose, mouth, and chin during time when some are wearing masks. Sonar similarly has such recognition features that may be missing, either because the environment masks the feature or because submarines, trying to be stealthy by design, try to hide such "features." The standard approaches for handling this missing-data problem deal with it indirectly (such as, by replacing the missing feature with its mean over the training data). They may also incorrectly assume missing features occur in a uniformly random manner throughout the data. As such, the standard approaches to missing data do not fully exploit the information contained in ephemeral features when they exist. Expanding sonar classification to include ephemeral features (features that are not always present) will give Navy systems increased capacity 1) to detect stealthy submarines or torpedoes that may not otherwise be detected or 2) to accelerate detection of targets in cases where time to react is limited and the consequences of delayed detection are potentially fatal.

One system where ephemeral features exist is the AN/SQQ-89A(V)15, which contains functions for pulsed active sonar, continuous active sonar, towed array passive sonar, and hull array passive sonar.

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Technology developed under this topic should be extensible to each of these functions, with initial adoption most likely to occur within the pulsed active sonar function.

The ideal solution will exploit off-the-shelf classifier technology, have practical implementation and training procedures, and handle features that occur rarely or frequently. As real-world data sets associated with the AN/SQQ-89A(V)15 are classified, companies are encouraged to plan to obtain or generate unclassified data sets that demonstrate their solution.

While proposers are encouraged to demonstrate the power of their approach on unclassified data they have obtained, created, or simulated, the Phase II effort will involve tests of the technology developed under this topic with recorded data provided by the Navy both to assess stand-alone performance, as well as provide for the technology to be assessed within the overall sonar processing string. Details of exactly how this is to occur will be dependent on the nature of the proposed technology. Once the technology is independently deemed to provide value, the Navy will commit to incorporating the technology into a future sonar system build, which will go through certification as an integrated system.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a concept for improved sonar classification algorithms with ephemeral features that meet the parameters of the Description. Demonstrate the feasibility of the concept through modelling, analysis, and simulation. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype improved sonar classification algorithm with ephemeral features based on the results of the research in Phase I. Demonstrate the prototype meets the required range of desired performance attributes given in the Description. System performance will be demonstrated through installation and prototype testing on a testbed with the lead system integrator.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Assist the Navy in transitioning the technology for Navy use in an operationally relevant environment to allow for further experimentation and refinement. The prototype algorithm will be integrated into the PEO-IWS 5 surface ship ASW combat system Advanced Capability Build (ACB) program used to update the AN/SQQ-89 Program of Record.

Commercial applications that could benefit from ephemeral features of sonar classification algorithms include both active and passive remote-sensing systems where the data includes ephemeral features. Examples outside of sonar include most applications of radar, lidar, satellite remote sensing, ultrasound, and thermal imaging.

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KEYWORDS: Classifier; sonar contact; ephemeral features of sonar; classification algorithms; machine learning, multiple hypothesis testing

VERSION 8

N221-037 TITLE: Compact Electron Beam Focusing System for Millimeter Wave Sources

OUSD (R&E) MODERNIZATION PRIORITY: Directed Energy (DE)

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a low-voltage, high-current, round-beam electron gun that significantly reduces the size and weight of high-power W-band traveling-wave tube amplifiers.

DESCRIPTION: Traveling Wave Tubes (TWTs) are the primary radiofrequency (RF) power amplifiers used in applications that require both high output power and wide bandwidth (large power-bandwidth product). However, systems that employ these critical components at high millimeter-wave (mmW) frequencies, up to and including W-band (75-110 GHz), are especially difficult to realize in low size, weight, and power (SWaP) form factors. They are also extremely costly. This is due to the extremely small size of the high-frequency RF components which impose electrical and thermal limits on device operation and result in demanding manufacturing tolerances. The state of the art for such devices at mid W-band frequencies (near 94 GHz) is approximately 100 W output power with an electron beam current of 100-250 mA and a beam voltage of 20-25 kV. In comparison, for practical applications in W-band, the Navy desires TWTs producing much greater power (5X nominally) and wide bandwidth. Such TWTs do not currently exist in acceptable form factors.

The fundamental enabling technology for such a TWT is the electron beam generation, focusing, and transport system. The formation of the electron beam, in terms of focusing, transport, and current density, ultimately determines the output power and instantaneous bandwidth of a TWT. While higher beam current allows more RF power to be generated in the amplifier circuit, a high magnetic field is required to confine and transport such a beam through the small beam tunnel transiting the circuit. In the present state of the art, the magnet required to generate the high quality and very intense magnetic field needed to confine such a beam is large and heavy. For example, at W-band a conventional magnet (either electromagnet or permanent magnet) used for high-current beams (> 500 mA) of appropriately tight focus typically weighs 50-100 pounds. Lower-current beams can be focused by more compact configurations, such as conventional periodic permanent magnets (PPM), but these TWTs produce significantly less RF power than required. Spatially-distributed beams, such as sheet beams, are effective at producing high device power density (electron beam power per device weight). However, at high frequencies, these devices are prone to beam-defocusing instabilities and parasitic RF oscillations due to limited fabrication precision that causes non-uniformities in the magnetic field and RF circuit. Therefore, compact electron beam generation, focusing, and transport systems suitable for high power W-band TWTs are a critical enabling technology for future millimeter wave systems.

The Navy needs a novel electron beam focusing system for generation and transport of high-power (10 kW peak) electron beams of round cross-section. Ultimately, the electron beam focusing system will be integrated with a broadband beam-wave interaction circuit and an electron beam collector to form a complete W-band TWT. Development of the complete TWT is beyond the scope of this effort and details

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of the intended interaction circuit need not be specified as multiple device concepts require this technology.

To achieve the required beam current while minimizing the overall volume and weight (including the size and weight of any power supplies necessary to operate the device), a solution utilizing PPM based focusing and precision fabrication methods is anticipated. The design (including the integral electron gun), the fabrication techniques for the magnet structure, the magnetic materials, and the methods for integration of the magnets with appropriate RF circuits should result in designs that produce higher transport magnetic fields for a given magnet volume than is possible with conventional PPM based focusing. Magnetic materials should be capable of stable operation at temperatures up to 200°C. The magnetic focusing system should maintain the transverse dimensions of the electron beam over the entire beam transport distance of 5 cm for 100% beam transport (no RF applied) and consistent with efficient beam-wave interaction at W-band. However, no RF circuit is required of this effort and the technology shall be demonstrated as a beam-stick (i.e., with a copper “blank” containing only the beam tunnel in place of the circuit). The beam-stick shall have a uniform 4 mm by 4 mm square cross-section extending along the entire 5 cm tunnel length, consistent with the expected size and shape of the envisioned W-band amplifier interaction circuit.

The electron gun shall operate at a voltage of 25 kV or less with a minimum peak beam current of 0.4 amperes and be capable of pulse repetition rates of 10-50 kHz with a minimum duty factor of no less than 3%. The round electron beam should be transported through a tunnel no larger than 0.5 mm in diameter, with a maximum average beam diameter of 0.3 mm. The pulse voltage required to turn the beam on and off is another key design consideration, as it affects the size and weight of the power supply and pulser circuit required to operate the device. Consequently, the electron gun should be designed to require the lowest possible voltage swing necessary for device operation. The electron gun should also be designed for maximum operational life.

Vacuum device performance is determined by mechanical dimensions and precision alignment of the electron beam, magnetic field, and RF circuit. Consequently, manufacturing, including yield, is the overwhelming cost driver for any vacuum device. For W-band devices, the small feature sizes and tight machining and assembly tolerances required for stable operation are extremely challenging. Therefore, advances in fabrication, machining, alignment, fixturing, and joining techniques are required to reduce the cost of manufacturing the electron beam focusing system. Consequently, designing critical components, such as the electron gun and magnet assembly, to take advantage of advanced fabrication techniques is also an important part of this effort.

Acceptable solutions must meet the mechanical and electrical requirements described above. The key goal is then to optimize the power density of the device where power density is defined as the peak beam power divided by the combined weight of the gun, beam transport system (including magnets), beam tunnel “blank”, and collector. A minimum power density of 500 W/lb is the goal of this effort. The solution should have some degree of scalability to accommodate different RF circuit lengths and widths (with proportional increases in beam focusing system size and weight).

Demonstration of a beam-stick prototype at the company facility is required to verify performance and assess power density. In order to confirm beam transmission, the collector should be isolated, though collector depression is not required. The physical interface of the electron gun should avail itself to integration with a W-band beam-wave interaction structure (circuit) according to standard industry manufacturing practice without compromise of performance or reduction in power density. Therefore, a technical data package (TDP) sufficient to facilitate replacement of the beam-stick “blank” with a future circuit, including modelling, simulation, assembly, processing, quality conformance, and test instructions, shall be delivered with the prototype to the Naval Research Laboratory at completion of the effort.

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PHASE I: Develop a concept for a compact electron beam focusing system that meets the objectives stated in the Description. Demonstrate the feasibility of the proposed approach by some combination of analysis, modelling, and simulation. The feasibility analysis should confirm the compatibility of the solution for integration with an appropriate W-band traveling-wave interaction structure (circuit) and beam collector through prediction of the expected performance from a complete device. The Phase I Option, if exercised, will include the initial design specifications, initial interface description, test specification, and capabilities description to build and test a prototype beam focusing system (with beam-stick and collector) in Phase II.

PHASE II: Develop, demonstrate, and deliver a prototype compact electron beam focusing system (with collector and beam-stick) that meets the requirements in the Description. Note that this effort is iterative by nature and more than one prototype (or partial prototype) may be developed. At the conclusion of the effort, test, seal, package for vacuum integrity, and deliver to the Naval Research Laboratory the best performing prototype. Test data shall also be delivered with the prototype as well as operating instructions and the TDP as noted in the Description.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Government use. Transition will include assisting with integration of beam-wave interaction circuits and scale the beam focusing system to produce specific device designs (for example, W-band TWTs). The technology will be validated by providing fabrication, process, and test support in manufacturing and demonstrating specific devices incorporating the electron beam focusing system.

The technology resulting from this effort is anticipated to have commercial application in the telecommunications industry; for example, as amplifiers in 5G backhaul transmitters.

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KEYWORDS: Traveling Wave Tube; periodic permanent magnets; PPM; PPM focusing; W-Band; Electron Beam Focusing; Power Amplifiers; Electron Gun

VERSION 8

N221-038 TITLE: Navy Threshold Velocity Detector Redesign

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a new threshold velocity detector that identifies two or more distinct velocities, uses little to no power, and reduces corrosion potential compared to the legacy device.

DESCRIPTION: The current threshold velocity detector system is manufactured primarily from aluminum and a custom rubber to allow for operation. This system experiences corrosion due to the direct interface with a sea-water environment and the mechanical design. This incurs a significant rework and life cycle cost. Some areas for improvement for the current system that could increase the performance and maintainability include:

1. Increase corrosion mitigation: The current system experiences corrosion of the mechanical parts as well as breakdown of the rubber compound over time due to interface with the seawater environment. This could be improved upon by integration of new non-interfacing technologies or new streamlined designs that reduced the parts that interface with the environment.
2. Integration of new technologies: The current system is a mechanical switch and due to the force/velocity being measured it can act temperamentally and the direct interface with the environment has led to issues with corrosion as previously mentioned.
3. Reduction in life cycle costs: This could be achieved by installing a Commercial off the Shelf (COTS) item with some modification or at least making the repair of the system easily performed. The current system requires an intensive rework and repair if malfunctioning that costs significant time and money to accomplish.
4. Ease of testing outside environment: This system has trouble with consistent testing and the new design would require a more reliable and repeatable testing mechanism to ensure proper function out of the environment before the use of the system.

Prototypes will be tested by the contractor and the Navy to meet the requirements of the detector and the program safety requirements.

Replacement of the current inventory of the legacy detectors will also be considered as the program is expected to remain in-service for at least 30 more years. This system could also be used to increase the information in future systems fed into the program and allow for better understanding of the current designs. This will provide opportunities for a lower cost design/simpler design that will relate to a smaller failure pool at the maintenance facilities and reduced downtime for current assets. Preventing corrosion will reduce the costs associated with rework and repairs during these maintenance actions.

The current leading technologies in the velocity detector industry include Coriolis, Differential Pressure, Magnetic, Multiphase, Turbine, Ultrasonic, and Flow velocity detectors. As this situation would support sea-water applications, gas measuring devices such as Vortex and differential pressure meters would

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likely not fit the application. There are other options in the industry and while these are the leaders in technology, other velocity detectors will be considered. Even using the backbone of a COTS unit, it will require significant R&D effort in order to successfully fulfill this application.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a concept for a threshold velocity detector, which will be considered for feasibility of manufacturing and ease of installation into the current operation. Design approaches will be developed that will allow all requirements to be met and discussed with the Government. Technology improvements and risk reduction of the aluminum mechanical components to indirect or more corrosive inhibitive materials interfaces will be another focal area of this phase. Upon selecting an approach, a concept will be defined and developed into a buildable design. Analysis will be performed on the concept to determine the feasibility of the concept to meet requirements. Manufacturing processes required to manufacture a threshold velocity detector will be investigated and defined. A cost analysis will be performed to document the total life cycle cost of a new threshold velocity detector in comparison to the legacy design. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Manufacture several prototype detectors utilizing the design and manufacturing processes defined in Phase I. These prototypes will be tested to meet the requirements of the detector and the program safety requirements. The testing will be conducted by the contractor and the Navy. When Navy specific assets are required for testing, the Navy will provide the assets or conduct the test for the contractor. In the event of any test failures, conduct root cause investigations and implement corrective actions as needed. Upon successful validation of the prototypes, the prototypes will be delivered to the Government for the completion of program integration testing and in-water testing.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the threshold velocity detector to Navy use through system integration and qualification testing. Upon completion of a successful Phase II and program integration testing, finalize the design and manufacturing processes into final production drawings that are representative of the end item as tested. Production drawings will be provided to the Government. Document and provide to the Government assembly & disassembly procedures, inspection procedures, maintenance procedures, and repair procedures that will be used to support threshold velocity detectors for the duration of their service life. Once this new detector design is qualified and determined to have cost benefits, and/or performance improvement the new detector will be cut into production. Replacement of the current inventory of the legacy detectors will also be considered as the program is expected to remain in-service for at least 30 more years. Commercial application of this technology can be in any system where a threshold velocity is required to initiate a safety intervention or sequential operation.

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KEYWORDS: Threshold velocity detector; corrosion mitigation; environment; seawater corrosion inhibition; repeatable; underwater body; life cycle cost

VERSION 8

N221-039 TITLE: Flexible Unmanned Vehicle Stowage System

OUSD (R&E) MODERNIZATION PRIORITY: Autonomy

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop a flexible, common stowage system for Unmanned Undersea Vehicles (UUVs) onboard surface ships.

DESCRIPTION: Current UUVs are provided with their own stowage and handling cradles, which require unique stowage space, material handling equipment and slings, and tie downs for securing to decks and bulkheads. There is no dedicated, common handling and stowage system for small or medium UUVs. A common, flexible handling and stowage system, that can accommodate different UUV configurations, can optimize the use of shipboard space, minimize development costs, and standardize operations. In Navy Large Unmanned Surface and Undersea Vehicles: In “Navy Seeking New Technology For Unmanned Boats, Subs,” an article in the October 18, 2019 National Defense Magazine [Ref 2], it was stated that Navy and DOD leaders believe that shifting to a more distributed fleet, to include Unmanned Systems, is operationally necessary, technically feasible, and affordable. No known commercial solution exists.

Unmanned vehicles of interest will generally be smaller than 20 feet in length, less than 2 feet in diameter and less than 2500 pounds. Available space reservations where the UUV stowage system might reside on LPD 17 Class should be constrained to upper vehicle deck areas and other locations accessible by ships elevator transport.

Stowage system must be capable of being prototyped for use with small and medium UUVs. System must be capable of meeting shipboard stowage requirements (sea state, tie downs, etc.) and interface with existing auxiliary systems which perform launch, recovery, refueling, recharging, rearming, and limited maintenance and repair.

The prototype will first be evaluated on land at the company’s facility to determine the system’s capability to meet performance goals defined in the Phase II Statement of Work (SOW). If Phase II testing is deemed successful, the project will move to at-sea testing on-board an LPD 17 Class ship. The at-sea testing will consist of maneuvering a UxV from the well deck area into stowage, securing for sea, and then unloading and maneuvering back to the well deck area.

PHASE I: Define and develop a concept for flexible stowage for Unmanned Systems that can be utilized on an LPD 17 Class of ship. Demonstrate feasibility of design through modelling and draft concept of operations. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I efforts and the Phase II Statement of Work (SOW), develop and deliver a prototype flexible handling and stowage system for UUVs for use on LPD 17 Class of ship. The prototype will first be evaluated on land at the company’s facility to determine the system’s capability to meet performance goals defined in the Phase II SOW. If Phase II testing is deemed successful, the project will move to at-sea testing on-board an LPD 17 Class of ship. The at-sea testing will consist of maneuvering a UUV from the well deck area into stowage, securing for sea, and then unloading and maneuvering back to the well deck area.

PHASE III DUAL USE APPLICATIONS: Upon successful completion of Phase II, support the Navy in transitioning the technology to Navy use to include test and validation in accordance with Navy regulations and requirements. Following testing and validation, the end design is expected to first be

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deployed on the LPD 17 Class of ship, and capable of being utilized across all Navy amphibious platforms. Larger scale commercial operations utilizing UUVs of this scale may benefit from the system.

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KEYWORDS: Unmanned Maritime Vehicle Systems; Unmanned Undersea Vehicle (UUV); Unmanned Vehicle Stowage; Common UxV Stowage; Modular Stowage; Flexible Stowage.

VERSION 8

N221-040 TITLE: Shipboard Advanced Metal Manufacturing Machine

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop a shipboard, advanced metal manufacturing system for Navy expeditionary environments with a closed-loop feedback system adaptable to operational conditions.

DESCRIPTION: Currently, Additive Manufacturing (AM) equipment suitable for afloat use is limited. The current capabilities were installed to support the development integration requirements for AM equipment, but is currently only limited to polymer machines. Current metal AM technologies are designed for the lab or machinery spaces shoreside, and have not been configured for the harsh shipboard environment. The inclusion of a metal AM capability shipboard would drastically improve ship self-sufficiency and increase readiness. There are increased needs for AM afloat as it is explicitly identified in the COMNAVSEA Campaign Plan 3.0 as a technology focus area. This SBIR topic directly supports efforts to integrate AM into the Fleet and support a more self-sufficient ship. In addition, the Design for Maintaining Maritime Superiority 2.0 requires that the Navy maximize its use of AM to fabricate “hard to source” or obsolete parts, reduce cost, field more effective systems, and reduce reliance on vulnerable supply chains through production at the point of need. Current metal AM technology can be classified under powder bed fusion (PBF), direction energy deposition, material extrusion, sheet lamination, or hybrid processes. These processes all have their benefits and limitations from a part production standpoint. At this time, these metal AM system installations are typically expected to be on the shop floor in industrial or lab settings. There is an interest to integrate these metal AM systems in more expeditionary settings to increase warfighter readiness and increase the Navy's distributed manufacturing capabilities and self-sufficiency. The operational conditions within these expeditionary settings include ship motion, ship vibration, shock, ventilation, and electromagnetic interference (EMI). In order to successfully install metal AM equipment and enable adequate operation of the equipment, the machine must not experience severe degraded performance under these conditions. Testing of these conditions in the lab environment should occur to determine system performance under shipboard environmental conditions. These tests should be comparable to the MIL-STDs mentioned below. The Navy is seeking a system that has optimized tool pathing and programming built-in, is able to additively build parts, and is capable of subtractive finishing said parts, all within the same unit. The machine must be able to be disassembled, to become a hatchable unit, and be able to additively manufacture as well as subtractive cut hard alloys, such as high carbon and stainless steels. The system must have a built-in sensor package to be able to monitor aforementioned operational conditions, perform in-situ monitoring of each build to inform part certification, and establish a report for each build capturing all the processed sensor data, print parameter information, and AM equipment health data. In addition, part removal is generally a post-printing machining event that uses specialized equipment, generally not available shipboard. This unit must demonstrate ease of part removal from the build plate. The solution should also have modular and scalable configurations to enable manufacturing of large parts, on the order of 5ft x 5ft x 5ft, and small parts, around 5 in x 5 in x 5 in. The design must address effects the expeditionary environment may have on the machine so that it can operate while deployed. The design must be able to perform at the same performance standard as current hybrid AM equipment on the market as it pertains to geometric complexity for laser DED manufacturing processes.

This SBIR topic will address the current shipboard mitigation requirements associated with shipboard integration and performance of metal AM. The product developed from this topic could result in the establishment of a Navy vendor for shipboard AM equipment. In addition, the current modifications, costs, and qualification to Commercial Off the Shelf (COTS) equipment would no longer be required if the system was designed around the shipboard environment. Additive manufacturing has the potential for

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major readiness impacts for the Fleet, improving self-sufficiency and reducing the reliance on the supply chain.

The product will be assessed against the MIL-STDs listed below:

1. MIL-S-901D, Amended with Interim Change #2, Shock Test, H.I. (High Impact); Shipboard Machinery, Equipment and Systems, Requirements for
2. MIL-STD-167-1, Mechanical Vibration for Shipboard Equipment (Type I - Environmental and Type II - Internally Excited)
3. MIL-STD-461F, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
4. MIL-STD-740-2, Structure-borne Vibration Acceleration Measurements and Acceptance Criteria of Shipboard Equipment

PHASE I: Develop a conceptual design of a modular, advanced metal manufacturing unit that can additively fabricate and subtractive machine different alloys, including, but not limited to high/low carbon steels, stainless steels, titanium, and various aluminum series as described in the Description. Show feasibility through analysis, modelling, simulation, and testing. Additionally, consideration to the on-board sensor packages should be identified to support in-situ monitoring of the build process, responsive feedback loops based on print conditions and monitoring, as well as operational envelope awareness to provide corrective action during a build when necessary. Finally, the logistics support trail required to sustain the technology should be identified as part of the conceptual design. Special considerations to consumables, HAMZMAT concerns, maintenance processes, and ancillary equipment requirements should be provided. Provide concepts for safety and equipment environmental (noise, structural vibration, heat output, habitability, etc.) management protocols to ensure safe operation of the sailors during general quarters and equipment operation.

The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Build and deliver a prototype advanced metal manufacturing system optimized for Navy expeditionary environments. The prototype should be characterized using environmental shipboard testing standards as a guide such as vibration (MIL-STD 167), shock (MIL-STD 901), and EMI (MIL-STD 461), and static angle testing. The prototype should demonstrate the ability to additively build the part and subtractive finish the part all within the same unit. The included sensor package should perform in-situ monitoring of each build to inform part certification and establish a report for each build capturing all the processed sensor data, print parameter information, and AM equipment machinery health data. Logistics support requirements, operations and maintenance manual, training, and installation/facility requirements must be provided. The equipment will be installed at a stateside Navy research and development location to be determined.

PHASE III DUAL USE APPLICATIONS: Develop production ready advanced metal manufacturing system optimized for Navy expeditionary environments in at least the smallest and largest configurations as mentioned in the Description. The equipment must be able to operate in the shipboard environment (machine shop or welding spaces) and be able to additively build the part and subtractive finish the part all within the same unit. The unit must meet all requirements stated within the Description. Shipboard installation guide, operations manual, maintenance manual, training, and logistics supply support packages must be included with the unit(s). This machine should have operational conditions established and tracking of the operational conditions to facilitate at-sea printing part certification. A sensor suite must be included to perform in-situ monitoring of the builds, environmental assessment of the ship space conditions (motion/vibration) to inform operation envelope fabrication restrictions, and a "health assessment" of the printed part. Considerations should be given for reducing the logistics footprint required to support the unit and minimize the reliance on the supply chain.

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The results of this SBIR topic will transition to the NAVSEA AM program and will be installed in a shipboard advanced manufacturing lab. It will develop technical authority guidance for qualification and certification in the afloat environment. A Phase III will focus on additional capabilities and acquisition of the system for installation on additional ships under the afloat AM program of record. Commercial applicability of this system could be found in the offshore drilling industry and commercial shipping industry.

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KEYWORDS: Additive metal manufacturing; 3D printing; shipboard Additive Manufacturing; optimized tool-pathing and programming; self-sufficient metal manufacture.

VERSION 8

N221-041 TITLE: Compact High Power Mid-Wave Infrared Laser System

OUSD (R&E) MODERNIZATION PRIORITY: Directed Energy (DE)

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a compact high power laser system that provides broad spectral coverage across both atmospheric transmission windows in the mid-wave infrared band.

DESCRIPTION: Infrared (IR) passive sensors, essentially IR cameras, have been widely used for intelligence, surveillance, reconnaissance, and tracking (ISRT) and are increasingly being deployed for targeting. For both purposes, the mid-wave infrared (MWIR) band is particularly attractive for conditions of poor visibility and for nighttime use. These sensors vary in sophistication but use arrays of photodetectors that are generally sensitive to IR radiation across a wide wavelength band. For high resolution ISRT applications, the detectors are large two-dimensional focal plane arrays (FPAs) with pixel counts in the millions. Driven by energetic research in the area, IR FPA format, efficiency, noise performance, and spectral sensitivity are steadily improving. Targeting sensors may not require such large format detectors but nonetheless benefit from the drive to produce ever larger, more sensitive, and more efficient IR FPAs at lower costs. In either case, the result is the proliferation of increasingly sophisticated, completely passive imaging sensors that can cover the entire MWIR band with high resolution, yet require little electrical power and are, overall, increasingly compact, and affordable.

Comparable active IR systems, whether active imaging sensors, range finders, illuminators, beacons, or robust countermeasures, are not so fortunate. Active IR systems – at least those exhibiting the most basic level of sophistication, require IR lasers as sources. Lasers, whether gas lasers, chemical dye lasers, or solid state lasers, emit radiation at very specific and stable wavelengths. This is one of their chief strengths. For some applications however, this is their chief drawback. Building an active IR laser source that emits across a wide band (a set of multiple discrete wavelengths) is difficult, typically requiring a separate laser for every wavelength desired within the band. True wavelength agility – that is, selecting individual wavelengths “on the fly” or by system presets is expensive because it typically requires complex tuning mechanisms or includes multiple individual lasers that are simply turned off when not needed. For example, a laser illuminator in which individual systems are programmed to emit at certain sub-bands so as to be distinguished from (or not interfere with) other such systems is inherently complex, heavy, and costly, especially if the emitted power is significant. Semiconductor lasers offer some relief since they are inherently compact. However, to achieve appreciable power levels and broad spectral coverage, multiple semiconductor laser diodes must be combined.

Complicating matters, the MWIR spectrum is divided into two main sub-bands separated by a region of virtually complete atmospheric absorption. Even within the sub-bands, atmospheric transmission is still highly variable with changes in absorption occurring with both season and latitude. Passive imaging sensors are not greatly handicapped by this fragmented spectrum of usable wavelengths because they still “see” across all the wavelengths that are transmitted and benefit from time integration of the received IR

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power. However, MWIR lasers, if unfortunate enough to be chosen at the wrong wavelength, simply waste their power trying to burn through atmosphere that is largely opaque to them. Consequently, active MWIR systems must be carefully designed at properly chosen wavelengths spanning the MWIR spectrum (or at least the portions of the spectrum of interest) in order to assure availability of operation. Multiple individual lasers are therefore an unavoidable consequence of agile active MWIR systems.

Multi-laser systems suffer from one additional constraint. To be tactically useful, they should emit a high-quality beam from a single aperture. Good beam quality (near diffraction limited) also provides for optimal system optics and beam propagation and therefore makes maximum use of the available system power. A single, well-formed beam at the output aperture simplifies the beam director, both mechanically and optically, reducing overall system size, weight, power, and cost (SWaP-C). System SWaP-C is often the overriding consideration in how widely a tactical system will be deployed.

The Navy needs a compact, high quality, broad-spectral laser source in the MWIR band. In this context, “laser source” is understood to mean an integrated assembly of individual lasers and beam combining optics. The laser source should cover both MWIR atmospheric sub-bands, nominally 3.5-4.1 microns and 4.6-4.9 microns, with a combined output optical power of 100 W minimum in continuous wave (CW) operation. Alternately, quasi-CW operation is allowable where the laser source is pulsed at a minimum of 100 kHz and a sufficiently high duty factor to achieve 100 W of average power output. The output power may be weighted toward either sub-band but each sub-band must include at least 30% of the total emitted power. Coverage of the sub-band is defined as at least three (more is preferred) discrete spectral lines across each sub-band (while taking into account the objective of maximizing atmospheric propagation). More lines may be chosen so as to spread the power more evenly across the sub-bands or to decrease the power required from each individual laser.

It should be noted that a scalable solution in which spectral lines can be added to future versions of the laser source is highly desirable. Spectral lines should be chosen for maximum atmospheric transmission in a tropical maritime environment as defined by MODTRAN® or an equivalent atmospheric propagation code evaluated for 10 km range at sea-level.

The laser source should have a single output aperture and emit a near-diffraction limited beam with a minimum M2 factor of 2.0 and a goal of 1.5 (M2 is herein defined according to ISO Standard 11146). In order to facilitate the safe testing of prototypes at low average power, the laser source shall include an interface for pulse operation at continuously variable pulse widths (starting from a 5 μ s minimum pulse width) and arbitrary duty factor. Note that, in pulse operation, the entire source (even if a quasi-CW solution is pursued) is intended for pulse operation as a unit, not individual laser lines separately. The laser source may be liquid cooled but note that the volume of cooling hardware (connectors, manifolds, cold plates) present in the source is included in the size goal for the unit. Chillers, heat exchangers, pumps and other cooling hardware required to supply the liquid coolant is considered external to the laser source and does not factor into the size and power budget calculations. Likewise, power supplies and power conditioning units are considered external to the laser source. The laser source has a desired minimum wall plug efficiency (WPE) of 10% where WPE is defined as the total CW (or quasi-CW) optical output power divided by the total electrical power provided to the source from the external power supplies. The laser source should not exceed three cubic feet in volume and gimbals, beam steering, and stabilization systems are not included as part of this effort. Testing will be done by the company in a laboratory environment.

Life-cycle cost is always a fundamental concern and the laser source should therefore be designed with affordable manufacturing, long-term reliability, and ease of use (including maintenance) in mind. Acceptable solutions are therefore assumed to incorporate solid state or semiconductor lasers and multiple-laser solutions should take into account the manufacturing cost associated with the beam

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combiner and the cost implications associated with a scalable architecture (scalable in spectral content and by extension, total power). However, any solution that meets the requirements (including solutions that employ single lasers as sources) is acceptable and, while the goal of this effort is not to produce manufacturing technology, the production cost of the laser source should be estimated and the key manufacturing steps and processes that are identified as cost drivers should be analyzed and prioritized for remediation under a follow-on effort with a goal of \$200K as the per-unit production price.

PHASE I: Propose a concept for a compact high power MWIR laser source that meets the objectives stated in the Description. Define the laser source architecture and demonstrate the feasibility of the concept in meeting the Navy need. Feasibility shall be demonstrated by a combination of analysis, modelling, and simulation. Identify key manufacturing steps and processes and estimate the cost of the laser source in low-rate production (10 units per month). The cost estimate for the concept shall be based on an analysis of key manufacturing steps and processes, their maturity and availability within the industry, the cost and availability of key components, and by comparison to the manufacture of similar items. The Phase I Option, if exercised, will include the laser source specification, test specifications, interface requirements, and capabilities description necessary to build and evaluate a prototype in Phase II.

PHASE II: Develop, demonstrate, and deliver a prototype compact high power MWIR laser source (the laser source plus chiller and the required power supply, pulse drive, and control electronics) based on the concept, analysis, architecture, and specifications resulting from Phase I. Demonstration of the laser source shall be accomplished through production and test of a prototype (or multiple prototypes) in a laboratory environment. The analysis of key manufacturing steps and processes identified in Phase I shall be refined and updated to reflect lessons learned in fabrication and test of the final prototype. The cost estimate for low rate production shall likewise be updated. Multiple prototypes (or partial prototypes) may be produced during execution of this Phase II as the design process is assumed to be necessarily iterative in nature. However, at the conclusion of Phase II, the final (best performing) prototype laser source system demonstrator shall be delivered to the Naval Research Laboratory along with complete test data, the final manufacturing analysis, and final low-rate production cost estimate.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Government use. Identify specific manufacturing steps and processes that require maturation, mature those steps and processes, establish a hardware configuration baseline, produce production level documentation, and transition the laser source into production. Assist the Government in integration of the laser source into next higher assemblies and deployable systems.

The technology resulting from this effort is anticipated to have broad military application. Law enforcement, commercial, and scientific applications include use as sources for laser spectroscopy for chemical detection and identification (detection of explosive compounds, for example).

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KEYWORDS: mid-wave infrared; MWIR Lasers; Laser Source; Semiconductor Lasers; Beam Combining; Wavelength Agility; Atmospheric Transmission

VERSION 8

N221-042 TITLE: Advanced Piezoelectric Materials in Maritime Surveillance Systems

OUSD (R&E) MODERNIZATION PRIORITY: Microelectronics

TECHNOLOGY AREA(S): Sensors

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OBJECTIVE: Integrate recent advances of piezoelectric materials with increased sensitivity and investigate innovative new sensor designs for robust deep water passive sensors.

DESCRIPTION: The current passive acoustic sensors used in Maritime Surveillance arrays are based on conventional piezoelectric materials. The current sensors employed in arrays include omni-directional hydrophones and multi-axis vector sensors. These are strung together similar to towed arrays used by the submarine fleet but are slightly larger in size. The Navy wants to enhance the current sensors with the latest developments of advanced piezoelectric materials and investigate innovative sensor designs enabled by these new piezoelectric materials, to provide enhanced sensitivity and lower noise floor in an equivalent, or smaller, size package. Any new sensor designs must maintain resiliency to extreme hydrostatic pressures (full ocean depth is an objective) and low deep ocean temperatures (nominally 3°C), across a range of frequencies; robustness to deployment shock (lightweight equivalent within MIL-S-901) and accelerations (on the order of 100g as would be experienced during deployment, and the transportation vibration requirements as per MIL-STD-167); and robustness to temperature shock from 100°F to 0°F. An end-to-end solution utilizing innovative packaging methodologies to reduce overall sensor form factor to facilitate array deployment in conjunction with the advanced sensors is a significant part of this SBIR research and development effort. The enhancement in sensitivity (> 8 dB re VRMS/μPa) and reduction in low frequency noise floor (> 5 dB re μPa/vHz) are primary components of this effort. These benefits will enable greater detection ranges and greater areas of sensing coverage, which can reduce operating hours on deployment handling equipment and provide a timely modernization of fixed sensor systems used within the U.S. Navy. The ultimate design will be measured against the existing family of acoustic sensors utilized across the Maritime Surveillance portfolio. The measurements will include acoustic calibration at a certified Navy test facility; the environmental robustness would be evaluated at a qualified test facility with the ability to evaluate against the requirements mentioned above: temperature, shock, and vibration.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

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PHASE I: Provide a concept and demonstrate its feasibility to achieve the Navy's goals. The primary objective is to develop a concept for a passive acoustic sensor that meets the requirements outlined in the description. The design will include details of the acoustic sensing mechanism and associated pre-amplifier network (if required). The feasibility of the design will be established through modeling and simulation. The Phase I Option, if exercised, will include the specifications, and anticipated (i.e., modeled) performance characteristics to build the prototype in Phase II.

PHASE II: Develop and deliver a prototype system(s) for testing and evaluation based on the results of Phase I. The evaluation and testing of the prototypes will be based on the requirements stated in the maritime surveillance performance specification, which includes contractor's low-level subassembly performance tests. This maritime surveillance performance specification will be provided to Phase II awardee. Evaluations and testing will include acoustic evaluation, both under ambient conditions and under hydrostatic and temperature stresses. As such, a total of 10 prototypes will be provided as deliverables. Initial testing will be the responsibility of the executing company, while follow-on testing will be the responsibility of the Navy, with the company's assistance.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. Provide engineering support for full environmental testing, which could include low temperature thermal dwell testing, lightweight shock testing, vibration analysis, and additional acoustic evaluation testing. There is potential for some of this testing to occur in Phase II. During Phase III, a minimum of ten prototypes is anticipated to be utilized in at-sea demonstrations to assist in the full circle environmental evaluation of the design.

Some alternative Naval applications include sonobuoys, and alternative acoustic sensors residing on manned and unmanned platforms. Some commercial applications include marine mammal acoustic detection arrays and geological exploration receive arrays. This support is expected to be in the form of follow-on prototypes incorporating any lessons learned from the Phase II acoustic testing.

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KEYWORDS: Piezoelectric sensors; Maritime Surveillance; Deep-water sensing; Bottom-mounted sensors; Sensor arrays; Deployed sensors

VERSION 8

N221-043 TITLE: Enhanced Performance Radome Materials for High Speed Missiles

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Materials / Processes

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OBJECTIVE: Develop a common radome architecture for multiple future missile systems which provides a significant increase in thermo-structural capability while maintaining electrical performance across wide frequency bands.

DESCRIPTION: Evolving weapons technology is driving advanced missiles (supersonic and hypersonic) and other flight vehicles to greater speeds and higher accelerations. Consequently, existing materials do not exist to answer the problems being caused. The result of increased speed and acceleration is higher temperatures and thermal stresses. For instance, vehicles traveling over Mach 4 reach surface temperatures of 1,500°C or higher. Rapid acceleration results in extreme thermal gradients, translating to high stresses. Flight through adverse weather such as rain or sleet, and sand and dust add additional environmental hazards which must be survived. These conditions, resulting from the evolving technologies, will require changes in materials to meet or exceed requirements to negate the effects on missile radomes. There are specific material properties, namely dielectric constant and loss tangent, which need to be low (preferably below 5 and .05 respectively). An innovative solution may consider both advanced materials and existing state-of-the-art materials. Existing materials include slip cast fused silica, oxide ceramic matrix composites, and various forms of silicon nitride. Current materials suffer inadequacies including low thermostructural robustness, excessive electrical property variation with temperature, and excessive heat conduction through the radome. Radome materials must provide for stable performance over the duration of its flight. Thermal shock is particularly difficult and can cause expansion of the outer surface during acceleration, thereby impacting both electrical performance and material structural integrity.

A critical component of future Navy missile concepts is a radome that will operate while exposed to high temperatures (~2400K) in a harsh flight environment while maintaining legacy strength and Radio Frequency (RF) transmission properties, surpassing both the capabilities of legacy radomes and current commercially available materials. It is desired that this future radome will have a common design architecture which will allow use across multiple missile types, and reduce production costs by eliminating multiple radome types. With these objectives in mind, the U.S. Navy seeks a radome design that utilizes proven materials and manufacturing methods, but also material innovations to provide increased thermal survivability while minimizing temperature-related RF performance loss.

Concepts are sought to significantly enhance the survivability of radomes while maintaining the required RF performance. Novel constructs are envisioned that build upon current state-of-the-art with material additions, substitutions, or layering. Novel new materials, or novel combinations of known appropriate materials, may be considered. It is preferred that materials with known properties be incorporated into the proposed solution to potentially reduce the time to meet the technology readiness. Proven

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manufacturability and properties will be favorably considered. Advanced and novel materials could be integrated into the basic structure and/or added as additional elements or layers.

Selection and fabrication of these advanced materials to achieve novel constructs is desired. In-depth characterization and testing are critical for elucidating the mechanisms to achieve advanced survivability. Some critical considerations for any such RF radome system include electrical properties (dielectric constant, loss), thermal properties (conductivity, emissivity), structural properties across the service temperature range, and a manufacturing approach which allows for tight control of shape, size, and thickness. The awardee must propose adequate test protocols to demonstrate suitability of the proposed technology to satisfy Navy requirements. Testing can be conducted on coupons combined with modeling, or on notional prototypes. The solution must show resiliency in high temperature mechanical tests, thermal shock tests, electrical tests, non-destructive testing, and microstructural examinations.

High temperature RF property measurements of the radome materials will be needed for use in radome-level models. Tradeoffs between materials that are optimal for thermal survivability and those that are optimal for radome function will likely be encountered, requiring material development iterations. To optimize performance in all aspects, materials can be tailored in chemistry, thickness, and density.

PHASE I: Develop a concept for a common radome architecture that meets the parameters in the Description. Demonstrate that the concept can feasibly meet the requirements through analysis, modeling, and experimentation of materials of interest. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver notional full-scale prototypes (minimum of two) that demonstrate functionality under the required service conditions including thermal and mechanical stresses. Demonstrate the prototype performance through the required range of parameters given in the Description.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use in the STANDARD Missile program. Support the manufacturing of the components employing the technology developed under this topic and assist in extensive qualification testing defined by the Navy program. It is likely that the Phase III will involve classified information.

Potential commercial uses for high temperature radome performance improvements exist in the commercial spacecraft and aircraft industries and satellite communications.

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KEYWORDS: Radomes; Advanced Missiles; Thermal Shock; Radio Frequency; RF; RF Transmission; Supersonic; Hypersonic

VERSION 8

N221-044 TITLE: Compact, High Performance Mid-Wave Infrared Sensor for Intermittent Deployment

OUSD (R&E) MODERNIZATION PRIORITY: Microelectronics

TECHNOLOGY AREA(S): Sensors

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OBJECTIVE: Develop a compact and high performance mid-wave infrared (MWIR) imaging sensor for intermittent deployment on Unmanned Aerial Vehicles (UAV) in environments where attrition is expected.

DESCRIPTION: Infrared (IR) imaging sensors (IR cameras) are especially useful for intelligence, surveillance, reconnaissance, and tracking (ISRT) missions as well as target acquisition for weapons and fire control systems. The mid wave infrared (MWIR) band is particularly attractive for conditions of high humidity, poor visibility, and nighttime use. Highly sophisticated MWIR cameras are expensive but fully justified when deployed to high-value platforms such as surface warships and combat aircraft and where exists the near certainty that the platform will be recovered, such as with large UAVs. In these cases, not only must the MWIR imaging sensor meet extensive performance requirements (i.e., field of view, resolution, sensitivity, frame rate, slew rate, stabilization) but expectations for continuous use over long periods as well.

Not every application demands both the full range of performance and the requirement for repeated long-term operation. There are many instances when an imaging sensor of modest performance, compact size, and low cost can perform much needed, but short duration tasks. For example, a small UAV with a suitably chosen imaging sensor can be launched from virtually anywhere to “pop up” and view targets that are still over the horizon for mast-mounted sensors. Small UAVs can be sent out to closely monitor and interrogate suspect vessels, floating debris, and indented shorelines, inlets, coves, and other littoral waters hidden by barrier islands. These missions are, by nature, intermittent and of typically short duration. These missions also have a high probability of loss of the UAV due to weather conditions, enemy action, or errors made during recovery. Consequently, the imaging sensor, like the UAV, must be very affordable.

The affordability of any imaging sensor is improved by trading off performance. Native resolution – that is, pixel count of the Focal Plane Array (FPA), can be reduced if the sensor is intended to approach the target of interest. For the same reason, large aperture, long focal length, and zooming lenses are not required. Acceptable image stabilization can be achieved electronically and the sensor can be aimed by maneuvering the UAV, simplifying the sensor mount. Taken collectively, these trade-offs can greatly reduce the sensor cost. Decreasing the specifications for environmental ruggedization and operational durability normally required of military systems results in a system (sensor plus small UAV) that is highly compact, affordable, energy efficient, easily manufactured, and therefore widely deployable.

This is already the case for small UAVs fitted with cameras for amateur and commercial photography in the visible spectrum. However, comparable systems for imaging in the IR suffer from additional factors

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that drive up cost substantially. IR FPAs (and especially MWIR FPAs) are comparatively expensive. In addition, to achieve acceptable imaging, MWIR FPAs must also be cooled to elevated cryogenic temperatures, most typically between 120 K and 150 K (depending on FPA material and wavelength cutoff). Consequently, the basic MWIR sensor package (not including the image processor and mounting and positioning hardware) incorporates the FPA, the read-out integrated circuit (ROIC), the optics, and the cooling hardware in a tightly integrated package. The cost is typically an order of magnitude more than for a comparable imaging sensor (comparable in format and resolution) in the visible spectrum.

Recent improvements in MWIR FPA technology have resulted in small pixel (8 micron or less) FPAs that have lower manufacturing cost. However, the use of smaller pixels requires faster (larger) optics to maintain sensitivity comparable to the larger pixel technology. So the cryo-cooler becomes the dominant cost component and the optics become the dominant weight component. However, being typically used in large, expensive, and high performance IR cameras, neither component has benefitted much from targeted research designed to reduce cost and weight.

The Navy needs a low cost, highly compact, and energy efficient MWIR imaging sensor package for intermittent, short duration missions where attrition is expected. In this context, “sensor package” is understood to include the FPA, ROIC, cryo-cooler, optics, and the enclosure that isolates the cooled components from the outside ambient temperature. The FPA must have a format of at least 1000 x 1000 pixels with small pitch (8 microns or less) and be integrated with a ROIC having the capability for high dynamic range (using variable integration time). The sensor is required to be able to focus to a blur spot of no larger than 1-2 sensor pixels in each direction. The full framerate must be at least 60 frames per second with the capability to increase the framerate to 240-1000Hz in small Regions of Interest (ROI) with addressable windowing.

Innovation is desired that fundamentally reduces the size and weight of the optical components. For the defined FPA format and pixel pitch, a 6° field of view (FOV) with conventional optics (lenses) is considered typical and is taken as the benchmark for comparison of sensor performance and Size, Weight, and Power and Cost (SWaP-C) where the power is understood to be the power required by the cryo-cooler and the FPA/ROIC pair. Solutions may incorporate gradient index optics, flat optics, microlensing, or other techniques that meet benchmark performance while reducing SWaP-C.

The integration of the FPA and ROIC with an affordable, compact, and efficient cryo-cooler is considered the key challenge in this effort. Because it has mainly been used for sophisticated, persistent systems, available cryo-cooler technology is typically specified for 10,000 to 20,000 hours of Mean Time Between Failure (MTBF). This results in greatly overpriced coolers for platforms whose total operational time will likely be less than ten hours accumulated during a handful of mission deployments. Specifically, the operational MTBF of the desired sensor package is relaxed to a value of 500 hours. The 500-hour MTBF is specified as “operational” to distinguish from the period of time that the sensor package is expected to sit unused between missions. In addition, when between missions, the sensor package must sit “cold”. That is, no power shall be required to maintain the functionality and reliability of the sensor package when not in use. The sensor package must also be cable of imaging at full performance within a minimum 120 seconds of deployment in ambient temperatures ranging from -5 °C to 45 °C. The time from deployment to operation is assumed to be determined by sensor cool-down and solutions that minimize this time are highly desirable (below 60 seconds is a goal). The attritable nature of the mission set anticipates no more than ten operational deployments before loss. However, to accommodate periodic system checks, training, and aborted missions, the sensor package should be designed to withstand 100 on-off cycles before failure with 99% confidence. Mission duration is not anticipated to exceed 60 minutes.

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The benchmark for cooling is 120-150 K, consistent with HgCdTe, nbn, or Strained layer Superlattice (SLS) background-limited High Operating Temperature (HOT) FPA technology. FPAs that operate at warmer temperatures are acceptable but the solution must convincingly demonstrate that the warmer sensor package meets or exceeds the performance, size, weight, and (especially) cost of a same size, format, and pitch HOT FPA, properly cooled and operated. The sensor package must be a closed system, only requiring external electrical power and data lines for operation. The most compact and efficient solution is desired and design for depot-level repair is not needed. Solutions that require pre-mission preparation, recharging of cooling fluids, periodic field maintenance, or specialized storage conditions are unacceptable. The 1.0 megapixel FPA is defined as the minimum size of interest for the anticipated mission set. It is also chosen as a reasonable size for demonstration. The solution however should be scalable (upward) in size with proportional increases in size, weight, and power consumption. No fundamental limit should restrict the technology to the 1.0 megapixel format and the optics should allow for individual designs with different (fixed) fields of view in the range 3° to 10° (minimum). Within these limits, any cooling technology is acceptable. A final projected sensor package cost (for the 1.0 megapixel-size sensor package, including the cryo-cooler) of \$2000, when produced in quantities of 1000 or more, is the goal.

The sensor package will be demonstrated by fabrication, testing, and delivery of at least two successful prototypes. The sensor package does not include power supplies, the image processing board, static mounting hardware, or the display. However, these items must be delivered for successful demonstration of the prototype. The electrical inputs and outputs of the sensor package shall be commercially available connectors and the connectors are considered an integral part of the sensor package.

PHASE I: Propose a concept for a MWIR imaging sensor package that meets the parameters stated in the Description. Demonstrate the feasibility of the concept in meeting the Navy need through a combination of analysis, modeling, and simulation. The Phase I Option, if exercised, will include the sensor package specification, preliminary optics design, interface requirements, performance test specification, reliability test plan, and capabilities description necessary to build and evaluate a prototype solution in Phase II.

PHASE II: Develop and demonstrate a prototype MWIR imaging sensor package based on the concept and specifications resulting from Phase I. Demonstrate the prototype meets the parameters described in the Description through testing in a laboratory environment. The laboratory environment will be provided by the company. Multiple prototypes (or partial prototypes) may be produced during execution of this effort as the design process is assumed to be necessarily iterative in nature. However, at the conclusion of Phase II, two final (best performing) prototypes will be delivered, one with a 3° FOV and one with a 6° FOV, to the Naval Research Laboratory (NRL) along with complete test data and final manufacturing cost estimates. The image processing board, display, and any specialized fixturing or equipment necessary to replicate testing of the prototype sensor packages shall also be delivered to NRL.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Government use by scaling the technology to meet specific sensor program requirements and identifying specific manufacturing steps that require maturation, maturing those steps and processes, establishing a hardware configuration baseline, producing production level documentation, and transitioning the sensor package into production. Assist the Government in integration of the sensor package into next higher assemblies and deployable systems.

The technology resulting from this effort is anticipated to have applications in law enforcement, security monitoring, search and rescue, and remote imaging applications for commercial and scientific programs.

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KEYWORDS: Imaging Sensors; MWIR Imaging; Cryo-Cooler; Focal Plane Array; Gradient Index Optics; Microlensing

VERSION 8

N221-045 TITLE: Fiber Optic Cable for Radio Frequency Over Fiber Links

OUSD (R&E) MODERNIZATION PRIORITY: Networked C3

TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a military fiber optic cable for analog optical communication operating at no less than 45 GHz in air and sea platform fiber optic links.

DESCRIPTION: Current military shipboard and aerospace platform communications and electronic warfare systems require ever-increasing bandwidths while simultaneously demanding reductions in space, weight, and power (SWaP). The replacement of shielded twisted pair (STP) wire and coaxial cable with earlier generation length-bandwidth product multimode optical fiber has given increased immunity to electromagnetic interference, bandwidth, and throughput, and a reduction in size and weight. To address the emerging needs of radio frequency (RF), microwave and millimeter-wave applications to route and process increasingly high-frequency signals, photonics, and fiber optics play an important role in future military shipboard and aerospace platform applications. Polarization modulation with interferometric detection and balanced intensity modulation with direct detection (IMDD) provide advantages over conventional IMDD links.

In order to realize polarization modulation and balanced IMDD photonic link technology on military platforms, polarization maintaining and multi/dual-core fiber optic cable development and qualification is required. Shipboard and aerospace optical fiber and fiber optic cable share military specifications. MIL-PRF-49291/11 [Ref 1] describes modern examples of single mode optical fiber for shipboard and aerospace application. MIL-PRF-49291/11 specifies 8.2 to 9.5 μm mode field diameter (at 1,310 nm) and from 9.4 to 10.5 μm mode field diameter (at 1,550 nm) single mode fiber. Two operating temperature ranges are specified (-46 to +85°C and -55 to +165°C). Maximum macro-bend attenuation at 1,550 nm is 0.03 dB for ten turns around a 30 mm diameter mandrel. MIL-PRF-49291/7D describes modern examples of single-mode optical fiber for shipboard and terrestrial applications.

MIL-PRF-85045/16 [Ref 2] and MIL-PRF-85045/31 [Ref 3] are modern examples of fiber optic cable for shipboard and aerospace application, respectively. Two cable operating temperature ranges are specified (-40 to +85°C and -55 to +165°C). Short-term minimum bend diameter is eight times the cable outer diameter and long-term minimum bend diameter is 16 times the outer diameter. The maximum cable attenuation rate for cable with 9/125 μm single mode fiber is 1.0 dB/km at 1,310 nm, 1.0 dB/km at 1,383 nm, and 0.75 dB/km at 1,550 nm.

Shipboard and aerospace military installation requirements are well defined. No military specifications address polarization maintaining and dual-core optical fiber cable types. Innovation is needed to demonstrate military qualifiable polarization maintaining and dual-core fiber optic cables. One aspect of this research is to specify related optical fiber design and qualification test considerations relating to polarization maintaining and dual-core fibers. Another aspect of this research is to compare conventional

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single-mode fiber and fiber optic cable, as specified in MIL-PRF-49291 and MIL-PRF-85045, to polarization maintaining and dual core fiber optic cables with respect to military specification and application to polarization modulation and balanced IMDD photonic links. The testing will be defined in the MIL-SPEC, which is an output of proposal and early phase of effort. Testing to be done by SBIR awardee. Using data from this research effort, the Navy seeks to create new fiber and cable specifications and update MIL-STD-1678, MIL-PRF-85045, and MIL-PRF-49291.

PHASE I: Develop a concept for polarization maintaining and dual-core fiber optic cables for military and commercial applications. Demonstrate the feasibility of fiber optic cable designs, showing the path to meeting Phase II goals. Design polarization maintaining fiber optic cable prototypes that are compatible with distributed feedback laser outputs and high-speed electro-optic modulator inputs. Design dual-core fiber optic cable prototypes that are compatible with balanced photodetector inputs. Demonstrate the feasibility of the concept to meet the described parameters listed in the Description through modeling, simulation, and analysis. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype fiber optic cable design optimized from Phase I. Build the fiber optic cables to meet performance requirements described in the Description and draft specification planned for publication in MIL-PRF-85045 and MIL-PRF-49291. Test the fiber optic cables. If necessary, perform root-cause analysis and remediate fiber optic cable failures. Deliver fiber optic cables to the Navy.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use by verifying and validating the cable performance for transition to military and commercial fiber optic platforms. Commercial sector telecommunication systems, fiber optic networks, and data centers optical networks could benefit from the development of Polarization Maintaining and Dual-Core Fiber.

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KEYWORDS: Multicore Fiber; Polarization Maintaining Fiber; Fiber Optic Cable; Radio frequency; RF; Single Mode Fiber; IMDD photonic link technology

VERSION 8

N221-046 TITLE: Velocity-Over-Ground Sensor for Inertial Navigation System Error Reduction

OUSD (R&E) MODERNIZATION PRIORITY: Autonomy

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a velocity-over-ground sensor capability that accurately and covertly measures velocity relative to the ground for surface and subsurface naval platforms.

DESCRIPTION: Nearly all Navy platforms rely on Inertial Navigation Systems (INSs) to provide continuous position, attitude, and velocity information for accurate navigation. Without periodic external fix aiding, INS errors grow with time. However, INS errors can be controlled and reduced by employing various external position and velocity sources to bound and reduce errors. For example, use of velocity damping mechanisms can reduce velocity errors, which, when integrated, are the cause of navigation position errors. Ships systems integration enables the INS to receive Global Positioning System (GPS) updates to correct its velocity and position estimates and to detect sensor biases, but when GPS is unavailable, the system must rely on alternative sensors to maintain accuracy.

Currently, when GPS is not available, the electromagnetic log serves as this reference velocity source through the measurement, processing, and feedback of speed-through-water to the INS. Electromagnetic logs are reliable, passive, and covert, but they measure speed relative to surrounding water, rather than speed relative to the ground, and are subject to ocean currents and environmental distortions due to salinity, aeration, and temperature. The GPS, when unavailable, and electromagnetic logs are not adequate in providing velocity information for continual accurate navigation and currently there are no other solutions to fill the need. The velocity-over-ground sensor will complement, and in some cases, replace more conventional electromagnetic logs. In many operational scenarios, the velocity-over-ground sensor will enable superior navigation above and below the surface.

The Navy needs an innovative sensor that can determine velocity relative to the ground in the oceanic environment and under operating conditions typical to surface and subsurface naval vessels.

Typical conditions include:

- Operating speeds in the range of 0 to 20 knots
- Operational range/altitude from 10 to 6000 meters
- Roll/pitch changes from $\pm 5^\circ$ to $\pm 20^\circ$
- Sea floor type variations from sand/gravel to mud
- Water temperature in the range of 0°C to 30°C

The sensor may use any signal, modeling, or processing technique so long as it maintains a long-term velocity root-mean-square accuracy in the range of 0.2 m/s to 0.7 m/s. The specified accuracy range is a function of the minimum and maximum operating and environmental conditions described in the bulleted list above. For instance, the larger velocity variance is attributed to the maximum operating range, and

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vice versa. The sensor prototype may also utilize an external inertial navigation system as a co-sensor in a loose or tight coupling configuration, but target the same performance goals with size, weight, and power profile = 0.1m³, 100kg, 100W. The proposed sensor prototype will be compared with conventional sensors and evaluated based on how well it performs under the typical conditions outlined.

Absent from the list are specific covertness metrics; however, covert operations are a significant attribute to subsurface naval operations. Conventional acoustic sensors can employ covert transmissions and avoid host vehicle detection with use of high transmit frequencies which demonstrate higher seawater absorption compared to lower frequency devices. However, conventional high-frequency sensors remain limited in their range of operations, limiting use to shallow waters. In this regard, there are design considerations such as signal bandwidth, transmit power, beam width, and unique wave forms, as well as transmitted acoustic frequencies that offer a trade space in performance. Covertness considerations, such as ocean bottom bounce impacts, bottom backscatter loss, transmit side-lobes, and noise, should be incorporated in the prototype sensor concept design process. Furthermore, the sensor prototype should be able to provide an underwater vehicle with velocity-over-ground without surface expression, enabling superior navigation in operational scenarios both above and below the surface.

As noted, acoustic sensors are potential solutions to this problem, but the standard Doppler velocity log (DVL) and correlation velocity log (CVL) approaches have downsides. Projecting acoustic waves into the environment broadcasts the location of the vessel and requires many assumptions about the sea floor which may not be valid in certain instances. An ideal acoustic sensor would compensate for operating depth, roll, pitch, sea floor bathymetry, or other relevant factors by combining different operational concepts with innovative methods and models. Currently, no generic acoustic solution exists. At-sea testing will be scheduled by the Government for using an inertial navigation system comparable to the WSN-7.

This product will find its greatest use in surface and subsurface environments where GPS is unavailable or degraded, and where highly accurate positioning is necessary. While velocity-over-ground measurements have proven applicable in Remotely Operated Vehicle (ROV), Autonomous Underwater Vehicle (AUV), and towed vehicle navigation, the sensor prototype sought here supports inertial navigation correction and integration in large-scale naval platforms capable of surveying 95% of the world's ocean depths.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a concept for a velocity-over-ground sensor that meets the parameters in the Description. Demonstrate its technical feasibility using analytical models, simulations, and testing. The modeling effort should consider a list of potential noise sources and characterize their potential impact on the overall measurement accuracy of a hypothetical sensor. Develop a trade space analysis to identify optimal covertness while achieving performance targets. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

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PHASE II: Develop and deliver a prototype velocity-over-ground sensor based on the results of Phase I. Demonstrate the prototype meets the parameters of the Description through initial laboratory testing to confirm the design, functioning of components, and physical model underlying the theory of measurement for the sensor.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Assist the Navy in transitioning the velocity-over-ground sensor prototype through testing and further development to facilitate the adaptation of the technology to Navy use. The final product will be tested and verified according to the relevant military specifications for Navy use.

The technology is expected to be of use in the commercial manufacturing industry for AUVs for exploration and other sea floor uses.

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KEYWORDS: Correlation Velocity Log; Electromagnetic Log; Doppler Velocity Log; GPS Challenged Environments; Inertial Navigation; Velocity-over-Ground Sensor

VERSION 8

N221-047 TITLE: Over The Shore Messenger Line Delivery System

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Battlespace Environments

OBJECTIVE: Develop autonomous Over the Shore (OTS) refueling capabilities to make an initial connection to shore without putting manned surface craft in the surf zone. Develop a messenger line delivery system that will enable rapid and minimally manned deployment of OTS refueling hose systems.

DESCRIPTION: The first and most difficult aspect of delivering Navy fuel OTS to support Expeditionary Advanced Base Operations (EABO) is to make the connection from vessel to shore. For some new OTS systems, this is done with a messenger line using legacy line delivery methods that are complex, delay system deployment, and require additional manpower. Kinetic line firing equipment does not have sufficient range to reach from the fuel delivery vessel to shore. Deploying craft in the surf zone is manpower intensive, dangerous, and subject to surf restrictions. The currently fielded system uses craft that are large and difficult to store and maintain as capabilities to be readily available from a smaller fuel carrying vessel.

Multiple technologies exist that may safely and easily deliver the messenger line to shore, but need further development to be adapted to this specific application. The delivery system must be capable of handling the forces acting on it by the messenger line and survive the littoral environment from the vessel to shore at distances up to 2,000 feet. Some level of automation should be customized for this application to further reduce manpower requirements for system deployment. The system should not require physical human interaction after deployment and until the messenger line is received by shore side personnel or equipment and the system has confirmed that the line was received.

A successful concept will enhance OTS fuel delivery capabilities, reducing deployment time, manpower requirements and complexity while increasing personnel safety, reliability, efficiency, range, accuracy, and overall performance. The concept should demonstrate the potential to be applied to any ship or fuel carrying asset designed to provide OTS fuel delivery.

The OTS Messenger Line Delivery System must provide the required tension to pull a 6mm High Molecular Weight Polyethylene (HMPE) messenger line a minimum of 2,000 feet autonomously from ship to shore in less than 30 minutes to within a 3ft radius of a specified marked point and confirm that the messenger line has been received by shore side personnel before returning to its point of deployment. The system design may directly pull the messenger line from ship to shore or may pull a pilot line to allow shore side personnel to reel in the pilot line and tow the messenger line. A pilot line must withstand 500 lbs of tension with a safety factor of 3-5 to survive open ocean sea state 3, associated surf state conditions, currents of 2 knots, and winds up to 35 knots in a corrosive marine environment in air temperatures from -40 to 140°F and water temperatures from 29 to 95°F. The system should be fully deployable by two or fewer people. Demonstrate capability to successfully complete three consecutive deploy, deliver, return cycles with necessary maintenance performed by two or less people in 10 minutes or less between each cycle. Support the Navy's testing in a relative environment to certify and qualify the system for Navy use.

PHASE I: Develop a messenger line delivery system concept to transfer a messenger line from a host vessel to shore at distances of at least 2,000 feet, meeting the objectives stated in the Description.

The concept development effort shall consist of an analysis of alternatives for the delivery system, a breakdown of major system components, a rough order of magnitude (ROM) cost estimate for prototype

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development, a detailed concept of operations (CONOPS), and a discussion of how automation will be optimized to reduce manpower requirements. Show feasibility through analysis, modelling, simulation, and testing.

The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II, along with identification of long lead materials.

PHASE II: Based on the results of Phase I and the Phase II SOW, develop and deliver a full-scale prototype for evaluation in a representative environment demonstrating capabilities as listed in the Description. The prototype will be evaluated to determine its capability in meeting the performance goals defined in the Phase II SOW and the Navy requirements for the OTS Messenger Line Delivery System. System performance will be demonstrated through prototype evaluation and modeling or analytical methods over the required range of parameters including numerous deployment cycles. Evaluation results will be used to refine the prototype into a mature design that will meet Navy requirements. Assess integration and risk and develop a Software Development Plan (SDP). Prepare a Phase III development plan to transition the technology to Navy use, including a cost estimate for Phase III.

The Phase II Option, if exercised, will include further testing of the prototype system deployed on a Navy vessel.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Navy use. Refine an OTS Messenger Line Delivery System for integration and evaluation to determine its manufacturability and effectiveness in an operationally relevant environment. Support the Navy for test and validation to certify and qualify the system for Navy use.

Line firing guns, the current technology used to deliver messenger lines from ship to shore, are commonly used in many industries, including utilities, fire and rescue squads, commercial fishing, shipping, and oil companies. Technology developed during this effort could potentially be introduced in any of these industries as an alternative with longer range and more capabilities than line firing guns.

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KEYWORDS: Unmanned; Surf Zone; Rapid Deployment; Messenger Delivery Line; Autonomous; Fuel Delivery

VERSION 8

N221-048 TITLE: Well Deck Securing System for Landing Craft Utility

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop a maintenance-free securing system that can reliably secure Landing Craft Utility (LCU) vessels in the well deck of Navy Amphibious Class Ships in extreme sea conditions.

DESCRIPTION: Overview: L-Ships embark, transport, deploy, command, and fully support all elements of a marine expeditionary unit (MEU) of 2,000 marines, inserting forces ashore via helicopters and landing craft such as LCUs. This capability enables the Navy and Marine Corps team to accomplish a seamless transition from the sea to land to support ground forces on enemy territory by an amphibious assault.

Operation: LCUs weigh approximate 256 Long Tons when empty and 428 Long Tons when fully loaded and are transported to designated operating areas in the well decks of amphibious ships (L-ships). L-ships are capable of lowering the aft end of the ship to a depth of up to 10 ft at the stern ramp to float craft into and out of the well deck. The well deck is then pumped dry and then timber shoring and chain lashing is installed to secure the craft. The desired craft stabilization system must be able to secure the craft in robust sea state conditions. Excessive flexing of the ship can result in the legacy shoring falling loose with possible catastrophic results.

Current state: The legacy shoring system for the LCUs consists of high maintenance timber supports installed between the hull of the craft and the L-ship's well deck bulkheads and metal lashings. Each support is comprised of lengths of fire retardant timbers which are cut in place and assembled in various configurations. There are five 6" x 6" shores per side for a total of 10 per craft, or three 8" x 8" shores per side for a total of six per craft. A 8"x8" timber 15 feet long weighs approximately 215 to 250 lbs. There are then 11 lashings per side for a total of 22 per craft. The length of the timbers is determined by the location of the LCU in the well deck and must be one piece. With the difficulty to position the LCU in the exact same location every time, timbers are eventually trimmed to the extent that they become too short for most installations and need to be discarded. Cutting and installing the timbers and installing the lashings is cumbersome, a personnel hazard, and very time consuming.

Requirements: An alternate securing system that can quickly secure the craft is needed. The securing system will need to be able to secure a 482 LT LCU in a well deck in sea states up to Sea State 8. The securing system will need to be easily adjustable, simple to operate, and can stow the LCU in less than 3 hours. Concepts previously looked at include metal "timbers", air bags, tie rods, and friction mats. These concepts have been proposed but none have been prototyped on a ship.

PHASE I: Define and develop a concept for securing an LCU in the well deck that meets the requirements as stated above. Demonstrate the feasibility of the concept in meeting the Navy needs and establish that it can be developed into a useful product for the Navy. Feasibility that the LCU Securing System concept can be readily manufactured will be established by material testing and analytical modeling.

The Phase I Option, if exercised, will include the initial design specifications and a capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I effort and the Phase II Statement of Work (SOW), develop and deliver a prototype LCU Securing System. The prototype will be evaluated to determine its capability in

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meeting the performance goals defined in the Phase II SOW and the Navy requirements for adjustability, simplicity, weight, and maneuverability. System performance will be demonstrated through prototype evaluation including shipboard testing and modeling or analytical methods over the required range of parameters. Evaluation results will be used to refine the prototype into a design that will meet Navy requirements. Prepare a Phase III development plan to transition the technology to Navy use.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the system to the amphibious ships with well decks. Transition opportunities for this technology include commercial ship and offshore systems that must secure heavy cargo in extreme conditions.

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KEYWORDS: Shoring; Landing Craft Utility; Well Deck; Amphibious Ships; Legacy shoring system; Lashing

VERSION 8

N221-049 TITLE: Radar Absorbing Material Maintainability Improvements

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Materials / Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop innovative and durable materials to support the installation and maintenance of Radar Absorbing Material (RAM).

DESCRIPTION: The DDG 1000 class was designed for stealth operation utilizing Radar Absorbing Material (RAM). The RAM tiles currently have an environmental layer material designed to protect the tile from the elements such as Ultraviolet (UV), wind, rain, snow, etc. In-service experience has shown that the environmental layer begins to peel off at the edges within two years and if not serviced will completely peel off, thereby leaving the tile exposed to the elements, which degrades the performance of the material. The newly developed environmental layer should last three years, threshold, with an objective of a seven year lifespan. The environmental layer material is estimated to be about 60% of the total cost of the tile. Installation of current environmental layer is a depot level repair requiring trained technicians. There is nothing currently in the commercial market that meets the requirements.

Maintenance of RAM has been identified as an area of concern due to its use on topside components and specialized work requirements. Development of new materials that support crew maintenance and non-specialized installation procedures will lower life cycle maintenance costs and increase supportability of RAM. Navy desires development of novel environmental layer materials, including a glue and filler system for repair. Environmental layer should be able to be installed by a sailor with limited training and provide a 50% reduction in installation labor.

All proposed materials must be non-radar reflective and are expected to withstand temperatures of -25 to 50°C, wind gusts of 100 knots, and solar radiation of magnitude 1120 W/m² as defined in MIL-HDBK-310 and MIL-STD-810F, method 505. Prototype material will undergo performance testing to quantify radar transmissibility. Material composition will be finalized through environmental and qualification testing.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

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PHASE I: Develop prototype materials in accordance with the specifications and requirements outlined in the topic Description section. Demonstrate the feasibility of fabrication through the production of material. The Phase I effort will include plans for the prototype development of proposed technology during Phase II.

The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Refine and deliver prototype materials to undergo performance testing to quantify radar transmissibility. Material composition will be finalized through environmental and qualification testing in accordance with requirements. Fabrication process and installation procedures will be developed with a focus on aiding transition into Phase III. Prepare a Phase III development plan to transition the technology for Navy and potential commercial use.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the material to DDG 1000 class destroyers. Support development of documentation including, but not limited to; technical manuals, parts lists, drawings, training guides, installation procedures, and logistics documents.

Commercial transition of this technology can be applied to aircraft, aerospace, ships, communications, and construction. Markets which focus on electromagnetic wave transmission and absorption such as cellular and communication towers would benefit from the developed materials.

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1. Gaylor, Kevin. Radar Absorbing Materials – Mechanisms and Materials. Australia: DSTO Materials Research Laboratory, 1989. <https://apps.dtic.mil/sti/citations/ADA215068>.
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KEYWORDS: Radar absorbing material; RAM; environmental protection of radars; radar absorption paint; marine sealant; stealth material; environmental layer

VERSION 8

N221-050 TITLE: Advanced Cyber Threat Hunting Toolkit for Deployed Tactical Platforms

OUSD (R&E) MODERNIZATION PRIORITY: Cybersecurity

TECHNOLOGY AREA(S): Ground / Sea Vehicles

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop an open architecture, modular cyber search, detection, attribution, and mitigation toolkit to directly support cyber threat hunt on tactical platforms.

DESCRIPTION: A necessary part of defense capabilities is the ability to detect highly advanced nation-state cyber implants and supply chain attacks within Defense systems. While evolving cyber adversary detection technologies have matured for enterprise mission and business systems, constrained tactical systems often lag behind the lifecycle of these capabilities. Unique standalone tools, supported by automation and machine-assisted decision making, are needed for deployment in austere tactical platform environments. U.S. Navy surface ship combat, weapon, navigation, and control systems are highly complex, heavily networked, and reliant upon core commercial technologies – making them susceptible to advanced cyber threats. Innovative solutions are needed to enable the search, detection, attribution, and mitigation of these advanced threats within these constrained systems.

Cyber threat hunting is reflected in current standards as a proactive search capability in specified organizational systems to detect, track, and disrupt advanced persistent threats. While emerging control system architectures support cyber hygiene and rudimentary defense and response, well-tailored cyberattacks remain elusive to current detection technology. Reliance of next generation surface tactical platforms on technology for combat systems and navigation functions with growing concerns of cyberattacks at sea demonstrates the need for advanced tools that can be used in constrained environments.

The Navy seeks an open architecture, modular cyber search, detection, attribution, and mitigation toolkit that will be deployed as a standalone capability and scalable to work within a larger system of systems distributed platform or tiered architecture. The envisioned solution will leverage the detection and response capabilities planned for employment on U.S. Navy surface ships. It will allow for automated and semi-automated operation supported by intelligent autonomy that does not require continuous connectivity to shore-based defensive cyber operations infrastructure. When connected to shore-based or distributed maritime operations infrastructure; threat intelligence including tactics, techniques, and procedures (TTPs) and observable attribution shall be shared for attack progression tracking and proactive mitigation. Favorable consideration will be given to solutions which include advanced malware threat hunting capabilities, applicability to distributed and underway environments, and conformance to DoD and U.S. Navy requirements for cybersecurity capability deployment (DoD Instruction Number 8500.01 dated March 14, 2014 with Incorporating Change 1 Effective October 7, 2019. Subject: Cybersecurity). The solution will be tested by the Government on a representative tactical system to validate its effectiveness. Testing will include identification of gaps to target specific, custom built technologies to address those gaps.

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Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a concept for an open architecture, modular cyber search, detection, attribution, and mitigation for a cyber-threat hunting toolkit. Demonstrate the concept can feasibly meet the parameters of the Description. Show feasibility through a combination of analysis, modelling, and simulation. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop, demonstrate, and deliver a prototype toolkit based on the results of Phase I. The prototype will be tested on a representative tactical system to validate effectiveness in meeting the Description parameters. Testing will include identification of gaps to target specific, custom built technologies to address those gaps.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use through one or more managed acquisition activities. The prototype is a toolkit of targeted cyber threat hunter tools for niche operational technology in tactical environments, specifically U.S. Navy surface tactical platforms. Assist technology transition through developmental and operational test of the technology under cooperative and adversarial assessment conditions in an operational test environment. The technology will be matured to include a forensic capability. During product maturation, assist in conducting appropriate cyber engineering to include a security risk assessment, test and evaluation (T&E), and ensure compliance with pertinent regulatory principles and best practices (i.e., National Institute of Standards (NIST) 800 series publications, Risk Management Framework (RMF), and Cybersecurity Technical Authority (CS TA) Standards). Product may be licensed for deployment to U.S. Government users for direct use and/or licensed to a Software Support Activity (SSA) for additional integration and sustainment support.

This technology will be useful by any software company that has a need to protect their applications from cyber-attacks.

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2. Jacq, Olivier, Boudvin, Xavier, Brosset, David, Kermarrec, Yvon, and Simonin, Jacques. "Detecting and Hunting Cyberthreats in a Maritime Environment: Specification and Experimentation of a Maritime Cybersecurity Operations Centre," 2018 2nd Cyber Security in Networking Conference (CSNet), Paris, 2018.
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KEYWORDS: Cyber Threat Hunting; Tactical Platform; Advanced Cyber Threats; Detection Technology; Cyber Attacks; Advanced Persistent Threats.

VERSION 8

N221-051 TITLE: Enhanced Performance for Fin and Control Surface Materials for High Speed Missiles

OUSD (R&E) MODERNIZATION PRIORITY: Hypersonics

TECHNOLOGY AREA(S): Materials / Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a common missile fin and control surface architecture which provides a significant increase in thermostructural capability for multiple future missile systems.

DESCRIPTION: Evolving weapons technology is driving advanced missiles (supersonic and hypersonic) and other flight vehicles to greater speeds and higher accelerations. The result of increased speed and acceleration is higher temperatures and thermal stresses. For instance, vehicles traveling over Mach 4 may reach surface temperatures of 2,100°C at their leading edges. Rapid acceleration results in extreme thermal gradients, translating to high stresses. Flight through adverse weather such as rain or sleet, and sand and dust add additional environmental hazards which must be survived. These conditions resulting from implementation of the evolving technologies will require changes in materials to meet or exceed requirements to negate the effects on missile fins and control surfaces. Current materials do not address the problems occurring. Existing solutions are based on stainless steel or nickel-based super-alloys. Temperatures experienced in hypersonic flight will exceed the structural limits of these materials. An innovative solution will consider both advanced materials and existing state-of-the-art materials. Thermal shock is particularly difficult and can cause expansion of the outer surface during acceleration, thereby impacting fin and control surface effectiveness and material structural integrity.

Critical components of future Navy missile concepts are fixed body fins and articulating control surfaces. These fins and control surfaces must withstand significant mechanical loads, extreme surface temperatures, significant temperature gradients, and avoid conducting excessive heat back into the missile body. The fixed fins may be mounted on the rocket motor, and the articulating control surfaces are mounted via an actuator shaft which is connected to an internal actuator mechanism. Thermal limits for internal components behind fins and control surfaces may be as low as 225°C. It is desired that this future fin and control surface technology have a common design architecture which will allow use across multiple missile types and reduce production costs by eliminating multiple fin types. With these objectives in mind, the U.S. Navy seeks a fin and control surface design that utilizes proven materials and manufacturing methods, but also material innovations to provide increased thermal performance while maintaining structural functions.

Notional control surface geometries are like those found on legacy Navy interceptors, which are generally approximately 9" length and span, and no more than 1" thick at the root. Lower-weight assemblies are favored. The control surfaces should be capable of withstanding panel loads of 1,500 lbf with hinge moments of 2,000 in-lb. to the actuator. Novel constructs are envisioned that build upon current state-of-the-art with material additions, substitutions, or layering. Novel new materials, or novel combinations of known appropriate materials, may be considered. It is preferred that materials with known properties be

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incorporated into the proposed solution to potentially reduce the time to meet the technology readiness. Materials with smoother properties are favored. Proven manufacturability and properties will be favorably considered. Advanced and novel materials could be integrated into the basic structure and added as additional elements or layers.

Some critical considerations for any such control surface design and materials system include: (1) design optimized for both thermal and mechanical considerations; (2) high temperature chemical compatibility between multiple materials; (3) adhesion between material interfaces or layers; (4) thermal properties (conductivity, emissivity, coefficient of thermal expansion); (5) mechanical properties (strength, strain to failure); and (6) shape control in fabrication. Adequate test protocols must demonstrate suitability of the proposed technology to satisfy Navy requirements. Testing can be conducted on coupons combined with modeling, or on notional prototypes. Testing must demonstrate the proposed technology can withstand anticipated hypersonic flight conditions. While testing to MIL-STD-810 is beyond the scope of this SBIR effort, proposers may wish to consider the potential effects of all storage and flight environments on proposed materials and structures.

PHASE I: Develop a concept for a common fin and control surface architecture that meets the parameters in the Description. Demonstrate that the concept can feasibly meet the requirements through analysis, modeling, and experimentation of materials of interest. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver notional full-scale prototypes that meet the requirements in the Description. Note that this effort is iterative by nature and more than one prototype (or partial prototype) may be developed. Demonstrate functionality under the required service conditions including thermal and mechanical stresses. Demonstrate the prototype performance through the required range of parameters given in the Description. Number of prototypes tested will depend on the details of test methods chosen. Additionally, deliver two untested prototypes, test data, and remnants of tested prototypes to the Navy (NSWC Carderock Div., West Bethesda, MD).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use in the STANDARD Missile program. Support the manufacturing of the components employing the technology developed under this topic and assist in extensive qualification testing defined by the Navy program. It is likely that the Phase III work will involve classified information. While it is not a requirement for the offeror to be capable of classified work, such capability would simplify future efforts. It may also be possible for the offeror to partner with a classified-capable manufacturing firm to accomplish this step in the future work.

Potential commercial uses for high temperature performance improvements exist in the commercial spacecraft and aircraft industries and satellite communications.

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2. Ognjanovic, Ognjen; Maksimovic, Stevan; Vidanovic, Nenad; Kastratovic, Gordana and Maksimovic, Katarina. "Structural Analyses Of Ballistic Missile Fin Configuration During Supersonic Flight Conditions." Annals of the Faculty of Engineering Hunedoara; Hunedoara, Vol. 16, Iss. 1, Feb 2018, pp. 179-182. <http://annals.fih.upt.ro/pdf-full/2018/ANNALS-2018-1-30.pdf>.
3. Ognjanovic, O.; Maksimovic, S.; Vidanovic, N.; Segan, S. and Kastratovic, G. "Numerical aerodynamic-thermal-structural analyses of missile fin configuration during supersonic flight conditions". Thermal Science, 21(6 Part B), January 2017, pp. 3037-3049.

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KEYWORDS: Missile Fins; Control Surfaces; Advanced Missiles; Thermal Shock; Supersonic; Hypersonic

VERSION 8

N221-052 TITLE: Low Hazard Heat Pump for Distributed Cooling

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop an affordable point-of-use water-to-water heat pump using a low hazard refrigerant or solid-state device with a small footprint, low weight, low vibration, high reliability, and low maintainability cost.

DESCRIPTION: Electronics are an increasingly prominent part of ship systems and weapons. The standard U.S. Navy cooling system provides 44°F chilled water throughout the ship. However, electronics equipment typically require 67°F cooling water to prevent condensation, short circuit, shock hazards, and corrosion. This (a 23°F) delta creates condensation conditions that can present an electrical hazard and accelerate corrosion. Raising the temperature of the 44°F chilled water at point-of-service (for multiple electronics cooling loads) is less efficient than lowering only for specific loads. However, raising temperature requires a heat exchanger while lowering requires a heat pump. The U.S. Navy seeks an innovative heat pump to support development of a distributed cooling architecture and topology where centralized chillers provide 67°F cooling water (instead of the 44°F chilled water). The water temperature is then reduced at point-of-service to 42-44°F (where needed) for air conditioning purposes. The net result is a more efficient cooling system onboard.

The U.S. Navy seeks heat pumps with innovative solutions to minimize environmental impact and meet volume, weight, power, noise, and refrigerant charge requirements. The global warming potential requirement limits the refrigerants used to carbon dioxide, air, water, and a short list of other compounds. Solid-state thermoelectric cooler devices or other unconventional refrigeration systems will be considered in this SBIR effort.

Operational requirements of proposed heat pumps include:

- Chilled water supply and return flow rate of 12 GPM
- Electrical power input is limited to 2 kW at 3 Phase / 450 VAC
- Total volume and weight of the system are limited to 3 ft³ and 150 lbs
- Must fit down a standard Navy hatch (36 in. x 36 in.)
- Noise limit is 65 dB
- Global warming potential of the refrigerant, if used, must be less than or equal to 1
- Maintain the 42°F water outflow temperature within $\pm 2^\circ\text{F}$ using internal controls
- User-configurable thermostat setpoints capable of turning the system ON and OFF based on external temperature and humidity sensor input
- Maximum refrigerant charge is .66 lb (0.3 kg)
- Mean time to failure > 200,000 hours
- Ability to operate in cooling and heating mode
- Meet relevant qualification testing including shock, vibration, electromagnetic interference (EMI), humidity, and temperature in product at end of Phase II

The proposed solutions shall be initially targeted for transition to backfit opportunities where the technology provides a solution to HVAC challenges in existing systems. Other transition targets include the Future Large Surface Combatant program DDG(X), the amphibious transport dock (LPD), and potential use in submarines.

The low Global Warming Potential (GWP) requirement in the solution will provide the ability to transition commercial and residential heat pumps away from high GWP refrigerants such as R-134a and

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R-12. This addresses the California governmental push for transitioning away from high GWP refrigerants; specifically the requirement for centrifugal chillers to move away from R-134a by January 1, 2024 [Ref 1]. One of the available refrigerants in the solution is carbon dioxide. This effort will push the limit of carbon dioxide heat pump development that has seen little to no commercial or residential application in the United States. Another potential solution is solid-state thermoelectric cooling devices. The efficiency requirement of this effort will push the limits of thermoelectric device coefficient of performance to that of only cutting edge developments relating to ZT factor (main figure of merit in thermoelectric efficiency). [Ref 2].

Current platforms are not able to integrate advanced radar, electronic weapons, and lasers due to the limited capacity of the chilled water system. The Navy transition to electric drive presents issues as the chilled water demand will reach levels that are unsustainable with existing chilled water architecture designed around 44°F. Designing the shipboard distribution system for 67°F chilled water doubles the capacity of existing chillers without any size, weight or power increases, and the temperature allows for direct cooling of equipment with chilled water removing the need for cooling equipment units. The tradeoff in the removal of the cooling equipment units is the integration of the distributed heat pumps throughout the ship.

PHASE I: Develop a design for a low hazard heat pump as described in the Description. The Phase I final report shall be supported by predicted data from a subscale design of the proposed system. This subscale design must be capable of reducing a primary/internal chilled water loop from 67°F to 42°F by rejecting heat to cooling water supplied at 52°F. Proposed solution shall provide a thermodynamic analysis of the solution, estimate of the anticipated total volume and weight of the system referencing weights and volumes of individual components, documentation of estimated noise level, estimate of total refrigerant charge, evidence supporting the mean time to failure, estimate of power use, and an estimate of global warming potential of proposed refrigerant. Identify risks and mitigations, as applicable.

The Phase I Option, if exercised, will include the initial design specifications and a capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a full-scale prototype designed around 12 GPM of water flow with scaled power, weight, volume, and refrigerant charge (if applicable). Work with the Navy to develop requirements and demonstrate system performance through evaluation in a laboratory environment over the required range of agreed upon requirements. Refine the heat pump design and fabrication process to manufacture consistently in hundreds of units. Calculate a preliminary return on investment. The final product shall be designed to meet all relevant qualification testing including shock, vibration, electromagnetic interference (EMI), humidity, and temperature. Support the development of documentation including, but not limited to; technical manuals, parts lists, drawings, training guides, and logistics documents. Prepare a Phase III development plan to transition the technology for Navy and potential commercial use.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the system to large surface combatant and amphibious ships.

Transition opportunities for this technology include commercial ship and offshore systems that could benefit from efficient, low condensation cooling systems for electronics.

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KEYWORDS: Heat Pump; Chilled Water; Thermal; Carbon Dioxide; Thermoelectric; Thermal Management

VERSION 8

N221-053 TITLE: Multi-Aperture Vector Sensor Vertical Array Processing Enhancements to Reduce Operator Workload

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop automation technology to fuse together vector sensor multi-axis direction information with high-resolution multi-aperture/multi-frequency vertical sensor beams.

DESCRIPTION: Advanced fielded surveillance systems include both sophisticated sonar arrays and processing to provide state-of-the-art real-time maritime surveillance. Over the last decade, both sensors and processing techniques have advanced considerably to keep ahead of quieting sonar contacts. Very recently, vector sensors have been developed that possess the ability to provide acoustic field directionalities at the element level. Processing techniques to fully exploit this added capability are of interest to the U.S. Navy. Additionally, advanced computing hardware has allowed sensor processing to evolve to very high directional resolutions. The existence of such high resolution creates many surfaces over which surveillance operators must manually search on many sensors individually with very minimal automation support technology.

This SBIR topic seeks to develop a technology that will both leverage new vector sensing vertical linear sonar arrays and reduce operator workload associated with the tracking and localization of sonar contacts during surveillance. Vertical linear arrays have been used for surveillance for decades and provide good vertical depression/elevation angle resolution. With the addition of vector sensor elements, improved angular resolution is possible. Proposed solutions should be capable of executing, within the framework of the Integrated Common Processor (ICP), adhering to available computational footprints, supporting single sensor processing with multiple sensing modalities such as frequency and angle, supporting multiple-sensor processing, and reducing operator workload by a factor of 6. The automated multi-aperture signal processing and data fusion required for the intended transition is highly specialized and not available commercially.

Certification of technology will require the company to collaborate with the Government's Integrated Common Processor (ICP). The integrator will be designated by the PMS-485 Program Office. Testing and certification of the software module will be performed using operational system data against relevant performance metrics. The contractor and integrator will demonstrate the capability using multiple datasets and support future changes as required by an Advanced Processing Build (APB)-like development cycle.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret

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level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop an algorithmic concept to address the single- and multiple-sensor processing of vector sensor-based vertical linear arrays to simultaneously reduce sonar operator workload associated with contact tracking and localization. Demonstrate algorithmic feasibility using simulated data and realistic sonar array parameters. Provide a justification for how the proposed approach will reduce operator workload.

The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype by acquiring real sensor data from the Government with actual sonar array physical and processing parameters and demonstrate the ability to achieve improved contact localization and decrease sonar operator workload. Further refine the algorithm based on the findings when processing the real data. Collect and collate supporting results and provide briefings to the program office and technical points of contact.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Transition the software module to an appropriate surveillance system. Support the full integration, testing, and validation of the developed software module in the Government's Integrated Common Processor (ICP). The integrator will be designated by the PMS-485 Program Office. Testing and certification of the software module will be performed using operational system data against relevant performance metrics. Demonstrate the capability using multiple datasets and support future changes as required by an Advanced Processing Build (APB)-like development cycle.

In addition to the surveillance sonar benefits of the technology developed under this SBIR, many other opportunities exist for its dual use. For example, both surface sonars and submarine sonars experience similar operator workload challenges.

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KEYWORDS: Vector sensors; vertical linear array; multi-aperture signal processing; multi-sensor data fusion; operator workload reduction; automation.

VERSION 8

N221-054 TITLE: Modernized Navy Fan-Coil Assembly

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop and demonstrate durable, long-life, modernized Fan-Coil Assembly (FCA), while reducing required motor horsepower, lowering noise levels, using less chilled water flow than legacy FCA units, maintaining or improving weight/volume requirements, providing greater standardization, and lowering overall life cycle as well as maintenance costs.

DESCRIPTION: Fan-Coil Assemblies (FCAs) are typically used in recirculation systems using modular design, which allows for quick and easy installations. However, FCAs on Navy ships have changed little over the last 60 years. These legacy systems are heavy, energy inefficient, and operate at a single fan speed using a V-belt-driven fan. This has the unintended consequence of causing the temperature in the supplied spaces to be either too hot or too cold, and requires the system to switch on and off intermittently during operation, thus cooling and heating the same air, and wasting energy.

This SBIR topic will seek to develop compact, light, and efficient, drive systems that can react smoothly to temperature variations. The proposed solution will develop a new series of FCAs that are efficient, acoustically compliant, aerodynamically-optimized, lightweight, and reduced size, all of which will be necessary for the next-generation Navy HVAC system. The new design will incorporate improvements that result in a reduction in the required fan motor horsepower by 30% from the legacy units per MIL-PRF-23798D, Performance Specification, Air Conditioner, Fan-Coil Assembly [Ref 1], compliance with noise levels in accordance with MIL-STD-1474D, Change Notice 1 - Change Notice 1, Noise Limits [Ref 2], and reduced chill-water flow per developing Navy requirements.

The fan shall be designed for continuous operation, have a minimum efficiency of 80 percent, and be equipped with variable speed controls meant to replace the belt-driven system on legacy FCA units. The Variable-Speed Drive (VSD) controller will be in accordance with MIL-PRF-32168, PERFORMANCE SPECIFICATION: VARIABLE SPEED DRIVE SYSTEM FOR INDUCTION AND SYNCHRONOUS [Ref 3]. The targeted water-side pressure drop is 6 lb/in² across the heat exchanger, with a maximum of 10 lb/in². The design conditions of the entering air temperatures will be assumed to be 80°F dry bulb and 67°F wet bulb temperature, and under ambient temperatures between 40 °F and 95 °F. Design conditions for the entering chill water temperature is 43°F, supplied at 2.1-2.3 gallons per minute per cooling ton, reduced from legacy design specifications to meet new equipment performance.

The FCA shall be a complete assembly, that contains all components necessary for providing cooling and air recirculation required to satisfy compartment environmental design conditions. Each unit shall consist of a fan with a variable speed motor, a variable speed controller, air filter, thermal and acoustic insulation, a common open protocol control system, and a chilled water cooling coil. The performance of each unit will meet or exceed the performance requirements of legacy FCA units per MIL-PRF-23798D [Ref 1] and be tested to address shock, vibration, electromagnetic interference, performance testing, airborne testing, structure borne vibration testing, motor testing, and electrical power interface testing. The awardee will be responsible for the performance of all examinations and tests. The Government will reserve the right to perform any of the tests which, upon determination and capability of awardee, are deemed necessary to ensure the FCAs conform to prescribed requirements. Test plans will be developed during Phase I, with testing to take place during Phase II.

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Fan-Coil HVAC systems similar to legacy Navy FCAs are commercially available, and the operating principles are well understood within the HVAC industry. However, a complete FCA system package that meets the performance requirements outlined by the existing system performance specification, MIL-PRF-23798D, while also integrating a Variable-Speed Drive (VSD) fan controller meeting MIL-PRF-32168, has yet to be realized. This topic seeks to leverage industry-developed technologies to develop a family of modernized FCAs that improve upon the legacy systems.

PHASE I: Develop an innovative concept for the next generation of naval FCAs by meeting requirements above and targeting the performance specifications for the FCA Size 25 per MIL-PRF-23798D. Evaluate the feasibility of concepts through analytical modeling. Define strategies and technologies related to cooling coil performance, optimized air-side aerodynamic performance, reduced air-borne noise, and improved component reliability. Determine the size and weight improvement expectations over existing components. Determine coefficient of performance for cooling and heating applications as well as identify water-side pressure drop and fan performance expectations. Identify risks and mitigation measures, as applicable. The Phase I Option, if exercised, will include the initial design specifications and a capabilities description to build and test a prototype solution in Phase II. This will also include the development of test plans to identify all test procedures, test facilities, sequence of test procedures, component set-up, instrumentation and data to be collected. The tests included in the Phase I test plans will be as follows:

- Motor tests
- Permeability tests
- Leakage tests
- Electrical Power Interface test
- Communication Interface
- Performance tests
- Airborne noise tests
- Electromagnetic Interference (EMI)
- Structure borne Vibrations tests
- Shock tests
- Maintainability demonstration

PHASE II: Design and deliver the prototype, full-scale, next generation Fan-Coil Assembly (FCA) Size 25 (largest size) unit (151,300 Btu/h, 3080 SCFM). Performance data shall be collected at a variety of flow rates (both air and water), air temperatures/humidity, and water temperatures. Air-borne and structure-borne noise testing shall be conducted. Validate and expand analytic models developed in Phase I. Investigate the scalability of design and identify commonality efforts. Refine calculation and estimates provided in Phase I. This first-article prototype unit must also meet Navy unique requirements, such as shock and vibration in accordance with -S-901 - Shock Tests, H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, Requirements for [Ref 4] and MIL-STD-167-1 - Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited) [Ref 5], as well as Electromagnetic Interference in accordance with MIL-STD-461 - Requirements for the Control of Electromagnetic Interference Emissions and Susceptibility Requirements for Characteristics of Subsystems and Equipment [Ref 6]. The final product will be a modernized first-article Size 25 Fan-Coil Assembly (FCA) which meets the test requirements established in the test plans developed during Phase I.

PHASE III DUAL USE APPLICATIONS: Following the successful design of the modernized FCA 25 and the satisfactory results of Phase II, the remainder of the series will be designed based on the qualified design and the company will assist the Navy in transitioning the technology for Navy use. Scale the results to design and develop the new series of modernized FCAs. To qualify the designs and collect data for future-program use, each size of the new FCA series will be installed on an operating Navy vessel, or

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tested in such a way to qualify the unit(s) design. Comparisons of existing systems will be made so the energy usage of the modernized FCAs can be directly compared with similar legacy unit(s) that will operate under the similar shipboard parameters. Each unit's energy usage, system reliability, and maintenance will be assessed to inform the comparison. Demonstrate successful performance of the new series units to meet and/or exceed all specified modernized FCA requirements. It is envisioned that this development work for the remainder of the series will be covered by the program office(s) electing to integrate the modernized FCA line into their ship program.

Demonstrate large-sale manufacturability of the full series of FCAs, as well as provide maintainability support through operational and maintenance documentation. Develop the manufacturing plan, based on Navy-driven need for the units, and provide assistance with system integration as needed during Navy design efforts.

The development of the modernized FCA is envisioned to primarily benefit the Large Surface Combatant (DDG(X)) program, as well as future Navy ship programs. However, with much of the development carried out during the preceding Phases, the technology innovations developed through this project could be leveraged for potential back-fit modernization applications across the Surface Fleet. Current in-service ships in the Surface Fleet carry a total of between 30 and 50 total legacy FCAs, distributed among the different sizes in the family. This represents an opportunity to encourage commonality and form-fit-function design intent for the modernized version to help make back-fit more feasible.

Additionally, the innovation addressed in the project could potentially allow the company to expand its advantage in the industrial HVAC market. By designing the modernized FCAs with aerodynamically optimized air flow and airborne noise requirements, those innovations could inform the awardee's commercial product line to enhance air-side efficiency and reduce airborne noise, while meeting the unique cooling requirements for an industrial or residential setting.

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8. Frank, Matthew V.; Helmick, Dick. 21st Century HVAC System for Future Naval Surface Combatants - Concept Development Report. NSWCCD-98-TR-2007. Naval Surface Warfare Center Carderock Division. September 2007. <https://apps.dtic.mil/sti/pdfs/ADA473662.pdf>.

KEYWORDS: V-belt fan driven; Navy Ventilation and Air Conditioning; Heating, Ventilation, and Cooling; HVAC; cooling coils; Variable speed; Fan Coil Assembly; Thermal Management

VERSION 8

N221-055 TITLE: Improved Towed Array Acoustic Hose

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a towed array acoustic hose that prevents permanent hose deformation (creep), reduces water permeability, increases resilience against physical damage, and increases useful life.

DESCRIPTION: An improved hose for the acoustic modules of towed arrays for Navy submarines and surface combatants is desired. Current commercial state of the art for hosing on these acoustic modules leads to hoses that are often damaged by 1) marine life (e.g., shark bites), 2) fishing gear such as hooks and nets, and 3) typical wear and tear from vibration and torsion during normal operations. Further, there is reason to expect that it could be possible to improve the acoustic performance of the hose over the existing state of the art, which would enhance the ability of the towed array system to detect acoustic signals.

Towed arrays are streamed in the ocean by Navy combatants to detect underwater acoustic signals. Current towed array acoustic hoses are fluid-filled thermoplastic polyurethane (TPU) extrusions that contain towed array sensors and electronics. These hoses perform various functions to optimize towed array functionality and performance. The hose material provides some isolation from noise through a variety of factors (such as modulus, loss-tangent, material selection, and reinforcement design), protects the array from the surrounding environment, relieves some mechanical load on the array internal components during handling, storage, and shipping, and generally functions as the primary physical interface between the towed array and the environment. The hose typically experiences significant mechanical, environmental, and chemical stresses like high pressures, a wide range of temperatures, tension, torsion, vibration, exposure to seawater, isoparaffinic solvents, and so on. In addition to these harsh conditions, the hose is also often exposed to free floating fishing gear (known as “ghost fishing”), marine animal attack, abrasive surfaces, and other mechanically harsh situations.

The solution sought is expected to endure the aforementioned conditions for a period of at least 5 years before requiring replacement for any reason presuming a maximum of 25% array deployment at a maximum average of 15 knots across the 5 year period. The hose should resist physical damage due to sharp objects or abrasion (be at least 50% more cut-resistance than current hoses). The hose should reduce the ability of water to permeate the hose by at least 3 orders of magnitude over a 1-year period of immersion in sea-water. The hose should reduce mechanical creep by 2 orders of magnitude compared to legacy towed array hoses when exposed to axial loading for a period of up to 3 consecutive months.

In addition to achieving these requirements, the towed array hose must achieve the basic functions of legacy towed array hoses (listed below) and must not negatively impact towed array acoustic performance.

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Baseline Requirements:

- Temperature: -28°C to 60°C
- Pressure: -5 to 1200 psi
- Vibration: MIL-STD-167A
- Chemical:
 - o 5-year exposure to seawater
 - o 5-year exposure to ISOPAR L and/or ISOPAR M
- Suitable for reinforcement with various cords or yarns, such as Polyester, Kevlar, and Vectran
- Suitable for outside diameters of 1.1” to 3.5”
- Suitable for lengths up to 200’
- Suitable for hose wall thicknesses of 0.11” to 0.375” with a 125 micro-inches RMS surface finish
- Suitable for wrapping on drums with a d/D ratio of 1:24
- Suitable for achieving a leak-proof swaged or crimped termination
- Suitable for filling to a “firm and round” condition using internal pressure and maintaining that condition for 90 days
- Must not negatively impact towed array acoustic performance

The government will provide support for testing prototype assemblies in unique environmental testing facilities as required (such as towed array handling systems, long tension beds, large environmental chambers, etc.).

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a concept for an Improved Towed Array Acoustic hose that meets the requirements in the Description. Demonstrate the feasibility of the approach based on analysis, modeling, simulation, and evaluation. Demonstration must show an understanding and estimation of the critical performance factors as set for in the Description and explains that the approach is feasible. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build full scale prototype solutions in Phase II.

PHASE II: Develop and deliver a prototype Improved Towed Array Acoustic hose based on the results of Phase I and the parameters in the Description. A number of prototype hose samples may be required for testing and evaluation to be conducted. The system will be evaluated, tested, and certified by the government.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Assist the Government in transitioning the technology to Navy use. This will include experimentation and refinement of the prototype to qualify the technology for use on towed arrays. The government will provide the performer access to a Navy ship or research vessel where the final system validation and performance verification will be conducted. Support installation and

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removal from a test platform and assist in data analysis and interpretation. Existing data will be used to verify the measurements and accuracy of the system.

This system would prove useful for oceanographic research, oil and gas exploration, and potentially any industry where rugged, flexible, chemically resistant hoses are used, such as transportation, industrial plants, and automotive.

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3. "AN/SQQ-89(V) Undersea Warfare / Anti-Submarine Warfare Combat System," Navy Fact File. <https://www.navy.mil/Resources/Fact-Files/Display-FactFiles/Article/2166784/ansqq-89v-undersea-warfare-anti-submarine-warfare-combat-system/>.

KEYWORDS: Towed Array; Hose Deformation; Towed Array Sensor; Cut-Resistance; Water Permeability; Mechanical Creep

VERSION 8

N221-056 TITLE: Unmanned, Autonomous Avoidance of Active Acoustics Harassment of Marine Mammals

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Investigate and develop a conceptual design for a model prototype with a low-power, autonomous marine mammal harassment mitigation or avoidance capability for use during active sonar operations of unmanned, autonomous Deployable Surveillance Systems (DSS), whose feasibility is demonstrated using modeling and simulation (M&S).

DESCRIPTION: The U.S. Navy has been and continues to be a leader in environmental stewardship for maintaining a healthy marine ecology of the world's oceans through its heavily funded research and environmental protection practices. Moreover, federal regulations have invoked certain policies for Navy to use mitigation practices in order to avoid harassment or injury to marine mammals when operating active sonar during training and testing operations. At the same time, federal law requires the Navy, under Title 10 of the U.S. code, to uphold its military obligation to defend the security interests of the nation that include use of its active sonar during training and testing operations during peacetime in order to maintain wartime readiness. The Navy continually sustains the required balance to keep in compliance with both federal laws. The scope of this SBIR topic concerns continuing to maintain this balance for DSS. Current mitigation practices enforced by the Navy require a human in-the-loop for visual sightings of nearby surfaced marine mammals during daytime operations of active sonar and/or passive acoustics to detect nearby vocalizing marine mammals during training and testing exercises. A technical problem/challenge for the proposer is to provide an innovative solution for conducting autonomous active sonar DSS operations by developing an unmanned, autonomous mitigation prototype without the requirement of human intervention for performing mitigation or avoidance procedures. DSS are a family of unmanned, autonomous systems which provide acoustic surveillance mission capabilities for maritime theater undersea warfare. Transition of DSS capability is accomplished through systems increments and spiral developments.

DSS is a middle-tier acquisition program with rapid-prototyping and rapid-fielding demands which necessitate modularity and shorter timeframes to transition DSS increments and spiral capabilities while still considering total ownership costs over the life of the capability (e.g., development, test/evaluation, sustainment, manufacturing, modernization, obsolescence, sunset) to transition the capability.

The purpose of an autonomous prototype is to: (a) detect vocalizing marine mammals with passive acoustic sensor(s) in the harassment range of active sonar operations; (b) replace the human lookout/on watch to look for non-vocalizing marine mammals; (c) make autonomous decisions to ascertain the presence of animal(s) in vicinity of operations in which case the sonar cannot go active; and (d) reduce active power emissions or turn off active sonar, as appropriate, if marine mammals are detected within a prescribed harassment area. The desired built-in prototype capability shall have low-power and shall be

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integrated into the autonomous prototype as a 'go/no go' decision for using active acoustics (vice as a modeling tool for understanding acoustic impact to marine mammals).

DSS systems, which may use active acoustics during operations, will need to avoid harassment of marine mammals, which could result in behavior modification or harm to marine mammals. Current military active acoustic harassment mitigations all include manned (human in-the-loop) operations.

The Navy needs an innovative solution that provides the ability to sense/detect, without any human involvement, marine mammals (whether vocalizing or not) that are within range of active acoustics harassment and prevent such harassment from occurring. If a potential harassment situation occurs, the goal is to provide and integrate decision-making algorithms to the DSS system to prevent, without any human involvement, such harassment with least impact to the DSS maritime surveillance mission that requires employment of its active sonar.

The solution must provide an energy-efficient capability that does not negatively impact power and energy needs in other areas of DSS system operations. Energy consumption is just one of many other examples. In a second example, when no marine mammals are present in the operating area and mitigation steps are not being required to reduce DSS operational source level, the automated marine mammal harassment mitigation prototype should not cause any interference or degradations to DSS normal mission/sonar operational performance capability. In a third example, the DSS prototype may be provided with a communications link to command authority with a mitigation disabling option for wartime combat missions. These are just a few trade-space examples. Offerors are asked to research, develop, and demonstrate new solutions to the stated problem.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a conceptual design for an energy-efficient low-power, autonomous marine mammal harassment mitigation or avoidance capability, an innovative technology solution that will fill the current technology gap.

Base the solution on a model design identifying key elements that are used to determine the technical feasibility of the approach through computer modeling and simulation, and best available science. (Note: Examples of the available science on marine mammals and sonar technologies are provided as illustration in references 1 through 3.)

Identify anticipated performance milestones.

Demonstrate, via computer modeling and analysis, the operational feasibility for fielding the modeled design for a Phase II prototype build, test, and at-sea demonstration.

Provide: (a) a detailed description of the concept design (hardware and software) architecture; (b) description of the analytical approach, the methods and results of computer modeling and simulation

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(M&S) performed as a basis for justifying the proposed architecture; and (c) the plan for incorporating the proposed architecture into a prototype build in Phase II (Phase I Option).

The Phase I Option, if exercised, will include notional design specifications and a capabilities description to build a prototype in Phase II. Include how total operating costs of the solution can be addressed while maintaining state-of-the-art advances as future DSS increments and spirals are transitioned, for example, additive manufacturing, advanced materials, modularity of subcomponents.

PHASE II: Implement the proposed architecture developed in Phase I and deliver and test at-sea a prototype to implement an unmanned, autonomous solution for avoidance of active acoustics harassment of marine mammals for effective use of DSS systems using active acoustics. The feasibility of the proposed solution will be demonstrated in a variety of potential ocean environments, system integration architectures, and for mission concepts of operation using modeling tools. Build and demonstrate components or sub-components of the system to validate the accuracy of the model.

Validate that the prototype operates in accordance with the model in a laboratory or at-sea environment. Incorporate lessons learned from simulated computer simulation and modeling, actual at-sea acoustic measurement trials, and analysis of the collected test data into a full system design. A final prototype will be delivered at the end of Phase II.

It is probable that the work under this effort will be classified under Phase II (see Description for details).

PHASE III DUAL USE APPLICATIONS: Provide total operating costs of a transitioned capability (including but not limited to manufacturing, integration, deployment, sustainment, and modernization).

Support the Navy in transitioning the technology to Navy and commercial use. Further refine, fabricate, and implement the developed hardware and/or software to suit the operation of a capability for DSS systems to avoid active acoustics of marine mammals and support testing in laboratory and ocean environments to meet requirements for functionality, environmental extremes, reliability, safety, and other requirements to certify the system for Navy use. (Note: The Navy will support operational testing.) Deliver hardware/software, related documentation, support installation on existing systems, and retrofit technology for use in operational testing.

Provide an execution plan for commercial dual-use application of the advanced technology. One example of a technology application of an autonomous mitigation prototype device for dual-use in the commercial sector is in the commercial fishing and shipping industries for possible mitigation of net entanglements, bi-catch, and ship strikes.

REFERENCES:

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4. NOAA National Marine Fisheries Service: Marine Mammal Acoustic Technical Guidance, 2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing.

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5. National Oceanographic and Atmospheric Administration (NOAA), U.S. Department of Commerce; <https://www.noaa.gov/fisheries-regulations-permits-data-reporting-restoration-projects>.

KEYWORDS: Marine Mammal Harassment; Active Acoustics; Maritime Surveillance; Theater Undersea Warfare; behavioral response; auditory sensitivity

VERSION 8

N221-057 TITLE: Alternative Power for Anti-Submarine Warfare Targets

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop an alternate power source greater than 3.6 KWhrs in a 6.75 inch diameter by 30 inch length extended endurance section for the MK39 Expendable Mobile Anti-Submarine-warfare Training Target (EMATT).

DESCRIPTION: Anti-Submarine Warfare (ASW) training is conducted most effectively when air, surface, and subsurface platforms train in the operational environment. Training against live submarines is costly and often not available; therefore, mobile ASW training targets fill this critical training need. The addition of a larger and higher density power source to the MK39 EMATT would give its users more options to improve its emulation of a submarine for ASW proficiency training. The baseline MK39 EMATT is powered by a Li SO₂ battery capable of doing 3 to 8 knots, is very high in energy density, is low cost, has a long active life, contains lithium metal, and is pressurized. The existing battery uses L026SXC cells manufactured by SAFT, Inc. The battery pack consists of two (2) parallel strings of fifteen (15) D-size L026SXC cells connected in series (15S2P). This provides a 45 Volt (V) power source with a capacity rating of 16 Ampere-hours (Ah). Each string is protected by redundant diodes and the pack is fused with an 8 amp slow blow fuse. The existing form factor is much smaller than the 6.75 inch diameter by 30 inch length extended endurance section to be investigated under this SBIR effort.

The objective is to develop an alternative power source that accomplishes the requirements and meets the goals set by the MK39 EMATT program and ASW targets.

The Navy is in need of an innovative way of powering the MK39 EMATT and ASW targets. The SBIR topic seeks development of a power source that is expended after one use that is not required to be recharged. This SBIR effort would evaluate concepts based on specific needs such as endurance and sprint speed. Currently there are emerging methods such as fuel cell, battery paper, carbon zinc, etc. both commercially and in Government. Increasing the power capabilities of an ASW training target will make it more realistic to real world threats. Also, with increased power ASW targets will have a wider range of capabilities. This includes increased speed, additional sensors, and increased endurance. With the addition of an extended endurance section to the EMATT that is 6.75 inch diameter by 30 inch length, the cg (Center Of Gravity) becomes an issue to investigate as the EMATT is negatively buoyant. The goal is to have a cg of -1.5 inches or less below the center of buoyance. The goal for buoyancy of the section to be approximately neutrally buoyant.

An innovative way of powering the MK39 EMATT and ASW targets should enable a longer run time per vehicle, looking at approximately an objective time of 24 hours. Desired voltage is to maintain the baseline 45Volts. Estimated amperage required for the speed range of the larger vehicle is approximately

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10-15 amps. Driving down the cost per hour below \$100 per hour is also desired. The Navy would like to develop and build thirty to forty prototype power sources for testing and evaluation.

System performance will be demonstrated through bench and safety testing. The awardee will perform bench testing, at the awardee's facility, to determine if the prototype meets size, weight, and power. Bench testing is expected to be conducted halfway through the Phase II effort. Evaluation results will be used to refine the prototype into an initial design that will meet Navy requirements. Conduct safety testing in accordance with Navy lithium safety program responsibilities and procedures of S9310-AQ-SAF-010 [Ref 1] as applicable with Naval Surface Warfare Center Carderock. Conduct safety testing in accordance with High-Energy Storage System Safety Manual, SG270-BV-SAF-010 [Ref 2] with Naval Surface Warfare Center Carderock. Safety testing will be conducted at the end of the Phase II effort. The prototype shall meet operational temperature requirements of -5°F to 135°F. The prototype shall meet operational vibration requirements of exposure to a random vibration of 20 Hz to 1126 Hz for duration of 3 hours. The prototype is not required to meet any operational shock requirements, however the prototype design shall be evaluated to determine shock survivability.

PHASE I: Develop an initial concept design and feasibility of an extended endurance power source. Consider how the candidate alternate power supply can be integrated into the ASW mobile training target. Provide design data and analysis to substantiate the findings. Demonstrate the feasibility of the concept to meet the parameters listed in the Description through modeling, simulation, and analysis. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I and the Phase II Statement of Work (SOW), the small business will develop and deliver a prototype for evaluation as appropriate. Approximately Thirty power sources shall be built for testing and evaluation. The prototype will be evaluated to determine its capability in meeting the performance goals defined in the Phase II SOW. System performance will be demonstrated through prototype evaluation as described in the Description. Evaluation results will be used to refine the prototype into an initial design that will meet Navy requirements. Conduct safety testing in accordance with Navy lithium safety program responsibilities and procedures of S9310-AQ-SAF-010 as applicable. Conduct safety testing in accordance with High-Energy Storage System Safety Manual, SG270-BV-SAF-010. Conduct environmental testing.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to its intended platform for Navy use. Develop the extended 6.75 inch diameter by 30 inch length extended power source for evaluation to determine its effectiveness in an operationally relevant environment. Support the Navy for test and validation to certify and quantify the system for Navy use. The developed power source will be transitioned for use in the MK39 EMATT and other ASW targets.

Compact High-Energy Storage Systems are in demand for a variety of commercial applications including automobiles, unmanned undersea vehicles, emergency and portable power systems, and residential storage.

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KEYWORDS: energy source; energy density; endurance; Anti-Submarine Warfare; ASW targets; Expendable Mobile Anti-Submarine Warfare Training Target; MK39 EMATT; advanced power source

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N221-058 TITLE: Electronic Warfare Human Machine Interface Training

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Human Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a game-based, dynamic Electronic Support Measures (ESM) training prototype utilizing TI-20 AN/BLQ-10 automation, displays and capabilities to include realistic scenarios and environmental factors enabling stress-habitation.

DESCRIPTION: The operation of modern submarines is complex and requires continuous training to learn how to effectively operate the warfighting systems. The current trend is to extend classroom training with advanced training techniques through the Navy's "Sailor 2025" program. This program describes the urgent need for Ready, Relevant Learning (RRL) to ensure that sailors have the warfighting skills they need. RRL requires a reconstruction of training techniques, adaptability of training location (i.e., standalone systems, classroom-based workstations, or cloud-based programs), a learning continuum (to ensure skill acquisition, mastery and maintenance), and requires that training products take advantage of the latest in learning technology (i.e., serious games and YouTube-like videos). The focus of this SBIR topic is discovering the best combination of cognitive experiences and computer-guided gamification learning techniques. Coupled with existing combat system simulation systems, the trainer will use cognitive training techniques to teach sailors how to effectively learn and operate advanced Electronic Support Measures (ESM) systems quickly and accurately. This SBIR effort is about connecting with each individual and coaching them to reach their highest potential using advanced training capabilities.

PMS-435 seeks to develop an engaging, multi-modal, performance-based ESM trainer that addresses the Navy's vital need for RRL by amending the deficiencies of the current AN/BLQ-10 Computer-Based Training (CBT) as well as the lack of commercially available software to adapt to such a need by utilizing the automation and advanced displays associated with the TI-20 upgrade to the AN/BLQ-10 system. This SBIR topic seeks development of innovative training techniques and their integration with a performance-based navigation engine. The state-of-the-art trainer shall utilize an innovative training engine that calculates in-situ proficiency measurements, which provide unique learning paths through the material. The training engine will be implemented with three additional innovation areas to develop a unique trainer that accelerates learning and improves performance. The following areas of innovation are to be addressed by this trainer:

1. **Dynamic Training Scenarios:** The current AN/BLQ-10 CBT uses a pre-defined calibrated set of scenarios to measure performance and drive navigation. Continued use of CBT indicates that sailors become accustomed to the existing scenarios, therefore diminishing its effectiveness. The solution involves the development of a dynamic scenario generator that enables endless variances of scenarios and ensures a unique training experience each time the CBT is used. This innovative generator will incorporate traditional navigation methods with innovative techniques that allow scenarios to fit into the robust algorithms as they are made.

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2. **Gamification:** Develop software that leverages game-based learning for its innovative training solution. Game-based learning, or gamification, is a novel teaching approach that utilizes certain gaming principles (i.e., badges, points, and leaderboards) and applies them to training practices. Studies show that gamification increases user engagement and keeps trainees in the zone of engaged development – improving skill acquisition and retention, while maintaining an exciting and entertaining game. This shall be accomplished by implementing an engaging, game-like environment with multi-modal, robust training methodology. The gamification approach shall follow extensive research on this topic in commercial gaming.
3. **Stress-habituation:** Sailor stress elicits physiological and emotional responses that diminish warfighting decision-making performance. Presently, the sailor is trained to read and analyze various electromagnetic warfare (EW) phenomena to make tactical decisions but does not learn how to operate under severe stress. The proposed trainer shall institute modalities that habituate sailor stress during the training cycle to utilize the brain's experience-dependent neuroplasticity. This refers to the brain's capacity to change in response to experience, repeated stimuli, environmental cues, and learning. The training solution will expose the sailor to stressful stimuli such that the brain adapts and becomes more tolerant of and less reactive toward stress, consequently preparing them for warfighting experiences.

The core of this SBIR research effort is to determine how to accelerate learning and improve stress-related responses using psychological methodologies to fulfill the Navy's need for RRL. The results will provide metrics for determining the level of each trainee's improvement during a training session, and these metrics will be logged over time. The pursued innovation will provide each trainee the ability to improve his/her training efficiency and learning retention as well as enhance their actual performance. By addressing the foundational skills at a deep level in which the sailor can act nearly instinctively in their role, the Navy will have expanded capabilities and create an advantage that empowers the fighting force with expertise in their actions and supports fielding a precision team. This is to be accomplished by developing a training solution based on the following parameters:

1. Define and develop a hardware and software architecture trainer concept that would connect to the submarine TI-20 AN/BLQ-10 system,
2. Define metrics for measuring stress and determine how to implement stress factors into the trainer,
3. Develop methods to implement and utilize dynamic scenarios, and
4. Produce a conceptual design of a game-based, dynamic, performance-based trainer and model key components such as TI-20 AN/BLQ-10 interface display, operator performance, stress metrics, and course content.

The innovative training solution shall maximize learning and gaining proficiency through easily accessible learning and training platforms. This trainer would ideally be viewed through various learning platforms, such as the Moodle Learning Management System, the Multifunctional Instructional Trainer (MIT) and/or the Submarine On Board Training (SOBT). Integration onto these platforms will enable the use of multiple, concurrent training sessions and ensure the widespread use of the trainer.

Initial testing of this trainer can be accomplished at the company site, where TI-20 automation and advanced display capabilities shall be applied in a performance-based training environment. This testing will be conducted by the developer with Government representatives. Final testing and certification will occur at the prime system integrator site and will be conducted by Government representatives in collaboration with Naval submarine force active-duty operators.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been

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implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a concept for an improved ESM trainer that incorporates dynamic scenarios, gamification, and stress habituation for inclusion as part of the TI-20 AN/BLQ-10 system per the requirements in the Description. Demonstrate the feasibility of the concept to meet the described parameters listed in the Description through modeling, simulation, and analysis. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Using results from Phase I, develop, validate, and deliver the prototype for an improved ESM trainer that establishes modalities to acclimatize sailor stress. The operator interface will emulate and directly interact with the TI-20 AN/BLQ-10 operator machine interface. System performance will be demonstrated through prototype evaluation and modeling or analytical methods over the required range of parameters. Develop and demonstrate a dynamic scenario environment via the generation of multiple scenario variances. Develop and demonstrate an engaging, game-based training environment that mirrors TI-20 AN/BLQ-10 displays. Develop and demonstrate environmental factors that take advantage of experience-dependent neuroplasticity and habituate stress. Implement and test the dynamic, game-based training prototype. The field test data collection should demonstrate that operators have an improved resilience and reaction to stress-inducing environments as well as demonstrate skill level improvements in comparison to operators that use traditional TI-20 AN/BLQ-10 training methods.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use in which the final product delivered to the Navy will be an improved ESM trainer that incorporates dynamic scenarios, gamification, and stress habituation to increase operator skill and proficiency in employing the TI-20 AN/BLQ-10 system in a variety of operating environments. This trainer will be incorporated into the TI-20 update to the AN/BLQ-10 system on designated submarines. Work with the associated Integrated Product Team (IPT) and provide hardware and/or software to the system prime contractor for inclusion and integration. The improved ESM trainer performance will be evaluated as part of the overall TI-20 AN/BLQ-10 system testing and evaluation.

Dual use potential exists for any field where operator performance is or could be tracked and developed using CBT. Examples of potential applications include:

1. Operator response to system failures in power generation or manufacturing plants, ensuring systems are placed in a safe condition for subsequent troubleshooting and repair.
2. Operator response to vehicle and/or control system failures in transit systems, such as air traffic control, railway signaling, and subway signaling.
3. Operator response to system failures in commercial shipping vessels.

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1. Wemm, Stephanie E., and Wulfert, Edelgard. "Effects of Acute Stress on Decision Making." *Applied Psychophysiology and Biofeedback*, vol. 42, no. 1, 2017, pp. 1–12., doi:10.1007/s10484-016-9347-8, <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5346059/>.

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4. Davidson, Richard J, and McEwen, Bruce S. “Social Influences on Neuroplasticity: Stress and Interventions to Promote Well-Being.” *Nature Neuroscience*, vol. 15, no. 5, 2012, pp. 689–695., doi:10.1038/nn.3093.

KEYWORDS: Electronic Support Measures; Game-Based Training; Gamification; Experience-Based Neuroplasticity; Electronic Warfare; Sailor 2025

VERSION 8

N221-059 TITLE: Directional Acoustic Communications Transmitters

OUSD (R&E) MODERNIZATION PRIORITY: Autonomy

TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop directional acoustic transmitters that can be scaled for use on medium, large, and extra-large unmanned undersea vehicles (UUVs).

DESCRIPTION: The Navy seeks to develop directional acoustic transmitters for use on UUVs. The commercial market lacks directional transducers appropriate for UUV integration/usage due to lack of commercial demand/use cases for such a capability. The closest commercial equivalents would be spherical arrays targeted for vertical (in water column) applications, but such arrays are not suitable for the UUV applications targeted by the Navy. Directional acoustic transmitters will enable the Navy to more effectively conduct UUV swarming operations by reducing mutual interference, as well as more clandestine communications by directing the transmitted acoustic beam pattern main response axis (MRA) toward the intended receive array. Current commercial UUV transmit/receive transducers project omni-directional acoustic energy in all directions, whereas directional transmitters are generally limited to larger manned platforms such as submarines. Development of directional projectors compatible with size, weight, and power (SWaP) constraints of UUVs is challenging. The available SWaP within UUVs varies greatly by class and design, but rough order of magnitude (ROM) allowances are provided in the table below. It is noted that the values in this table are provided for guidance only – they are not to be considered formalized requirements against which the proposals will be adjudicated.

UUV Class	Medium	Large	Extra-Large
ROM Volume:	216 in ³ (6” cube)	1728 in ³ (12” cube)	5832 in ³ (18” cube)
ROM weight in air:	8 lbs	64 lbs	216 lbs
ROM Tx Power:	250W	350W	500W
ROM Standby Power:	5W	10W	20W

These SWaP challenges are exacerbated by the requirement to withstand large hydrostatic pressures experienced during UUV missions. Larger projectors are required to generate narrower/more focused beams, so a prime challenge is optimizing the transmitter to fit within the existing UUV platforms. Another challenge is the pointing of the transmit beam, i.e., its MRA as well as its width while

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maintaining sidelobe rejection at other angles. For longer ranges (> 1km) acoustic transmission paths are more complex and require knowledge of the environment and a modeling capability. In addition to development of the directional transmitters, proposers should include the pointing method of the resultant beam, control of the beam's sidelobes and the main lobe width, minimizing size, weight, power, and cooling (SWaP-C) associated with the solution, and the novelty of the approach.

The technical merit of the proposed solutions will be evaluated on factors including:

1. Ratio of the energy to the targeted region vs. the energy transmitted over the entire (360°) geographic region
2. Required level of in-situ environmental knowledge in order for the transmitter to point itself and achieve the focused gain described in #1
3. Transmitter gain over a variety of environmental and bathymetric conditions
4. Maximum volume and maximum physical or synthetic transmit aperture dimension
5. Estimated weight of the system
6. Maximum power draw by the transmitter when in use and during standby
7. Suitability of chosen projector technology to operate/survive over the variety of operational depths over which PEO-USC UUVs operate

The company will test the prototype system, first in a controlled laboratory environment, then in an in-water (saltwater) environment, to determine its capability to meet all relevant performance metrics outlined in the Phase II SOW. Testing shall characterize the optimization of directional transducer control, coupled with the communication function, in the presence of interfering and mutual interference of external assets. The company shall demonstrate the prototype system performance in both environments (laboratory and in-water) to the Government and present the results in two separate test reports.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a concept for a directional acoustic transmitter that meets the requirements in the Description. Establish feasibility by developing system diagrams as well as Computer-Aided Design (CAD) models that show the transmitter concept and provide estimated weight and dimensions of the concept. Feasibility will also be established by computer-based simulations that show the transmitter's pointing capabilities are suitable for the project needs. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of Phase I and the Phase II Statement of Work (SOW), develop and deliver a prototype system for in-water testing and measurement/validation of the Phase I performance attributes. Test the prototype system, first in a controlled laboratory environment, then in an in-water (saltwater) environment, to determine its capability to meet all relevant performance metrics outlined in the Phase II SOW. Testing shall characterize the optimization of directional transducer control, coupled with the communication function, in the presence of interfering and mutual interference of external assets. Demonstrate the prototype system performance in both environments (laboratory and in-water) and

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present the results in two separate test reports to the Government. Use the results to correct any performance deficiencies and refine the prototype into a pre-production design that will meet Navy requirements. P Prepare a Phase III SOW that will outline how the technology will be transitioned for Navy use.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: If successful, in addition to UUV applications, these directional acoustic transmitters could be applied to other unmanned Navy assets including buoys and subsea nodes. These assets have communications requirements, some of which require clandestine communications, for which these directional acoustic transmitters could provide a solution. In addition to such DoD applications, these directional acoustic transmitters could be used in commercial oil, gas, and oceanographic sensing applications, where the prevention of mutual interference between submerged assets is required.

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KEYWORDS: Transducers; acoustic communications; clandestine communications; swarming UUVs; mutual interference; beam pointing; in-situ environmental collection.

VERSION 8

N221-060 TITLE: Chip Scale Oceanographic Sensor

OUSD (R&E) MODERNIZATION PRIORITY: Microelectronics

TECHNOLOGY AREA(S): Sensors

OBJECTIVE: Create a chip scale oceanographic sensor that can be integrated onto a ship or unmanned underwater vehicle (UUV) hull to accurately measure ocean water chemistry in real-time.

DESCRIPTION: A new generation of measurement technology is developing new, ultra-compact, ultra-reliable, low-power sensors with accuracy linked by a known degree of error to U.S. standard measurements. Partnerships with industry are developing fabrication processes similar to existing microelectromechanical systems (MEMS) that will manufacture these sensors as a rugged and inexpensive device. These new developments offer a new opportunity for the submarine community to access and utilize environmental data on the outer hull of a submarine. At present, these sensors have not been ruggedized to reliably function in the harsh environments the external hull of a U.S. Navy submarine endures during its service life. This SBIR topic seeks a hull-mounted (i.e., external) chip scale sensor for in-situ monitoring of oceanographic chemical parameters.

To protect against corrosion, a ship's Impressed Current Cathodic Protection (ICCP) distributes electrical energy between sections of the hull. The ICCP control system measures voltages using seawater silver/silver-chloride reference electrodes and adjusts the electrical potentials appropriately. Changes in seawater chemistry near the hull will change the electrical potentials, creating the need for a real-time oceanographic measurement input to the ICCP feedback control. The objective of creating a chip scale sensor should integrate the following threshold oceanographic chemical parameter measurements into a single device without causing interference on the reference electrodes:

- Temperature: $0-50 \pm 0.1$ °C
- pH: $7-11 \pm 0.1$
- Conductivity: $1-6 \pm 0.001$ S/m
- Dissolved oxygen: $1-14.6 \pm 0.1$ ppm [2]
- Sampling rate of at least one per minute (required)
- Additional chemical parameters of interest include: chloride (± 0.1 mg/L), bromide (± 0.1 mg/L), sodium (± 0.1 mg/L), calcium (± 0.1 mg/L), sulfate (± 0.1 mg/L), and sulfide (± 0.1 mg/L)

These sensors will modernize the ICCP system to provide real-time ambient oceanography measurements that correlate with noise on cathodic protection reference cells. This will enable minimum impressed current emissions while still maintaining cathodic protection of the hull. The Naval Research Lab (NRL) has started modifying the ICCP controller to accept these oceanographic inputs, and has historic studies documenting the correlations between the oceanographic chemical parameters and corrosion polarization curves.

It is essential that the sensors maintain these accuracies under environmental stresses experienced by underwater hulls. These conditions include: temperature $0-50$ °C, hydrostatic pressure cycling from $0-10,000$ kPa, grade B shock requirements from MIL-DTL-901E [Ref 1] without leakage when subjected to hydrostatic pressure, total suspended solids of $0-120$ mg/L, fouling and biofouling over extended deployment periods. Chip scale sensors have been demonstrated for the identified parameters and proposals should identify the sensors that are envisioned for integration. The integrated sensor should fit in a space less than 10.0 cm x 7.5 cm x 5.0 cm, use less than 10 watts of power, meet the Navy's goal of a 20-year lifetime, and utilize low-cost MEMS manufacturing methods. Smaller sensors that meet these requirements will leave space for additional future sensors.

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PHASE I: Develop a concept for an integrated sensor that achieves the needed measurement accuracy under temperature and pressure cycling presented in the Description. Determine the feasibility of the concept to meet the described parameters listed in the Description through modeling, simulation, and analysis. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver two prototypes of a chip scale sensors. Modify the sensors as needed and integrate the sensor package into a shipboard ICCP reference electrode holder. Demonstrate the prototype's performance under the necessary environmental stresses: one month in a natural seawater environment where biofouling colonization is prevalent, such as Port Canaveral, FL. Certification of the natural seawater test environment will be conducted by the Naval Research Laboratory and Naval Surface Warfare Center, but the testing and evaluation will be conducted by the performer. Required hydrostatic pressure cycle evaluation will be conducted under laboratory conditions at the Naval Research Laboratory using a seawater pressure chamber. Documentation of all Phase II testing results should include independent parameter measurements documenting required accuracy. Identify the largest costs in manufacturing the sensor and assess cost reduction measures.

Deliver, for the environmental exposure demonstration, two packaged sensors for Navy evaluation.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use through system integration and qualification testing. Integrate the sensor package into the shipboard ICCP architecture and data acquisition system as part of a Temporary Alteration (TEMPALT). Demonstrate environmental exposure operation of the sensor package for a minimum of two years. Implement cost reduction measures and install sensors aboard a ship at multiple reference electrode locations. Mortality analysis and documentation of any failed elements will be required. This sensor can provide a low Size, Weight, Power and Cost (SWAP-C) replacement for existing oceanographic sensors, which are routinely used for oceanographic surveys or environmental ocean monitoring. Reassess and document the largest costs in manufacturing the sensor as well as cost reduction mitigations.

REFERENCES:

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KEYWORDS: Oceanographic chemical analysis; Microelectromechanical Systems; MEMS; Impressed Current Cathodic Protection; Corrosion Protection; Measurement-science sensor; Underwater Electromagnetic Signatures

VERSION 8

N221-061 TITLE: Kill Assessment and Closely Spaced Object Resolution with Elevated Electro-Optic/Infrared (EO/IR)

OUSD (R&E) MODERNIZATION PRIORITY: Directed Energy (DE)

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop an Electro-Optical/Infra-Red (EOIR) imaging system with capability to provide Kill Assessment (KA) and Raid Counting from an elevated position.

DESCRIPTION: Current U.S. Naval combat systems use onboard radar systems and processing for tracking, classification, and discrimination of incoming threat complexes. Threat complexes comprised of Closely Spaced Objects (CSOs) will fall within the resolution of onboard radar systems causing blind spots and preventing an accurate count of the number of threats present. Without an accurate count of inbound threats, the combat system must make choices on how to respond, which may be less than optimal and may not achieve raid annihilation. The same argument extends to KA after intercept, which is a critical time for the Combat System to make further engagement decisions. There is currently no known solution that will solve the blind spots issue.

Placing an off board EO/IR system at operationally relevant locations with respect to the ship will allow for the Ship Self-Defense System (SSDS) Combat System (CS) to observe incoming threats from a perspective which will address the stated KA and CSO blind spots. While it would be possible to gain some performance improvement on these KA and CSO concerns by upgrading the native radar systems, this would be time and cost prohibitive. Observing the incoming threat complexes and intercept points from a different aspect with commercial off-the-shelf (COTS) EO/IR sensors is desired to address performance and cost concerns.

By placing an EO/IR imaging capability at an operationally relevant elevation (to be determined in Phase I), inbound threat complexes could be observed from a different perspective than what is currently available to the shipboard sensors. The Navy seeks a system consisting of an EO/IR imaging capability with a mechanism to deliver it to a tactically useful off board position (to be determined in Phase I) to support self-defense engagement timelines. Current systems do not provide this capability. Selecting a platform capable of supporting not just an imaging capability but also computer hardware and software would allow for the development of a set of functions to observe inbound threats at pre- and post-intercept to supplement KA capabilities. Final system solution should satisfy testing requirements cited in Phase II. Solutions must cover both sub and supersonic Anti-Ship Cruise Missiles (ASCMs) and must meet or exceed current time to engagement timeline and SSDS CS survivability. The solution can consist of physical hardware, models and high-fidelity simulations, or a combination thereof. Any model and related simulation(s) used must be based on the detection parameters of EO/IR sensor(s) which are currently commercially available. The solution will be evaluated against scenarios provided by the sponsor. Provided scenarios will contain threat or threat surrogate information. Examples of desired detection capability would be Night Vision Integrated Performance Model (NV-IPM) developed by

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Command, Control, Communications, Computers, Combat systems, Intelligence, Surveillance and Reconnaissance (C5ISR) Center's Night Vision and Electronic Sensors Directorate. Detection models of similar fidelity and capability will be acceptable. The solution used to demonstrate initial KA and Raid Counting algorithms may be based on synthetic data representative of selected sensor(s). Final delivered solution must also meet MIL-STD-810 for environmental conditions.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

Phase III demonstration will allow for the opportunity to demonstrate the full solution capability against live scenarios of the same scope as those provided by sponsor during development phases. The solution developer will be responsible for providing any solution specific instrumentation and data collection necessary to prove the solution satisfies the criteria for success. SSDS system data will be made available for use in post-test analysis.

PHASE I: Develop a concept for an EO/IR imaging system with the capability to provide KA and Raid Counting from an elevated position. Demonstrate the feasibility of the concept to meet the described parameters listed in the Description through modeling, simulation, and analysis. Simulation results should be presented in the form of parameterized sweeps to demonstrate tactical regions of effectiveness and boundaries. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype of an EO/IR imaging system with the capability to provide KA and Raid Counting from an elevated position capable of stand-alone operation and a notional plan for integration into the SSDS CS. Demonstrate at a Government- or company-provided facility that the prototype meets all parameters presented in the Description. Final delivered solution must also meet MIL-STD-810 for environmental conditions.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use through system integration and qualification testing for the EO/IR prototype developed in Phase II. The EO/IR imaging system prototype will be delivered to support an IWS-10 critical experiment conducted jointly by the company and Combat System Engineering Agent (CSEA). This is expected to take place in a live environment with tactical SSDS CMS SW. Live fire test scenarios will be similar in scope to test scenarios provided by the sponsor during development phases. The transition will require integration of the prototype into SSDS CS.

Elevated EO/IR imaging system has applications in managing disaster relief efforts and addressing wildfires.

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KEYWORDS: Electro-Optical/Infrared; EO/IR; Kill Assessment; KA; Raid Counting; Inbound Threats; Raid Annihilation; Detection models for incoming threats

VERSION 8

N221-062 TITLE: Universal Environmental Controls for AM Machines

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop and demonstrate innovative technology to mitigate or eliminate environmental effects on Additive Manufacturing (AM) machines, as well as the effects AM machines have on their environment, through the use of modular controls that can be implemented as needed to augment Commercial-off-the-shelf (COTS) AM equipment for Navy use. This can be achieved by integrating COTS and or custom hardware into AM equipment to support Navy environments.

DESCRIPTION: The Navy develops specifications and standards for AM and the development of shipboard AM capabilities. The ability to produce components while at sea drastically reduces the burden on the supply and requisition systems while increasing platforms' abilities to complete missions. Currently, AM equipment suitable for afloat use is limited to small capacity, polymer-based, material extrusion systems. These systems were selected and integrated based on the fact that they are low cost, generally small, and easily integrated into existing platforms. These machines were installed to support the development of low risk, non-critical components in an effort to reduce supply chain burden and prove the concept of AM at sea. There are increased needs for AM afloat as explicitly mentioned in the NAVSEA Campaign Plan to Expand the Advantage 3.0 [Ref 1] as a technology focus area. This SBIR topic directly supports efforts to integrate AM into the Fleet and support a more self-sufficient ship. In addition, per the strategic document "A Design for Maintaining Maritime Superiority 2.0" [Ref 2] requires the Navy to maximize use of AM to fabricate "hard to source" or obsolete parts, reduce cost, field more effective systems, and reduce reliance on vulnerable supply chains through production at the point of need.

Currently, there is a need to mitigate or eliminate the environmental effect on AM machines and the effects AM machines have on their environment. The NAVSEA 05T AM Afloat program will benefit from a collection of equipment or systems that can be applied as standardized controls applicable to all polymer AM equipment. These controls will be installed/integrated to reduce safety and integration risks as well as increase use of AM equipment onboard Navy platforms and Shoreside facilities. As AM equipment is integrated in both afloat and shore based environments there is an increasing need for environmental controls to mitigate Shock, Vibration, ships motion, as well as temperature and humidity on AM machines. In addition, there is a need to mitigate Ultrafine Particles (UFPs) i.e. particles with a diameter < 100 nm, Volatile Organic Compounds (VOCs) emissions, EMI, and machine noise from AM equipment during operation. This topic is specifically interested in keeping machine noise below 85 decibels per OSHA standards [Ref 15].

The Navy environments, both Afloat and Shoreside, can have adverse effects on AM machines and their ability to produce parts consistently and accurately. The AM machines can also have adverse effects on their surrounding environment, which may impact nearby equipment or personnel, to include UFPs and VOCs emissions. Fortunately, control processes can be put in place to reduce and/or mitigate these risks. Such controls or mitigations vary based on AM process, machine type, and the environment they are installed in. As a result, these controls or mitigations must be modular or configurable to support a variety of scenarios. AM machines are not currently developed with the Navy in mind and therefore do not meet military standards or have environmental controls in place from the Original Equipment Manufacturer (OEM). However, due to the rate at which technology changes, it is not feasible to expect every AM machine to meet military standards. It is more sustainable for AM machines to use modular controls that can be implemented as needed to augment COTS AM equipment for Navy use. In addition, standardized filtration systems for polymer AM equipment is either non-existent, or relies on filtration technology with

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little modeling and simulation to ensure the filters are adequately removing the UFP and VOC emissions produced by the AM equipment. In many cases, High-Efficiency Particulate Absorbing (HEPA) filters sufficiently capture the UFPs emissions. Unfortunately, ensuring the UFPs actually make it to the HEPA filters is where there is significant uncertainty. As this equipment becomes more prevalent shipboard, UFP and VOC emissions control will become paramount to ensure the safety of the crew when using these machines. Furthermore, the standards and baselines by which the equipment is tested are currently in the early stages of research, and a better understanding of the requirements for filtration and duration of filtration must also be investigated. Additionally, AM equipment may cause electromagnetic interference (EMI) or acoustic issues while onboard Navy platforms.

These machines and the controls applied will be tested at Navy facilities or by Government contractors who are certified to test at the Mil Standards listed below. In addition, the controls will be tested on multiple machine types determined by the Navy based on applicability. Prototype solutions delivered to the Government for shipboard integration testing must comply with all MIL-STDs in the references section of this topic. The solutions delivered to the Government must include all applicable equipment to be tested. For example, if the mitigation solution is physically attached to a piece of AM equipment, the solution must also include the AM equipment to be tested.

MIL-STDs tested against:

- MIL-S-901D, Amended with Interim Change #2, Shock Test, H.I. (High Impact); Shipboard Machinery, Equipment and Systems, Requirements for
- MIL-STD-167-1, Mechanical Vibration for Shipboard Equipment (Type I - Environmental and Type II - Internally Excited)
- MIL-STD-461F, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
- MIL-STD-740-2, Structure-borne Vibration Acceleration Measurements and Acceptance Criteria of Shipboard Equipment
- UL 2904, ANSI/CAN/UL Standard Method for Testing and Assessing Particle and Chemical Emissions from 3D Printers
- MIL-STD 810, Environmental Engineering Considerations and Laboratory Tests

PHASE I: Define and develop a conceptual system capable of environmental control/mitigation that is tailorable to the integration scenario (shipboard, expeditionary, or maintenance/shop environment). Formulate supportive modeling and simulations for feasibility and verification. Develop notional Computer Aided Design (CAD) designs (as appropriate), bill of materials, and build plans, to support the conceptual system. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Using the deliverables from Phase I, produce and deliver four (4) functional prototypes of environmental controls to be tested. These Prototypes must be modular and/or tailorable to support integration of AM equipment into shipboard (surface/undersea), expeditionary, or maintenance environments. Include a sensor suite capable of determining various environmental conditions and printer-induced environmental impacts (VOCs, UPFs, etc.). Provide integration plans, initial installation, operational, and maintenance documentation to support prototype systems. Provide test and verification data indicating that controls properly mitigate or eliminate environmental effects on AM machines as well as effects AM machines have on their environment.

PHASE III DUAL USE APPLICATIONS: Stand up a production line of tailorable, physical environmental controls to support the integration of AM equipment into shipboard, expeditionary, and maintenance environments with a minimum production run that is able to support existing shipboard equipment at the time of Phase II completion. Provide the ability to test and validate environmental

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effects caused by shipboard AM equipment and mitigation solutions. Offer the expanded development of an environmental standard for mitigation requirements in the shipboard environment. The ability to tailor controls for different machines and different environments will enable NAVSEA 05T to safely and rapidly integrate AM equipment on Navy platforms and Shoreside. This capability will ultimately support the Navy's adoption of AM across the fleet and into the future as technology evolves to support just in time delivery of components necessary to complete the mission. The solution(s) developed under this SBIR topic could transition to various industries leveraging polymer AM in their business. Filtration of the UPFs and VOC emission will be a commercially marketable product not specific to DON requirements. In addition, the environmental mitigation controls implemented could transition to other DOD or commercial entities operating in fluctuating or dynamic environments that require control of the temperature and humidity of the AM platform. Since development of this solution(s) is around COTS equipment, AM OEMs may also be interested in the technology developed.

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KEYWORDS: Additive Manufacturing; Volatile Organic Compounds; Ultrafine Particles; UFP; Volatile Organic Compounds; VOC; Environmental Controls; Atmospheric Monitoring; Shipboard Motion

VERSION 8

N221-063 TITLE: Nonlinear Mitigated Gain Fiber Development for kW-class Fiber Lasers

OUSD (R&E) MODERNIZATION PRIORITY: Directed Energy (DE)

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop Stimulated Brillouin Scattering (SBS) mitigated rare-earth-doped fibers supporting the advancement of narrow-linewidth kW-class fiber amplifiers essential for future high-energy laser (HEL) weapons integration with reduced cost and power scalability.

DESCRIPTION: The rapid development and deployment of HEL systems have enabled laser weapons in different platforms for DoD's applications. Kilowatt (kW)-class single-mode fiber lasers have been the key engines for these HEL systems because of their inherent advantages including excellent beam quality, outstanding heat dissipation capability, high single-pass gain, hermetically guided laser beam, and high-power scalability. There is high demand for kW-class fiber amplifiers for narrow-linewidth HELs that are required for specific applications. However, kW-class fiber amplifiers always suffer from SBS, RAMAN scattering, and other nonlinear effects such as four-wave mixing (FWM), self-phase modulation (SPM), and stimulated RAMAN scattering (SRS), etc. Although several types of large-mode-area (LMA) fibers have been fabricated and used to demonstrate kW-class fiber amplifiers with mitigated nonlinear Kerr effects and SRS, SBS is still a major constraint on the power scaling of kW-class fiber amplifiers for narrow-linewidth lasers. Therefore, innovative rare-earth-doped fibers with mitigated SBS and other nonlinear effects are crucial for the development of narrow-linewidth kW-class fiber amplifiers. The U.S. Navy is searching for an innovative nonlinear mitigation kW class rare-earth doped fiber at 1 to 2 μm wavelength. Current commercially available kW class amplifier power is limited to approximately 2 kW per amplifier. This SBIR topic seeks innovative technology to increase the HEL SM (Single mode) narrow line width amplifier to approximately 4 kW. This topic seeks design, development, and fabrication of > 6 kW-class rare-earth optical fiber. Commercial state of the technology is only around 2 kW per amplifier due to SBS.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a concept and demonstrate the feasibility of that concept to meet the Navy's requirements as outlined in the Description. Demonstrate the power scalability of the new single mode

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SBS reduced optical fibers for narrow-linewidth laser amplification. Provide the design of kW-level fiber amplifiers and show path to reaching 6-kW laser output without mitigated SBS and other nonlinear effect. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Under Phase II base period develop the SBS reduced fiber that can meet the Navy requirements and in Phase II Option I use this type of SBS reduced doped fiber for > 5kW class amplifier design and demonstrate the performance to the Navy. And in Phase II deliver a prototype system for testing and evaluation based on the results of the Phase II base and Option I. Phase II Option II, deliver SBS reduced doped fiber > 200 meter to the Navy for the final evaluation done at a Navy lab. Results shall be used to optimize the design, modeling and fabrication of the rare-earth-doped optical fibers and provide a fiber amplifier prototype that can be used to achieve 6-kW narrow-linewidth (< 0.5 nm) laser at – 1 micro meter, 1.5 micro meter and 2 micro meter.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. Advanced rare-earth doped optical fibers with mitigated SBS and other nonlinear effects can be used in various HEL weapon systems for DoD applications, DOE's accelerator lasers, the laser sources for free-space communication, kW class optical power delivery over > 300 meter, and remote sensing systems.

For commercial and industrial application; this technology could produce compact, efficient, kW class HEL systems for industrial material processing applications such as welding, cutting, soldering, marking, cleaning, etc., in the automotive and aerospace industries.

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KEYWORDS: Stimulated Brillouin scattering; SBS; RAMAN scattering mitigation; Rare-earth-doped fibers; kW-class fiber lasers; Nonlinear effects; Large-mode-area fibers

VERSION 8

N221-064 TITLE: Medium Voltage Direct Current Disconnect Switches

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop a family of disconnect switches and associated switchgear enclosures for 12 kV Medium Voltage Direct Current (MVDC) electrical distribution systems for naval combatant applications.

DESCRIPTION: Integrated Power and Energy System (IPES) offers the potential to provide revolutionary warfighting capability at an affordable cost. IPES utilizes integrated energy storage and power along with advanced controls to provide a distribution bus suitable for servicing highly dynamic mission loads and propulsion demands while keeping the lights on. Additionally, such a system can enhance survivability, reliability, and flexibility while providing new capabilities, such as the ability to quietly maneuver solely on energy storage. IPES development is focused on a Medium Voltage Direct Current (MVDC) system evolved from the DDG 1000 1kVDC Integrated-Fight-Through-Power system, combined with shared and distributed energy storage as well as advanced controls with active state anticipation data linkage between machinery and combat systems. As threat capabilities improve over the coming decades, the Navy anticipates a heavy reliance on high power, highly dynamic, pulsed weapons and sensors. Because the need for generator synchronism is eliminated, MVDC is anticipated to be able to support these systems at lower cost, lower weight, and lower space requirements. Details on IPES are provided in the Naval Power & Energy Systems (NPES) Technology Development Roadmap [Ref 1].

One of the key enablers of an MVDC IPES is a reliable means for MVDC equipment isolation to conduct maintenance and fault isolation on the MVDC bus. Disconnect switches, in conjunction with appropriate protection relays, offer the opportunity to fulfill these functions at a lower size, weight, and cost than MVDC circuit breakers. MVDC disconnect switches and associated switchgear are enablers for affordable naval power and energy systems to support multiple future high power, pulsed sensors, and weapons on future surface combatants. Commercial or military MVDC disconnect switches and associated switchgear are not currently manufactured by any company. More information on MVDC Fault Detection, Localization and Isolation can be found in Doerry and Amy [Ref 2].

The objective of this SBIR topic is to develop a family of MVDC two pole disconnect switches and associated switchgear for 12 kV MVDC distribution systems on naval ships with continuous current ratings ranging from 100 amps to 3,500 amps (threshold) and 4,000 amps (objective). The challenge will be to develop affordable, power dense disconnect switches suitable for naval surface ship applications that can be locally or remotely controlled and can be opened or closed within 50 milliseconds (ms) (threshold) or 10 ms (objective). The disconnect switches shall be capable of interrupting at least 2% (threshold) or 100% (objective) of the rated current. The disconnect switches shall have a design life of 30 years (threshold) or 50 years (objective) and be capable of up to 10,000 switch operations (threshold) or 20,000 switch operations (objective). The disconnect switches shall be compatible with 12 kV power as detailed in the Preliminary Interface Standard, Medium Voltage Electric Power, Direct Current [Ref 3]. The steady-state efficiency of the disconnect switch shall be greater than 99.98% (threshold) or 99.99% (objective).

The switchgear enclosure for the disconnect switches should be modular to enable custom configurations of disconnect switches based on the sources and loads within a zone. The switchgear should minimize weight and maximize power density. For a single 2,000 amp two pole disconnect switch, the associated switchgear module shall have a power density greater than 20 MW/m³ (threshold) or 50 MW/m³ (objective) and shall weigh (including the disconnect switch) no more than 1,200 kg (threshold) or 200 kg (objective). The switchgear should be deck mounted (threshold) or bulkhead mounted (objective) while

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still meeting Grade A shock requirements. The switchgear should be air cooled. The switchgear should be capable of being integrated with MVDC cables or with MVDC insulated bus pipe. All repair parts should fit through standard shipboard hatches. The contractor shall demonstrate through testing in their own facilities the ability of the switchgear and disconnect switches to achieve the design ratings.

These MVDC disconnect switches are anticipated to have commercial applications as MVDC systems are increasingly employed in micro grids, offshore wind, cruise ships, and solar power installations.

PHASE I: Develop initial design concepts for the disconnect switches and associated switchgear for the complete family of disconnect switches. Establish the standard disconnect ratings comprising the family based on minimizing cost and size of switchgear for shipboard applications. Conduct electrical, mechanical, and thermal dynamic simulations to demonstrate the feasibility of the design. Assess risks associated with the design and develop mitigation plans. Risks not requiring physical testing of the prototype shall be addressed in the Phase I option.

In the Phase I option, if exercised, develop test plans that include risk mitigation requiring physical testing of the prototype for Phase II. Develop interface descriptions and performance data for the disconnect switches and associated switchgear necessary for successful integration into a shipboard power system.

PHASE II: Develop, test, and deliver to the Navy prototype switchgear and installed prototype disconnect switches in accordance with the draft specifications developed in Phase I or an update to the draft specification. The ratings of the prototype disconnect switches and the configuration of the prototype switchgear shall be chosen to maximize learning and risk mitigation. Demonstrate through testing in their own facilities the ability of the switchgear and disconnect switches to achieve the design ratings. Validate or update simulations from Phase I based on test results. Deliver to the Navy an update to the interface descriptions and performance data and develop design guidance for configuring and integrating the disconnect switches and associated switchgear into an MVDC power system design.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. The MVDC disconnect switch and associated switchgear are planned to be incorporated into a future surface combatant to support high power and pulsed power weapon systems. Commercial applications may include cruise ships, offshore platforms, wind farms, and solar farms. Produce and test production representative disconnect switches and associated switchgear enclosures in accordance with the Phase III SOW. These production representative disconnect switches and associated switchgear shall be delivered to the Navy for integration into a test system to evaluate the disconnects and switchgear for application in a future surface combatant. Deliver to the Navy an update to the design guidance from Phase II, an update to the simulation models (as required), a maintenance manual, and user training material.

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3. Doerry, Norbert, "Preliminary Interface Standard, Medium Voltage Electric Power, Direct Current," Naval Sea Systems Command, Technology Office (SEA 05T), Ser 05T/002 of 16 January 2020. <https://apps.dtic.mil/sti/pdfs/AD1090170.pdf>.

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KEYWORDS: Medium Voltage Direct Current; MVDC Disconnect switch; Switchgear; MVDC Equipment Isolation; MVDC Distribution System; MVDC Bus; MVDC Fault Isolation

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N221-065

TITLE: Low Cost, Small Form Factor Scalable Receive Array

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Apply innovative technology to develop a five-band compact Modular Expansive Spectrum Passive Receiver (MESPR) to address gaps in fielding passive sensor recognition and countermeasure algorithms.

DESCRIPTION: Navy surface ship and submarine probability of survival improves when protected by torpedo defense countermeasure systems. Adversarial weapons are increasing sophistication that requires the Navy to rapidly implement and integrate pace-the-threat technology via the Navy's Technical Insertion/Advanced Processor Build (TI/ABP) process. Traditional receivers perform at a purposed frequency band of specific interest. Legacy system architectures typically do not easily support technology insertions. The Navy has invested in system updates for cost-effective technology insertions. MESPR would directly benefit Surface Ship Torpedo Defensive (SSTD) and submarine torpedo defense programs. MESPR addresses the need to counter technology improvements inherent in threat torpedoes. The innovative technology could be dual purposed to enhance or replace unmanned undersea vehicle (UUV) and torpedo sensor suites. The expansive spectrum is comprised of the Super Low Frequency (SLF), Ultra Low Frequency (ULF), Very Low Frequency (VLF), Low Frequency (LF), and Medium Frequency (MF) frequency bands as designated by the International Telecommunications Union (ITU) for radio spectrum designators and bandwidths to include:

- SLF: 30 Hz-300 Hz
- ULF : 300 Hz-3 kHz
- VLF: 3K Hz-30K Hz
- LF: 30K Hz to 300K Hz
- MF: 300K Hz to 3,000K Hz

A technology challenge will be to implement MESPR using traditional and non-traditional materials and hardware to achieve efficient transduction across the defined bandwidth. A second technology challenge addresses complex issues related to spectrum detection and correlation across a five-band receiver. A third technology challenge defines a prototype capable of performing while a local host is transmitting broadband and structured energy. To decrease technical risk for modularity and Space, Weight and Power (SWaP), improvements can be incrementally addressed as Phase II and Phase III activities progress. The SWaP of the MESPR prototype must be developed for technology insertion within three inch, four inch, and six inches countermeasure systems. Operational depth of the MESPR is up to 2,000 feet below ocean surface. The MESPR concept must include passive sensor and sensor configurations for sensitive detection with high dynamic range, dynamic array gain, volumetric localization, and beam steering. Traditional and non-traditional sensor and mechanical model and simulation analysis will support the proposed concept to meet the requirements in this Description. Modeling and simulation will address receive sensor and detection degradation caused by flow noise, local coherent signals and interferers. A

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variety of torpedo defense land-based and at-sea demonstrations may be utilized to assess technology performance and viability.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. Owned and Operated with no Foreign Influence as defined by DOD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this contract as set forth by DCSA and NAVSEA in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Define and identify a feasible concept for the innovative MESPR prototype to demonstrate performance, modularity, and SWaP constraints. Identify candidate sensor and hardware culminating in a modular and compact design approach. Perform modeling and simulation to provide initial assessments of performance and SWaP limitations. Incorporate a Transmission Control Protocol/Internet Protocol (TCP/IP) electrical to optical Ethernet interface for receipt of command-and-control messages while sending MESPR raw and processed sensor data and hardware status. The development approach will address how compact processing and programmable logic are utilized to locally process sensor receive data. Intelligent hardware must have features to meet Cybersecurity and data protection requirements. Commercial Off-The-Shelf (COTS) components must be in production currently and planned to be in production for a minimum of three years. A hardware obsolescence approach must be addressed in Phase I. Develop a risk adverse approach to incrementally demonstrate MESPR performance, modularity, and cost management. The Phase I Option, if exercised, will include the initial layout and capabilities description to implement the concept and approach in Phase II. A final Phase I report for this SBIR effort will identify an innovative and feasible approach for Phase II to demonstrate working prototypes. A schedule will be provided to identify key Phase I and Phase II component and MESPR technology milestones.

PHASE II: Develop the MESPR prototype based on Phase I modeling and analysis, Establish performance parameters through continued modeling, sensor, and hardware experimentation. Construct and demonstrate an operational prototype. Perform performance and environmental evaluation testing of the MESPR prototypes based on the derived performance parameters. Testing will be the responsibility of the executing company, to include static and dynamic testing to assess utility for passive receive sensitivity and directionality across the MESPR band of interest. A functional prototype will be demonstrated in a relevant environment at a Navy facility such as the Naval Undersea Warfare Center (NUWC) Seneca Lake Sonar Test Facility. A prototype will demonstrate temperature thermal cycling, Grade A shock, vibration analysis and cyber resilience. Prepare a technical description document and user guide. Update the schedule prepared in Phase I to identify key Phase II and Phase III technology milestones. Deliver three to five working prototypes for further assessment by the Government. In support of Phase II prototype development and Phase III technology transition, the Navy will identify specific torpedo defense hardware targeted for MESPR integration, test, and demonstration.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Integrate the Phase II delivered MESPR prototypes with Government identified torpedo defense hardware. Identify incremental technology improvements to achieve end goals. Demonstrate MESPR technology improvements through planned prototype updates

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using lessons learned in Phase II and Phase III. Demonstrate the MESPR technology can be inserted and interoperable with torpedo defensive countermeasures to achieve performance and SWaP objectives. Evaluate three to four Phase III final prototypes for delivery. Support at-sea demonstration from a U.S. Navy platform to assist evaluation of the design in a relevant environment. Technical and logistic documentation will be developed to support technology transition to a PMS415 program of record. The schedule prepared in Phase II will be updated to identify key Phase III component technological milestones and will include a 12-to-24-month technology transition schedule.

A Commercial application of MESPR could support a producer of Autonomous Undersea Vehicles (AUVs). As an example, an AUV could search for a black box from a downed airplane.

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KEYWORDS: Undersea defensive systems; acoustics; non-traditional sensor materials; sonar signal processing; signal detection; signal localization

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N221-066 TITLE: New Water-Blocking Chemicals/Materials for Zero Longitudinal Seawater Flow through Navy Outboard Cables

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop new outboard cable water-blocking chemicals/materials system that prevent the longitudinal movement of seawater through a cable after the watertight integrity of the cable jacket or connector is breached (thereby allowing seawater to enter the interior of the cable).

DESCRIPTION: When the watertight integrity of an outboard cable is breached, the navy depends upon a water-blocking compound within the interior of the cable to slow/prevent the movement of seawater down the length of the cable. Seawater moving through the interior of a cable will eventually reach either end where it will come in contact with sensors, power supplies, and other electrical components and connectors. This often results in extensive and costly damage to these crucial pieces of equipment and could trigger system failures that can compromise the ability of Navy ships and submarines to perform their assigned missions.

The objective is to develop new saltwater-blocking materials that will prevent the longitudinal movement of seawater through the interior of a breached/flooded outboard cable both at high (500 - 1000 psi) and low (25 psi) hydrostatic pressure conditions. The governing military specification for outboard cables (MIL-DTL-915G; reference 1) contains two water-blocking requirements: section 4.5.12 (hydrostatic/open end – high pressure) and section 4.5.17 (water tightness - low pressure). Although reference 1 allows some water flow through the interior of cables undergoing these tests, the goal of this SBIR topic is to develop a water-blocking chemical/material system that prevents any saltwater from flowing through the cable segments used in these tests. Commonly used Navy outboard cable jacket materials include polychloroprene, polyurethane, poly (vinyl chloride), and chlorosulfonated polyethylene. The water-blocking chemical/material in a non-compromised/flooded cable must allow individual conductors within the cable to be easily accessed and separated from other conductors/wires.

The chemical composition of the most commonly used water-blocking materials used in outboard cables is unknown to the Navy. The material is soft and rubbery and typically performs acceptably during the MIL-DTG-915G hydrostatic/open end test. We believe it is successful because the high hydrostatic pressure allows the formation of a compression seal with the water-blocking compound. It typically allows some water to pass through the interior of the cable during the MIL-DTG-915G water tightness test (presumably because the much lower hydrostatic pressure is not sufficient to form a pressure seal). For the purposes of this SBIR topic, the Navy will not forbid or restrict the use of any particular materials/chemistries for the new water-blocking material, but materials of low toxicity and environmental impact are preferred over those of high toxicity and environmental impact. New water-blocking materials may utilize non-reversible chemistries as long as the longitudinal flow of saltwater is prevented (proposers may assume the breached cable will be scrapped/never used again upon return of the vessel to port); the goal is to protect the equipment attached to the ends of the cable. The Navy notes that it has tested super water absorbent gels (e.g., sodium polyacrylate) as a possible candidate for a new/improved cable water-blocking material. However, the results were disappointing since the absorption of water by such materials is impeded by the presence of dissolved ions in the water, so this material does not work well with seawater. The Navy will consider modified versions of super water absorbent gels that have been modified to work acceptably (per the MIL-DTL-915G requirements) with seawater. For example, the new water-blocking material could be a polymer system that reacts irreversibly with seawater to form a water-block; however, the material should be designed to react with seawater flooding a cable, but not with water diffusing through the cable jacket. The

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flexibility/bendability of the affected cable need not be retained once the water blocking reaction is triggered.

Major goals/considerations for this SBIR topic:

The new water-blocking chemical/material MUST:

1. Work with SEAWATER.
2. PREVENT/STOP the longitudinal flow of seawater through a cable at both high (up to 1000 psi) and low (25 psi) hydrostatic pressures.
3. NOT be triggered by (fresh) water diffusing through the cable's outer jacket.
4. BE COMPATIBLE WITH the outboard cable manufacturing process
5. Have as low an ENVIRONMENTAL and TOXICITY impact as possible

PHASE I: Define and develop a concept for innovative water-blocking materials/chemistries that could be used inside Navy outboard cables to prevent saltwater from flowing longitudinally through such cables. "Simulated cables" (rubber tubes filled with the proposed water-blocking material) may be used to demonstrate proof of concept. During phase I, the emphasis should be on the chemistry of water-blocking material. The proposer will be expected to contact cable manufacturers to verify that the proposed chemistries would be compatible with commonly used cable manufacturing processes. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and deliver a prototype of at least three different types of navy outboard cables of sufficient length to be tested for hydrostatic pressure/open face and water tightness in accordance with a modified version of the MIL-DTF-915G tests that will substitute seawater for freshwater. Both kinds of hydrostatic testing shall be conducted and no passage of seawater through the cables should occur. Refinement of the water-blocking chemistry/material will be conducted, as necessary. The new water-block chemical/material will be tested with the commonly used cable jacket materials noted in the "description" section.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use through one or more commercial cable manufacturers to incorporate the new water-blocking material/technology into operational Navy outboard cables used by the sponsoring Navy Program Office. Work with the Navy to obtain approval for Navy use of such cables by the appropriate Navy authority.

Potential employment for this technology in the private sector is good. Outboard submerged cables can be found on civilian ships, submarines, and unmanned undersea vehicles. Additionally, this cable technology has use on submerged civilian marine infrastructure such as seabed power and communication cables.

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KEYWORDS: Underwater Cables; Hydrostatic Pressure; Water-blocking; Water-Proofing; Water-Tightness Testing; Super-Absorbent Polymers.

VERSION 8

N221-067

TITLE: Improved Reliability of Composites Pi-Joints for use in Primary Aircraft Structures

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Air Platforms; Materials / Processes

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Improve reliability, reduce uncertainty and scatter in performance and hence enhance the user communities' confidence in the use of pi-preform-based primary bonded composite structures.

DESCRIPTION: While the robustness and load-carrying capability of pi-joint based primary bonded structures have been demonstrated in past development programs [Ref 1], the joining technology is not widely used. Fabricated joints still show variable porosity and resin-pooling [Ref 2]. This in turn provides a large scatter in failure strength. Repeatability of the process remains an issue. This uncertainty hinders characterizing the bondline of as-built geometry and subsequent use of analysis techniques to prognosticate structural performance.

There can be multiple approaches to address this topic:

1. Interface improvement by using film resins that are currently being developed [Ref 2]. Additionally, interface toughening with nano-additives shows promise in providing more control on the interface and reducing the scatter.
2. A method to efficiently create a digital twin of the fabricated joint in the as-built condition using X-Ray/ Ultrasonic (UT)/ or Computed Tomography (CT) can be a solution [Ref 3]. Such digital twin can be used to develop high fidelity models to predict failure. The accumulated digital data can also be used to develop a database of critical joints that can be used with big-data algorithms to extend building block testing.
3. A sensor based Non-destructive Inspection (NDI) system that can monitor cure directly or indirectly. These sensors can also be potentially used during service life of the part for health monitoring system.

The above are suggestions only – any viable method to improve pi-joint reliability will be responsive to the SBIR topic. Additionally, the robustness, manufacturability, maintainability, and affordability of the proposed technology will be important consideration in the selection process.

PHASE I: Focus on establishing feasibility of a proposed concept via a flat panel with a single stringer attached by a pi-joint. The joint should be able to transfer shear, tension, compression, and torsion. Proof of concept testing will be at lab scale to establish joint allowable and associated scatter in data. Additionally the effectiveness of any sensors used for cure monitoring has to be established. Preliminary scale up plans have to be established in this Phase.

PHASE II: Mature and demonstrate the methods developed in Phase I. Further develop and optimize the pi-joint through testing a relevantly-sized, fixed wing or rotorcraft-representative skin-to-frame joint to

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demonstrate the reliability, durability, inspectability, maintainability, weight efficiency, and affordability of the method. Models to predict performance and inform design choices of the joint shall be developed and verified/validated using the test data. Potential use of any sensors used for health monitoring will need to be planned. A study to assess the maintenance and cost requirements shall be performed in preparation for Phase III.

PHASE III DUAL USE APPLICATIONS: Further mature and commercialize the novel and reliable pi-joint for composite skin-to-frame connection and load transfer. Consideration shall be given to improving manufacturing readiness level and airworthiness qualification through modeling and testing with a vision toward reliable, durable, inspectable, maintainable, lightweight, and affordable joints that will ease their insertion in both manned and autonomous platforms.

Lightweight fastener free joints are as attractive to the commercial sector as it is for the military. This is especially true in the vibrant Urban Air Mobility Sector. Additionally, composites are increasingly used in high end automobiles, especially in electric vehicles.

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KEYWORDS: Composites pi-joint; bonded joint; skin-stringer joint; toughened adhesive; in-situ cure monitoring; health monitoring

VERSION 8

N221-068 TITLE: DIGITAL ENGINEERING - Requirements Management Tool for Design of Effective Human Machine Systems with Evolving Technologies

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence (AI)/Machine Learning (ML);Autonomy;General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Human Systems;Information Systems

OBJECTIVE: Develop an interactive environment that allows all stakeholders in the Acquisition lifecycle to participate in the design of a 'platform' using a set of tools and supporting methodology for systematically capturing requirements and decisions made for the human components of complex human-machine systems from initial system conception, through systems design, and on into systems acquisition and deployment.

DESCRIPTION: Mismatches between system requirements and human operator capabilities are a recurring problem that are being exacerbated by the rapid evolution of automation & "smart" technologies [Ref 1]. Design and acquisition of Naval systems cannot anticipate the capabilities on the near and far term horizons. Deciding which functions (tasks, jobs) of a human-machine system should be allocated to the human and which to the machine (typically a computer) is one of the most essential activities within human factors research [Refs 2-4]. A new approach to managing human requirements and matching them to technical capabilities throughout the development and acquisition process is needed. A system is needed that captures and documents those functions and capabilities that are determined to be fundamentally human and they must be documented and tracked throughout the system design and acquisition process.

This SBIR topic seeks innovative approaches to identify, document and systematically track those task functions and capabilities that are assigned to Sailors or Marines as they are proscribed to human operators throughout the design and acquisition process. By capturing initial design decisions – and their underlying decision trees – and advances in technology and how they impact the role of humans in the system will be documented. Further, changes in capabilities enabled with future technologies can be accommodated and upgraded/updated recommendations could be made throughout the platform's lifecycle that adequately address the impacts to human operators and users. The evolution of systems must be considered in parallel with recommendations to the Manpower, Personnel, Training & Education lifecycle that prepares Warfighters to use these systems. Accounting for these advances will ensure that platform/system designs will continue to account for and address the needs of our Sailor and Marine end users as technologies evolve – without risking mission effectiveness.

The tools developed through this effort will assist in identifying, defining, and specifying the role of humans in using technologies in complex systems. The desired system would characterize those functions that are determined to be fundamentally human, and which must be addressed throughout the design and acquisition process, regardless of what technology solutions might be brought to bear as the system evolves. The system should provide operational descriptions of the functions, fundamental assumptions and assertions for the role of the humans interacting with these systems, along with objective (quantifiable) metrics for human performance with the system being developed. The desired capability will create a record of what humans are expected to do in the systems, and how they are addressed through the design, acquisition, and deployment process. The system would document design decisions and tradeoffs that are made, ensure that requirements are appropriately addressed, and provide structured documentation. While the desired system should be broadly applicable to a range of human-machine system teams, of particular interest are those hybrid systems that involve significant decision-making support or human-automation/autonomy interactions. Both types of systems may evolve with the introduction of artificial intelligence and/or machine learning, and significant evolution in capabilities are

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expected, so use cases addressing the use of the proposed design tool(s) for these applications is highly desired. Failure to adequately consider and manage these issues during system design, development and acquisition reduce platform resiliency at the cost of a sub-optimized force and reduced mission success for the entire Naval enterprise.

PHASE I: Address the state of the art in system design and functional requirements tracking tools. Define how the engineering tool(s) to be developed will capture, document and track requirements related to human roles and activities in complex human-machine systems. Develop at least two use cases for how the proposed system will be used to support human-machine system design. Develop and describe a concept prototype tools / workflows / processes with storyboards, mission narratives, and functional flow diagrams (or equivalent) to demonstrate how the technology being developed will support system design. A prototype description should be developed to include appropriate standards-based approaches to defining the human role in systems to the maximum practical extent. Define operational and technical metrics that will permit the demonstration of the utility of the approach during Phase II development. Propose notional elements on how the products created using the proposed tools would be stored and disseminated across a distributed design team. Describe the functionality of the anticipated for software prototypes being developed during Phases II and III of the effort. Software will need to run on a local machine, and work well in field conditions (i.e., no internet, no external connections or cloud connections, etc.). Define the proposed transition model and a development plan for successful development through Phase III of the SBIR/STTR process. Provide a Final Phase I report that includes detailed descriptions of the development approach, and the technical challenges to be addressed in Phase II. Develop a Phase II plan that includes detailed Program Objectives and Milestones (POAM) for the duration of the project effort. Describe proposed performance criteria and metrics to be used in evaluating technical progress of the effort through Phases II and III of this SBIR project. Identify transition targets (e.g., Naval Programs of Record or potential commercial customers) who are prepared to invest in the tool during Phases II and III.

PHASE II: Develop, demonstrate, and refine the Phase I concept prototype(s). Validate utility in supporting the design in one or more systems. Demonstrate applicability to system design for an actual system design. The demonstration should be based upon the planned commercialization / transition strategy. The effectiveness of the tool(s) / processes for using the tool(s) shall be demonstrated by applying the utility metrics defined in Phase I, as well as any additional metrics that may be developed in Phase II. Develop and document a specific plan for Phase III transition and commercialization for the identified transition customer(s). Provide a Final Phase II report that includes a detailed description of the approach and results measured against metrics developed in Phase I.

PHASE III DUAL USE APPLICATIONS: Refine the prototype and make its features complete in preparation for transition and commercialization based upon the requirements of the transition customer(s). In addition to the DoD, there will be an increasing demand for human performance system design tools and techniques useful for complex systems in the commercial sector, and in federal and state agencies, for example, self-driving cars, intelligent monitoring and clinical decision support for medical devices, and geophysical surveillance for mining and agriculture. These domains, and any domain looking to inject AI into existing structures involving humans and teams of humans could benefit significantly from the application of the solutions developed in this effort.

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KEYWORDS: Human; Machine; Acquisition; Life cycle; Automation; Artificial Intelligence; AI; System Design; Requirement; Technology Management; Human Factors

VERSION 8

N221-069 TITLE: DIGITAL ENGINEERING - Digital Twins to Enable Training (DTET)

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Human Systems;Information Systems

OBJECTIVE: Develop an enterprise training solution that integrates digital twin models [Ref 1] and their related data with immersive training content capabilities and adaptive training algorithms to accelerate the acquisition of knowledge and increase learning gains with a focus on maintenance tasks.

DESCRIPTION: Current maintenance training systems lack several modern training capabilities: (1) easily created and modified immersive training content; (2) algorithms and technologies that enable adaptive and tailored training; and (3) an enterprise focus that allows for automated content creation across many domains, whether it be immersive content, tailored lesson plans, or adaptive tutoring through a curriculum. The current state of the art of digital twin technologies in development to design new systems could also be used for training and education. However, new capabilities are required to link the underlying authoritative models with immersive content creation pipelines that can leverage poor-quality source data in an automated fashion requiring minimal personnel interaction. Additionally, new training and education systems must be developed to allow for adaptive and tailored training [Ref 2] that can be applied to a variety of maintenance domains, and do not require specialized personnel to develop training content and curricula. A convergence of key enablers exists to pivot towards an immersive and tailored training approach by exploiting the availability of computer vision, advances in machine learning, and science of learning. Proposals should leverage emerging commercial technologies while addressing the technical challenges associated with supporting distributed military environments and training at an enterprise scale.

The overarching goal of this effort is to connect authoritative digital twin models, developed as part of an overarching Digital Engineering approach to streamline new platform development, with a generalized and domain-agnostic persistent training platform for automated content creation and tailored learning guidance at an enterprise scale connected to an eLearning system (such as Moodle). The immersive content creation pipeline may need to rely on a suite of technologies, such as object scanning, photogrammetry, and computer vision to create content usable in current and future classrooms [Ref 3]. These technologies should be able to be integrated with and leverage models from existing Marine Corps digital twin efforts. Respondents are expected to have existing content for which to use for the topic. Authoring, content development, and management of the tailored training system should leverage machine learning and other adaptive algorithms.

The end state of this program is a capability to leverage already-validated digital twin models as part of a broader maintenance training tool that tailors instruction to each individual student. This program should automate source material ingest and immersive content creation reducing the time to create training curricula and increase learning gains (e.g., test scores) by creating opportunities to interact with immersive content and be guided through curricula by macro- and micro-adaptive tailored training algorithms. Human Subjects testing may be needed in Phase II to assess content creation efficiency increases and training effectiveness outcomes. The anticipated skill sets necessary to support this topic are: maintenance subject matter experts, computer scientists, software engineers, instructional designers, data scientists, and human factors psychologists.

PHASE I: Develop early mockups and prototypes for software, the associated workflow and requirements for supporting an enterprise capability for source content ingest, automated immersive content creation, and adaptive learning within a Marine Corps eLearning ecosystem (e.g., Moodle). Source content could vary from static images to 3D scans of physical objects to CAD models.

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Produce the following deliverables: (1) requirements for the system components including leveraging and integrating with existing Digital Twin models; (2) methods to efficiently ingest poor-quality, limited source data and automate immersive content creation; (3) learning sciences approaches for delivery of content; and (4) overview of the system and plans for Phase II, which should include key component technological milestones and plans for at least one operational test and evaluation, to include user testing.

If exercised, the Phase I Option should also include the processing and submission of all required human subjects use protocols as needed for Phase II training effectiveness evaluations. Due to the long review times involved, human subject research is strongly discouraged during Phase I. Phase II plans should include key component technological milestones and plans for at least one operational test and evaluation, to include user testing.

PHASE II: Develop a prototype system and conduct a hands-on demonstration with Marines (coordination aided by ONR) in a designated field of maintenance (e.g., ground vehicles, radio communications, etc.). Conduct a usability assessment and perform a training effectiveness evaluation. Specifically, develop an early-stage prototype focused on no more than two task domains to support the source ingest and content creation pipeline and adaptive training technologies. Construct a survey to provide feedback from maintenance instructors and students (assistance in determining relevant population and coordinating for demonstration/field test by ONR). Collect impressions of usability, develop objective metrics of time and effort to create immersive content, and measure learning gains (including quantity and quality of acquired knowledge). Perform all appropriate engineering tests and reviews, including a critical design review to finalize the system design. Once system design has been finalized, conduct a usability test of the immersive content creation system and training effectiveness evaluation with a relevant Marine Corps population.

Produce the following deliverables: (1) a working prototype of the system that is able to interact with existing system specifications; (2) evaluation of system usability and efficiency to ingest source data and create immersive training content; and (3) a training effectiveness evaluation of system capabilities to provide demonstrable improvement to the instructor population (Human Subjects protocol needs to be approved in Phase I Option if needed for this evaluation). Institutional Review Board approval for human subjects research can take 6-12 months, and this must be taken into account if human subjects research will be part of the proposed work.

PHASE III DUAL USE APPLICATIONS: Support the Marine Corps in transitioning the technology for Marine Corps use. Develop the software for evaluation to determine its effectiveness in either a formal Marine Corps school setting or other training setting. As appropriate, focus on broadening capabilities and commercialization plans.

Development of affordable, scalable, non-proprietary technologies are needed in order to integrate immersive content creation and accelerated learning concepts across the DoD. The commercial sector is developing some of these technologies, but they often do not have critical issues regarding non-existent, limited, or low-quality source data, nor do they often address encryption and classification. This technology will have broad application in the commercial sector, such as in manufacturing and industrial equipment maintenance.

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KEYWORDS: Digital Twin; Adaptive Training; Content Creation; Maintenance; 3D Models

VERSION 8

N221-070 TITLE: Acoustic Vector Sensors that Achieve Affordable Array Directivity

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR);Networked C3

TECHNOLOGY AREA(S): Electronics;Information Systems;Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Achieve substantially more affordable application of acoustic vector sensors, particularly under less extreme contexts (e.g., ocean shelf vs. deep ocean applications, fat-line vs. thin-line towed array form factors, deployment packages larger than A-sized) through concurrent application of recent acoustic vector sensor design and manufacturing advancements.

DESCRIPTION: Acoustic vector sensors deliver directionality by virtue of sampling the kinetic energy portion of the propagating acoustic field rather than simply the potential energy portion of that field using a hydrophone. Such directionality can be achieved via a direct measurement of acoustic particle velocity; by temporal integration of measurements of acoustic particle acceleration; by temporal differentiation of measurements of acoustic particle displacement; or by spatial differentiation of the acoustic pressure field using an adjacent pair of hydrophones. Much progress has been made in the design and employment of highly compact, low power, and low noise-floor acoustic vector sensors in applications at lower frequencies, particularly within arrays that are relatively stationary in relation to the surrounding sea water or, if moving, include a substantial decoupler. For applications under circumstances of low environmental noise and/or harsh volume constraints, high strain sensitivity materials in combination with sophisticated signal conditioning electronics have been required to deliver the requisite sensor self-noise performance. Particularly in deep ocean applications and for thin-line towed array applications, the material and manufacturing requirements for the sensor housings have been extremely challenging. Sensor and array costs and their in-situ performance have also been substantially complicated by, and in some cases compromised by, the adoption of proprietary telemetry schemes that promised low technical risk and/or avoidance of non-recurring costs. SONAR array employment at shallower ocean depths and across a larger frequency band leads to arrays with more sensor elements which simultaneously and harshly drive up array costs and telemetry bandwidths.

This SBIR topic specifically addresses cost-effective manufacturing approaches that will enable wider adoption of acoustic vector sensor technologies by making directional sensors and arrays simultaneously more effective, more reliable, and more affordable. By employing the lessons learned in design, manufacturing, and employment of acoustic vector sensors for use in the most extreme operating conditions of depth and low background environmental noise, sensible options emerge for substantially reducing the cost of manufacturing sensors good enough for more less demanding operational circumstances. A combination of these steps should reduce the total cost of a joint pressure velocity sensor by more than 50%. Specific examples might include the use of lead zirconate titanate (PZT) or textured ceramics in lieu of more expensive PMN-PT materials, or concurrent additive manufacturing of sensor housings and vector sensor accelerometer beam mechanical components, or incorporation of a government-owned (e.g., non-proprietary) signal conditioning and digital telemetry architecture to

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reliably enable dramatic flexibility in array bandwidth, or some combination. Hybrid arrays that simultaneously sample the acoustic and kinetic energy field using either joint pressure-velocity sensors or co-located hydrophone/particle velocity sensors are also of interest.

PHASE I: Identify the tradeoffs between transduction materials, acoustic particle velocity sensor channel fabrication methods, telemetry alternatives, and environmental noise vs. array employment strategy to offer more cost-effective passive acoustic SONAR sensors and arrays.

The proposed approach should directly identify and address:

1. Identify and address Navy end user(s) requirements/constraints (e.g., the noise floor, size array packing volume/cost, size, weight, power requirements) that can be improved/relaxed.
2. Define clear objectives and measurable results for the proposed solution(s) – specifically how the combination of improvements will impact the end user application context.
3. Describe the cost variance and design feasibility when integrated vs a legacy capability.
4. Describe material science and manufacturing technology developments that would be required to successfully field the proposed solution(s).

Develop a Phase II plan.

PHASE II: Develop, integrate, and demonstrate a prototype acoustic vector sensor determined to be the most feasible solution during the Phase I period. The demonstration should focus on:

1. Evaluate the proposed solution vs performance requirements and cost and reliability objectives defined in Phase I.
2. Describe in detail how the resulting sensor design and production innovations can be adopted widely.
3. Identify a clear transition path by which a solution appropriate to a specific transition context can be advanced in collaboration with transition stakeholders.
4. Incorporate specific feedback from transition customer(s) regarding how the proposed solution can be integrated, supported, sustained, and relied upon to reduce acoustic vector sensors costs and to support the unique priorities of other applications/customers.

PHASE III DUAL USE APPLICATIONS: Expand mission capability vs. affordability options to include a broad range of government and civilian users and applications. Coordinate with the government for additional research and development, or direct procurement of products and/or services developed in coordination with the Navy.

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KEYWORDS: acoustic vector sensor; acoustic particle velocity; PMN-PT single crystal material; lead zirconate titanate; PZT ceramic material; Open Architecture Telemetry; textured ceramics

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N221-071 TITLE: Forensic Memory for Self-Cued, Data-Thinning Receivers

OUSD (R&E) MODERNIZATION PRIORITY: 5G;Microelectronics;Networked C3

TECHNOLOGY AREA(S): Electronics;Information Systems;Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Demonstrate a digitally-based, forensic First-In, First-Out (FIFO) memory technology. Then, at a threshold level of performance, develop methods to locate within the exiting flowing data the specific subset corresponding to cued time/frequency segments and deliver them into a back-end data fusion processor. At the objective level of performance, demonstrate successful sub-nanosecond re-aggregation of common time of arrival events from multiple disjoint frequency subchannels. Ensure memory concepts are compatible with data rates scaling to multi-bit, 40 GSamples per second or more and provide time offsets of 100 microseconds or more per modular copy. Consider desirable low power operation and low acquisition cost.

DESCRIPTION: The increasing military use of highly adaptive transmit signals mean that U.S. electronic support receivers need to respond to unpredicted single pulses. Hence they need to include the ability to self-cue on signals within their input bandwidth that just appeared in the spectrum and match the current criteria of signals of interest. Unfortunately, by the time the new signal is detected and categorized as of interest, its occurrence is often over. Hence unless the entire spectrum has been recorded, there is then no possibility to study that first occurrence in greater detail, especially if the data was consumed in the event detection process. In particular, there is no way to look just before the pulse's onset to see whether there is a characteristic precursor signal. What is needed is a forensic memory, a way to look back in time and access the entire signal after it is declared of interest. To be practical, this memory ought not to require massive RAM memories, cost, or power consumption to operate and should produce a long enough delay to allow digital processors working in parallel on multiple, identical quality copies of the entire spectrum data sufficient time to provide cueing information for all the currently prioritized events of interest happening in the given time window.

Today such memories do exist where a power divider sends an analog copy of the signal into passive optical fiber, while the rest of the received energy feeds a receiver that detects the signals of interest (SOI). This architecture can work but requires substantial distortion--inducing amplification to achieve long enough delays and often an entire digitization front end per SOI output. For full spectrum, many simultaneous signal systems, the cost and complexity/volume of the resulting redundant hardware and control networks becomes prohibitive.

Future ES systems need to surveil over 20 GHz of instantaneous bandwidth and respond to a variable but potentially large number of simultaneous signals in all frequency channels monitored, without having the rigidity of designating which frequency channel a given processor addresses. The Analog to Digital Converters required increasingly exist. What is missing is a way to capture and hold temporarily the digital representation of the entire spectrum and then in real time fan out perfect copies to a scalable set of following digital processors that have been cued as to the time, as well as frequency, of the individual SOI

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they are to process. The ability to aggregate information derived from disjointed frequency channels is also required. A permanently-record-everything approach allows deep inspection of what happened, but normally only after the immediate operational value of the information has expired. It also requires prodigious volumes of memory that consumes energy and volume and manpower to keep changing storage devices. Real-time systems must have a way to reduce the volume of data being extensively processed to what processing the system can accomplish in real time. Therein copies of the same digital data as used for event detection/cue preparation need to be sent to the data thinning circuits. Memory delays sufficiently long for the cues to be prepared and prioritized for further attention are required. Ideally the temporary digital data storage mechanism should not depend on the digital data sample rate. Here the first demonstration ought to consider use of the COTS 100 GbE fiber data links commonly used in server farms. Other solutions suitable for > 20 GSps multi-bit analog to digital converters (ADC) will be considered if the proposals persuasively argue their applicability to real time processing of dense signal environments.

Proposals must define a detailed path to an experimental demonstration of the memory module during the Phase I base period and a more notional plan for demonstrating the entire self-cued data thinning system before the end of the Phase II base period. These plans need to discuss how any components/functionality not existing today would be produced and with what technical risks.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and ONR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Demonstrate the feasibility of a way of providing a properly synchronized FIFO copy of 3 or more bit wide digital words at a flowing data rate above 20 GSps with time delays above 100 microseconds and a bit error rate below 10⁻¹². Prepare a preliminary Phase II plan that discusses how to scale to wider words, higher data rate, and longer delays, plus comment on details like the impact of data packetization on the system performance. The Phase I option work, if exercised, should complete the production of the prototype memory module suitable for multi-bit 40 GSps ADCs and ideally demonstrate scaling to longer delays with no drop in BER, the bit error rate.

PHASE II: Develop and demonstrate a modular, adaptive, high bandwidth data thinning system. Functionalities that shall be demonstrated include: 1) proper recovery of a truncated data set containing the data that produced the self-cueing alert for a single < 10% duty cycle signal; 2) two differently processed signals from the same frequency sub-band within the same original data stream arriving into a data fusion processor with the proper relative timing; and 3) two differently processed signals from different frequency sub-bands within the same original data stream arriving into a data fusion processor with the proper relative timing. Progress on monitoring and controlling the absolute delivery- time delay and inserting the delayed data into the further back processors will be expected. Preference will be given to proposed efforts with little development work on the cue producing subsystem. The Phase II option effort, if exercised, shall incorporate the new delay module in some existing, probably classified signals analysis system and demonstrate the improved functionality. A proof that the improved system's operation is independent of the signal waveform is expected to be included.

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It is probable that the work under this effort will become classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Full integration of the time delay unit into a working, classified ES system is predicted and tests of its performance advantages will follow. If the suggested server farm data links can be adapted for this use, the topic will be a dual use application, but the technology advancement driver will be dominated by the commercial side of the equation.

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KEYWORDS: First-in-first-out memory; FIFO; adaptive signals; Electro-magnetic support systems; time delay; digital data transmission; channel/time domain synchronization

VERSION 8

N221-072 TITLE: Low-Cost Deployable Structures for Sonobuoy Arrays

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR);Microelectronics

TECHNOLOGY AREA(S): Sensors

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OBJECTIVE: Develop and demonstrate affordable and reliable high packing ratio deployable structures for advanced sonobuoy arrays to enable future U. S. Naval anti-submarine warfare operations.

DESCRIPTION: The Department of the Navy (DON) seeks to develop and demonstrate reliable deployable structures for highly capable volumetric acoustic arrays from compact air-deployed canisters. These arrays require stability once deployed with the sensor elements having predictable and repeatable spacing to allow optimal system array performance. The deployable structures should be acoustically quiet and transparent and/or not interfere with any acoustic nodes that may be placed on the structure. Sonobuoy deployable arrays are deployed from patrol aircraft or helicopters and need to meet all the requirements of production sonobuoys. The deployable structures need to be able to reliably deploy even after resting up to five years on the shelf. The deployable mechanisms need to fit within the confines of the A-size sonobuoy (18" x 5") and expand to a cylindrical array up to 6,100x the original volume all while holding ~100 sensor nodes. The lifetime of these systems once deployed should be no more than a day and the overall cost of the deployment system should be less than \$500.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this project as set forth by DCSA and ONR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Develop a conceptual design for the proposed component(s) and its integration into a chosen deployable array. Phase I awardees will be granted access to specifications of production sonobuoys. Conduct a conceptual design review of the analysis and results of Phase I work. Develop a Phase II plan.

PHASE II: Develop and test a prototype for the key components of the proposed approach. Complete preliminary performance testing in a surrogate environment such as a large tank or lake test facility. Report the results of testing and analyze the expected performance for the reference mission.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

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PHASE III DUAL USE APPLICATIONS: Integrate the technology using the prototype fabricated in Phase II. Conduct a demonstration to examine mission performance under nominal operating conditions. Based on the results, analyze performance in a variety of suboptimal environments and conditions.

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KEYWORDS: Undersea sensor; deployable array; sonobuoy

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N221-073 TITLE: Radio Frequency Spectrum Patterns of Life

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence (AI)/Machine Learning (ML);General Warfighting Requirements (GWR);Networked C3

TECHNOLOGY AREA(S): Electronics;Ground / Sea Vehicles;Sensors

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OBJECTIVE: Develop an automated system that characterizes the Radio Frequency (RF) emitter behaviors and patterns of life for a geographic area with no to minimal operator intervention.

DESCRIPTION: The RF spectrum is a congested medium shared by a wide range of private, commercial, civil, and military users to communicate, navigate, and characterize the environment using increasingly diverse signal waveforms and shared-access methods. Spectrum use varies as a function of time, space, and frequency, resulting in a highly dynamic environment that challenges traditional methods of spectrum monitoring and evaluation. This lack of understanding limits the use of opportunistic spectrum applications (e.g., cognitive radio, dynamic spectrum access) and makes it difficult to detect anomalous spectrum use.

Despite the dynamic nature of spectrum use, most of the activity is routine, and therefore potentially predictable. In much the same way that human cognition works, learned models of expected or predictable features and feature dynamics of the environment can be used to focus attention primarily on new or unusual features. Such an approach is necessary when constrained resources are required to make sense of complex situations. By reducing the amount of information that must be processed at any given time, the limited available resources can be allocated more efficiently to characterize the most important aspects of the environment, not wasted by repeatedly evaluating the same features and behaviors.

To support this objective, this SBIR topic will explore algorithms that detect, characterize, and learn “normal” spectrum activity and behaviors. Learned models should be able to represent signal types and their temporal and spatial qualities sufficiently to predict when and where typical activity will occur. An important aspect of this research will be to demonstrate ways that the learned model can be used to focus attention on novel signals in the spectrum, as well as unusual spectral patterns of activity. Note that methods of interest must be able to generalize over a wide range of signal types, including those used by communications devices and radars. Approaches that operate only on limited or specific signal types are not of interest.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this project as set forth by DCSA and ONR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent

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requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Conduct a study to evaluate the technical feasibility of learning RF spectrum patterns of life to automatically bring to the operators attention novel and unusual activities in the RF environment. Given a simple radio receiver (e.g., single channel, ≤ 500 MHz instantaneous bandwidth, $\sim 18+$ GHz tuning range), develop an approach to learn spectrum patterns for a day in the life of a moderately congested RF environment (e.g., an airport, a littoral maritime environment). Demonstrate for a simulated environment that the learned model can discriminate between new signals and those normally present in the environment when a new signal shares several attributes (waveform, frequency, timing, etc.) with those signals typically present in the environment. For example, the system should be able to detect when an arbitrary but common communications signal appears at an unusual frequency or time of day, or when a radar changes its' waveform or pulse repetition rate to something not previously observed. Develop a Phase II plan.

PHASE II: Given a set of 3-4 simple receivers geographically distributed to span an 100 SQ mile area of interest, develop an approach to learn spectrum patterns for a day in the life of a moderately congested RF environment. Demonstrate in a lab environment that the learned model can detect unusual signals and spectral activities that vary over space, time, frequency, and/or signal type. Build and deliver a prototype system that can monitor the RF spectrum, collect sufficient examples to train the learned model, and then operate in near-real-time to identify spectrum anomalies.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Develop an improved spectrum patterns of life modeling system integrated onto a fielded RF sensor(s). The system will show that it achieves the objective capability described above. Deliver the prototype to be independently evaluated by the Government to determine if the technology has the potential to meet the Navy's performance goals for patterns of life modeling.

Develop an automatic capability for RF spectrum monitoring and analysis by commercial ventures who enforce Spectrum utilization for the Federal Communications Commission (FCC) and Homeland security. This capability can also be used by cell tower infrastructure companies to understand the RF environment they are placing new or existing cellular infrastructure in.

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KEYWORDS: Electronic Surveillance; Radio Frequency; RF; Spectrum Monitoring; Patterns of Life; Emission Classification; signals intelligence; SIGINT

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N221-074 TITLE: Turbine Engine Efficiency improvements by Additive Manufacturing

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence (AI)/Machine Learning (ML);General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Air Platforms;Ground / Sea Vehicles;Materials / Processes

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OBJECTIVE: Link heat transfer and solidification modeling, material databases, innovative cooling design concepts, and Additive Manufacturing (AM) process variables that will enable repair and enhanced efficiency improvements for gas turbine blades and other potential high temperature engine components.

DESCRIPTION: Improving engine performance requires creating new materials and improving design and manufacturing. AM is capable of producing details of complex shapes that cannot be produced by traditional methods. AM could produce nickel-based turbine blades with complex geometries with optimized internal cooling pathways and lattice-structure interiors.

Microstructural control can enable tailored properties. Modeling and simulation tools that analyze thermal flow and solidification, coupled with alloy property databases within a machine learning framework, can link varying AM process variables to arrive at new complex blade designs with optimized, integrated cooling networks and lattice blade structures rather than solid blades to reduce blade weight and improve engine efficiency by increasing operational engine temperatures. Fabricating blades in this manner would avoid current processing steps. With AM processing of these complex architectures, the effects of internal surface roughness will also need to be evaluated.

The AM process should present unique designs not possible with more conventional fabrication processes. The use of AM could lead to more innovative designs capable of more efficiently removing heat for both Navy and commercial applications. The outcome of this technology development effort will be a commercial suite of informatics-derived tools that can be able to reliably analyze and discriminate various sources of materials databases to optimize the capability for developing and new design and fabricating turbines blades with more effective use of the cooling air available to the engine.

PHASE I: Explore the literature to determine the initial AM parameters for a nickel-based superalloy such as Alloy 738 or 718. The focus of Phase I will be to fabricate a generic artifact with a simple network of internal cooling holes, overhangs, and thin/thick sections. The performer can suggest the artifact for evaluation. Suggested size would be an isosceles triangle cross-section about 3-inches (7.5cm) long. The unequal side should be 1-inch (2.5-cm) wide. The company should select an AM process capable of sufficient control and resolution to enable a good understanding of the heat transfer, solidification variables, and other material/process factors which cause defects. Develop conceptual models/algorithms that link alloy chemistry/heat transfer/solidification to the AM process shows geometric and material control while minimizing defects. Consideration will be given to the size of the internal holes and cooling network generated. Analysis of the defects is suggested to be done by non-destructive processes such as

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optical tomography, in-situ thermographic analysis, ultrasonic monitoring or x-ray tomography. ICME should link to AM process parameters with defect frequency and distribution in the component design, employ and prove feasibility of an approach for a metal AM method. Develop a Phase II plan.

PHASE II: Focus on increasing complexity of the linked AM process and on fatigue critical properties and temperature ranges of interest. In addition to evaluation of microstructure, Phase II should focus on fatigue critical properties at temperature ranges of interest. The AM process should be assessed to fabricate an internal surface roughness that maximizes cooling effectiveness. Further evaluation of effects of defects and control of defects should provide a more in-depth link to ICME-based tools. Residual stress should also be considered within modeling and fabrication tools to reduce residual stresses during fabrication and prevent cracking. The company should work with a turbine engine Original Equipment Manufacturer (OEM). The OEM should provide a range of conditions (cooling channel size, pressure drop tolerance, cooling efficiency).

PHASE III DUAL USE APPLICATIONS: Commercialize the alloys for use in DoD and commercial markets. Engage with the Government and/or public, commercial, company, or professional technical societies that retain materials databases. Interface with a software company that promotes and delivers materials computational programs to explore and develop an integration pathway for the database discriminating program with their software. Transition the material production methodology to a suitable industrial material producer. Transition the ICME code to the commercial entity for potential incorporation of a more comprehensive ICME code.

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KEYWORDS: Additive manufacturing; AM; turbine components; materials databases; machine learning; modeling; solidification; design; heat transfer; AM defects

VERSION 8

N221-075 TITLE: Enhanced Lethality Warhead

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR);Hypersonics

TECHNOLOGY AREA(S): Materials / Processes;Weapons

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OBJECTIVE: Develop and demonstrate new warhead configurations that leverage new and existing energetic and reactive materials in addition to novel design and manufacturing tools to significant increase warhead damage on target to achieve (1) decreased warhead size and weight while maintaining the lethality of today's fielded weapons (e.g., Harpoon, LRASM for anti-ship), and (2) increased warhead lethality in the same form-factor to allow previously undersized weapons to engage a broader range of difficult target sets.

DESCRIPTION: Conventional kinetic weapons generally rely on some combination of high explosive formulation fill and inert metal fragments to damage targets. Mechanisms include detonation/shock wave, post-detonation-combustion/blast, and fragment perforation. Legacy warhead designs are often decades old and do not incorporate state of the art ingredients and design concepts. More importantly, these weapons are proving inadequate for emerging and even current threats, as they were originally developed for different historic target sets. Where more complex explosive responses are desired for special target applications and lethality enhancements, few material solutions have been available short of combinations of legacy warhead design features: complex fuzing, shape-charge jets, enhanced-blast fuel addition, etc.

More recently, advances in warhead material solutions and manufacturing/prototyping methods are emerging and have untapped potential to facilitate the development of modernized, enhanced lethality warheads with greater target damage potential at equal and reduced form-factors. For example, high density reactive materials (HDRM) are being explored for fragmenting warhead applications, providing additional incendiary and overpressure effects beyond conventional steel fragments. This will result in enhanced lethality and a reduction in the number of fired munitions to achieve confirmed kill on specific target sets, while maintaining the same warhead form-factor. 3D printed explosives and fragment architectures are also of recent interest for fragmentation size/shape control and directional damage effects on targets rather than conventional 360-degree blast and fragment dispersal.

While examples like reactive materials and 3D printing have been under development for decades, there remain numerous challenges and great potential for further warhead technology development and maturation. For instance, recent efforts, including those pertaining to HDRM fragmenting warheads, demonstrate the need for less complex, lower cost reactive material prototyping and manufacturing. In addition, accurate models are needed to facilitate adequate target damage credit for new warhead effects in main-stream lethality tools (AJEM, ASAP, etc.). Numerous other technical challenges and examples of desired warhead technologies include but are not limited to: explosive formulation 3D printing of complex shapes vs. poured/casted billets, bi/tri-metallic 3D printing of warhead relevant materials (titanium, tungsten, steel, zirconium, aluminum, etc.), incorporation of highly survivable (temperature, vibration) warhead materials (structural, energetic, or both), exploration of other tertiary lethal

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performance effects (e.g., enthalpic chemical reactions), combinations of the above to provide directional and selectable effects on target, and overall, a more complete fundamental understanding of how to take advantage of the specific location of metal and other reactive components within a warhead to control mixing/combustion/blast process fluid dynamics. Considering recent progress in warhead relevant ingredients, new processing, prototyping and manufacturing methods, material models and predictive design tools in tangential technology areas, it is anticipated that the “toolbox” of warhead material combinations and configurations can be greatly expanded and demonstrated to assure future Naval weapon overmatch.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this project as set forth by DCSA and ONR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Develop and design, on paper, several feasible candidate warhead concepts using any combination of previously described or other novel technologies. Describe candidate prototype configurations and architectures in terms of: (1) expected lethality enhancements, (2) suitability for weapon speed regime (subsonic, supersonic, and hypersonic), (3) suggested warhead mass/volume/form factor, (4) example platform/weapon, and (5) example target sets.

Identify anticipated materials, manufacturing methods, design tools, and other relevant technologies that would enable the candidate warhead designs. Identify Technical and Manufacturing Readiness Levels (TRL/MRL) and cost of identified materials, methods, and other tools.

Complete initial modeling/simulation to provide some level of lethality assessment for candidate warhead concepts. At this stage, this modelling needs to be able to show that the new design has the potential to meet increased lethality goals. While this task may require Navy/DoD laboratory collaboration, truly high fidelity modelling is not the goal; the focus of the project is novel design/material use/et al.

Down-select to the most promising warhead designs and create technology and critical experiment demonstration plans and roadmaps.

Develop a Phase II plan.

PHASE II: Create preliminary designs for Phase I down-selected prototypes and execute material development and testing, demonstrating affordable and scalable manufacturing.

Execute critical experiments to demonstrate warhead concept(s) feasibility for lethality enhancements in laboratory/field test environment as appropriate. Sub-scale and sub-component test iterations are expected at this stage for concept refinement.

Complete detailed modeling and simulation, using higher fidelity tools as appropriate, to assess lethality for each prototype against selected target sets.

Pursue partnerships and work with appropriate DoD and/or DoD contractor points of contact (POCs) to down-select to the most promising prototypes. Create Phase III design, build, and demonstration plan(s).

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It is likely that work and information exchanges during Phase II will become classified (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Complete detailed prototype design of down-selected concept(s), build prototype(s) and complete laboratory/field environment testing.

Leverage DoD/DoD Contractor POCs for transition of manufacturing capabilities as appropriate and transition into programs of record (POR) and/or other advanced demonstration programs.

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KEYWORDS: Weapons; Warheads; Energetic Materials; Explosives; Reactive Materials; Lethality

VERSION 8

N221-076 TITLE: Lightweight, Compact, and Cost-effective Gaseous Hydrogen Storage System

OUSD (R&E) MODERNIZATION PRIORITY: Autonomy; General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Air Platforms; Materials / Processes

OBJECTIVE: Develop a lightweight, compact, and cost-effective gaseous hydrogen storage system for Naval Aviation applications.

DESCRIPTION: Hydrogen fuel cells are gaining traction for propulsion and power requirements of small unmanned air systems (UAS) [Refs 1-4]. Compressed hydrogen is the most attractive form for hydrogen storage; however, flight-worthy storage vessels can be heavy, bulky, and expensive [Refs 5,6]. This can lead to sub-optimal vehicle designs by placing excessive volume constraints on UAS manufacturers for hydrogen fuel storage and added costs to users.

This SBIR topic seeks innovative concepts for low cost, high performance gaseous hydrogen (GH2) storage tanks for use in UAS. The Navy and USMC are interested in conformal and traditional storage vessels. Concepts include, but are not limited to, (1) conformal storage tanks that fit into either vehicle wings or non-traditional air vehicle form factors [Ref 7], and (2) novel coatings and materials for Type IV tanks that reduce cost without sacrificing robustness. The proposed concepts will be evaluated on their hydrogen storage performance metrics. Metrics include stored hydrogen weight per storage system (including regulator) weight, total volume of storage system, refill rate, manufacturability, and cost (dollar per system-weight of hydrogen stored). An understanding of how hydrogen storage systems can act as structural elements of the UAS is desired.

The GH2 storage tanks must be compatible with Groups I-III UAS including environmental, shock, and vibration requirements of MIL-STD-810H [Ref 8]. Solutions must demonstrate the safe operation of the vessels including fill, storage, and use of hydrogen [Ref 9]. Solutions must also show refill capabilities using standard interfaces and a cycle lifetime of over 1,000 cycles.

The storage system designs should focus on:

- 200 g minimum GH2 stored, can perform trade study on size and weight impacts for >200 g
- Operating pressures from 350 to 700 bar
- Storage minimum of 7 wt% GH2 per storage system
- UAS integration

PHASE I: Develop a conceptual design of a gaseous hydrogen (GH2) storage system for a minimum of two hundred grams (200 g) of compressed GH2. Identify and model the trade space for key storage system characteristics. Show feasibility for the integration into the Unmanned Aerial System (UAS) through the use of conceptual drawings or modeling and simulation. Perform initial analyses on GH2 consumption rates based on government-selected fuel cells and UAS propulsive and power requirements to meet UAS endurance targets. Produce a final Phase I report that includes plans for a storage system that stores 200 g GH2 and does so at operating pressures from 350-700 bar with a storage minimum of 7 wt.% GH2 per storage system. Develop a Phase II plan.

PHASE II: Build a prototype GH2 system that is lightweight, compact (>20g H2/L), safe, and cost-effective.

PHASE III DUAL USE APPLICATIONS: Incorporate the system into existing and/or future UASs of defined form factors. Target development of larger GH2 storage systems. Work with the DoD and partners to mature and manufacture products to produce systems that are lightweight, compact, and cost-

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effective and can be used on UASs that require longer duration flight and highly adaptable form factors. The platforms of potential applicability do not rely solely on military UAVs, but also in UAVs for commercial/private use and the use of city and local governments and law enforcement. Smart agriculture, critical infrastructure inspections, and perimeter security are all likely dual-use applications.

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9. Safety of Mobile Hydrogen and Fuel Cell Technology Applications: An Investigation by the Hydrogen Safety Panel, PNNL-29341, October 2019. https://h2tools.org/sites/default/files/Safety_of_Mobile_Hydrogen_and_Fuel_Cell_Technology_Applications-Oct_2019.pdf.

KEYWORDS: Hydrogen; Unmanned Aerial Systems; UAS; Conformal; Fuel Cells; Lightweight; Cost-effective; Sustainability

VERSION 8

N221-077 TITLE: DIGITAL ENGINEERING - Semantically-Driven Data Integration Software Solutions

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a software solution to facilitate the integration of data across disparate electronic sources of technical information in accordance with a pre-defined ontology that semantically informs that integration through prescribed concepts and relationships. Solutions must directly address challenges associated with cross-tool/cross-vendor inoperability.

DESCRIPTION: As Strategic Systems Programs (SSP) transitions from traditional, document-based engineering processes to a digital engineering approach, more and more software tools and databases are being used to create, modify, and analyze massive amounts of data during all phases of a given system's lifecycle. Though many domain-specific modeling tools and capabilities are quite mature and meet the needs of the day, the ability to associate/link technical data across domains in a semantically consistent manner is severely lacking. While commercial digital threading solutions exist, none of them are either semantically-driven in nature or have been validated in digital engineering environments representative of SSP's. The absence of tools for rigorous integration poses a significant risk for large acquisition programs as inconsistencies in data across domain tool and database boundaries could lead to faulty analysis results and poor decisions during key stages during the engineering design process.

To support the development of its model-based and digital engineering environments, SSP needs novel software solutions to create a dynamic "data fabric" across disparate electronic sources of technical information in accordance with a pre-defined ontology. These semantically-driven "data integrators" should facilitate, either automatically or semi-automatically, the integration of data through tool-specific means that enforce adherence to the ontology and provide the following functionality:

- Retrieve data from the various data sources (e.g., model files, applications, and databases) collectively considered an authoritative source of truth (ASOT),
- Associate/link data across various data sources and convert one tool-specific language convention to another,
- Infer duplicate entities across and merge into single representations as needed,
- Push "round trip" changes between data sources through the integrator subject to certain synchronization triggers,
- Obfuscate data based on user/organization roles and access restrictions when required, and,
- Provide a means to traverse data across sources to understand and analyze the entire dataset.

Candidate data integration solutions must be compatible with the Web Ontology Language (OWL) files generated with the Protégé ontology and knowledge management system [Ref 3]. Minimum desired target data sources include IBM Rational DOORS for system requirements, No Magic Cameo Systems Modeler (CSM) for use cases and architecture (i.e., model-based system engineering), and PTC Windchill for

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various other artifacts including mechanical (mCAD) and electrical (eCAD) computer aided design models.

PHASE I: Develop an approach to semantically integrate targeted data sources based on SSP's required capabilities and preliminary requirements. Phase I efforts shall articulate the functional design, algorithms, and framework required for interfacing with CSM, DOORS, and Windchill. Additionally, Phase I deliverables shall include detailed information regarding the software architecture and identification of a robust set of test cases that will be used to verify functionality. Licenses for all commercial software to be employed are required. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop a semantically-driven data integrator prototype that incorporates data from CSM, DOORS, and Windchill and demonstrate functionality with a sample data set. Phase II shall include testing based on test cases identified in Phase I (updated during prototype development, as needed). Lastly, the prototype shall demonstrate functionality to representative members of the SSP user community, implement prototype updates per test results and community feedback, and devise a set of use cases applicable to SSP and similar (dual use) digital engineering environments and workflows.

PHASE III DUAL USE APPLICATIONS: Transition the data integrator for Navy use by deploying the software on SSP's "Blue" digital engineering environment. Support user testing in accordance with the use cases developed in Phase I and Phase II, implementing improvements in the tool based on user feedback, and providing product documentation, including installation and user guides. Successful deployment on the SSP Blue digital engineering environments will demonstrate dual use since the target data source tools here (CSM, DOORS, and Windchill) are ubiquitous in many industrial/engineering sectors such as aerospace, automotive, agriculture, mining, and oil/gas.

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KEYWORDS: Digital engineering; model-based engineering; model-based systems engineering; semantically-driven data integration; ontology; digital thread; data integration; semantic analysis.

VERSION 8

N221-078 TITLE: Split Ratio Fine-Tuning Feature for Integrated Optical Circuits in Interferometric Fiber-Optic Gyroscopes

OUSD (R&E) MODERNIZATION PRIORITY: Nuclear

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a new feature for Y-branch dual phase modulator integrated optical circuits (IOC) that enables fine tuning of optical power splitting ratio after assembly.

DESCRIPTION: The performance requirements for strategic-grade inertial sensors based on optical interferometry continue to become more stringent, necessitating continued innovation for optical component technologies. For example, the interferometric fiber-optic gyroscopes (IFOGs) used in inertial navigation systems for fleet ballistic missile (FBM) submarine applications require unprecedented precision, characterized in terms of long-term bias stability, scale factor linearity, angle random walk performance, etc. [Ref. 1]. A key component in these types of sensors is the integrated optical circuit (IOC). The IOC is typically comprised of Y-branch dual phase modulators based on waveguides and electrodes formed on the surface of a crystal such as lithium niobate, and assembled (pigtailed) to optical fiber (one input and two output fiber ports) [Ref 2]. The non-ideal behaviors of these IOCs are well known, and the precision of the parent inertial sensors is limited by this non-ideal behavior. Of particular concern is the optical power splitting ratio between the two output ports. Ideally the split ratio of the IOC should be precisely a 50%/50% even divide, both intrinsic to the Y-branch and after fiber pigtailling. However, manufacturing tolerances typically limit the actual IOC split ratio to a small but nonetheless significant percentage offset, and further limitations on the precision of fiber splicing the IOC into the IFOG optical circuit typically compounds split ratio offset. This SBIR topic relates to advanced lithium niobate IOCs for IFOGs with 1550 nm operating wavelength that shall include a new feature for fine-tuning the split ratio, with precision as good or better than 0.1%, after assembly. The fine tuning shall be achieved by controlling the optical loss of one output port relative to the other, and this control may be implemented by a new feature of the lithium niobate chip, the fiber, or an additional subcomponent. The new feature shall have negligible impact on other IOC design and performance criteria such as overall size, overall optical insertion loss, polarization extinction ratio (PER), and switching voltage-length product (Vpi-L).

PHASE I: Perform a design and materials study aimed at a new feature for fine-tuning the split ratio of a lithium niobate IOC after assembly. The new feature shall be compatible with IOCs having either annealed proton exchange (APE) or reverse proton exchange (RPE) waveguides with 1550 nm operating wavelength. The study must assess performance criteria and consider all aspects of device fabrication. The study shall include a preliminary assessment of long-term environmental stability assuming a design life of 30 years at 50°C based on a materials physics analysis, including Mean Time Between Failure (MTBF), Mean Time to Failure (MTTF) and Failure In Time (FIT) values, along with identification of the assumptions, methods, activation energy, and confidence levels associated with these values. The study shall justify the feasibility/practicality of the approach for achieving split ratio fine-tuning with

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0.1% precision with negligible impact on other IOC design and performance criteria including overall size, overall optical insertion loss, polarization extinction ratio, and switching Vpi-L. The study shall estimate the effects of the new split ratio fine-tuning feature on IOC design and performance criteria relative to a control prototype design that does include the new feature. The Phase I Option if exercised, will include the initial design specifications and capabilities description to build prototype solutions in Phase II, as well as a test plan for an accelerated aging study (minimum 5 year real-time equivalent) to be conducted in Phase II.

PHASE II: Based on the Phase I results, design, fabricate, and characterize six (6) prototype IOCs, complete with fiber-optic pigtails and electrical connectorization suitable for incorporation into test beds for interferometric inertial sensors. Characterization must comprise of evaluation of split ratio tunability, as well as electrical measurements including half-wave voltage (Vpi), frequency response and residual intensity modulation (RIM), and optical measurements including optical insertion loss, chip PER, optical return loss (ORL) or coherent backscatter, and wavelength dependent loss (WDL). An accelerated aging study involving IOCs at elevated temperatures under vacuum must be performed to develop a predictive model of long-term environmental stability. The prototypes should be delivered by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Based on the prototypes developed in Phase II, continuing development must lead to productization of IOCs suitable for interferometric inertial sensors. While this technology is aimed at military/strategic applications, phase modulators are heavily used in many optical circuit applications, including in telecom industry hardware. A phase modulator with split ratio tunability is likely to bring value to many existing commercial applications, such as optical internet, satellite communications, and electric field sensing. Also, technology meeting the needs of this topic could be leveraged to bring IFOG technology toward a price point that could make it more attractive to the commercial markets for land, sea, and aerial systems, including unmanned and autonomous systems.

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KEYWORDS: Integrated Optical Circuit; Phase Modulator; Lithium Niobate; Waveguides; Inertial Sensor; Fiber-optic Gyroscope

VERSION 8

N221-079 TITLE: Low-Loss, Low-Aberration, Numerical Aperture-Matched Microlens Arrays to Improve Coupling Efficiency onto Photonic Imaging Devices.

OUSD (R&E) MODERNIZATION PRIORITY: Quantum Science

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop novel microlens arrays to improve coupling of light onto photonic imaging devices by reducing aberrations and improving mode matching to the collection aperture.

DESCRIPTION: This SBIR topic seeks to develop and fabricate microlens arrays optimized for coupling power onto a photonic imaging device to enable enhanced performance of a variety of integrated photonics systems. Most photonic imaging devices collect light and couple it into photonic integrated circuits (PIC) using grating couplers [Refs 1-2], but photonic chips can suffer significant loss from absorption and scattering within PICs. It is critical that enough light reaches the detectors for the scene to be imaged, so it is necessary to maximize the amount of usable light that couples onto the photonic chip.

Because photonic grating couplers are generally rectangular, they have axis-dependent numerical aperture (NA). The NA is greater along the shorter rectangular axis and smaller along the longer rectangular axis. Furthermore, the grating efficiency and angle of collection are both wavelength dependent. Current Commercial Off the Shelf (COTS) microlens arrays have axis-independent numerical apertures, chromatic aberrations, and also high surface roughness; making them sub-optimal for coupling light onto the chip. Integrating a low-aberration, achromatic, axis-dependent NA and pitch-matched microlens array with photonic imagers would increase the optical throughput by approximately 10 dB, increasing the detected signal.

PHASE I: Perform a design and fabrication analysis to assess the feasibility of producing low-aberration, achromatic in the near-infrared (across 700 – 900 nm) microlens arrays for integration with photonic imaging systems. The design must be able to accommodate NA values that differ significantly along two axes (for example: an NA of 0.045 along one grating axis, 0.15 in the other), while focusing light into a spot on a single plane. The thickness of the microlens array, including any substrate, must be less than 1.5mm. Array pitch should be in the 60-100 um range. Include the expected NA tolerances along both axes (no greater than 2%), pitch tolerance (within 1 micron of expected location, across 200 lenslets), and achromaticity over the near-infrared wavelength range (no more than 15 nm short of bounds). Develop a detailed plan of fabrication that identifies risks and risk mitigation strategies. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build prototype solutions in Phase II.

PHASE II: Fabricate and characterize twenty (20) prototype microlens arrays, measuring at least 1 cm by 1 cm square, with a thickness of less than 1.5 mm, to be integrated with a photonic imaging system. Surface roughness-induced loss, achromaticity, and NA should be characterized and should fall within

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1% of the values determined from the work in Phase I. Evaluate the device's thermal, vibration, and radiation sensitivities by performing tests in accordance with MIL-STD-883L [Ref 3].

Produce a final report that includes a discussion of potential near-term and long-term development efforts that would improve the technology's performance and/or ease of fabrication. It will also include an evaluation of the cost of fabrication and how that might be reduced in the future. The prototypes should be delivered by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Based on the prototypes and continual advancement of photonics, grating-matched microlens arrays should lead to the production of a design suitable for use in integrated photonic imaging and photonic sensing applications. Support the Navy in transitioning the technology to Navy use. The lenslet arrays will be evaluated through optical characterization and testing with prototype devices. The end product technology could be leveraged to bring photonic imaging and sensing towards a more mature state with a lower Size, Weight, and Power (SWaP) profile that could make it more attractive to biomedical, navigation, and vehicle autonomy commercial markets.

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KEYWORDS: photonic imaging; microlens array; photonic integrated circuits; numerical aperture; low-aberration, achromatic

VERSION 8

N221-080 TITLE: Development of a Time-Triggered Ethernet Intellectual Property Block

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR);Hypersonics;Space

TECHNOLOGY AREA(S): Air Platforms;Battlespace Environments;Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop an implementation of a Time-Triggered Ethernet (TTEthernet) Intellectual Property (IP) block for hard real-time control applications in next-generation avionics architectures.

DESCRIPTION: Currently, non-deterministic Ethernet (as defined by IEEE 802.3 [Ref 3]) is utilized in many of the Navy's weapon and avionics systems, including hypersonics. While commonly used for non-critical data, non-deterministic Ethernet does not provide temporal guarantees on data delivery needed for safety-critical real-time control. This often necessitates the use of a secondary, supplemental, real-time network for safety-critical applications. In high threshold, event-driven applications, such as hypersonics, non-deterministic Ethernet limits data rates. The data network in this weapon system plays a crucial role in error prevention and failure recovery, and in high-speed systems, time critical data is vital for mission success. Developing an event-driven, real-time deterministic Ethernet system has the potential to accommodate the full spectrum of traffic criticality levels required in hard real-time applications such as hypersonic systems, as well as a variety of aerospace systems. Time-Triggered Ethernet (TTEthernet, as defined by SAE AS6802 [Ref 2]) unifies real-time and non-deterministic traffic into a single coherent Ethernet-based communication network. Foreign-based TTEthernet implementations are already in use on NASA's Orion spacecraft (NASA Spinoff) [Ref 1].

The U.S. Navy desires a U.S.-based implementation of trusted TTEthernet available in the form of an IP block for inclusion in future aerospace microelectronics. The implementation should consist of the following:

- Must comply with SAE AS6802 (Society of Automotive Engineers)
- Must be operable with non-deterministic Ethernet networks (IEEE 802.3 (IEEE))
- Must include both Endpoint and Network Switch implementations
- Be capable of 10/100/1000 Mbit/sec operations
- Be available in either Verilog, SystemVerilog, or VHDL
- Be fully synthesizable in at least two technology nodes, examples include Intel 22FFL, GlobalFoundries 12LP, and Skywater 90RH
- Must include a verification suite
- Must include full government purpose rights to all design and verification IP
- Must include 32-bit user application layer compliant with RISC-V and ARM processor core bus standards such as AXI4-ST
- Be certifiable

Work produced in Phase II may become classified. The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program

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Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this project as set forth by DCSA and SSP in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Provide a proof-of-concept IP block that implements either Endpoint or Switch functionality and is capable of at least 10Mbit/sec operation with a path towards synthesis on at least one of the above mentioned technology nodes. This IP block must also include an initial verification suite.

The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Provide the TTEthernet IP block as specified in the Description and fabricate a validation Integrated Circuit (IC) containing the IP block on at least one of the above-mentioned technology nodes. Both the IP block and fabricated IC will be made available to the U.S. Navy. The developed prototype shall meet all performance and technical requirements listed in the Description section above. Furthermore, the prototype shall be either benchtop tested or tested in a relevant environment such as a sounding rocket.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the resulting IP block to deployment on at least one future IC developed by the Navy and/or its contractors. This likely includes radiation-hardened ICs used in hypersonic applications. Work with the government to validate and qualify the resulting technology via sounding rocket campaigns, HWIL validation simulations, and eventually all-up flight testing. Developing an event-driven, real-time deterministic Ethernet system has the potential to accommodate the full spectrum of traffic criticality levels required in hard real-time applications such as hypersonic systems, as well as a variety of aerospace systems. Additionally, commercial rocket and space sectors could utilize this technology in their rockets/spacecraft systems.

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3. IEEE, "802.3-2018 - IEEE Standard for Ethernet," https://standards.ieee.org/standard/802_3-2018.html.

KEYWORDS: Time-Triggered Ethernet; TTEthernet; Hypersonics; Avionics; Time-critical, Real-Time Systems; Data Rates

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N221-081 TITLE: Development of an Aerothermal Modeling and Simulation Code for Hypersonic Applications

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR);Hypersonics

TECHNOLOGY AREA(S): Battlespace Environments;Space Platforms;Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a high fidelity modeling and simulation code that can be used to accurately model the physics associated with aerothermal flow, high temperature material response, and thermal protection system (TPS) design for hypersonic flight systems. Emphasis should be placed on non-linear structure analysis, material contact, and thermal conduction and radiation analysis between material interfaces.

DESCRIPTION: The extreme operating environments of hypersonic flight systems require ultra high temperature capable aeroshell materials that have robust loading capability to ensure mission survivability. These aeroshell materials experience very challenging aerothermal and thermo-structural environments during flight which is very challenging to predict. There are a number of legacy and commercial codes that have proven to be accurate when calculating aeroheating effects such as nosetip, leading edge, and missile body heating and material ablation, which include physics such as inviscid and viscous flow, shock structure, and boundary layer transition. Likewise, there are a many Finite Element Codes that are excellent for calculating 3D structural response to understand material loading capability including non-linear, transient thermostructural response of a full size Thermal Protection System (TPS) component. However these Finite Element Analyses (FEA) codes are not capable of adapting to the transient aerothermal flow physics that aeroshell materials experience during a hypersonic flight environment such as calculating shape change to the missile body as a function of time. Current modeling and simulation techniques for Navy TPS systems utilize these tools by making assumptions and manually mapping results from aerothermal specific codes to an FEA simulation, which is very time consuming and costly. There is a need for an improved methodology for coupling aerothermal codes to these FEA solvers to provide an integrated simulation capability.

The government is seeking a solution to bring these tools together to provide a high fidelity aerothermal and TPS design tool that can automate the process of coupling aerothermal physics and material response into FEA thermo-structural models for a complete aero-thermal-mechanical survivability analysis across Navy hypersonic flight trajectories.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence Security Agency (DCSA). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on advanced phases of this project as set forth by DCSA and SSP in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent

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requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: Demonstrate proof of concept, knowledge and understanding of codes that provide accurate aerothermal and heating codes to prove the applicability to Navy hypersonic flight systems. A clear concept on how to demonstrate that the outputs from the aerothermal codes can be brought in as inputs to the FEA software to update the 3D structural model as a function of time. Decide the best method to apply the coupling of the aerothermal and FEA codes (relevant codes will be provided upon Phase I award) for the most robust and feasible solution (e.g., sub routine, script interface, or a completely separate executable/file). Demonstrate software and sequence diagrams of how the tool(s) will calculate results. Analysis will be performed to show feasibility of aerothermal and FEA solvers functionality. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop a prototype utilizing representative vehicle geometry and flight trajectories as provided by the government and also based on the results of Phase I and the Phase II Statement of Work (SOW). The developed model should consist of two concepts: computational fluid dynamics (CFD) and a heat transfer portion. Phase II will include utilizing classified vehicle geometry and flight trajectories to provide benchmark testing versus as-flown Navy hypersonic flight data. In Phase II, verification and validation (V&V) should be in the scope of work. Compare the prototype with bench test and flight test data.

It is probable that the work under this effort will be classified under Phase II (see Description section for details).

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. The final product shall be a delivered code, package outlining the script/functionalities of the developed code and documentation for the model. The final design will be in consideration for being transitioned into the Navy's Conventional Prompt Strike (CPS) hypersonic weapon system modeling and simulation tools. A suitable code solution, verified with benchmark testing with as-flown data is required for the future toolset to optimize vehicle design. In addition, this technology can be transitioned for use in analyzing other Navy and Air Force hypersonic and ballistic weapon systems for optimization of vehicle design. Commercially, future hypersonic transportation vehicles and high speed aerospace systems would benefit from this code solution as it would provide valuable data for design optimization of the mentioned vehicles.

REFERENCES:

1. Blades, E.L.; Shah, P. N.; Nucci, M.; Miskovich, R. S. "Demonstration of Multiphysics Analysis Tools on Representative Hypersonic Vehicle Structures." Boston, Massachusetts: ATA Engineering, Inc., 54th AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 11 April 2013. <https://arc.aiaa.org/doi/pdf/10.2514/6.2013-1746>.
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3. Shih, Peter; Zwan, Allen; Kelley, Michael. "Thermal Protection System Optimization for a Hypersonic Aerospace Vehicle." San Diego, California: General Dynamics Convair Division, 17 August 2012. <https://arc.aiaa.org/doi/abs/10.2514/6.1988-2739>.

KEYWORDS: Hypersonics; Modeling and Simulations Code; Aerothermal Analysis; Thermal Protection System; Ablation; Non-linear Structure Analysis; Radiation Analysis

VERSION 8

N221-082 TITLE: Integrated Complementary Metal Oxide Semiconductor Nuclear Event Detector for System on a Chip Applications

OUSD (R&E) MODERNIZATION PRIORITY: Nuclear

TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop the techniques and circuitry needed to deploy a fully integrated Complementary Metal Oxide Semiconductor (CMOS) Nuclear Event Detector (NED). Additional objectives include the development of an all-digital interface to enable increased security and circumvention and recovery concepts of operations (CONOPS) flexibility.

DESCRIPTION: Nuclear Event Detectors are used in strategic systems to detect when a preset rate of prompt dose is deposited on the detector. Traditionally Nuclear Event Detectors are Hybrid type devices that incorporate a P-Type Intrinsic N-Type (PIN) semiconductor diode, which acts as a photocurrent collection volume which is then mated with other electronic components that appropriately bias the diode and detect when a set level of photo current is exceeded. These hybrid designs can be expensive and unwieldy – it would be highly desirable if a NED circuit could be fully incorporated into any CMOS Application Specific Integrated Circuit (ASIC). Additionally, an ASIC implementation would facilitate the inclusion of an all-digital threshold set point. This NED concept should be deployable into any CMOS Silicon on Oxide or bulk process. Since most commercial foundries do not allow modifications to the process flow, the expectation is that no modifications to the CMOS process recipe are allowed and adherence to process design rules must be followed. The challenge will be to fully integrate both the needed collection volume and related circuitry onto one CMOS die.

PHASE I: Develop a concept design for a fully integrated CMOS NED. Design concepts can be demonstrated in a Defense Microelectronics Activity (DMEA) certified trusted CMOS foundry. Simulation results utilizing industry standard Integrated Circuit Simulation Tools are expected to show concept feasibility including fidelity of the detection set point as well as the ability of the detection circuit itself to operate correctly in a prompt dose environment. A discussion of the technology volume limitations should be included in the Phase I study. Industry benchmarks of commercially available Nuclear Event Detectors should be used. For example, the HSN-3000 Nuclear Event Detector design benchmarks include [Ref 1]:

- Dose Rate (operate-through): 1×10^{12} rad(Si)/sec
- Total Dose Performance: 1×10^6 rad(Si)
- Neutron Fluence: 5×10^{13} n/cm²
- Approximate Detection Range: 2×10^5 - 2×10^7 rad(Si)/sec

The Phase I Option, if exercised, will include the initial design specifications, selected foundry, and capabilities description to build a prototype solution in Phase II.

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PHASE II: The concept design and specifications from Phase I will be fully developed as a standalone Integrated Circuit (IC). Final circuit design viability will be demonstrated by simulations across process corners, the standard military temperature range, and modeled strategic radiation environments. The resulting design database will be used to fabricate a minimum of twenty-five (25) prototype die. All design schematics and layout files are part of the required deliverable. The prototypes should be delivered by the end of Phase II. These prototype parts will be tested and evaluated across environments by the SBIR sponsor [Ref 2].

PHASE III DUAL USE APPLICATIONS: The final version of the NED (in its standalone form) will be productized at the selected DMEA certified trusted foundry and made available to Strategic Programs. This final design should be suitable for either fabrication as a standalone NED or the design database could be leveraged by Strategic programs for the deployment into a larger SoC. Having the option to integrate the NED into program required ICs would reduce component costs as well as potentially provide additional detection coverage due to the increased number of locations in the weapon system the NED will reside.

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KEYWORDS: NED; Nuclear Event Detector; collection volume; prompt dose; foundry; radiation environment

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N221-083 TITLE: Variable Conductance Thermal Management Technology

OUSD (R&E) MODERNIZATION PRIORITY: Quantum Science

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a technology that dynamically adjusts the thermal conductivity between a sensor and its environment to assist in maintaining a stable temperature with minimal power draw. The technology should be compact, robust, and easily adaptable to a variety of sensor shapes, sizes, and internal heat loads.

DESCRIPTION: For a wide variety of sensing systems, a stable temperature is crucial to minimize systematic errors in the measurement output; however, a fieldable sensor is often expected to operate through extreme environmental temperature swings that often exceed 100°C. To combat this temperature swing, a sensor is stabilized by a thermal management solution. Reference 1 contains a summary of a variety of such solutions. Of these, the most common options for the high-precision inertial sensors of primary interest are thermoelectric coolers or simple heaters to actively control the temperature. But while the efficiency of these options are good when the sensor temperature setpoint and the ambient temperature are similar ($\Delta T \sim 0^\circ\text{C}$), the power draw becomes large when those two temperatures differ significantly ($\Delta T \gg 1^\circ\text{C}$).

Variable conductance heat pipes (VCHP) suggest an interesting possibility. The thermal conductance of these devices passively changes depending on the temperature of the environment. With a careful selection of materials and dimensions, the VCHP can provide an extremely small thermal conductance when the environment is much colder than the sensor, and a high conductance when the environment and sensor are similar in temperature [Ref. 2]. As a direct consequence of this variable conductance, the demand on the active portion of the thermal stabilization is reduced, resulting in a much lower overall power draw. The promise of this variable conductance has been successfully demonstrated in designs intended for lunar landers and rovers immersed in the large lunar daytime/nighttime temperature swings [Ref. 2] And yet VCHPs are not a universal solution. In particular, they are rigid devices that require highly customized designs depending on the sensor size and shape.

The proposed variable conductance solution (VCS) will comprise an alternative material or technology that has the benefits of a variable conductance, but is more easily adaptable to unusual shapes, including a combination of flat and curved surfaces. Table 1 outlines three model environments and a model sensor. The VCS will act as the interface between the sensor and environment, limiting the temperature swing of the sensor to the specified range even as the environment's temperature varies much more widely.

Table 1. Proposed Variable Conductance Solution (VCS) Scenarios

	Scenario 1	Scenario 2	Scenario 3
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Environment temperature range	-10°C to 40°C	20°C – 85°C	-40°C to 85°C
Nominal sensor temperature setpoint	55°C	50°C	25°C
Sensor temperature deviation from nominal setpoint over environmental temperature range after application of the VCS*	$\pm 5^{\circ}\text{C}$		
Sensor steady state heat load	Threshold: 1W – 10W Objective: 1W – 50W		
Sensor Shape	Must include at least one curved and one flat surface (specifically, the sensor shape could be a cylinder or hemisphere).		
Sensor Volume	Threshold: < 25L Objective: < 2.5L		
Additional volume allotted to the VCS	< 10% sensor volume		
VCS power draw	< 1W		

*In a fieldable device, a secondary active temperature stabilization system will provide the final stabilization < 1°C.

In these configurations, a range of model sensor heat loads and volumes are provided. A single instance of the VCS does not need to accommodate all of these loads and sizes simultaneously. Instead, the system can be designed for a single heat load and a single shape; however, proposed solutions must be sufficiently flexible in design and fabrication to be easily adaptable to other shapes and heat loads.

PHASE I: Perform a design and materials study to assess the feasibility of the selected technology and its ability to meet the goals of one of the scenarios in Table 1. For the chosen scenario, the study will include:

- An estimate and justification of the dependence of the thermal conductivity on the environmental temperature.
- An estimate and justification of the range of sensor heat loads the system can accommodate while still meeting temperature stability specification.
- An evaluation of the technology's SWaP that would be built for Phase II.
- A discussion of the fabrication process including an assessment of risks and risk mitigation strategies.
- A discussion of the technology's compatibility with the other two scenarios not selected.
- A discussion of the technology's rate of adjustment
- A discussion of the technology's radius of curvature limitations.

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- A discussion of the technology's compatibility with shock/vibration mounts.
- A discussion of the technology's sensitivity with respect to orientation to gravity.
- A discussion of the technology's ability to be adapted to different sensor shapes, including smaller sensor sizes, concave curves, and tight radii of curvature.

The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build prototype solutions in Phase II, as well as a proof-of-principle demonstration of thermal conductivity variation of the proposed technology.

PHASE II: Fabricate and test three (3) prototypes of the design developed in Phase I, ? one for each sensor shape. A mock sensor can be constructed from a simple shell with an internal heat load and sufficient thermal sensors to capture potential thermal gradients. The completed prototypes will undergo testing at a minimum of five temperatures that completely span the specified environmental temperature range. the technology's thermal conductivity and power draw will be reported. At each temperature, the mock sensor's steady state temperature and settling time constant will be reported for sensor heat loads that span the range specified. The final report will include a discussion of potential near-term and long-term development efforts that would improve the technology's performance, SWAP, and/or ease of fabrication. It will also include an evaluation of the cost of fabrication and how that might be reduced in the future. The prototypes should be delivered by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Continue development to assist the Government in applying the VCS to a fieldable, thermally stabilized inertial sensor. As thermal management is also an important consideration for high-precision sensors outside of military applications, development should continue to assist interested commercial parties. Geological resource exploration and monitoring require ruggedized sensors that would benefit from this technology. It could also be applied in medical systems as those often have stringent thermal and power draw requirements. More generally, thermal management is an important consideration in areas as wide ranging as solar cells, rechargeable batteries for electric vehicles, and data centers.

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1. Lupu, A.G., et al. "A review of solar photovoltaic systems cooling technologies." IOP Conference Series: Materials Science and Engineering. Vol. 444. No. 8. IOP Publishing, 2018.
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KEYWORDS: Thermal management; power draw; environmental temperature; sensors; inertial sensors; thermal conductance; materials

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~~N221-084~~

TITLE: [Navy has removed topic N221-084 from the 22.1 SBIR BAA]

VERSION 8

N221-085 TITLE: Integration Strategy for Complementary Metal Oxide Semiconductor-based Terahertz Spectroscopy Systems

OUSD (R&E) MODERNIZATION PRIORITY: Nuclear

TECHNOLOGY AREA(S): Sensors

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop prototypes that achieve low-loss coupling of sub-THz radiation (frequency range: 200-300 GHz) between a Complementary Metal Oxide Semiconductor (CMOS)-based structure and a compact, hermetically-sealed waveguide. The integration strategy must minimize size, weight, and power (SWaP) of the combined CMOS plus waveguide system; and must be robust to environmental instabilities such as ambient temperature changes.

DESCRIPTION: In the past decade there has been significant interest in and development of THz-based instruments for applications including imaging (e.g., non-ionizing medical diagnostics, security screening), molecular spectroscopy (chemical detection and precision timekeeping), extreme wideband communications, and radar [Ref 1]. Recently, advanced high-speed CMOS integrated circuit designs have led to transmitters (Tx) and receivers (Rx) in the THz regime with vastly reduced SWaP relative to competing technologies [Refs 2, 3]. In addition, THz waveguides have been miniaturized via microfabrication techniques [Ref 4]. When coupled to a millimeter-scale waveguide filled with a molecular gas, these CMOS-based Tx/Rx designs can form the basis of an extremely low-SWaP spectroscopy platform for use in DoD-relevant applications (e.g., a chip-scale clock [Ref 5]). This architecture also contains no electro-optic components, making it much more resilient to radiation effects that are known to degrade the performance of lasers, photodetectors, etc. As a result, CMOS-based THz spectroscopy systems are of great utility in DoD applications that require a combination of low-SWaP and radiation hardness.

Despite the recent CMOS design progress, significant additional development is needed to fully integrate a low-SWaP, low-cost, manufacturable spectroscopy instrument. Given the scalable advantages of CMOS-based manufacturing, this effort is anticipated to yield units that match the SWaP of modern miniaturized atomic systems (e.g. chip-scale atomic clock; ~100mW, 15 cm³) but at > 10X reduced cost (hundreds of dollars rather than thousands of dollars per unit) Some development considerations include:

1. The coupling efficiency between the CMOS Tx/Rx and the waveguide structure must be maximized without introducing stringent alignment requirements that introduce high assembly costs.
2. The waveguide containing the molecular sample must be designed to maximize its length while minimizing its volume and loss properties.
3. The mechanical coupling between the CMOS and waveguide must be robust enough to operate in a shock/vibe/temperature range environment consistent with DoD applications.

Design concepts must be communicated in sufficient detail that their approach can be adapted straightforwardly to any frequency in the specified range of 200-300 GHz. The performance targets in

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Table 1 must be achieved through the production of an integrated prototype. This does not require the waveguide to be sealed with a specific molecular species, it does require that the waveguide incorporates a hermetic seal.

Table 1: Performance targets

Parameter Value

CMOS-to-Waveguide coupling loss: < 3 dB per interface

Waveguide loss: < 0.5 dB/cm

Waveguide dimensions Goal: maximize length within a 1 cm³ volume constraint; minimum acceptable length = 3 cm

Integrated CMOS + waveguide volume: < 2 cm³

Temperature Sensitivity: < 3 dB change in end-to-end coupling over temperature range of -20° to +85°Celsius

PHASE I: Perform a design study that includes a trade space analysis and modeling of system performance with sufficient completeness and fidelity to demonstrate the feasibility to achieve the performance targets in Table 1. This includes a design of a CMOS device with sufficient test structures to demonstrate the required CMOS-to-waveguide coupling efficiency, the waveguide, and the details of how it will be fabricated, and the mechanical structure and assembly procedure for integration. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II. A detailed test and evaluation plan is required in order to assess the hardware developed in Phase II.

PHASE II: Finalize designs of the CMOS-to-waveguide coupling strategy (CMOS device plus waveguide input/output), the waveguide structure, and the mechanical approach for integration. Produce and deliver five (5) integrated CMOS Tx/Rx structures plus waveguide prototypes and evaluate them against the performance targets in Table 1. A detailed test report must be delivered that clearly documents test procedures, performance vs. targets, hermetic seal leak rates, and a path forward to meet any targets not achieved. The prototypes should be delivered by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: The prototypes developed in Phase II establish a path to integrating sensors based on THz spectroscopy. Further development must lead to fully miniaturized systems that robustly operate in shock and vibration environments relevant to Navy missions. In addition to the metrics demonstrated by the Phase II prototypes, this goal will require hermetically sealing a target gas species in the waveguide structure, incorporating all spectroscopic functionality (e.g., THz generation, transmission, reception, and signal processing) onto the CMOS chip, and generating derived sensor outputs. Support the Navy to ensure that the integration strategy can be included in future system development efforts that are targeted at specific applications. For example, a low-SWaP, low-cost, radiation-hardened clock based on a THz frequency reference would find wide usage in military, space and commercial applications that require a stable and precise timing source. Examples include navigation and communications in GPS-challenged environments, communication via satellite constellations, high-speed network synchronization, and undersea oil exploration via reflection seismology.

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KEYWORDS: Terahertz; Transmitters; Receivers; Waveguides, Spectroscopy; CMOS; Radiation Hardness

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~~N221-086~~ [Navy has removed topic N221-086 from the 22.1 SBIR BAA]

VERSION 2

DEPARTMENT OF THE NAVY (DON) 22.1 Small Business Innovation Research (SBIR) Direct to Phase II (DP2) Announcement and Proposal Submission Instructions

IMPORTANT

- The following instructions apply to Direct to Phase II (DP2) SBIR topics only:
 - N221-D01 to N221-D04
- The information provided in the DON Proposal Submission Instruction document takes precedence over the DoD Instructions posted for this Broad Agency Announcement (BAA).
- Proposers that are more than 50% owned by multiple venture capital operating companies (VCOC), hedge funds (HF), private equity firms (PEF) or any combination of these are eligible to submit proposals in response to DON topics advertised in this BAA. Information on Majority Ownership in Part and certification requirements at time of submission for these proposers are detailed in the section titled ADDITIONAL NOTES.
- A DP2 Phase I Feasibility proposal template, unique to DP2 topics, is available at https://www.navysbir.com/links_forms.htm; use this template to meet Volume 2 requirements.
- DON provides notice that Basic Ordering Agreements (BOAs) or Other Transaction Agreements (OTAs) may be used for Phase II awards.

INTRODUCTION

The DON SBIR/STTR Programs are mission-oriented programs that integrate the needs and requirements of the DON's Fleet through research and development (R&D) topics that have dual-use potential, but primarily address the needs of the DON. More information on the programs can be found on the DON SBIR/STTR website at www.navysbir.com. Additional information on DON's mission can be found on the DON website at www.navy.mil.

During government fiscal years (FY) 2012 through 2022, the Department of Defense (DoD), including the Department of the Navy (DON), may issue an SBIR award to a small business firm under Phase II, without regard to whether the firm received a Phase I award for such project. Prior to such an award, the head of the agency, or their designee, must issue a written determination that the firm has demonstrated the scientific and technical merit and feasibility of the technology solution that appears to have commercial potential (for use by the government or in the public sector). The determination must be submitted to the Small Business Administration (SBA) prior to issuing the Phase II award. As such, DON issues this portion of the BAA in accordance with the requirements of the Direct to Phase II (DP2) authority. Only those firms that are capable of meeting the DP2 proposal requirements may participate in this DP2 BAA. No Phase I awards will be issued to the designated DP2 topic.

The Director of the DON SBIR/STTR Programs is Mr. Robert Smith. For questions regarding this BAA, use the information in Table 1 to determine who to contact for what types of questions.

TABLE 1: POINTS OF CONTACT FOR QUESTIONS REGARDING THIS BAA

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Type of Question	When	Contact Information
Program and administrative	Always	Program Managers list in Table 2 (below)
Topic-specific technical questions	BAA Pre-release	Technical Point of Contact (TPOC) listed in each topic. Refer to the Proposal Fundamentals section of the DoD SBIR/STTR Program BAA for details.
	BAA Open	DoD SBIR/STTR Topic Q&A platform (https://www.dodsbirsttr.mil/submissions) Refer to the Proposal Fundamentals section of the DoD SBIR/STTR Program BAA for details.
Electronic submission to the DoD SBIR/STTR Innovation Portal (DSIP)	Always	DoD Help Desk via email at dodsbirsupport@reisystems.com
Navy-specific BAA instructions and forms	Always	Navy-sbir-sttr.fct@navy.mil

TABLE 2: DON SYSTEMS COMMAND (SYSCOM) SBIR PROGRAM MANAGERS

<u>Topic Numbers</u>	<u>Point of Contact</u>	<u>SYSCOM</u>	<u>Email</u>
N221-D01 to N221-D04	Mr. Shawn Slade (Acting)	Naval Air Systems Command (NAVAIR)	navair.sbir@navy.mil

Each DON SBIR DP2 topic requires documentation to determine that Phase I feasibility, described in the Phase I section of the topic, has been met.

The DON SBIR DP2 is a two-step process:

STEP ONE: Prepare and Submit a Phase I Feasibility Proposal (instructions and link to template provided below). The purpose of the Phase I Feasibility Proposal is for the firm to provide documentation to substantiate that both Phase I feasibility and the scientific and technical merit described in the topic have been met. **The Phase I Feasibility Proposal must:** demonstrate that the firm performed Phase I-type research and development (R&D) and provide a concise summary of Phase II objectives, work plan, related research, key personnel, transition/commercialization plan, and estimated costs. Feasibility documentation **MUST NOT** be solely based on work performed under prior or ongoing federally funded SBIR/STTR work. The government will evaluate Phase I Feasibility Proposals and select firms to submit a Full DP2 Proposal. **Demonstrating proof of feasibility is a requirement for a DP2 award. The firm must submit a Phase I Feasibility Proposal to be considered for selection to submit a Full DP2 Proposal.**

STEP TWO: **If selected, the cognizant SYSCOM Program Office will contact the firm directly to provide instructions on how to submit a Full DP2 Proposal.**

DON SBIR reserves the right to make no awards under this DP2 BAA. All awards are subject to availability of funds and successful negotiations. Proposers must read the topic requirements carefully. The Government is not responsible for expenditures by the proposer prior to award of a contract. For 22.1 topics designated as DP2, DON will accept only Phase I Feasibility Proposals (described below).

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DP2 PROPOSAL SUBMISSION REQUIREMENTS

The following section details what is required for a DON SBIR DP2 proposal submission to the DoD SBIR/STTR Programs.

(NOTE: Proposers are advised that support contract personnel will be used to carry out administrative functions and may have access to proposals, contract award documents, contract deliverables, and reports. All support contract personnel are bound by appropriate non-disclosure agreements.)

DoD SBIR/STTR Innovation Portal (DSIP). Proposers are required to submit proposals via the DoD SBIR/STTR Innovation Portal (DSIP); follow proposal submission instructions in the DoD SBIR/STTR Program BAA on the DSIP at <https://www.dodsbirsttr.mil/submissions>. Proposals submitted by any other means will be disregarded. Proposers submitting through DSIP for the first time will be asked to register. It is recommended that firms register as soon as possible upon identification of a proposal opportunity to avoid delays in the proposal submission process. Proposals that are not successfully certified electronically in DSIP by the Corporate Official prior to BAA Close will NOT be considered submitted and will not be evaluated by DON. Please refer to the DoD SBIR/STTR Program BAA for further information.

Eligibility. Each proposing firm must:

- Have demonstrated feasibility of Phase I-type R&D work
- Have submitted a Phase I Feasibility Proposal for evaluation
- Meet Offeror Eligibility and Performance Requirements as defined in the Proposal Fundamentals section of the DoD SBIR/STTR Program BAA
- Comply with primary employment requirements of the principal investigator (PI) during the Phase II award including, employment with the firm at the time of award and during the conduct of the proposed project. Primary employment means that more than one-half of the PI's time is spent in the employ of the firm
- Register in the System for Award Management (SAM) as defined in the Proposal Fundamentals section of the DoD SBIR/STTR Program BAA. To register, visit <https://beta.sam.gov>

Proposal Volumes. The following six volumes are required.

- **Proposal Cover Sheet (Volume 1).** As specified in DoD SBIR/STTR Program BAA.
- **Technical Volume (Volume 2).**
 - Technical Proposal (Volume 2) must meet the following requirements or it will be REJECTED:
 - Not to exceed 30 pages, regardless of page content; Phase I Proof of Feasibility portion not to exceed 20 pages, Snapshot of Proposed Phase II Effort portion not to exceed 10 pages
 - Single column format, single-spaced typed lines
 - Standard 8 ½" x 11" paper
 - Page margins one inch on all sides. A header and footer may be included in the one-inch margin.
 - No font size smaller than 10-point
 - Additional information:
 - It is highly recommended that proposers use the DP2 Phase I Feasibility proposal template at https://navysbir.com/links_forms.htm to meet DP2 Technical Volume (Volume 2) requirements.
 - A font size smaller than 10-point is allowable for headers, footers, imbedded tables, figures, images, or graphics that include text. However, proposers are cautioned that if the text is too small to be legible it will not be evaluated.

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- Cost Volume (Volume 3).** The text fields related to costs for the proposed effort must be answered in the Cost Volume of the DoD Submission system (at <https://www.dodsbirsttr.mil/submissions/>), however, proposers DO NOT need to download and complete the separate cost volume template when submitting the DON SBIR Phase I Feasibility Proposal. Proposers are to include a cost estimate in the Order of Magnitude Cost Estimate Table (example below) within the Technical Volume (Volume 2). Please refer to Table 3 below for guidance on cost and period of performance. Costs for the Base and Option are to be separate and identified on the Proposal Cover Sheet and in the Order of Magnitude Cost Estimate Table in the Technical Volume (Volume 2).

Order of Magnitude Cost Estimate Table			
Line Item – Details	Estimated Base Amount	Estimated Option Amount	Total Estimated Amount Base + Option
Direct Labor (fully burdened) – Prime			
Subcontractors/Consultants			
Material			
Travel & ODC			
G&A			
FCCM			
Fee/Profit			
TABA (NTE \$25K, included in total amount)			
Total Estimated Costs			

TABLE 3: COST & PERIOD OF PERFORMANCE

Topic Number	Base		Option One		Total (NTE)
	Cost (NTE)	POP (NTE)	Cost (NTE)	POP (NTE)	
N221-D01 to N221-D04	\$800,000	24 mos.	\$300,000	12 mos.	\$1,100,000

- Additional information:
 - Provide sufficient detail for subcontractor, material, and travel costs. Subcontractor costs must be detailed to the same level as the prime contractor. Material costs must include a listing of items and cost per item. Travel costs must include the purpose of the trip, number of trips, location, length of trip, and number of personnel.
 - Inclusion of cost estimates for travel to the sponsoring SYSCOM’s facility for one day of meetings is recommended for all proposals.
 - The “Additional Cost Information” of Supporting Documents (Volume 5) may be used to provide supporting cost details for Volume 3.
- Company Commercialization Report (Volume 4).** DoD collects and uses Volume 4 and DSIP requires Volume 4 for proposal submission. Please refer to the Phase I Proposal section of the

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DoD SBIR/STTR Program BAA for details to ensure compliance with DSIP Volume 4 requirements.

- **Supporting Documents (Volume 5).** Volume 5 is for the submission of administrative material that DON may or will require to process a proposal, if selected, for contract award.

All proposers must review and submit the following items, as applicable:

- **Telecommunications Equipment Certification.** Required for all proposers. The DoD must comply with Section 889(a)(1)(B) of the FY2019 National Defense Authorization Act (NDAA) and is working to reduce or eliminate contracts, or extending or renewing a contract with an entity that uses any equipment, system, or service that uses covered telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system. As such, all proposers must include as a part of their submission a written certification in response to the clauses (DFAR clauses 252.204-7016, 252.204-7018, and subpart 204.21). The written certification can be found in Attachment 1 of the DoD SBIR/STTR Program BAA. This certification must be signed by the authorized company representative and is to be uploaded as a separate PDF file in Volume 5. Failure to submit the required certification as a part of the proposal submission process will be cause for rejection of the proposal submission without evaluation. Please refer to the instructions provided in the Phase I Proposal section of the DoD SBIR/STTR Program BAA.
 - **Disclosure of Offeror's Ownership or Control by a Foreign Government.** All proposers must review to determine applicability. In accordance with DFARS provision 252.209-7002, a proposer is required to disclose any interest a foreign government has in the proposer when that interest constitutes control by foreign government. All proposers must review the Foreign Ownership or Control Disclosure information to determine applicability. If applicable, an authorized firm representative must complete the Disclosure of Offeror's Ownership or Control by a Foreign Government (found in Attachment 2 of the DoD SBIR/STTR Program BAA) and upload as a separate PDF file in Volume 5. Please refer to instructions provided in the Phase I Proposal section of the DoD SBIR/STTR Program BAA.
 - **Majority Ownership in Part.** Proposers which are more than 50% owned by multiple venture capital operating companies (VCOC), hedge funds (HF), private equity firms (PEF), or any combination of these as set forth in 13 C.F.R. § 121.702, are eligible to submit proposals in response to DON topics advertised within this BAA. Complete certification as detailed under ADDITIONAL SUBMISSION CONSIDERATIONS.
- Additional information:
 - Proposers may include the following administrative materials in Supporting Documents (Volume 5); a template is available at https://navysbir.com/links_forms.htm to provide guidance on optional material the proposer may want to include in Volume 5:
 - Additional Cost Information to support the Cost Volume (Volume 3)
 - SBIR/STTR Funding Agreement Certification
 - Data Rights Assertion
 - Allocation of Rights between Prime and Subcontractor
 - Disclosure of Information (DFARS 252.204-7000)
 - Prior, Current, or Pending Support of Similar Proposals or Awards
 - Foreign Citizens
 - Do not include documents or information to substantiate the Technical Volume (Volume 2) (e.g., resumes, test data, technical reports, or publications). Such documents or information will not be considered.

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- A font size smaller than 10-point is allowable for documents in Volume 5; however, proposers are cautioned that the text may be unreadable.
- **Fraud, Waste and Abuse Training Certification (Volume 6).** DoD requires Volume 6 for submission. Please refer to the Phase I Proposal section of the DoD SBIR/STTR Program BAA for details.

DP2 EVALUATION AND SELECTION

The following section details how the DON SBIR/STTR Programs will evaluate Phase I Feasibility proposals.

Proposals meeting DoD SBIR/STTR submission requirements will be forwarded to the DON SBIR/STTR Programs for evaluation. Prior to evaluation, all proposals will undergo a compliance review to verify compliance with DoD and DON SBIR/STTR submission requirements. Proposals not meeting submission requirements will be REJECTED and not evaluated.

- **Proposal Cover Sheet (Volume 1).** Not evaluated. The Cover Sheet (Volume 1) will undergo a compliance review (prior to evaluation) to verify the proposer has met eligibility requirements.
- **Technical Volume (Volume 2).** The DON will evaluate and select Phase I Feasibility proposals using the evaluation criteria specified in the Phase I Proposal Evaluation Criteria section of the DoD SBIR/STTR Program BAA, with technical merit being most important, followed by qualifications of key personnel and commercialization potential of equal importance. “Best value” is defined as approaches containing innovative technology solutions to the Navy’s technical challenges for meeting its mission needs as reflected in the SBIR/STTR topics. This is not a FAR Part 15 evaluation and proposals will not be compared to one another. Cost is not an evaluation criteria and will not be considered during the evaluation process. Due to limited funding, the DON reserves the right to limit the number of awards under any topic.

The Technical Volume (Volume 2) will undergo a compliance review (prior to evaluation) to verify the proposer has met the following requirements or it will be REJECTED:

- Not to exceed 30 pages, regardless of page content; Phase I Proof of Feasibility portion not to exceed 20 pages, Snapshot of Proposed Phase II Effort portion not to exceed 10 pages
 - Single column format, single-spaced typed lines
 - Standard 8 ½” x 11” paper
 - Page margins one inch on all sides. A header and footer may be included in the one-inch margin.
 - No font size smaller than 10-point, except as permitted in the instructions above.
- **Cost Volume (Volume 3).** Not evaluated. The Cost Volume (Volume 3) will undergo a compliance review (prior to the proposal evaluation) to verify the proposer has complied with not to exceed values for the Base and Option detailed in Table 3 above. Proposals exceeding either the Base or Option not to exceed values will be REJECTED without further consideration.
 - **Company Commercialization Report (Volume 4).** Not evaluated.

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- **Supporting Documents (Volume 5).** Not evaluated. Supporting Documents (Volume 5) will undergo a compliance review to ensure the proposer has included items in accordance with the DP2 PROPOSAL SUBMISSION REQUIREMENTS section above.
- **Fraud, Waste, and Abuse Training Certificate (Volume 6).** Not evaluated.

ADDITIONAL SUBMISSION CONSIDERATIONS

This section details additional items for proposers to consider during proposal preparation and submission process.

Discretionary Technical and Business Assistance (TABA). The SBIR and STTR Policy Directive section 9(b) allows the DON to provide TABA (formerly referred to as DTA) to its awardees. The purpose of TABA is to assist awardees in making better technical decisions on SBIR/STTR projects; solving technical problems that arise during SBIR/STTR projects; minimizing technical risks associated with SBIR/STTR projects; and commercializing the SBIR/STTR product or process, including intellectual property protections. Firms may request, in their Cost Volume (Volume 3), to contract these services themselves through one or more TABA providers in an amount not to exceed the values specified below. The Phase II TABA amount is up to \$25,000 per award. The TABA amount, of up to \$25,000, is to be included as part of the award amount and is limited by the established award values for Phase II by the SYSCOM (i.e. within the \$1,700,000 or lower limit specified by the SYSCOM). The amount proposed for TABA cannot include any profit/fee by the proposer and must be inclusive of all applicable indirect costs. A Phase II project may receive up to an additional \$25,000 for TABA as part of one additional (sequential) Phase II award under the project for a total TABA award of up to \$50,000 per project. A TABA Report, detailing the results and benefits of the service received, will be required annually by October 30.

Request for TABA funding will be reviewed by the DON SBIR/STTR Program Office.

If the TABA request does not include the following items the TABA request will be denied.

- TABA provider(s) (firm name)
- TABA provider(s) point of contact, email address, and phone number
- An explanation of why the TABA provider(s) is uniquely qualified to provide the service
- Tasks the TABA provider(s) will perform
- Total TABA provider(s) cost, number of hours, and labor rates (average/blended rate is acceptable)

TABA must **NOT**:

- Be subject to any profit or fee by the SBIR proposer
- Propose a TABA provider that is the SBIR proposer
- Propose a TABA provider that is an affiliate of the SBIR proposer
- Propose a TABA provider that is an investor of the SBIR proposer
- Propose a TABA provider that is a subcontractor or consultant of the requesting firm otherwise required as part of the paid portion of the research effort (e.g., research partner, consultant, tester, or administrative service provider)

TABA requests must be included in the proposal as follows:

- Phase II:
 - DON Phase II Cost Volume (provided by the DON SYSCOM) - the value of the TABA request.

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- Supporting Documents (Volume 5) – a detailed request for TABA (as specified above) specifically identified as “Discretionary Technical and Business Assistance” in the section titled Additional Cost Information.

Proposed values for TABA must NOT exceed:

- Phase II: A total of \$25,000 per award, not to exceed \$50,000 per Phase II project

If a proposer requests and is awarded TABA in a Phase II contract, the proposer will be eliminated from participating in the DON SBIR/STTR Transition Program (STP), the DON Forum for SBIR/STTR Transition (FST), and any other Phase II assistance the DON provides directly to awardees.

All Phase II awardees not receiving funds for TABA in their awards must attend a one-day DON STP meeting during the first or second year of the Phase II contract. This meeting is typically held in the spring/summer in the Washington, D.C. area. STP information can be obtained at: <https://navystp.com>. Phase II awardees will be contacted separately regarding this program. It is recommended that Phase II cost estimates include travel to Washington, D.C. for this event.

Disclosure of Information (DFARS 252.204-7000). In order to eliminate the requirements for prior approval of public disclosure of information (in accordance with DFARS 252.204-7000) under this award, the proposer shall identify and describe all fundamental research to be performed under its proposal, including subcontracted work, with sufficient specificity to demonstrate that the work qualifies as fundamental research. Fundamental research means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons (defined by National Security Decision Directive 189). A firm whose proposed work will include fundamental research and requests to eliminate the requirement for prior approval of public disclosure of information must complete the DON Fundamental Research Disclosure and upload as a separate PDF file to the Supporting Documents (Volume 5) in DSIP as part of their proposal submission. The DON Fundamental Research Disclosure is available on https://navysbir.com/links_forms.htm and includes instructions on how to complete and upload the completed Disclosure. Simply identifying fundamental research in the Disclosure does **NOT** constitute acceptance of the exclusion. All exclusions will be reviewed and, if approved by the government Contracting Officer, noted in the contract.

Majority Ownership in Part. Proposers that are more than 50% owned by multiple venture capital operating companies (VCOC), hedge funds (HF), private equity firms (PEF), or any combination of these as set forth in 13 C.F.R. § 121.702, **are eligible** to submit proposals in response to DON topics advertised within this BAA.

For proposers that are a member of this ownership class the following must be satisfied for proposals to be accepted and evaluated:

- a. Prior to submitting a proposal, firms must register with the SBA Company Registry Database.
- b. The proposer within its submission must submit the Majority-Owned VCOC, HF, and PEF Certification. A copy of the SBIR VC Certification can be found on https://navysbir.com/links_forms.htm. Include the SBIR VC Certification in the Supporting Documents (Volume 5).
- c. Should a proposer become a member of this ownership class after submitting its proposal and prior to any receipt of a funding agreement, the proposer must immediately notify the Contracting Officer, register in the appropriate SBA database, and submit the required certification which can be found on https://navysbir.com/links_forms.htm.

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System for Award Management (SAM). It is strongly encouraged that proposers register in SAM, <https://sam.gov>, by the Close date of this BAA, or verify their registrations are still active and will not expire within 60 days of BAA Close. Additionally, proposers should confirm that they are registered to receive contracts (not just grants) and the address in SAM matches the address on the proposal.

Notice of NIST SP 800-171 Assessment Database Requirement. The purpose of the National Institute of Standards and Technology (NIST) Special Publication (SP) 800-171 is to protect Controlled Unclassified Information (CUI) in Nonfederal Systems and Organizations. As prescribed by DFARS 252.204-7019, in order to be considered for award, a firm is required to implement NIST SP 800-171 and shall have a current assessment uploaded to the Supplier Performance Risk System (SPRS) which provides storage and retrieval capabilities for this assessment. The platform Procurement Integrated Enterprise Environment (PIEE) will be used for secure login and verification to access SPRS. For brief instructions on NIST SP 800-171 assessment, SPRS, and PIEE please visit <https://www.sprs.csd.disa.mil/nistsp.htm>. For in-depth tutorials on these items please visit <https://www.sprs.csd.disa.mil/webtrain.htm>.

Human Subjects, Animal Testing, and Recombinant DNA. If the use of human, animal, and recombinant DNA is included under a DP2 proposal, please carefully review the requirements at: <https://www.onr.navy.mil/work-with-us/how-to-apply/compliance-protections/Research-Protections/Human-Subject-Research.aspx>. This webpage provides guidance and lists approvals that may be required before contract/work can begin.

International Traffic in Arms Regulation (ITAR). For topics indicating ITAR restrictions or the potential for classified work, limitations are generally placed on disclosure of information involving topics of a classified nature or those involving export control restrictions, which may curtail or preclude the involvement of universities and certain non-profit institutions beyond the basic research level. Small businesses must structure their proposals to clearly identify the work that will be performed that is of a basic research nature and how it can be segregated from work that falls under the classification and export control restrictions. As a result, information must also be provided on how efforts can be performed in later phases if the university/research institution is the source of critical knowledge, effort, or infrastructure (facilities and equipment).

SELECTION, AWARD, AND POST-AWARD INFORMATION

Notifications. Email notifications for proposal receipt (approximately one week after the Phase I BAA Close) and selection are sent based on the information received on the proposal Cover Sheet (Volume 1). Consequently, the e-mail address on the proposal Cover Sheet must be correct.

Debriefs. Requests for a debrief must be made within 15 calendar days of select/non-select notification via email as specified in the select/non-select notification. Please note debriefs are typically provided in writing via email to the Corporate Official identified in the firm proposal within 60 days of receipt of the request. Requests for oral debriefs may not be accommodated. If contact information for the Corporate Official has changed since proposal submission, a notice of the change on company letterhead signed by the Corporate Official must accompany the debrief request.

Protests. Protests of Phase I and II selections and awards must be directed to the cognizant Contracting Officer for the DON Topic Number, or filed with the Government Accountability Office (GAO). Contact information for Contracting Officers may be obtained from the DON SYSCOM Program Managers listed in Table 2. If the protest is to be filed with the GAO, please refer to instructions provided in the Proposal Fundamentals section of the DoD SBIR/STTR Program BAA.

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Protests to this BAA and proposal submission must be directed to the DoD SBIR/STTR Program BAA Contracting Officer, or filed with the GAO. Contact information for the DoD SBIR/STTR Program BAA Contracting Officer can be found in the Proposal Fundamentals section of the DoD SBIR/STTR Program BAA.

Awards. Due to limited funding, the DON reserves the right to limit the number of awards under any topic. Any notification received from the DON that indicates the proposal has been selected does not ultimately guarantee an award will be made. This notification indicates that the proposal has been selected in accordance with the evaluation criteria and has been sent to the Contracting Officer to conduct cost analysis, confirm eligibility of proposer, and to take other relevant steps necessary prior to making an award.

Contract Types. In addition to the negotiated contract award types listed in the section of the DoD SBIR/STTR Program BAA titled Proposal Fundamentals, for Phase II awards the DON may (under appropriate circumstances) propose the use of an Other Transaction Agreement (OTA) as specified in 10 U.S.C. 2371/10 U.S.C. 2371b and related implementing policies and regulations. The DON may choose to use a Basic Ordering Agreement (BOA) for Phase I and Phase II awards.

Contract Deliverables. Contract deliverables are typically progress reports and final reports. Required contract deliverables must be uploaded to <https://www.navysbirprogram.com/navydeliverables/>.

Transfer Between SBIR and STTR Programs. Section 4(b)(1)(i) of the SBIR and STTR Policy Directive provides that, at the agency's discretion, projects awarded a Phase I under a BAA for SBIR may transition in Phase II to STTR and vice versa.

PHASE III GUIDELINES

A Phase III SBIR/STTR award is any work that derives from, extends, or completes effort(s) performed under prior SBIR/STTR funding agreements, but is funded by sources other than the SBIR/STTR programs. This covers any contract, grant, or agreement issued as a follow-on Phase III award or any contract, grant, or agreement award issued as a result of a competitive process where the awardee was an SBIR/STTR firm that developed the technology as a result of a Phase I or Phase II award. The DON will give Phase III status to any award that falls within the above-mentioned description. Consequently, DON will assign SBIR/STTR Data Rights to any noncommercial technical data and noncommercial computer software delivered in Phase III that were developed under SBIR/STTR Phase I/II effort(s). Government prime contractors and their subcontractors must follow the same guidelines as above and ensure that companies operating on behalf of the DON protect the rights of the SBIR/STTR firm.

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Navy SBIR 22.1 Direct to Phase II Topic Index

N221-D01	DIRECT TO PHASE II – High-Speed Digital Fiber-Optic Transmitter
N221-D02	DIRECT TO PHASE II – Flight Operations Planning Decision Aid Tool for Strike Operations Aboard Aircraft Carriers
N221-D03	DIRECT TO PHASE II – Lowering Integrally Bladed Rotor Sustainment Costs Through Mistuning Characterization of Intentionally Mistuned Blades
N221-D04	DIRECT TO PHASE II – Cognitively Inspired Artificial Intelligence for Automated Detection, Classification, and Characterization

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N221-D01 TITLE: DIRECT TO PHASE II – High-Speed Digital Fiber-Optic Transmitter

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR);Networked C3

TECHNOLOGY AREA(S): Air Platforms;Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop and package an uncooled digital fiber-optic transmitter that operates at 100 Gbps, binary, non-return-to-zero for air platform fiber-optic link applications.

DESCRIPTION: Current airborne military (mil-aero) core avionics, electro-optic (EO), communications, and electronic warfare systems require ever-increasing bandwidths while simultaneously demanding reductions in space, weight, and power (SWAP). The replacement of shielded twisted pair wire and coaxial cable with earlier generation length-bandwidth product, multimode optical fiber has given increased immunity to electromagnetic interference, bandwidth, throughput, and a reduction in size and weight on aircraft [Ref 22]. The effectiveness of these systems hinges on optical communication components that realize high per-lane throughput, low latency, large link budget, and are compatible with the harsh avionic environment [Refs 1-7].

In the future, data transmission rates of 100 Gbps and higher will be required. Substantial work has been done to realize data rates approaching this goal based on the use of shortwave wavelength division multiplexing (SWDM) and coarse wavelength division multiplexing (CWDM) technologies. To be successful in the avionic application, existing non-return-to-zero (NRZ) signal coding with large link budget and low latency must be maintained. Advances in optical transmitter designs are required that leverage novel laser diode technology, semiconductor process technology, circuit designs, architectures, and packaging and integration techniques.

SWDM transmitters should be compatible with the SWDM4 wavelength grid (844 to 948 nm center wavelength range) [Ref 8]. CWDM transmitters should be compatible the CWDM4 wavelength grid (1271 to 1331 nm center wavelength range) [Ref 9]. Both transmitter types should support non-forward error correction application links as described in 100G CLR4 [Ref 10]. Optical Multimode 4 (OM4) and Optical Multimode 5 (OM5) optical fiber has been optimized for 100 Gbps and higher SWDM links [Refs 11–12]. The length of the transmitter fiber pigtails should be 72 in. (182.88 cm), +/- 2 in. (5.08 cm) long, terminated with ferrule connector/physical contact (FC/PC) connectors [Ref 20]. The fiber pigtails should be strain relieved (1 kg pull test) and protected via 900-micron buffered fiber. The FC/PC connectors must operate at room temperature. FC/PC polished endfaces should be per SAE AS5675A [Ref 21]. A fiber-optic boot or appropriate heat shrink tubing to control pigtail bend radius is required. Evaluation boards should be made of materials that operate from -40 °C to +95 °C.

The proposed avionics SWDM and CWDM transmitters must operate over a -40 °C to +95 °C temperature range, and maintain performance upon exposure to typical naval air platform vibration, humidity, temperature, altitude, thermal shock, mechanical shock, and temperature cycling environments

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[Refs 13–19]. The transmitter must support a 15 dB link loss power budget when paired with a receiver without forward error correction sensitivity performance and meeting similar environmental requirements. The SWDM transmitter must be compatible with receivers operating SWDM wavelength band. The CWDM transmitter must be compatible with receivers operating in the CWDM band. The SWDM and CWDM transmitters must be capable of transmitting multi-wavelength signals transmitted over 50 μm core multimode fiber. The transmitters would include four wavelength selected lasers, each operating at 25 Gbps to achieve an aggregate transmitter bandwidth of =100 Gbps. The transmitter optical subassembly optically multiplexes the four transmitter laser output wavelengths onto one 50 micron core multimode optical fiber. The transmitter must allow for 1×10^{-12} bit error rate operation in a 100 m long link. The electrical input of the transmitter must be differential current mode logic.

PHASE I: For a Direct to Phase II topic, the Government expects that the small business would have accomplished the following in a Phase I-type effort. Have developed a concept for a workable prototype or design to address, at a minimum, the basic requirements of the stated objective above. The below actions would be required in order to satisfy the requirements of Phase I:

1. Designed and analyzed an uncooled high-speed digital fiber-optic transmitter circuit and provided an approach for determining transmitter parameters and testing.
2. Designed a high-speed digital fiber-optic transmitter package prototype that is compatible with the transmitter circuit design and coupling to optical fiber.
3. Determined and demonstrated the feasibility of the transmitter design, the package prototype design, and a path to meeting Phase II goals based on analysis and modeling. The analysis and modeling should reference results obtained in previous efforts.

FEASIBILITY DOCUMENTATION: Offerors interested in participating in Direct to Phase II must include in their response to this topic Phase I feasibility documentation that substantiates the scientific and technical merit and Phase I feasibility described in Phase I above has been met (i.e., the small business must have performed Phase I-type research and development related to the topic, but from non-SBIR funding sources) and describe the potential commercialization applications. The documentation provided must validate that the proposer has completed development of technology as stated in Phase I above. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/results. Work submitted within the feasibility documentation must have been substantially performed by the offeror and/or the principal investigator (PI). Read and follow all of the DON SBIR 22.1 Direct to Phase II Broad Agency Announcement (BAA) Instructions. Phase I proposals will NOT be accepted for this topic.

PHASE II: Optimize the transmitter circuit and package designs. Build and test the transmitter circuit and packaged transmitter prototype to meet performance requirements. Characterize the transmitter over temperature, and perform highly accelerated life testing. If necessary, perform root cause analysis and remediate circuit and/or packaged transmitter failures. Verify OM5 fiber performance for CWDM transmitter based links. Create multimode fiber specification for CWDM transmitter based links. Deliver two prototype fiber pigtailed SWDM and two prototype fiber pigtailed CWDM transmitter prototypes and evaluation boards for 100 Gbps digital fiber-optic communication link application.

PHASE III DUAL USE APPLICATIONS: Finalize the prototype. Verify and validate the transmitter performance in an uncooled 100 Gbps fiber-optic transmitter that operates from -40°C to $+95^{\circ}\text{C}$. Transition to applicable naval platforms.

Telecommunication systems, fiber-optic networks, and data centers would benefit from the development of high-speed fiber-optic transmitters.

REFERENCES:

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KEYWORDS: Digital Fiber-Optic Transceiver; Binary Non-return to zero signaling; 100, 200 Gigabits per Second; Packaging; Highly Accelerated Life Testing; Data rate

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N221-D02 TITLE: DIRECT TO PHASE II – Flight Operations Planning Decision Aid Tool for Strike Operations Aboard Aircraft Carriers

OUSD (R&E) MODERNIZATION PRIORITY: Autonomy

TECHNOLOGY AREA(S): Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a decision support tool using intelligent agents to assist Strike Operations (Strike Ops) in scheduling flight operations aboard aircraft carriers.

DESCRIPTION: Flight operations planning on aircraft carriers is central to the success and efficiency of the carrier air wing (CVW) in executing missions. Scheduling is dependent on mission objectives, as well as available resources and strike group readiness. The schedule of all air operations within a day is documented in the Air Plan by the Strike Operations department. The Air Plan consists of events for each CVW squadron, which are broken down into details, such as launch and recovery times, mission type, and aircrafts assigned. A Load Plan is then generated to document the ordnance required to fulfill each event. These plans are distributed throughout the CVW for execution. The process of creating these plans can be challenging and time consuming. Information systems are in place for documenting and managing Air Plans but require expert input from Strike Ops planners. Additionally, there is a wide range of information sources that determine events to include within the Air Plan and it is difficult to gather information on readiness. These plans are likely to change on the fly as well, due to unforeseen changes to missions and resources. There is a technology insertion opportunity to reduce workload, increase planning efficiency, and improve adaptability through the use of a decision support application.

Intelligent agent technology can provide decision aids to reduce the complexity of flight operations planning. Agents would need to be able to generate plans based on mission requirements and strike group readiness. The system would need to collect and perceive all pertinent information required to fill out an Air Plan and a Load Plan. This includes tasks determined from mission requirements, maintenance requirements, carrier qualifications, logistics flights, and training requirements. Tasks would need to be mapped to resources such as squadron capability, ordnance required, and aircraft availability to populate an Air Plan and a Load Plan. For example, the system would need to automatically assign a squadron to a specific mission based on availability, capability, and readiness. The solution should include the ability to provide observability in its decisions while allowing for adjustments and alternative plans. Intelligent agents were proven applicable within many areas in industry, including defense and naval aviation. However, there is currently no intelligent agent technology directed towards the flight operations planning aboard aircraft carriers. This particular application's dilemma is due to the difficulty of gathering information required to create the Air Plan. Not only do the plans need to take into account the status of available CVW resources, but also the intent of the CVW as well.

The Navy is considering technology solutions to creating an intelligent decision support system. Methods that address the time-consuming nature of information capture, both manual input and sensory input, will

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be considered. Solutions that can be implemented to current shipboard flight operations planning processes with minimal impact is preferred.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: For a Direct to Phase II topic, the Government expects that the small business would have accomplished the following in a Phase I-type effort. Have developed a concept for a workable prototype or design to address, at a minimum, the basic requirements of the stated objective above. The below actions would be required in order to satisfy the requirements of Phase I:

Determined and demonstrated the feasibility of a decision support tool in providing decision aids for a scheduling application. Feasibility must be demonstrated through analysis, modeling or lab demonstration. Results and analysis from previous efforts should be referenced in feasibility documentation.

FEASIBILITY DOCUMENTATION: Offerors interested in participating in Direct to Phase II must include in their response to this topic Phase I feasibility documentation that substantiates the scientific and technical merit and Phase I feasibility described in Phase I above has been met (i.e., the small business must have performed Phase I-type research and development related to the topic, but from non-SBIR funding sources) and describe the potential commercialization applications. The documentation provided must validate that the proposer has completed development of technology as stated in Phase I above. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/results. Work submitted within the feasibility documentation must have been substantially performed by the offeror and/or the principal investigator (PI). Read and follow all of the DON SBIR 22.1 Direct to Phase II Broad Agency Announcement (BAA) Instructions. Phase I proposals will NOT be accepted for this topic.

PHASE II: Develop a decision support software prototype to assist in flight operations planning aboard aircraft carriers. Optimize intelligent agent outputs based on subject matter expert feedback. Demonstrate the technology through simulations and compare its effectiveness to traditional methods of scheduling and planning. Provide documentation on software and hardware architecture.

Work in Phase II may become classified. Please see note in Description paragraph.

PHASE III DUAL USE APPLICATIONS: Create a full-scale decision support software tool capable of supporting the process of flight operations scheduling aboard aircraft carriers. The system should be capable of providing schedules that increase the performance of flight operations.

Industry applications include production and manufacturing planning, shipping logistics, and medical scheduling.

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KEYWORDS: Intelligent Agents; Decision Support; Scheduling; Aircraft Carriers; Air Plan; Strike Operations

VERSION 2

N221-D03 TITLE: DIRECT TO PHASE II – Lowering Integrally Bladed Rotor Sustainment Costs Through Mistuning Characterization of Intentionally Mistuned Blades

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence (AI)/Machine Learning (ML)

TECHNOLOGY AREA(S): Air Platforms

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop the measurement equipment and analysis methods required to characterize mistuning in Integrally Bladed Rotors (IBRs) that have intentionally mistuned blades for the purpose of supporting airfoil Foreign Object Damage (FOD) and repair limit expansion.

DESCRIPTION: Foreign Object Damage (FOD) is a top driver of engine removal for nearly every platform in naval aviation. FOD is caused by the ingestion of airfield debris into aircraft engines during operation and thus impacting the blade and vane airfoils [Ref 1]. Newer aircraft engines utilize Integrally Bladed Rotors (IBR/Blisk), which complicates the analysis and repair of FOD. In an IBR, the blades and disk are a single monolithic part rather than removable blades inserted in disk dovetails. The IBR design architecture reduces the mechanical damping contributed by the blade dovetail and introduces the concept of mistuning [Ref 2]. Mistuning changes the dynamic response of the IBR airfoils and can limit the FOD tolerance or blend repair [Ref 3] capability.

The Navy seeks to expand IBR mistuning bench characterization technology to newer engine designs. These new engines utilize two additional design technologies that make vibration testing and analysis more challenging: blades have intentional (A/B) mistuning [Ref 4], and blade vibratory response is excited by asymmetric vane spacing.

This Direct to Phase II topic will develop the hardware needed to measure newer, larger fan IBRs, and also develop other necessary technologies and methods to accommodate intentional mistuning in the presence of asymmetric vane excitation. To demonstrate this capability, the proposed program requirements must include, but not be limited to, the design, build, and demonstration of a prototype IBR airfoil mistuning measurement system. The prototype software must be capable of characterizing dynamic response and driving relevant excitation. These relevant operational modes (excitation) will be used to define the baseline scan plan. The system must also be capable of acquiring the actual 3D geometry of the airfoil leading edge and characterizing the geometry of any blends or damage present. This data, in addition to the predicted and measured mode shape and frequency around the rotor, will be documented in a report generated by the software.

When high-value IBRs are repaired at depot, the repair limits must include additional design margins to accommodate the hypothetical worst-case IBR mistuning (+/- 5% frequency variation). This assessment methodology is governed by the Propulsion Structural Integrity Plan [Ref 5], which defines the requirements to design, sustain, and repair an engine component. With the technology proposed in this topic, the limits can be expanded by quantifying the actual mistuning amplification present in the IBR, thereby increasing repair limits and reducing the cost of scrapping and replacing IBRs.

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This measurement will be completed when the IBR is removed from the engine (uninstalled) and is placed statically on a benchtop. The measurement hardware must be designed to ensure that it does not damage the IBR and is capable of supporting its weight (up to 250 lb; (113.4 kg)). The end goal for the technology is to deploy bench measurement systems to relevant Navy and United States Air Force (USAF) engine support depots that can measure new production IBRs and field returned/repaired IBRs to verify that mistuning requirements are maintained.

In order to quantify the actual mistuning present in the IBR, the proposed technology must be able to meet the following technology requirements:

- a. measurement of the blade leading edge geometry (identify existing damage or blend repairs);
- b. measurement of blade modal frequency response;
- c. measurement of blade mode shape response (aid in identification of mode);
- d. excitation of all blades in rotor with relevant excitation, including multiple nodal diameters, engine orders, relevant engine rotation speeds, and asymmetric vane spacing;
- e. computer system capable of near-real-time processing of collected data and automated report generation of relevant mistuning response parameters;
- f. software and analysis methods capable of analyzing benchtop mistuning measurements and predicting the installed (engine operating) dynamic response. The Navy will translate this dynamic response prediction into FOD repair limits;
- g. equipment must not damage, mark, or create excessive vibration stress in the IBR (stay below 25% Goodman stress capability), and have provisions for safe handling and lifting of the part.

Although not required, it is highly recommended that the proposer work in coordination with the original equipment manufacturer (OEM) to ensure proper design and to facilitate transition of the final technology.

PHASE I: For a Direct to Phase II topic, the Government expects that the small business would have accomplished the following in a Phase I-type effort. Have developed a concept for a workable prototype or design to address, at a minimum, the basic requirements of the stated objective above. The below actions would be required in order to satisfy the requirements of Phase I:

The offeror must demonstrate the capability to characterize mistuning on traditional IBRs that use “equal” mass blades and synchronous excitation sources. The IBR used in this prior work may be small (prefer 10 in.; (25.4 cm) diameter or greater) and be designed for commercial or military application. The prototype should be able to measure blade frequency and mode shape for all blades on the IBR for at least the first 10 modes and 25 engine orders. The offeror should demonstrate feasibility of scanning the leading edge geometry capable of measuring existing blend repairs of 0.005 in. (0.127 mm) deep and greater. The software should be capable of recording the necessary mistuning parameters; however, automated processing is not required at this phase. While data storage requirements may vary depending on technology approach, IBRs may have up to 100 airfoils per part with up to 25 modes of interest. The system should be capable of storing vibration data and geometry scan data for at least 10 IBRs at a time.

FEASIBILITY DOCUMENTATION: Offerors interested in participating in Direct to Phase II must include in their response to this topic Phase I feasibility documentation that substantiates the scientific and technical merit and Phase I feasibility described in Phase I above has been met (i.e., the small business must have performed Phase I-type research and development related to the topic, but from non-SBIR funding sources) and describe the potential commercialization applications. The documentation provided must validate that the proposer has completed development of technology as stated in Phase I above. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/results. Work submitted within the

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feasibility documentation must have been substantially performed by the offeror and/or the principal investigator (PI). Read and follow all of the DON SBIR 22.1 Direct to Phase II Broad Agency Announcement (BAA) Instructions. Phase I proposals will NOT be accepted for this topic.

PHASE II: Develop and demonstrate a prototype measurement system based on the prior work capable of characterizing all relevant modes and excitation frequencies on intentionally mistuned blades. The Navy will provide these relevant parameters. The Navy will provide a relevant advanced IBR that contains intentionally mistuned blades and operates in an environment with asymmetric vane excitation. The program will conclude with delivery of the matured measurement system to the Navy or the USAF for verification testing and by holding a review with the Government of all data and analysis methods developed during this program.

PHASE III DUAL USE APPLICATIONS: Finalize the prototype and supporting software for deployment to the Navy and USAF engine depots. This will include working with the relevant sustainment support equipment and platform program offices to meet computer security and hardware interface requirements. Support design reviews with the Government to determine incorporation strategy. Deliver measurement systems to the depot(s) and support training and maintenance planning for the equipment.

Commercial aircraft engines are also susceptible to FOD and advanced designs also incorporate IBRs with mistuning and asymmetric vanes. The technologies developed under this program will be directly applicable to commercial aviation engines. Due to the larger size of the commercial fleets, the available market should be equal to, or greater than, the initial military application. FOD costs the commercial aviation industry over \$2 billion per year and an average of \$43 million per year at major U.S. hubs.

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KEYWORDS: FOD; Foreign Object Damage; mistuning; IBR; Integrally Bladed Rotor; Blisk; Bladed-Disk; propulsion; aircraft

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N221-D04 TITLE: DIRECT TO PHASE II – Cognitively Inspired Artificial Intelligence for Automated Detection, Classification, and Characterization

OUSD (R&E) MODERNIZATION PRIORITY: 5G;Artificial Intelligence (AI)/Machine Learning (ML);Autonomy

TECHNOLOGY AREA(S): Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a human-level/human-style artificial intelligence (AI) that can perceive and explain signals implicit in magnetics, electro-optical and infrared (EO/IR), and acoustics data to achieve long-range detection, tracking, and classification of maritime surface and subsurface contacts, which is an essential and imperative Naval capability.

DESCRIPTION: Nontraditional adaptive human-level/human-style artificial intelligence (AI) signal-processing algorithms have the potential to increase detection range in high littoral noise environment while extracting precise target signatures that optimize detection, tracking, and classification.

The consistently novel, noisy, and nonlinear aspects of magnetics, EO/IR, and acoustics data, critical for Navy detection, tracking, and classification, present particularly difficult problems for the standard techniques of machine learning (ML) (e.g., deep learning [Ref 1]). To be functional, the artificial neural networks of the latter must be trained on large curated data of “signal” in order to filter out noise. Such pattern recognition has revolutionized many domains [Ref 2], from image classification to game playing. However, such a methodology fails catastrophically in domains where data are frequently changing, and are neither large, curated, nor efficiently transformable into linear-vector form [Ref 3]. This is because engineers in standard ML fail to understand that “making comes before matching” [Ref 4]: a competence to generate general/adaptable pattern schemata prior to data processing is necessary to recognize novel (untrained) patterns in novel and potentially sparse and noisy/nonlinear data. Fundamentally, to be of greatest value to the Navy, these schemata ought to be conjectured explanations for the signals, beyond their mere detection. Such explanatory competence cannot be implemented in standard ML [Ref 5], hence the failure of ML to solve non-linear, signal-to-noise over noise problems.

However, such a competence is characteristic of some “good old fashioned artificial intelligence” architectures and the human intelligence they emulate [Ref 6]. Humans can routinely recognize novel signals in variable noise environments, and the Navy has relied on this human intelligence to process magnetic, EO/IR, and acoustics data for detection and classification of objects and environmental footprints. Indeed the evolutionarily-optimized, pattern-matching of the human mind/brain can expertly and efficiently recognize (i.e., “make-and-match”) patterns in novel/noisy time series as expertly and efficiently as it recognizes grammatical patterns in language [Ref 7]. Of profoundest importance—equipped with language—human intelligence seeks to explain these patterns. It generates causal knowledge. Obviously, however, it would be an intractably Herculean task for humans to process and interpret all the magnetics, EO/IR, and acoustics data necessary to satisfy naval objectives of near-real-time, long-range detection, tracking, and classification of surfaced and submerged objects with 90%

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probability of detection (Pd) rates. Hence, the optimal solution would be to implement the competence of human intelligence in the machinery of artificial intelligence. Thus, the Navy requires human-style AI.

Work produced in Phase II may become classified. Note: The prospective contractor(s) must be U.S. owned and operated with no foreign influence as defined by DoD 5220.22-M, National Industrial Security Program Operating Manual, unless acceptable mitigating procedures can and have been implemented and approved by the Defense Counterintelligence and Security Agency (DCSA) formerly Defense Security Service (DSS). The selected contractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances. This will allow contractor personnel to perform on advanced phases of this project as set forth by DCSA and NAVAIR in order to gain access to classified information pertaining to the national defense of the United States and its allies; this will be an inherent requirement. The selected company will be required to safeguard classified material IAW DoD 5220.22-M during the advanced phases of this contract.

PHASE I: For a Direct to Phase II topic, the Government expects that the small business would have accomplished the following in a Phase I-type effort. Have developed a concept for a workable prototype or design to address, at a minimum, the basic requirements of the stated objective above. The below actions would be required in order to satisfy the requirements of Phase I:

The development of Strong Artificial Intelligence: human-level/human AI capacitated with the linguistic competence to generate causal explanatory models via critical rationalism. Given a set of big or small data, constructs a Chomskyan grammar construct to model causal relations, thereby transcending descriptions that answer what is being observed, transforming data into evidence for/against conjectured explanations that answer why and how the data, or the phenomena underlying the data, - exist and behave.

The objective is a linguistically competent AI that can generate explanatory causal models. An example would be the classic board game Battleship. The strong cognitive AI is given a partially revealed board state and must, by its epistemic process of critical rationalism (i.e., conjecture-and criticism), discover the true state of the board. What the solution ultimately seeks is an explanation for the configuration of the partially revealed gameboard: "Why does the board appear this way?" The reason why is the complete configuration (i.e., the position of the hidden ships). It is an exercise in explanatory causal-model-construction. The Cognitive AI succeeds and surpasses humans in constructing "the ultimate question": one question whose answer reveals the true state of the board. This is formally analogous to a complete explanation for some complex phenomena in the real world. Importantly, this problem cannot be solved by reinforcement learning, as Google DeepMind did for "Go" and "Chess". It requires a cognitive strong intelligence: language and explanation. AI researchers have tested numerous techniques to solve this problem, from tree search to Bayesian models, but all fail to attain human-level competence, the common denominator being limitations imposed by hard-coded rules with single objectives that are insufficiently adaptive and creative.

FEASIBILITY DOCUMENTATION: Offerors interested in participating in Direct to Phase II must include in their response to this topic Phase I feasibility documentation that substantiates the scientific and technical merit and Phase I feasibility described in Phase I above has been met (i.e., the small business must have performed Phase I-type research and development related to the topic, but from non-SBIR funding sources) and describe the potential commercialization applications. The documentation provided must validate that the proposer has completed development of technology as stated in Phase I above. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/results. Work submitted within the feasibility documentation must have been substantially performed by the offeror and/or the principal investigator (PI). Read and follow all of the DON SBIR 22.1 Direct to Phase II Broad Agency Announcement (BAA) Instructions. Phase I proposals will NOT be accepted for this topic.

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PHASE II: Develop a prototype of a human-level/human-style AI that can perceive and explain “artificial” (i.e., invented) magnetics, EO/IR, and acoustics data in an idealized Navy war game simulation. Further development of the AI prototype and its demonstration on “natural” (i.e., real-world) data in a realistic Navy war game simulation. Perform sea trials data collection of individual vessels in terms of feature identification performance, operational agility, and accuracy. Perform limited sea trial test data analysis of surface and subsurface objects.

Work in Phase II may become classified. Please see note in Description paragraph.

PHASE III DUAL USE APPLICATIONS: Continue to refine magnetics, EO/IR, and acoustics data. Finalize sea trials data collection of individual vessels in terms of feature identification performance, operational agility, and accuracy. Complete final testing and perform necessary integration and transition for use in antisubmarine and countermine warfare, counter surveillance and monitoring operations with appropriate current platforms and agencies, and future combat systems under development.

Commercially this product could have applicability in search and rescue operations; and could be used to enable remote environmental monitoring of geophysical survey, facilities, and vital infrastructure assets.

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KEYWORDS: Artificial Intelligence; AI; Nonlinear; signal processing; Cognitive; Nontraditional

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR)
Phase I Proposal Submission Instructions
AMENDMENT 5
07 January 2022

The purpose of this amendment is as follows:

In Chart 1: Air Force 22.1 SBIR Phase I Topic Information at a Glance, the Technical Volume Contents for Topics AF221-0001, Experimental Digital Twins for Multi-GNSS Integrity Monitoring, and AF221-0026, Signal Processing Techniques to Enhance Anti-Jam Performance for Low SWAP-C M-Code-based GPS User Equipment, are both changed to “**White Paper NTE 25 Pages**”.

All other content, as previously amended, remains unchanged and in full effect.

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR)
Phase I Proposal Submission Instructions
AMENDMENT 4
20 December 2021

The purpose of amendment is to:

1. Chart 1: Air Force 22.1 SBIR Phase I Topic Information at a Glance, Technical Volume Content column information for each topic is changed to read, “White Paper NTE XX **Pages**”. The maximum number of pages specified for each individual topic **is unchanged**.
 2. Paragraph entitled “Limitations on Length of Proposal” is changed to read, “Phase I Technical Volume **page** limits as identified in Chart 1 (above) do not include the Cover Sheet, Cost Volume, Cost Volume Itemized Listing (a-h). The Technical Volume must be no smaller than 10-point on standard 8-1/2" x 11" paper with one-inch margins. Only the Technical Volume and any enclosures or attachments count toward the page limit. In the interest of equity, **pages** in excess of the stated limits will not be reviewed. The documents required for upload into Volume 5, “Other”, do not count toward the specified limits”.
 3. The Air Force Technical Point of Contact for Topic AF221-0008, Satellite and Debris Discrimination and Identification, from **TPOC** to **TPOC**.
- All other content, as previously amended, remains unchanged and in full effect.

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Phase I
Proposal Submission Instructions
AMENDMENT 3
10 December 2021

The purpose of this amendment is to correct the following:

Chart 1: Air Force 22.1 SBIR Phase I Topic Information at a Glance, Topic Number AF221-0024, Max SBIR Funding, is changed from “\$75,000” to “**\$150,000**”.

All other content remains unchanged and in full effect.

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Phase I
Proposal Submission Instructions
AMENDMENT 2
2 December 2021

The purpose of this amendment is to correct the Air Force Technical Point of Contact for Topic AF221-0014, Cross-Compatible Electronic Kneeboard Integration, from to **TPOC to TPOC**.

All other content remains unchanged and in full effect.

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Phase I
Proposal Submission Instructions
AMENDMENT 1
2 December 2021

The purpose of this amendment is to correct the following:

1. Air Force 22.1 SBIR Phase I Topic Index, page AF-7, topic number **AF213-0005**, i.e., Image-based COTS Bidirectional Reflectance Distribution Function (BRDF) Measurement, is changed to **AF221-0005**.
2. Topic **AF213-0005**, i.e., Image-based COTS Bidirectional Reflectance Distribution Function (BRDF) Measurement, page AF-18, is changed to read Topic **AF221-0005**.

All other content remains unchanged and in full effect.

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Phase I
Proposal Submission Instructions

AF Phase I proposal submission instructions are intended to clarify the Department of Defense (DoD) Broad Agency Announcement (BAA) as it applies to the topics solicited herein. **Firms must ensure proposals meet all requirements of the 22.1 SBIR BAA posted on the DoD SBIR/STTR Innovation Portal (DSIP) at the proposal submission deadline date/time.**

Complete proposals **must** be prepared and submitted via <https://www.dodsbirsttr.mil/submissions/> (DSIP) on or before the date published in the DoD 22.1 SBIR BAA. Offerors are responsible for ensuring proposals comply with the requirements in the most current version of this instruction at the proposal submission deadline date/time.

Please ensure all e-mail addresses listed in the proposal are current and accurate. The AF is not responsible for ensuring notifications are received by firms changing mailing address/e-mail address/company points of contact after proposal submission without proper notification to the AF. **If changes occur to the company mail or email addresses or points of contact after proposal submission, the information must be provided to the AF SBIR/STTR One Help Desk.** The message shall include the subject line, “22.1 Address Change”.

Points of Contact:

- General information related to the AF SBIR/STTR program and proposal preparation instructions, contact the AF SBIR/STTR One Help Desk at usaf.team@afsbirsttr.us.
- Questions regarding the DSIP electronic submission system, contact the DoD SBIR/STTR Help Desk at dodsbirsupport@reisystems.com.
- For technical questions about the topics during the pre-announcement and open period, please reference the DoD 22.1 SBIR BAA.
- Air Force SBIR/STTR Contracting Officers (CO):
 - Ms. Kristina Croake, kristina.croake@us.af.mil
 - Mr. James Helmick, james.helmick.2@us.af.mil

General information related to the AF Small Business Program can be found at the AF Small Business website, <http://www.airforcesmallbiz.af.mil/>. The site contains information related to contracting opportunities within the AF, as well as business information and upcoming outreach events. Other informative sites include those for the Small Business Administration (SBA), www.sba.gov, and the Procurement Technical Assistance Centers (PTACs), <http://www.ptacus.us.org>. These centers provide Government contracting assistance and guidance to small businesses, generally at no cost.

Chart 1: Air Force 22.1 SBIR Phase I Topic Information at a Glance

Topic Number	Performance Period	Max SBIR Funding	Technical Volume Contents
AF221-0001	9 months	\$150,000	White paper NTE 25 Pages
AF221-0002	9 months	\$150,000	White paper NTE 25 Pages
AF221-0003	9 months	\$150,000	White paper NTE 10 Pages
AF221-0004	9 months	\$50,000	White paper NTE 25 Pages
AF221-0005	9 months	\$150,000	White paper NTE 10 Pages
AF221-0006	9 months	\$150,000	White paper NTE 10 Pages
AF221-0007	9 months	\$150,000	White paper NTE 10 Pages
AF221-0008	9 months	\$150,000	White paper NTE 10 Pages
AF221-0009	9 months	\$150,000	White paper NTE 10 Pages
AF221-0010	9 months	\$150,000	White paper NTE 10 Pages
AF221-0011	9 months	\$150,000	White paper NTE 10 Pages
AF221-0012	9 months	\$150,000	White paper NTE 25 Pages
AF221-0013	9 months	\$150,000	White paper NTE 25 Pages
AF221-0014	9 months	\$150,000	White paper NTE 25 Pages
AF221-0015	12 months	\$250,000	White paper NTE 25 Pages
AF221-0016	9 months	\$150,000	White paper NTE 25 Pages
AF221-0017	8 months	\$150,000	White paper NTE 25 Pages
AF221-0018	8 months	\$150,000	White paper NTE 25 Pages
AF221-0019	9 months	\$150,000	White paper NTE 25 Pages
AF221-0020	9 months	\$150,000	White paper NTE 10 Pages
AF221-0021	9 months	\$150,000	White paper NTE 25 Pages
AF221-0022	9 months	\$150,000	White paper NTE 25 Pages
AF221-0023	9 months	\$150,000	White paper NTE 25 Pages
AF221-0024	9 months	\$150,000	White paper NTE 25 Pages
AF221-0025	9 months	\$150,000	White paper NTE 10 Pages
AF221-0026	9 months	\$150,000	White paper NTE 25 Pages
AF221-0027	15 months	\$150,000	White paper NTE 10 Pages
AF221-0028	8 months	\$100,000	White paper NTE 25 Pages
AF221-0029	9 months	\$150,000	White paper NTE 25 Pages
AF221-0030	9 months	\$150,000	White paper NTE 25 Pages
AF221-0031	9 months	\$150,000	White paper NTE 25 Pages
AF221-0032	9 months	\$150,000	White paper NTE 25 Pages
AF221-0033	9 months	\$150,000	White paper NTE 25 Pages

PHASE I PROPOSAL SUBMISSION: DoD 22.1 SBIR Broad Agency Announcement, <https://www.dodsbirsttr.mil/submissions/login>, includes all program requirements. Phase I efforts should address the feasibility of a solution to the selected topic's requirements. For the AF, the Phase I contract periods of performance and dollar values are found in the table above.

Limitations on Length of Proposal: The Phase I Technical Volume **page** limits as identified in Chart 1 (above) do not include the Cover Sheet, Cost Volume, Cost Volume Itemized Listing (a-h). The Technical Volume must be no smaller than 10-point on standard 8-1/2" x 11" paper with one-inch margins. Only the Technical Volume and any enclosures or attachments count toward the page limit. In the interest of equity, **pages** in excess of the stated limits will not be reviewed. The documents required for upload into Volume 5, "Other", do not count toward the specified limits.

Phase I Proposal Format

Proposal Cover Sheet: If selected for funding, the proposal's technical abstract and discussion of anticipated benefits will be publicly released. Therefore, do not include proprietary information in these sections.

Technical Volume: The Technical Volume should include all graphics and attachments but should not include the Cover Sheet, which is completed separately. Phase I technical volume (uploaded in Volume 2) shall contain the required elements found in Chart 1. Make sure all graphics are distinguishable in black and white.

Key Personnel: Identify in the Technical Volume all key personnel who will be involved in this project; include information on directly related education, experience, and citizenship.

- A technical resume of the principal investigator, including a list of publications, if any, must be included
- Concise technical resumes for subcontractors and consultants, if any, are also useful.
- Identify all U.S. permanent residents to be involved in the project as direct employees, subcontractors, or consultants.
- Identify all non-U.S. citizens expected to be involved in the project as direct employees, subcontractors, or consultants. For all non-U.S. citizens, in addition to technical resumes, please provide countries of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project, as appropriate. Additional information may be requested during negotiations in order to verify the foreign citizen's eligibility to participate on a contract issued as a result of this announcement.

Phase I Work Plan Outline

NOTE: The AF uses the work plan outline as the initial draft of the Phase I Statement of Work (SOW). Therefore, **do not include proprietary information in the work plan outline.** To do so will necessitate a request for revision, if selected, and may delay contract award.

Include a work plan outline in the following format:

Scope: List the effort's major requirements and specifications.

Task Outline: Provide a brief outline of the work to be accomplished during the Phase I effort.

Milestone Schedule

Deliverables

Progress reports

Final report with SF 298

Cost Volume: Cost information should be provided by completing the Cost Volume in DSIP and including the Cost Volume Itemized Listing specified below. The Cost Volume detail must be adequate to enable Air Force personnel to determine the purpose, necessity and reasonability of each cost element. Provide sufficient information (a-i below) regarding funds use if an award is received. The DSIP Cost Volume and Itemized Cost Volume Information will not count against the specified page limit. The itemized listing may be submitted in Volume 5 under the "Other" dropdown option.

a. **Special Tooling/Test Equipment and Material:** The inclusion of equipment and materials will be carefully reviewed relative to need and appropriateness to the work proposed. Special tooling and test equipment purchases must, in the CO's opinion, be advantageous to the Government and relate directly to the effort. It may include such items as innovative instrumentation and/or automatic test equipment.

b. **Direct Cost Materials:** Justify costs for materials, parts, and supplies with an itemized list containing types, quantities, prices and where appropriate, purpose.

c. **Other Direct Costs:** This category includes, but is not limited to, specialized services such as machining, milling, special testing or analysis, and costs incurred in temporarily using specialized equipment. Proposals including leased hardware must include an adequate lease vs. purchase justification.

d. **Direct Labor:** Identify key personnel by name, if possible, or by labor category if not. Direct labor hours, labor overhead and/or fringe benefits, and actual hourly rates for each individual are also necessary.

e. **Travel:** Travel costs must relate to project needs. Break out travel costs by trip, number of travelers, airfare, per diem, lodging, etc. The number of trips required, as well as the destination and purpose of each, should be reflected. Recommend budgeting at least one trip to the Air Force location managing the contract.

f. **Subcontracts:** Involvement of university or other consultants in the project's planning and/or research stages may be appropriate. If so, describe in detail and include information in the Cost Volume. The proposed total of consultant fees, facility lease/usage fees, and other subcontract or purchase agreements may not exceed **one-third of the total contract price** or cost (do not include profit in the calculation), unless otherwise approved in writing by the CO. The SBIR funded work percentage calculation considers both direct and indirect costs after removal of the SBC's proposed profit. Support subcontract costs with copies of executed agreements. The documents must adequately describe the work to be performed. At a minimum, include a Statement of Work (SOW) with a corresponding detailed Cost Volume for each planned subcontract.

g. **Consultants:** Provide a separate agreement letter for each consultant. The letter should briefly state what service or assistance will be provided, the number of hours required, and the hourly rate.

NOTE: If no exceptions are taken to an offeror's proposal, the Government may award a contract without negotiations. Therefore, the offeror's initial proposal should contain the offeror's best terms from a cost or price and technical standpoint. If there are questions regarding the award document, contact the Phase I CO identified on the cover page. The Government reserves the right to reopen negotiations later if the CO determines it to be necessary.

h. DD Form 2345: For proposals submitted under export-controlled topics, either International Traffic in Arms or Export Administration Regulations (ITAR/EAR), a copy of the certified DD Form 2345, Militarily Critical Technical Data Agreement, or evidence of application submission must be included. The form, instructions, and FAQs may be found at the United States/Canada Joint Certification Program website, <http://www.dla.mil/HQ/InformationOperations/Offers/Products/LogisticsApplications/JCP/DD2345Instructions.aspx>. DD Form 2345 approval will be required if proposal is selected for award.

NOTE: Restrictive notices notwithstanding, proposals may be handled for administrative purposes only, by support contractors TEC Solutions, Inc., APEX, Oasis Systems, Riverside Research, Peerless Technologies, HPC-COM, Mile Two, Wright Brothers Institute, and MacB (an Alion Company). In addition, only Government employees and technical personnel from Federally Funded Research and Development Centers (FFRDCs) MITRE and Aerospace Corporations working under contract to provide technical support to AF Life Cycle Management Center and Space and Missiles Centers may evaluate proposals. All support contractors are bound by appropriate non-disclosure agreements. Contact the AF SBIR/STTR COs with concerns.

Company Commercialization Report (CCR) (Volume 4)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR Program BAA for full details on this requirement. Information contained in the CCR will not be considered by the Air Force during proposal evaluations.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TAB A)

The Air Force does not participate in the Discretionary Technical and Business Assistance (TAB A) Program. Proposals in response to Air Force topics should not include TAB A.

PHASE I PROPOSAL SUBMISSION CHECKLIST

Firms shall register in the System for Award Management (SAM), <https://www.sam.gov/>, to be eligible for proposal acceptance. Follow instructions therein to obtain a Commercial and Government Entity (CAGE) code and Dunn and Bradstreet (DUNS) number. Firms shall also verify "Purpose of Registration" is set to "I want to be able to bid on federal contracts or other procurement opportunities. I also want to be able to apply for grants, loans, and other financial assistance programs", NOT "I only want to apply for federal assistance opportunities like grants, loans, and other financial assistance programs." Firms registered to compete for federal assistance opportunities only at the time of proposal submission will not be considered for award. Addresses must be consistent between the proposal and SAM at award. Previously registered firms are advised to access SAM to ensure all company data is current before proposal submission and, if selected, award.

Please note the FWA Training must be completed prior to proposal submission. When training is complete and certified, DSIP will indicate completion of the Volume 6 requirement. The proposal cannot be submitted until the training is complete. The AF recommends completing submission early, as site traffic is heavy prior to solicitation close, causing system lag. **Do not wait until the last minute.** The AF will not be responsible for proposals not completely submitted prior to the deadline due to system inaccessibility unless advised by DoD.

AIR FORCE PROPOSAL EVALUATIONS

The AF will utilize the Phase I proposal evaluation criteria in the 22.1 SBIR DoD announcement in descending order of importance with technical merit being most important, followed by principal investigator's (and team's) qualification, followed by the potential for commercialization as detailed in the Commercialization Plan.

The AF will utilize the Phase II proposal evaluation criteria in the 22.1 SBIR DoD announcement in descending order of importance with technical merit being most important, followed by the potential for commercialization as detailed in the Commercialization Plan, followed by the qualifications of the principal investigator (and team).

Proposal Status and Feedback

The Principal Investigator (PI) and Corporate Official (CO) indicated on the Proposal Cover Sheet will be notified by e-mail regarding proposal selection or non-selection. Small businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the Proposal Number and Topic Number referenced.

Feedback will not be provided for Phase I proposals determined Not Selectable. Feedback will be provided only for Phase II proposals determined Not Selectable.

IMPORTANT: Proposals submitted to the AF are received and evaluated by different organizations, handled topic by topic. Each organization operates within its own schedule for proposal evaluation and selection. Updates and notification timeframes will vary. If contacted regarding a proposal submission, it is not necessary to request information regarding additional submissions. Separate notifications are provided for each proposal.

It is anticipated all the proposals will be evaluated and selections finalized within approximately 90 calendar days of solicitation close. Please refrain from contacting the BAA CO for proposal status before that time.

Refer to the DoD SBIR Program BAA for procedures to protest the Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: Air Force SBIR/STTR Contracting Officers.

AIR FORCE SUBMISSION OF FINAL REPORTS

All Final Reports will be submitted to the awarding AF organization in accordance with Contract instructions. Companies will not submit Final Reports directly to the Defense Technical Information Center (DTIC).

PHASE II PROPOSAL SUBMISSIONS

AF organizations may request Phase II proposals while technical performance is on-going. This decision will be based on the contractor's technical progress, as determined by an AF Technical Point of Contact review using the DoD 22.1 SBIR BAA Phase II review criteria. All Phase I awardees will be provided an opportunity to submit a Phase II proposal unless the Phase I purchase order has been terminated for default or due to non-performance by the Phase I company.

NOTE: Air Force primarily awards Phase I and II contracts as Firm Fixed Price. However, awardees are strongly urged to work toward a Defense Contract Audit Agency (DCAA) approved accounting system. If the company intends to continue work with the DoD, an approved accounting system will allow for competition in a broader array of acquisition opportunities. Please address questions to the Phase II CO, if selected for award.

All proposals must be submitted electronically via DSIP by the date indicated in the Phase II proposal instructions. Note: Only ONE Phase II proposal may be submitted for each Phase I award.

AIR FORCE SBIR PROGRAM MANAGEMENT IMPROVEMENTS

The AF reserves the right to modify the Phase II submission requirements. Should the requirements change, all Phase I awardees will be notified. The AF also reserves the right to change any administrative procedures at any time that will improve management of the AF SBIR Program.

AIR FORCE 22.1 SBIR Phase I Topic Index

AF221-0001 Experimental Digital Twins for Multi-GNSS Integrity Monitoring

AF221-0002 Low C-SWaP EO/IR Sensor Technology for Attritable Platforms

AF221-0003 Effect of Control Surface Damage and External Defects on System Flight Dynamics

AF221-0004 Programmability of Niche Military Open Architectures

AF221-0005 Image-based COTS Bidirectional Reflectance Distribution Function (BRDF) Measurement

AF221-0006 Mid-Infrared High Efficiency Broadband Diffraction Gratings for Ultra-Short Pulse Compression

AF221-0007 RF System Response and Analysis

AF221-0008 Satellite and Debris Discrimination and Identification

AF221-0009 Enabling Thermal Solutions for Future Laser Weapon Systems

AF221-0010 Innovative Solutions for Laser Weapon Components, Devices, and Subsystems

AF221-0011 Multi-physics Modeling of the Ablation Process for Thermal Protection Systems

AF221-0012 Voice Control and Authentication on Mobile Tactical Systems

AF221-0013 Personnel Recovery Search and Evasion Guidance Planning Artificial Intelligence / Machine Learning Model Development

AF221-0014 Cross-Compatible Electronic Kneeboard Integration

AF221-0015 Fast Prediction of Human Safety Due to RF Exposure

AF221-0016 IoT testing and Experimentation for End-to-End Scenarios

AF221-0017 Development of a High-Fidelity DoD 5th Percentile Female Finite Element Model

AF221-0018 A Closed-Loop Sense/Assess/Augment Wearable Device for Autonomous Performance Enhancement

AF221-0019 Novel Techniques for Gas Turbine Engine Bearing Inspection

AF221-0020 Thermal Control Techs for High Performance, Resilient SmallSats

AF221-0021 Landing Area and Rocket Plume Diagnostics

AF221-0022 Explainable AI (XAI) for RF Applications of Deep Learning

AF221-0023 Energy Deposition Systems for Scramjet Engine Ignition and Combustion Augmentation

AF221-0024 Innovative Concepts for Runtime Assurance Technologies

AF221-0025 Autonomous Sensing of Defense Tactical Targets by LEO Imaging Systems

AF221-0026 Signal Processing Techniques to Enhance Anti-Jam Performance for Low SWAP-C M-Code-based GPS User Equipment

AF221-0027 Autonomous Target Track Management by Proliferated Space Constellations

AF221-0028 Novel Analytics for Characterizing Influence in Visual and Audio Social Cyber Data

AF221-0029 Big Data Analytics for Managing and Parsing Computational and Experimental Data

AF221-0030 Event-Based Infrared Read-Out Integrated Circuit for Neuromorphic Processing

AF221-0031 Publicly Available Information (PAI) Collection Management

AF221-0032 Low-Cost Scalable Ultrawideband Receiver Personality for Attritable Platforms

AF221-0033 Evolvable Software Workbench for Avionics Cyber Security

TECH FOCUS AREAS: Network Command, Control and Communications; Autonomy; Artificial Intelligence/Machine Learning; General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Sensors; Space Platform; Information Systems

OBJECTIVE: Develop experimental digital twin concepts for “eCreate before You Aviate” offering new digital engineering perspectives to competitive market-driven acquisition of Multi-GNSS Integrity Monitoring systems, e.g., in how US Space Force should effectively integrate and operate multi-GNSS software-defined receivers equipped with reprogrammable multi-GNSS integrity monitoring for increased anti-jam performance, signal flexibility, SWaP-C reduction, and increased supplier base.

DESCRIPTION: US Space Force is interested in exploring the value to Multi-Global Navigation Satellite System (Multi-GNSS) of recent developments in digital twin applied to position, velocity, and timing (PNT) information with different levels of integrity, accuracy, continuity, and reliability in GNSS-challenged environments. Digital twining is now an important and emergent design and development trend in many applications such as health, meteorology, manufacturing and process technology, etc. It is best known as a virtual representation of physical assets enabled through data and simulators for real-time forecast, optimization, monitoring, retrospective analysis, and improved decision-making. Multi-GNSS and multi-GNSS integrity monitoring applications could include exploitation of redundancy of observables available from legacy and modernized civil signal operations including non-GPS data sources, detection and identification of possible anomalies corrupting navigation solutions, and receiver autonomous integrity monitoring. Such technical areas typically involve multi-constellation GNSS physically in real-time, inbuilt spoof detection at GNSS navigation receivers, scenarios and integrity risk assessment, statistical hypothesis testing, availability of simulated and live-fed data and advanced analytics in real time. The topic solicitation envisions that the breakdown of an experimental digital twin should be consisted of three pillars: i) Virtual Twin – creation of virtual representations of different environments and available infrastructures (e.g., with dedicated infrastructure, with ad-hoc infrastructure or with no infrastructure at all), platform dynamics of multi-constellation GNSS, Inertial Measurement Units (IMUs), multi-GNSS receivers accessing a large number of ranging signals from multi-GNSS constellations via S and L bands, real-time IMU measurements, and the possible levels of hybridization within multi-GNSS integrity monitoring systems together with distributed telemetry, tracking and commanding (TT&C) data from control segments and user segments; ii) Predictive Twin – physics based, data driven or hybrid models operating on the virtual twin to predict the requirements for continuous, accurate and robust PNT services, including characterization of spoofing and navigation errors caused by multi-path propagation as well as signal accuracy and availability; and iii) Twin Projection – Integration of insights generated by the predictive twin into the proof of concept of multi-GNSS software-defined receivers equipped with reprogrammable multi-GNSS integrity monitoring for pseudo ranging operations. Proposed solutions are expected to demonstrate the feasibility of applying high-fidelity numerical simulators, physics-informed machine learning and artificial intelligence, data assimilation, hardware and software in the loop, etc. to multi-GNSS systems, received signals for any coverage services, and multi-GNSS integrity monitoring systems. Quantification of experimental characteristics and capabilities such as continuous updates with total integrity risk of positioning errors in near real-time, physical realism at high spatio-temporal resolutions, informed decision-making, and future predictions to be achieved is highly desirable.

PHASE I: Identify relevant characteristics, e.g., infrastructures, platform dynamics, multiple hypothesis solution separation techniques associating with potential multi-GNSS and multi-GNSS integrity monitoring applications and mapping them to corresponding enabling technologies with which digital twins have been previously demonstrated and evaluated for real-time communication of data and latency, physical realism and future projections, continuous model updates and modeling the unknown. Investigate new techniques, methods, and algorithms of representing the effects of GPS spoofing, multi-path propagation, and other factors affecting positioning errors to enable the feasibility of multi-GNSS, Inertial Navigation Systems, and multi-GNSS integrity monitoring applications of experimental digital twin technologies. Specify underlying datasets (e.g., live-fed INS, non-GPS core data, simulated/emulated GNSS signals, etc.) available for research and validated model building, and computational infrastructures.

PHASE II: Develop of an engineering development unit (EDU) to demonstrate the value of such an experimental digital twin in combination of live feeds of C/A and/or M-Code signals, to a continuous, accurate and robust service provision only offered by the multi-GNSS integrity monitoring, of which single GNSS integrity monitoring alone could not meet. Test out hypothetical scenarios for “what if?” analysis, performance gains and risk assessments of countering threats to integrity and exclusivity. Demonstrate physics/knowledge/science-informed machine learning as needed to enable the hybridization of a suite of different GNSS integrity monitoring solutions in addressing operational challenges of data management, data privacy and security, and data quality. Assess quantitative benefits, e.g., near real-time prediction of PNT resiliency in presence of ambiguity resolution of ephemeris, clock errors, interferences, etc. of using the digital twin EDU.

PHASE III DUAL USE APPLICATIONS: With the findings from Phase I and II, the construction of experimental digital twins will help the design of robust and resilient multi-GNSS, multi-GNSS receivers, multi-GNSS integrity monitoring systems and approaches not only during the conceptualization, prototyping, testing and design optimization phase but also during the operation phase with the ultimate aim to use them throughout the whole product life cycle. Potential Phase III military applications include enterprise tech solutions for robust, resilient PNT capabilities with anti-jam, anti-spoof, accuracy, integrity, and signal flexibility. Tech transition plan: Government organizations such as AFRL and SMC sponsor a government reference design of an experimental digital twin of multi-GNSS integrity monitoring systems in collaboration with small business and industry partners. Successful technology demonstrations will inform the technical requirements of future multi-GNSS integrity monitoring acquisitions by Primes and subcontractors. Improved multi-GNSS integrity monitoring and reprogrammability are generally in demand and thus are widely used in proliferated PNT and open architectures across all orbits.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Help Desk: usaf.team@afsbirsttr.us

REFERENCES:

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2. Oracle. Digital Twins for IoT Applications: A Comprehensive Approach to Implementing IoT Digital Twins. Accessed: Sep. 10, 2019. [Online]. Available: <http://www.oracle.com/us/solutions/internetofthings/digitaltwins-for-iot-apps-wp-3491953.pdf>
3. W. Roper. There is No Spoon: The New Digital Acquisition Reality, Official Purpose Only, 2020

KEYWORDS: Multi-GNSS; multi-GNSS receivers; multi-GNSS integrity monitoring; simulated/emulated GNSS signals; live fed INS measurements; non-GPS signals; digital twin; virtual twin; predictive twin; twin projection; PNT reprogrammability

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Sensors

OBJECTIVE: The objective of this topic is to develop low cost, size, weight, and power (C-SWaP) electro-optic/infrared (EO/IR) sensing technologies and capabilities that can be incorporated onto attributable platforms. The resultant sensing technology/capability will support air-to-ground mission areas in contested environments. Example mission areas include intelligence, surveillance and reconnaissance (ISR); target detection; and target identification.

DESCRIPTION: Future engagements may necessitate operations in contested environments, thereby putting high value platforms and associated sensors at risk. As such, future missions may utilize lower cost, attributable platforms to minimize those risks and provide support operations in contested environments. Objective EO/IR sensing technologies planned for attributable platforms have significant C-SWaP constraints over traditional platforms. Given the recent proliferation of small unmanned aerial vehicle technologies in the commercial sector, attributable platforms are experiencing significant development and maturation in their own capabilities. With the advent of new low C-SWaP EO/IR sensing technologies and capabilities that can couple with such platforms, the types of commercial applications able to leverage the combined technology becomes very broad (e.g., including but not limited to precision agriculture, land surveying, and environmental monitoring).

To advance toward the objective technologies and capabilities for the air-to-ground mission, many EO/IR sensing topologies are under consideration from imaging to non-imaging schemes using passive and/or active EO/IR sensing modalities. Examples include, but are not limited to: broadband EO/IR, multi-spectral, hyperspectral, polarimetric, direct-detect lidar, coherent lidar, vibrometry, etc. Research and development can include full system-level designs or advancement of component technology. Along with such development, physics-based and performance-based modeling and simulation of components and system-level designs are necessary to aid in evaluation of expected performance and in the development of a Concept of Operations (CONOPS). Examples of component and system-level designs include, but are not limited to: detectors, photonics, telescopes, transmitters, receivers, spectrometers, etc.

Currently, no attributable platforms have been identified to represent an objective platform. However, a minimum operating altitude requirement of 30 kft (T) is specified in order to provide rationale to any offeror-derived requirements/justifications for their proposed EO/IR sensing technology/capability. No government-furnished equipment, data, and/or facilities will be provided.

PHASE I: Develop necessary plans and concept designs for the proposed EO/IR technology or capability in order to demonstrate its viability. Include appropriate initial laboratory demonstrations as required.

PHASE II: Develop and execute detailed plans and designs for the proposed EO/IR technology or capability. Develop the model and simulation capability of the proposed EO/IR technology or capability in order to support CONOPS development. Develop breadboard prototype demonstrating the proposed EO/IR component or system.

PHASE III DUAL USE APPLICATIONS: Develop, refine, and execute detailed plans and designs for the proposed EO/IR technology or capability to be inserted onto an attritable platform. Develop and refine the model and simulation capability of the proposed EO/IR technology or capability in order to support CONOPS development for a designated military/commercial application. Develop a flight representative prototype demonstrating the proposed EO/IR component or system on an attritable platform in support of a designated military/commercial application.

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3. Zhou, J., Yang, Y., Li, L., Agarwal, S., Nguyen, S., Giljum, A., Kelly, K., "Developing, integrating and validating a compressive hyperspectral video imager" *Proc. SPIE. 11423, Signal Processing, Sensor/Information Fusion, and Target Recognition XXIX*

KEYWORDS: attritable; low-cost; sensor; sensing; optical; electro-optical/infrared; EO/IR; passive EO/IR; active EO/IR; broadband EO/IR; multi-spectral; hyperspectral; polarimetric; LIDAR; direct-detect LIDAR; coherent LIDAR; vibrometry; optical detectors; photonics; telescopes; optical transmitters; optical receivers; spectrometers; low-cost imaging; low-cost EO/IR sensing

TECH FOCUS AREAS: Directed Energy; General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: Develop a flight dynamics model capable of assessing the impact of externally generated defects in the outer mold line or control surfaces on the overall flight stability for high-speed aircraft and missiles.

DESCRIPTION: Defects on the outer mold or control surfaces of a high-speed system may lead to flight instability. Understanding the extent to which these defects alter system performance, dynamics, and controllability is crucial to system design. For the purposes of this topic, both the aerodynamic performance and flight dynamics of aircraft and highly maneuverable missile systems are of interest. Aerodynamic performance is typically described using static quantities such as the lift and drag coefficient. Flight dynamics are generally described in terms of aerodynamic stability derivatives, which includes terms that are both static and dynamic in nature. Accurate computation of the aerodynamic coefficients and full set of stability derivatives is essential to meeting the topic objectives, to include derivatives related to control surface actuation. Computational methods to assess aero-mechanics and flight dynamics include panel-based methods and volume-based computational fluid dynamics (CFD). Panel methods allow fairly rapid parametric variation of airframe properties and are computationally efficient and accurate for typical aircraft configurations but are not designed to represent fine-scale details such as surface defects and the mathematical formulations are likely incapable of doing so. CFD models the aircraft geometry in much finer detail but incurs a significantly higher modeling and computational cost due to the higher fidelity involved. Additionally, most CFD formulations are led for either steady-state or time-domain solutions which can provide static aerodynamic characteristics but do not directly yield the dynamic stability derivatives required for accurate flight dynamic assessment. To address these shortcomings, responses to this topic should propose a method computing the aerodynamic coefficients along with the static and dynamic stability derivatives of an aircraft subjected to parametric variations (size, shape, location, etc.) of one or more external defects. The method should enable the parametric alterations to be modeled in a reasonably automated manner requiring minimal analyst input. The method should correctly account for propulsive effects on the flowfield and aircraft flight dynamics, along with the potential to model damage to control surfaces and the associated impacts on vehicle control. Near-term applications are focused on the low-speed flight regime, but the method should be applicable at high subsonic and supersonic speeds as well. Although accurate aeromechanical modeling of the external defects is the primary goal, priority should also be given to developing a computationally efficient method that can feasibly simulate large numbers of parametric variations without requiring excessive schedule or computational resources. Candidate numerical methods which may fulfill the criteria include, but are not limited to, the use of alternatives to traditional CFD such as Lagrangian vortex methods [1], application of system identification procedures within a time-domain CFD solver [2] or use of frequency-domain CFD to directly compute stability derivatives [3].

PHASE I: Develop a simple prototype model or demonstrate the numerical strategy for computation of aerodynamic coefficients, stability derivatives, and a corresponding flight dynamics model. Using a notional test case, derive these parameters using a high-fidelity baseline (e.g., time-domain CFD results) to be used as a verification dataset.

PHASE II: Define a user-focused workflow to enable efficient definition of parametric defect sets, calculation of aerodynamic derivatives, and demonstration of defect impact on flight dynamics. Mature the prototype into a functional tool, to include a graphical interface and user documentation. Validate flight dynamic calculations using either wind tunnel or free-flight testing of a scaled model vehicle.

PHASE III DUAL USE APPLICATIONS: Unify the method with external solvers capable of computing realistic defect geometry. Investigate enhancements to computational efficiency to broaden the range of configurations which can be considered on a given schedule. Extend the method to account for aeroelastic effects and weakening of the underlying substructure to enable a larger range of system effects to be considered.

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KEYWORDS: Computational fluid dynamics; high speed flow; panel methods; flight dynamics; flight stability; surface defects; aerodynamics, aircraft; missiles

TECH FOCUS AREAS: Network Command, Control and Communications; Autonomy; Artificial Intelligence/Machine Learning

TECHNOLOGY AREAS: Sensors; Information Systems

OBJECTIVE: Develop programmability aid technologies to enable broad adoption of military sensor software focused open architectures.

DESCRIPTION: Open architectures (OAs) provide mechanisms for faster technology refresh, technology insertion, and enable a more competitive market. Adoption drives many of the benefits of OAs by allowing reuse and transfer of technology between systems. To be successful an OA must be published, public, and popular. However, many OAs struggle with adoption once published and public. Due to the timelines involved in OA development, they can emerge with outdated or insufficient programmability aids. The Air Force seeks solutions to enable broad adoption of emerging software focused Open Architectures including STITCHES, COARPs, and OMS. Phase I work will focus on COARPs, enabling the rapid integration of radar sensors, processors, and modes. Ideas may include but are not limited to: IDE improvements for automatic code generation or validation, integrated training, DevOps integrations, integration of data ingesters, playback tools, or any other programmability aids that can be shown to ease transition/adoption or modernize software development workflows. Acronyms: SOSITE – STITCHES System of Systems Integration Technology and Experimentation (SoSITE) - SoS Technology Integration Tool Chain for Heterogeneous Electronic Systems (STITCHES) COARPs: Common Open Architecture for Radar Programs OMS: (Open Mission Systems)

PHASE I: Determine appropriate programmability solutions. Consolidate lessons learned from multiple COARPs mode development projects into a technology implementation roadmap and adoption focused strategy to implement through technology development and insertion in Phase II.

PHASE II: Phase II will consist of expanding on and implementing the solution developed in Phase I. The programmability and adoption roadmap developed in Phase I will be prototyped and additional lessons learned developed. Phase II will require working directly with mode and software developers on detailed requirements definition for the programmability aids.

PHASE III DUAL USE APPLICATIONS: Phase III will focus on maturing the prototype technologies and processes developed in Phase II into commercial technologies. While potential commercial application and potential commercial customers are important in all three phases (especially to aid in requirements definition and feedback), they are especially important to success in Phase III. COARPs is a dual use technology, and it is expected that radar developers will be the primary customer of the products of this SBIR, with the government benefiting through increased adoption of the standard by industry. Dual Use: A primary goal of open architectures and COARPs in particular is to enable small businesses and non-traditional tech providers to be competitive in traditionally OEM/Prime and military industry areas. COARPs enables radar software development by 3rd parties, enabling a growing commercial sector for these technologies.

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1. COARPs Program Virtual Distributed Laboratory (VDL): Contact Austin Klaus for access DAU Definition of Open Architectures:
<https://www.dau.edu/glossary/Pages/GlossaryContent.aspx?itemid=28062>

KEYWORDS: COARPs; Open Architectures; programmability; automatic code generation; code validation;

TECH FOCUS AREAS: Directed Energy

TECHNOLOGY AREAS: Space Platform; Materials

OBJECTIVE: Develop an image-based system operated by a minimally trained operator for rapid BRDF generation.

DESCRIPTION: Generating realistic and radiometrically accurate images of modeled scenes, both for computer graphics and remote sensing applications, requires a complete description of the reflection from all material surfaces in the scene at all incidents and reflected angles and all wavelengths of interest. This description of the reflective behavior is commonly referred to as the BRDF. Many mathematical models describing the BRDF exist, some better suited to certain classes of materials than others. However, they all contain material-specific parameters that are not readily available and in the best case are derived from measured BRDF data. Instruments to make BRDF measurements are generally highly specialized, purpose-built, rare, and expensive. The measurements are also time-intensive and thus usually sparsely sampled. These drawbacks have been successfully addressed by previous efforts to generate BRDFs using an image-based technique.¹ These efforts utilized multiple cameras to illuminate a curved sample at different angles and capture many reflected angles simultaneously in each image. Computer vision and image post processing eliminates the need for precise positioning and generates millions of separate reflection measurements that cover the whole reflection hemisphere. However, the imaged-based system previously developed was a proof-of-concept instrument requiring expert operation and image processing. For a space domain awareness utility, this methodology has not been integrated into a commercially available system that can be operated by a minimally trained operator for rapid BRDF generation. Also, in the years since, enabling technologies have developed to further decrease the barrier to entry to performing these measurements, including cell phone cameras, 3D printing, and app-based software. Decreasing equipment cost and increasing user-friendliness would enable image and computer vision based BRDF measurement of individual materials over representative samples, on-site measurements, and more commonplace use of measurements over BRDF estimates. BRDF are generally used for: • Material identification of spacecraft surfaces for space domain awareness • Characterization and identification for RSO (Resident Space Objects), aircraft, and missiles • Understanding lighting conditions in an image due to foreign light sources (albedo, planetshine, retroreflection, ringshine, etc) • Modeling visible “glints” in space and aerospace applications • Rendering for computer applications and video processing

PHASE I: An initial solution to this topic would include the basic hardware required to re-create the image based BRDF generation demonstrated by Marschner, as detailed in reference 1. This would include the sample and camera mounts and COTS cameras to capture the necessary BRDF images. However, the major effort is in developing the software to enable BRDF generation. This includes computer vision algorithms to automatically generate the relative angles in the scene from the images themselves, combination/averaging of image pixels representing the range of BRDF angles, and fitting of the data to several popular BRDF models. Emphasis in the development is to be placed both on precision of the measurement and on reducing the investment necessary in the system. This could range from a bare-bones approach utilizing 3D printed parts and cell phone cameras, to specialized mounts and photographer-grade digital cameras.

PHASE II: Phase II efforts would seek to decrease the total cost of the system and the skill level and input required by the user. This may include transitioning from professional-grade cameras to consumer-grade or cell phone cameras, deriving more of the necessary inputs from the images themselves, rather than user inputs, or developing analysis software that self-guides the user through the BRDF generation process.

PHASE III DUAL USE APPLICATIONS: Phase III efforts would create a mass market product utilizing widely available hardware (ideally cell phone cameras) and packages the analysis software into a cell-phone application. This would allow BRDFs of individual materials or objects (rather than representative articles) to be captured on site and used to populate models for remote sensing or imported into individualized computer-generated scenes.

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1. Stephen R. Marschner, Stephen H. Westin, Eric P. F. Lafortune, and Kenneth E. Torrance, "Image-based bidirectional reflectance distribution function measurement," Appl. Opt. 39, 2592-2600 (2000)

KEYWORDS: Modeling and Simulation; Remote Sensing; Computer Vision; Space Domain Awareness; Image Rendering/processing

TECH FOCUS AREAS: Directed Energy

TECHNOLOGY AREAS: Space Platform; Air Platform

OBJECTIVE: This topic addresses the broadband nature of ultrafast optics and increase the efficiency of the diffractive elements in the Mid-InfraRed (MIR). Technological research areas which may enable reaching high efficiencies across broad bandwidths in the MIR include Ultrafast Laser Inscription (ULI) direct-writing of substrates [1], nano-structured substrate treatments to produce broadband anti-reflection properties [2], utilization of novel chalcogenide MIR substrates for transmission gratings [3], and engineered surface structures designed for multiple coupled blazing resonances [4]. The proposed technology should provide 94%+ diffraction efficiency in reflection or transmission across a minimum of 5% bandwidth wavelength range suitable for lasers operating between 3 μm and 5 μm , in addition to having high-power handling capabilities (>10 mJ), either via coating damage threshold or large substrates.

DESCRIPTION: Ultra-Short Pulse Laser (USPL) technology in the MIR is currently investigated for Directed Energy (DE) applications at AFRL. Recent studies have indicated that losses in power at target due to propagation through the atmosphere can be significantly reduced using USPL (femtosecond) systems operating in the MIR between 3-5 μm . This is primarily due to two factors: 1) atmospheric transmission windows are more prevalent in the MIR than visible-NIR wavelengths, where molecular absorption lines can produce severe limitations on how much energy can be delivered at target as a function of distance, and 2) the critical power for producing a single-filament scales quadratically with wavelength. Much of the physics for USPL propagation involves a phenomenon called filamentation [5-6] that can potentially enable delivery of high intensities to targets at distances that are much greater than expected by diffraction-limited beams. The power in a filament is limited to a so-called Critical Power (P_c) which increases proportional to the square of the wavelength ($P_c \sim \lambda^2$). For powers much higher than P_c for a given laser, modulation instabilities occur that cause the beam to break up into multiple filaments. Mid-Infrared USPLs will therefore propagate at much higher powers and for longer distances than NIR USPL systems before experiencing energy losses due to the formation of multiple filaments [7]. Furthermore, recent studies of Si and Ge [8-10] indicate that less fluence is required to damage semiconducting materials with a MIR USPL than with a NIR USPL because the damage threshold is reduced as the wavelength is increased. The ability for MIR USPLs to experience low-loss propagation through the atmosphere along with an increased efficacy in producing damage on-target offers a promising new avenue for producing low-SWaP Directed Energy platforms for military utility. However, in order for MIR USPL systems to be fielded in a military environment, higher efficiency elements are needed to improve the overall throughput, in addition to materials which can support the bandwidth necessary to produce ultra-short pulse operation. One of the most significant factors contributing to excess loss in MIR USPLs is the lack of availability of efficient MIR diffraction gratings to allow for pulse compression below 100 femtoseconds. While current state-of-the-art technology (COTS products) are capable of producing high peak diffraction efficiencies ($>95\%$), the efficiency quickly degrades outside of the design wavelength. The result is that the average intensity across sufficient bandwidth to produce.

PHASE I: Develop concepts illustrating a proof-of-concept design. This should include details 1) describing how the design(s) demonstrate manufacturability, 2) addressing how technical challenges

would be addressed, and 3) discussing how concepts may be reasonably scaled to accommodate a range of specifications for laser systems between 3-5 μm .

PHASE II: Design/construct/deliver set (2x) of prototype diffraction gratings, either reflection or transmissive. Each grating should be tuned for a central wavelength of 3.8 μm , and must maintain a diffraction efficiency of 94% or better across sufficient bandwidth to support 10mJ pulses, either by supporting a high-damage threshold, or by being large enough to support beam sizes sufficient to decrease the energy density to acceptable levels given the material. Each grating must have an identical groove density, which should be large enough to be suitable for pulse compression (>350 lines/mm).

PHASE III DUAL USE APPLICATIONS: Military application: Define product line for standard packages suitable for ruggedized applications on deployable platforms. Commercial application: Define product line for standard packages suitable for commercially available MIR laser sources to be used in research laboratories within Gov't agencies, national laboratories, academic laboratories, and other research institutions.

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KEYWORDS: Mid-Infrared; MIR; femtosecond; compressor; femtosecond; diffraction grating; OPA; OPCPA; OPA; USPL; Multi-Layer Coatings; Nano-Textured; Efficient Diffraction;

TECH FOCUS AREAS: Directed Energy

TECHNOLOGY AREAS: Electronics; Air Platform

OBJECTIVE: Analysis performed under this topic will be used to develop the capability to utilize these detailed predictive models for systems of interest to the Air Force and other DoD entities. The Air Force seeks tools capable of evaluating system performance of an actively tracking RF seeker system subject to HEL irradiation.

DESCRIPTION: This topic explores the current state of the art related to RF tracking systems. Offerors will select a surrogate system to conduct testing and measure response of damage testing. Utilizing high fidelity modeling and simulation tools selected, support system analysis related to degradation and mission level impact and conduct active system testing to evaluate utility of predictive capability conducted prior to test activity. End goal is to have a robust predictive capability.

PHASE I: Selecting a system of interest, develop a model using currently available RF models to develop a system performance simulation. Simulation will run expected HEL engagements, developing test matrices for Phase II efforts.

PHASE II: Conduct HEL engagement tests to evaluate simulation results providing necessary data critical for developing robust simulation capabilities.

PHASE III DUAL USE APPLICATIONS: Develop a robust predictive capability to support HEL engagement of RF systems used for both red and blue analysis and response supporting mission utility studies and AoA analysis efforts.

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KEYWORDS: RF missiles; HEL response; RF system response; mission analysis

TECH FOCUS AREAS: Directed Energy; Network Command, Control and Communications; Autonomy

TECHNOLOGY AREAS: Sensors; Information Systems; Battlespace

OBJECTIVE: This topic seeks new methodologies to characterize and discriminate between classes of space objects using available sensing and imaging technologies and be compatible with future imaging ground and space-based assets. The proposed approach should be extensible to autonomous and rapid operation.

DESCRIPTION: The growing number of man-made resident space objects (RSOs) orbiting the Earth poses a potential threat to US space assets and, therefore, to US national security. These RSOs include working satellites, used rocket stages, space debris, in-operable satellites, and other man-made space objects. All these objects represent various levels of threat and require different handling based on RSO functioning and mission. We seek innovative research employing AI/Machine Learning Techniques to identify, categorize, and characterize space objects in real data.

PHASE I: Develop understanding of real-world data and relevant characteristics of space objects to study the problem. Consider both ground-based and space-based observation [Murray-Krezan, et al, 2019] systems. This topic seeks new methodologies to characterize and discriminate between classes of objects using available sensing and imaging technologies and compatible with developing future imaging ground and space-based assets. The proposed approach should be extensible to autonomous and rapid operation. Consider size and illumination conditions for RSOs at various orbits, only dim and low-resolution images and light curves of these objects can be obtained. Use of advanced modern image processing techniques in combination with multispectral and hyper-temporal modalities can be explored. Considering the wide variety of RSO characteristics, machine learning techniques grounded in physical attributes may be employed.

PHASE II: Early phase research will develop and demonstrate the method to distinguish different classes of RSO using synthetic data (note: if AF satellite imagery data, real or simulated, is available for public release that would be ideal). An algorithm to estimate speed (in CPU hours) and accuracy of the method achievable under a variety of observation conditions (large ground-based telescope, space-to-space engagement, LEO, GEO etc.) will be developed. Later phase research will build and demonstrate a prototype end-to-end software/firmware system.

PHASE III DUAL USE APPLICATIONS: AI machine learning techniques developed can be adapted to technical problems across DoD and commercially.

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KEYWORDS: Space domain awareness; machine learning; AI, space debris; multispectral; space control

TECH FOCUS AREAS: Directed Energy

TECHNOLOGY AREAS: Electronics; Materials; Air Platform; Battlespace

OBJECTIVE: Perhaps the most critical obstacle limiting the scalability of Laser Weapon Systems is rugged, low volume and weight thermal dissipation architectures. Lightweight, compact system thermal management begins in the laser source itself.

DESCRIPTION: High Energy Laser Weapon Systems must perform in a highly transient environment with periodic short duration engagements in a rugged military environment in ground or air vehicles. Given current and projected efficiencies, a 300kW class laser would require dissipating in excess of 600kWt of heat. For a 30s engagement magazine this equals 18MJt of energy to store or reject. Current laser source thermal architectures are not able to take advantage of the lightweight, compact thermal solutions that are currently being developed, largely due to issues such as low-quality heat and high flow rates within the laser source itself. The following ideas are suggestive, not prescriptive. Any solution within the laser source for enabling lightweight, compact and rugged thermal architectures for High Energy Laser Weapon Systems is of interest. Areas of interest include but are not limited to: • Two-phase coolant systems • 'Common loop' cooling solutions • High-temperature diodes • Novel heatsink materials and geometries • Vapor chamber cooling • Low-flow, low pressure solutions • Lightweight, high efficiency/performance pumps • Passive thermal transient management. Combinations of the above approaches are also of interest. All solutions must take into account system level efficiencies and requirements of High Energy Laser Weapon Systems.

PHASE I: Offerors will propose a specific set of thermal management improvements and conduct design and feasibility study to validate assertions of high energy laser weapon system level SWaP improvement.

PHASE II: A successful phase II proposal will demonstrate technical feasibility at the system level by: - Construction of a TRL 4 prototype of the technology in question -Creation of a final report detailing the design and creation of said prototype -An outline of the "next-steps" needed to advance the prototype technology, as well as various paths said advances could take -A concept of how the prototype technology would fit into an HEL system architecture.

PHASE III DUAL USE APPLICATIONS: Phase III will build a drop-in upgrade to an existing ground or airborne high energy laser weapon system that will enhance existing capability of that system.

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KEYWORDS: Two-phase coolant systems; Common loop' cooling solutions; High-temperature diodes; Novel heatsink materials and geometries; Vapor chamber cooling; Low-flow, low pressure solutions; Lightweight, high efficiency/performance pumps; Passive thermal transient management

TECH FOCUS AREAS: Directed Energy

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: The objective of this topic is to advance the state-of-the-art in beam quality control in high energy lasers for directed energy applications through the development of a functional intra- or extra-cavity hardware/software implementation which would ultimately result in an innovative, robust, and scalable solution to actively monitor and control optical beam quality at multiple tens of kilowatts-optical continuous wave and multiple kilowatts-optical pulsed.

DESCRIPTION: The Air Force has identified High Energy Lasers as potential modern weapons as they offer the advantages of speed-of-light-delivery, multiple target engagements with rapid retargeting, deep magazines, low incremental cost per shot, exceptional accuracy and low logistical support requirements. As High Energy Lasers increase in power, their intra-cavity recirculating optical energy also increases, resulting in thermal loading in the laser cavity and, subsequently, optical path differences which negatively affect laser beam quality and effective range. In the effort to optimize power on target at range and prevent laser optics damage, there is much interest in pursuing innovative, robust, and scalable solutions to actively monitor and control optical beam quality at multiple tens of kilowatts-optical continuous wave and multiple kilowatts-optical pulsed with a wavelength of around 1 .m. Typical beam quality control solutions in open literature include wavefront sensors and deformable mirrors; therefore, a solution for High Energy Lasers may require advancement of the associated system components. Current areas of interest include but are not limited to the following: 1) innovative techniques to assess the health and status of High Energy Laser optics in-situ in near real-time, 2) innovative high-speed wavefront.

PHASE I: Establish feasibility of the proposed solution. Perform sufficient modeling and/or experimentation to determine high-risk components are attainable. Perform tradeoffs to establish a preliminary design leading for Phase II. Define a Phase II program plan. Identify and document endorsement from potential transition partners. Provide a thorough understanding of the solution to government in time to make a Phase II decision.

PHASE II: Finalize design of a demonstration prototype. Procure, develop, and integrate the solution prototype. Plan and coordinate one or more demonstrations to provide proof of concept determination. Perform experiments and analyze results to establish the adequacy of the solution approach and minimize transition risk. Contact potential customers and establish a transition plan with partners supporting Phase III activities. Provide regular communication to the government sponsor to ensure understanding and risk mitigation.

PHASE III DUAL USE APPLICATIONS: Integrate with prospective follow-on transition partners. The contractor will transition the solution to provide improved operational capability to a broad range of potential Government and civilian users and alternate mission applications.

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KEYWORDS: high energy/power laser; in-situ; real-time; beam quality (BQ); wavefront sensor (WFS); adaptive optics (AO); deformable mirror (DM)

TECH FOCUS AREAS: Directed Energy; General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials

OBJECTIVE: These efforts will develop a high-fidelity predictive capability to assess the ablation response of thermal protection system materials based upon first principles multi-physics models.

DESCRIPTION: The Air Force is researching materials with high ablation energies for use as thermal protection systems in extreme environments. Modeling the thermal degradation of these materials necessitates the use of an ablation response model (ARM). Traditional ARMs were designed with reentry applications in mind [1] and are not specifically tailored to address strong localized flux variations and the corresponding non-uniform ablation. ARMs typically rely on mass blowing (B-prime) tables to model the chemical reactions at the solid-fluid interface and assume equilibrium chemistry based on partial pressures and temperatures at the surface. B-prime tables can introduce a significant amount of uncertainty into the analysis as often times the required data can be difficult to obtain. Coupling an ARM with computational fluid dynamics (CFD) [2] can eliminate the need for B-prime tables but comes at considerable computational expense. Furthermore, the complex composite materials and surface coatings that are often used in thermal protection systems (TPS) present additional challenges for traditional ARMs. These materials and coatings can result in complex surface reaction mechanisms, which can increase the computational expense of simulation. The Air Force seeks advanced multiphysics tools for modeling ablation of TPS materials in highly non-linear heat flux environments and aero-assisted ablation due to surface defects for high-speed systems. In addition, enhanced tools are needed which can accurately model ablation of non-homogenous composite materials. The tools should require minimal supplemental data (e.g., B-prime tables) and be computationally efficient.

PHASE I: The Phase I proposal should focus on demonstrating the feasibility of one or more novel modeling ablation concepts under localized heating or aero-assisted ablation due to surface defects. The demonstrated concept should show an improvement over the state-of-the-art.

PHASE II: Phase II will validate the proposed tool using a composite material and non-uniform heat flux profile relevant to Air Force programs. Focus will be on extending the tool to higher fidelity analysis with the goal of modeling ablation due to hypersonic aeroheating through the full flight trajectory.

PHASE III DUAL USE APPLICATIONS: In Phase III, the firm will work with industry to make the novel concept widely available for material ablation simulation in a broad range of environmental conditions and materials. Relevant non-military applications may include the simulation of aircraft brake pad performance, rocket nozzle ablation and other high temperature material ablation problems.

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- [2] Marschall, J., and M. MacLean. "Finite-Rate Surface Chemistry Model, I." AIAA-2011-3783. 2011.

KEYWORDS: Ablation; surface chemistry; computational fluid dynamics; multi-physics model; thermal protection systems; composites, hypersonics

TECH FOCUS AREAS: Cybersecurity; Network Command, Control and Communications; Artificial Intelligence/Machine Learning; General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Bio Medical; Sensors; Electronics; Information Systems; Battlespace

OBJECTIVE: This topic seeks hands-off voice/acoustic recognition for increased usability and interoperability with TAK. Additionally, synchronous and automatic user authentication for enhanced information security, using two factors of authentication (something you are and something you have) is also sought, as well as detection and identification of various sounds.

DESCRIPTION: In tactical environments, existing authentication mechanisms in TAK and mobile devices have proven to be insufficient or cumbersome for operators. Gloves and other gear can make it difficult to interact with the phone's screen for passcode or other forms of authentication requiring contact with the screen. Likewise, for the same reasons, it proves difficult to interact with and control ATAK (Android Team Awareness Kit) efficiently to disperse and assimilate information relevant to the mission. These deficiencies point to a need for hands-off TAK authentication, through voice biometrics and proximity-based access control, as well as voice command and control of TAK devices. The ability to extract information from voice-based radio communications and/or detect and identify non-vocal sounds in the environment (i.e., gunshots and vehicles) could also prove to be useful as part of this effort. Proximity-based access control includes the ability to grant or deny access based on proximity to friendly forces and teammates, enemy forces, military bases, etc. This research aims to explore voice biometrics, voice commands, and proximity-based access control as it relates to the TAK ecosystem.

PHASE I: For all sub-efforts: based on the research performed within this phase, develop a roadmap for development in Phase II and determine the scientific, technical, and commercial feasibility of the proposed solution. For proximity-based access control: demonstrate in a simulated environment the ability to perform proximity-based authentication based on distance from peers and/or established locations. For voice authentication: identify strategies to mitigate vulnerabilities and exploits inherent in many voice authentication implementations, such as the replay and synthesis attacks, and explore the feasibility of detecting duress in an operator's voice to prevent coerced, unauthorized access. For voice command and control (VC2): demonstrate ability to perform very basic control of ATAK via voice and determine areas of future work for Phase II. For both VC2 and voice authentication: research techniques to minimize the effects of background noise in a tactical environment (e.g., shouting, gunshots, engines) while maintaining a low false negative rate for authentication and increased reliability for command and control. Incorporate all of these techniques into a proposed solution that provides offline voice authentication, proximity-based access control, and VC2 for mobile devices.

PHASE II: Implement the roadmap established during Phase I. Collect data and/or utilize public datasets as needed. Obtain necessary hardware (e.g., mobile phones), then implement and test the proposed solution. Demonstrate the solution's capability in tactical environments and revise as necessary to improve reliability and security, gathering and incorporating end-user feedback when possible. Develop a plan for Phase III.

PHASE III DUAL USE APPLICATIONS: A commercial solution for proximity-based access control, voice authentication in tactical and loud environments, and VC2 would be marketable to military and

first-responder users of ATAK, as well as other users who simply desire enhanced voice recognition in tumultuous environments.

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5. <https://ieeexplore.ieee.org/abstract/document/7815208/>

KEYWORDS: TAK; Biometrics; Authentication; Voice

TECH FOCUS AREAS: Autonomy; Artificial Intelligence/Machine Learning; General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The objective of this topic is to research, develop, integrate, and test various models/algorithms for personnel recovery and/or isolated personnel evasion. Personnel recovery goal – given a last known location or area of interest, reduce the search space to find an isolated person. Evasion goal – given warfighter position and potentially a target evacuation zone (or zones), plan a route that allows the warfighter to evade capture and get to a safe area. The solutions sought should: take into consideration additional information, attempt to model personnel under different circumstances (injured, elderly, etc.), or be created with unique/novel Artificial Intelligence and/or Machine Learning-based approaches. The technology can be applicable to military environments as well as civilian search and rescue.

DESCRIPTION: Currently, the Joint Personnel Recovery Agency utilizes various tools (LandSAR, OSPRE, FINDER) to 1) narrow a search space to find lost/isolated personnel and 2) allow isolated personnel to plan evasion routes. These technologies utilize terrain data, land cover data, points of interest, etc. to determine the best route for evasion or the most likely area that a lost person may be located. Each of these tools could be supplemented with additional models/approaches. The framework for integrating these approaches is under ongoing development; the main request is to integrate new approaches into that framework.

PHASE I: Conduct a study to understand personnel actions in various settings when lost AND/OR how they should best act when evading hostile forces, ensuring developed algorithms will accurately align with what can be expected in a real-life scenario. Survey the types and formats of data available for use for these algorithms including terrain, land cover, watershed data, etc. Develop a plan with the Technical Point of Contact (TPOC) for the environment to be used for testing and simulation. Develop a roadmap for phase II work.

PHASE II: Implement the roadmap developed in Phase I. Collect additional data if necessary. Develop the system and implement on relevant hardware (if applicable). Demonstrate capability and gather feedback from relevant end-users. Develop a plan for Phase III and dual use.

PHASE III DUAL USE APPLICATIONS: Successful/promising evasion algorithms could lead to additional Phase III work with the DoD or law-enforcement agencies to expand models to various situations and environments. For search and rescue algorithms, there is vast commercialization potential. Various humanitarian groups would utilize the technology for their search and rescue missions.

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KEYWORDS: Evasion; Personnel Recovery; Algorithms; Artificial Intelligence; Search and Rescue; Optimization; Planning

TECH FOCUS AREAS: Network Command, Control and Communications; General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Electronics; Information Systems; Battlespace

OBJECTIVE: This topic seeks to provide cross-compatible software between iOS flight planning and execution software and Tactical Assault Kit / Team Awareness Kit (TAK), thereby eliminating the need for pilots/aircrew to actively engage with two separate devices during mission execution.

DESCRIPTION: Air Combat Command (ACC) identified a need for the development of cross-compatible software between TAK and iOS devices. This proposed project would provide integration between native iOS apps used extensively by pilots for mission planning and execution to eliminate the need for aircrew to actively engage with two different devices (i.e., an iPad for flight apps and an Android tablet for ATAK). This functionality would allow pilots to interact with ground units without the added distraction of a second electronic kneeboard device.

PHASE I: In Phase I, this topic seeks to develop a plan for cross-compatible software that allows the TAK environment and native iOS apps to interact on the same electronic kneeboard device. This software must allow pilots to actively interact with both environments without the need for two separate devices. Program report must outline at least two methods for a cross-compatible electronic kneeboard solution and provide a detailed roadmap of the project objectives for phase II.

PHASE II: In Phase II, firms will develop and integrate cross-compatible solution on a single electronic kneeboard device. Initial prototype must demonstrate the ability to engage with native iOS applications and ATAK using one tablet. Prototype must be tested during a live exercise alongside existing system to demonstrate its capabilities and effectiveness. Integrate solution with the latest version of ATAK and establish procedure for regular updates.

PHASE III DUAL USE APPLICATIONS: Software has the potential to be utilized in government, commercial, and civilian applications. The final product would help bridge the gap between native iOS applications used extensively across the aviation community with the ground-based situational awareness features of TAK. Widespread use of the software would provide feedback to improve the integration of these two systems and allows avenues for continued improvement.

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KEYWORDS: Electronic Kneeboard; Flight Companion; Electronic flight bag; aerial situation awareness; ADS-B

TECH FOCUS AREAS: Directed Energy

TECHNOLOGY AREAS: Biomedical

OBJECTIVE: This topic seeks to design, develop, and test fast, automated tools for predicting safety of humans in Radiofrequency (RF) exposure environments for integration into DoD modeling, simulation, and analysis frameworks such as advanced framework for simulation, integration, and modeling (AFSIM). Technology approaches may take advantage of existing machine learning tools (e.g., Varied Interface & Phenomenology Engineering Relationship Suite Relationship Suite (VIPERS), TensorFlow), and existing software end-to-end frameworks (e.g., the Galaxy framework).

DESCRIPTION: The government has access to a suite of tools for simulating the human body's thermal response to radio frequency (RF) exposure from nearby electronic equipment, radar, and other RF devices, with a focus on the safety of soldiers in these scenarios. Separate tools also exist for analysis of laser-tissue interaction at the physics-level. These tools are not currently integrated with mission-level applications such as AFSIM; however, the VIPERS tool, for example, enables AFSIM to directly drive arbitrary surrogate models. VIPERS also provides a linkage to Galaxy, which can be used to drive the physics simulations that produce data for the surrogate models. Therefore, while it is not necessary to integrate the thermal modeling tools with AFSIM, it is crucial that the thermal modeling workflows can be automated from frameworks such as Galaxy to be run on DoD clusters to produce input data for surrogates. Unfortunately, the process of combining physics-level thermal tools with machine learning applications and end-to-end simulation frameworks currently requires an analyst in the loop. These main-in-the-loop pieces include armature registration and posing for RF analysis of whole-body models, and uncertainty quantification across broad parameter spaces for RF and laser-tissue interactions. The government is interested in methodologies and implementations that will enable full automation of the thermal simulation workflow across whole populations of virtual humans, poses, and exposure scenarios. Current human body simulations can predict whole body energy deposition from microwave exposures at a 2-millimeter resolution in 10s of minutes, and large uncertainty quantification runs of RF and laser-tissue interaction may take days on high performance computing clusters. In order to be appropriate for use in DoD MS&A environments, quasi-real time operation (10s of seconds) of the developed surrogate models is desired, which should include the output of confidence intervals from the surrogate model simulations.

PHASE I: Offerors should propose design methods for implementing existing tools for simulating the human body's thermal response to RF and laser exposure in quasi real-time (a $\geq 60\times$ increase in execution speed). Methods should predict core and local temperature changes as a function of time, beam parameters, and body position. Method should also provide a measure of uncertainty quantification for the results.

PHASE II: Phase II efforts will implement and deliver code to execute on DoD computing clusters. Accurate and quasi-real time performance on whole body thermal response to RF exposure will be demonstrated.

PHASE III DUAL USE APPLICATIONS: Military applications include engagement modeling and simulation, risk assessment, and occupational health evaluations. Civilian applications include real time prediction of risks from RF occupational exposure.

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KEYWORDS: Computation models; RF exposure; modeling environments

TECH FOCUS AREAS: Cybersecurity; Network Command, Control and Communications; Autonomy; Artificial Intelligence/Machine Learning; 5G

TECHNOLOGY AREAS: Sensors; Information Systems

OBJECTIVE: This topic seeks to establish the tools and processes, and best practices for integrating and testing real and simulated IoT edge devices and telemetry in the context of digital twins defined for testing and evaluation of Air Force mission use cases.

DESCRIPTION: Efforts will develop an IoT test environment for modeling end-to-end solutions for mission-centric scenarios. This will be accomplished by leveraging a cloud-centric ecosystem for developing processes and methodology for end-to-end IoT testing and evaluation of AF mission-centric scenarios.

PHASE I: Phase I will establish a methodology around a flexible ecosystem of tools to enable digital twins modeling, data analytics and data management capabilities. Internet of Things/Internet of Battlefield Things (IoT/IoBT) implementations are proliferating across Air Force Installations of the future, offering improvements in efficiency, readiness and situational awareness. At the same time, this technology also presents new attack vectors for potential adversaries. A flexible and modular data architecture is required to thoroughly test and evaluate IoT technologies, as well as to support operational use cases. The Phase I concept development will consist of an initial capability description including a baseline testbed architecture, a cloud-centric data management concept description, and a description of a flexible ecosystem of tools to enable digital twin modeling, data analytics and data management. Phase 1 will provide foundational artifacts that will lead to a Phase 2 prototype.

PHASE II: Based on the results of Phase 1, develop and demonstrate an initial framework, a detailed architecture design, and a cloud-based digital twin IoT testing prototype ecosystem. The framework will describe all capabilities required to perform IoT modeling, simulation and testing for Air Force system application. The ecosystem shall include a multi-layer architecture to effectively collect, process, analyze and store data collected by IoT/IoBT devices to drive operational technology and/or inform command-level decision making. Phase 2 will additionally involve collaboration with AFRL engineers/AF community to establish mission-centric use cases to demonstrate and evaluate the digital twin's prototyped architecture's ability to support next generation Air Force mission scenarios.

PHASE III DUAL USE APPLICATIONS: Work with the DoD to demonstrate the use-cases and exemplars developed during Phase II are applicable to DoD systems and software. Further demonstrate and deploy the capability within diverse environments.

Potential PH III military applications

1. Smart base digital twins (such as Tyndall) would utilize the proposed capability to model the base before acquisition of IoT hardware, devices, and IT support.
2. UAS digital twins would be a low-cost method of testing autonomous vehicles before actual flight.
3. Use of data analytics and data modeling when preparing for theater-level events

Potential commercial applications of this technology:

1. Using the developed processes and methodology to efficiently model and plan a manufacturing factory that will utilize IoT devices and communication within the factory and the cloud. This will ensure all devices send correct data and as efficiently as possible. In addition, the security of the devices would be modeled and analyzed to ensure safety.
2. Any product that utilizes IoT devices/sensors (e.g., vehicles, homes, medical equipment) can be represented by a digital twin model in order to discover any problems before prior to development. The proposed capability would be useful for both military and non-military (commercial, medical, manufacturing, etc.) applications.

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KEYWORDS: IoT; methodology; Digital Twin; best practices; modeling

TECH FOCUS AREAS: Biotechnology Space

TECHNOLOGY AREAS: Bio Medical; Air Platform

OBJECTIVE: This topic will focus on development and validation of a high-fidelity DoD-defined 5th percentile female finite element human body model for use in the evaluation of aircraft safety system performance and injury prediction during high dynamic loading events.

DESCRIPTION: The Airworthiness process for aircraft safety systems and aircrew flight equipment safety evaluations requires data specific to the likelihood of injury of both large male and small female occupants. Historic methods for acquiring these data includes the use of USAF-modified hybrid III manikins undergoing a series of specific high dynamic loading events while collecting data on the manikin response for evaluation. Not only is the required testing extremely costly but the facilities required to perform the tests are few, resulting in difficulties meeting program schedules and ultimately a delay in providing capabilities to the warfighter. Advancements in finite element modeling and the ability to accurately model human interaction within environments has led to an increased use of such methods during the development process of various system types. The most complex of these models utilize magnetic resonance imaging (MRI) and computerized tomography (CT) imaging techniques to develop subject specific computer aided design (CAD) geometries of all major organs, bones and subject musculature. From these high-fidelity CAD models, finite element meshes are derived and individual components combined using various techniques to create the detailed human body model. Consisting of upwards of 3 million nodes and elements, these models are capable of providing insight into things from lower extremity fractures to head injuries and many things in between. The primary driver for the development of these models for safety evaluations, however, is the automotive industry, and with differing loading cases as well as certification criteria, there are still gaps if these are to be utilized for aircraft development. Mainly, the primary focus for human body model development thus far has been on high fidelity 50th percentile male models. While there have been small efforts looking into female human body model development as well as morphing existing 50th percentile male models to various anthropometries (5th through 95th percentile males), there has not been an extensive effort to directly generate a high-fidelity DoD defined 5th percentile female (103 lbs, Joint Primary Aircraft Training System Case 7 anthropometry) model and validate that model for aerospace level loading in the Gx, Gy and Gz directions. Not only would the development of such a model aide in the development and evaluation of new aircrew flight equipment and safety systems by reducing the cost and time required for certification, but it also directly supports the current Air Force Acquisition (SAF/AQ) initiative for digital engineering, the Biomedical and Air Platform Technology Areas, as well as the Biotechnology Technology Focus area.

PHASE I: For the Phase I effort, contractors shall develop and execute a plan for establishing end user requirements and develop a proof-of-concept model to illustrate functionality. The proof-of-concept model should incorporate geometries generated directly from a DoD defined 5th percentile female human body. The level of detail desired in the model should be determined through discussion with the end user and any simplifications to tissue morphology, interactions and/or connections should be agreed upon before implementation in the model. The model should demonstrate realistic joint motions, hard/soft tissue connections and tissue response in end user specified loading scenarios. Validated material properties shall be used for all materials being modeled as defined in related literature. At the

conclusion of the effort, a functional version of the model shall be delivered to the end user along with a perpetual license for operation, if required.

PHASE II: Contractors awarded a Phase II shall mature their 5th percentile female human body model to include active musculature throughout and validate the model response against human subject and cadaver data for both the active and passive muscle states, respectively. Requirements for validation should be discussed with the end user and the data utilized for comparison agreed upon. The model should demonstrate the ability to accurately predict gross kinematic response during defined loading events such as aircraft hard landings, crash and occupant ejections. The model should also provide the ability to further investigate localized forces/moments and accelerations in regions of interest defined by the end user and the ability to utilize that data in the injury predictions equations provided by the USAF. The environment chosen to house the model shall contain a graphical user interface (GUI) that allows for quickly modifying model position to adjust for different seated and standing postures. The model shall also contain the ability to incorporate interactions with external structures, such as aircraft crew member seats and/or ejection seats. At the conclusion of the effort, a validated, functional 5th percentile female model with active and passive musculature along with a GUI to enable model re-posturing/repositioning shall be delivered to the end user along with a perpetual license for model operation, if required.

PHASE III DUAL USE APPLICATIONS: Phase III awardees shall build upon their Phase II 5th percentile female model to expand model fidelity and functionality. The GUI shall also be expanded to allow for easy creation of critical aircrew restraint systems, such as standard aircrew harnesses and lap belts, as well as modifications to the occupant environment. The final deliverable will contain a validated 5th percentile female finite element model with the ability to model active and passive musculature. A supported GUI will be provided to enable easy re-posturing of the model as well as generation of restraint systems and additional structures, such as seats and standard aircrew flight equipment of interest, to include aircrew helmets and helmet mounted displays. Typical scenarios agreed upon by the contractor and end user shall be pre-programmed into the GUI for quick setup and/or the appropriate setup files provided for an equivalent ease of use. At the conclusion of the effort, a functional version of the model shall be delivered to the end user along with a perpetual license for operation, if required. This capability will provide the ability to evaluate the injury potential for high dynamic loading scenarios specific to small female occupants for use in evaluating new aircraft safety system design, aircrew flight equipment design, as well as existing safety system modifications. Potential avenues for transition include Air Force, Navy and Army Aircraft Program Offices for use in Safe-to-Fly evaluations as well as any commercial air and spacecraft manufacturers that have requirements related crash safety standards for certification.

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KEYWORDS: finite element modeling; human body modeling; 5th percentile female; crash safety; aircraft ejection; head injury; neck injury; spine injury; ejection injury

TECH FOCUS AREAS: Biotechnology Space

TECHNOLOGY AREAS: Bio Medical; Sensors

OBJECTIVE: This topic seeks to develop a closed-loop wearable system to continuously measure a subject's performance indicators, identify performance decay episodes, and deliver, in a controlled and automated manner, enhancement agents to return the subject's performance to optimal levels.

DESCRIPTION: Missions in remote locations, including U.S. Africa Command (AFRICOM), require service members to operate with minimal on-site support for extended durations. Operations in these locations often demand that "go or no-go" decisions be made with limited situational awareness regarding the risks to service members. Emerging technologies that enable assessment of their physical and mental state can greatly inform upon those decisions, leading to better command and control (C2) decision-making that reduces the potential for loss of life and mission failure, as recommended in the Air Force S&T 2030 strategy, "demands on combat decision-makers are outstripping the cognitive capacity of the unaided human". Moreover, technologies capable of automated assessment can augment force readiness with minimum embedded medical support. A significant body of work has been devoted to the design of systems to monitor neurochemicals in the brain for closed-loop neuromodulation to address conditions including Parkinson's disease and other medical conditions. Along the same lines, the concept of an artificial pancreas is based on the availability of the continuous glucose monitoring and the ability to use its data to control the delivery of insulin through an external pump. Less attention has been placed on closed-loop systems for non-medical conditions, including stress and fatigue, which critically affect performance in the field. Recent work has demonstrated that electrochemical aptamer-based sensors can be used for feedback-controlled drug delivery of an antibiotic, providing an opportunity to expand the development of these closed-loop systems to other molecular targets using a variety of sensor architectures. The aim of this topic is to demonstrate new capabilities in the bio medical and sensors technology areas consisting of a wearable sensor that can monitor personalized performance indicators. The sensor should assess the information and autonomously initiate delivery of the performance enhancement agent(s) when performance decay is detected, until the metrics evaluated return to pre-intervention values. This technology will provide capabilities to restore service members operating in austere environments back to full capacity, addressing needs in the focus area of biotechnology.

PHASE I: Phase I firms will perform a literature search to determine the ideal prototype architecture to demonstrate a closed-loop sense/assess/augment capability and identify the appropriate molecular performance biomarkers to be monitored by the device and the enhancement agents to be delivered. Based on these studies, develop a product development project plan adapting existing technology as much as possible or developing a new platform, if necessary. Efforts will define a use case, expected benefits, development milestones, and schedule for a Phase II prototype, as well as identifying key risk areas and associated mitigations. Performers will engage with and support USAF sponsors and partners to develop concepts of operation.

PHASE II: Companies selected for Phase II will execute the plan designed in Phase I. Development should include validation of performance in a representative environment for both intermediate and final

system prototype deliverables. Efforts will demonstrate the performance of final prototype system by measuring stress-related biomarkers, assessing a subject's stress levels based on biomarkers and delivering enhancement chemicals when stress adversely affects performance in a realistic or actual environment of intended use. User interface functionality will be demonstrated, and an integration pathway defined to make data available for decision actions. This will require engagement with USAF sponsor and end-user representatives to guide development and test and evaluation strategy.

PHASE III DUAL USE APPLICATIONS: The “artificial pancreas” is a recent product realizing the concept of a closed-loop system for a non-neuromodulation application. Recent advances in Academia have demonstrated it is possible to expand these capabilities beyond glucose/insulin. The performer could look into the medical field for dual-use opportunities for the closed-loop sensors to be developed. For instance, these types of systems could be applied to the care of patients in emergency units by providing pain medicine as well as antibiotics, only when needed and until the patient does not need this intervention any longer, which would dramatically decrease the workload of first responders and care professionals.

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KEYWORDS: closed-loop system; drug delivery; sensors; stress; performance recovery

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: This topic seeks to develop a novel strategy to reduce the cost and time to inspect Silicon Nitride (Si₃N₄) bearing rolling elements. Concepts focus to reduce the cost and inspection time of conventional non-destructive inspection (NDI) by a margin of 30% while maintaining the current standard of inspection. The strategy should accommodate multiple sizes of rolling elements, and accommodate both rollers and ball designs.

DESCRIPTION: Turbine engines utilize Si₃N₄ rolling element bearings within the engine. Si₃N₄ has become the material of choice for rolling elements in turbine engine bearings due to its ability to withstand high loads, reduce frictional heat generation in the bearing contact, and reduce overall component weight. The proliferation of Si₃N₄ rolling elements in all bearing locations both in the main shaft bearings and in gearbox support bearings places more importance on both the accuracy and expedience of inspection methods. The strategy should accommodate multiple sizes of rolling elements and accommodate both rollers and ball designs.

PHASE I: Phase I efforts will show the feasibility for a novel concept or new method to NDI Si₃N₄ rolling elements. Develop a design/test strategy for evaluating the ideas and identifying the key performance parameters necessary to document ability to meet the minimum flaw size and probability of inspection requirements utilizing assets owned by AFRL. Selected companies will also develop an initial transition and business plan.

PHASE II: In Phase II, the methodology developed in Phase I should be validated for additional conditions replicating those found in practice with physical testing and show feasible build processes and stable quality assurance processes. In the Phase II effort, steps should be taken to establish requirements for integration of the new inspection method into a production facility. The work should be transitioned to interested OEMs and/or bearing suppliers.

PHASE III DUAL USE APPLICATIONS: Si₃N₄ has become the material of choice for rolling elements in turbine engine bearings for advanced military engines. Recently, this material has been implemented into large commercial engines due to the beneficial weight savings as well as improved resistance to wear and fatigue relative to metallic rolling elements. Improved inspection technologies under this effort will have a direct impact on commercial airline operators by reducing both part cost and lead time for main-shaft bearings.

REFERENCES:

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KEYWORDS: non-destructive inspection; silicon nitride; ceramic; rolling element bearing; rolling elements; ball bearing

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Space Platform

OBJECTIVE: This topic seeks to provide next-generation thermal control technology to enable high performance, resilient small satellites for the hybrid space architecture. Technologies must be leveraged to reduce spacecraft overall size, weight, power, cost, and operational constraints and increase spacecraft overall reliability, capability, and operational agility.

DESCRIPTION: Thermal technologies are required on every spacecraft and their resource demand (size, weight, power, etc.) cause them to be design-drivers for the overall spacecraft. The current push toward SmallSats, alongside the ever-present need to manage higher electronics heat fluxes, creates a need for a new generation of thermal control technologies. This topic solicits novel thermal technologies to address a variety of pressing needs in the electronics Thermal Stackup. Technologies of interest are: 1. High thermal conductance die attach materials – must function in space electronics environment 2. Heat spreaders for High Heat flux electronics (such as GaN and laser diodes) including for Transmit/Receive modules 3. Digital electronics (e.g., ASIC, FPGA) thermal straps – much higher thermal conductance than standard conductive thermal straps, a passive convective solution is anticipated 4. High thermal conductance electronics cards heat sinks – again, a passive convective solution is anticipated 5. Reworkable thermal interface materials for electronics units 6. SmallSat deployable radiators – mass and cost competitive thermal radiators ranging from 0.5ft² to 15 ft² 7. Autoregulating thermal radiator coatings – strike a balance between performance and operation in the space environment 8. Spacecraft materials resistant to directed energy (DE) – either purpose-built shields or materials incorporating shielding as a secondary capability 9. Pulsed power thermal energy storage – novel phase change materials that have realistic operation (enough useful life, non-corrosive, etc) 10. Self-regulating heaters – for use on propellant lines and other bus components, design for the space environment 11. Battery thermal control for CubeSats & SmallSats – provide better isothermality to enhance life 12. Cryogenic thermal control technologies with no-moving-parts – seeking simpler designs yielding enhanced reliability, no induced vibration, savings of size, weight, and cost; consideration of system-wide concept-of-operation impacts required 13. On-orbit robotically mated/demated conductive thermal interfaces Offerors should emphasize understanding of the relevant space and spacecraft environments in planning the research of the proposed technologies. Space environments include thermal cycling, microgravity, ionizing radiation, launch vibration, vacuum, and more. Spacecraft environments include all of the competing constraints of various components and subsystems. Offerors must demonstrate that their technology does not invalidate the use of other incumbent technologies functioning as part of other subsystems. Actively pumped systems are highly unreliable, heavy, and expensive and are thus strongly discouraged. Passively driven convective systems (e.g., heat pipes, vapor chambers) are encouraged.

PHASE I: Phase I proposals should define requirements to survive and perform with intended space and spacecraft environments. Engagement with spacecraft prime integrators or 2nd tier integrators is encouraged. Analyze technologies' capability to meet thermal subsystem needs in the context of USSF spacecraft. Offerors should highlight how studies will transition to follow on physical hardware tests or how benchtop demonstrations will scale up to more representative demos in later phases.

PHASE II: If selected for Phase II, companies will design, analyze, build, and ground test the technology, showing capability to survive and perform in the space and spacecraft environment. If possible, space qualification testing should be performed such that the offeror is prepared to sell the product to the space market at the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Phase III effort will design, build, and deliver a flight experiment to demonstrate the technology in the space environment.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Help Desk: usaf.team@afsbirsttr.us

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KEYWORDS: Thermal Control Subsystem; Space; Thermal; Thermal Interface Materials; Heat Pipes; Oscillating Heat Pipes; Deployable Radiators; Phase Change Materials; Variable Emissivity Materials; Smart Heaters; DE Hardening; Passive Cryogenics

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Space Platform

OBJECTIVE: Landing on unimproved, irregular surfaces will be required for Rocket Cargo and would enable many missions supporting Tactically Responsive Space Access. Little information is available on the interaction of a plume and different types of surfaces. Additionally, necessary data for anchoring and improving models is unavailable. The objective of this topic is to develop diagnostics capable of measuring velocity and/or structures involved in plume-ground interactions. Solutions will be demonstrated at the 1 klb thrust scale, and attention should be given to scale limitations.

DESCRIPTION: Although vertically landing a rocket on an improved, flat surface has been achieved by multiple launch vehicle companies (Masten Space, SpaceX, Blue Origin) [for example, 1], landing a rocket vehicle on an irregular, unimproved surface has a number of challenges including, but not limited to the plume kicking up dust and creating an observable event and erosion of the surface leading to a crater and/or rocket instability. The terrain the rocket vehicle may land on is not known a priori and may vary widely. Plume-ground interactions must be sufficiently understood to make decisions on acceptable landing sites and to provide necessary mitigations to enable the use of initially unsuitable sites. Additionally, information on what happens to eddies and heat after the ground stagnation point are required to determine safe stand-off distances for equipment, ensuring they are not impacted by debris (e.g., rocks) nor experience unacceptable temperatures. This information on interactions will additionally aid rockets operated for commercial applications since many companies are focused on landing and reusing their rockets, and the data can be used to inform decisions on manufacturing landing pads. Some information on plume-ground interaction is available from landing on improved surfaces and from NASA investigations of extraplanetary landing [2]. Such data is of limited scope and fidelity, however. Small-scale studies of plume-ground (simulant) interactions are of interest due to the increased fidelity available. Both improved surface landings and small-scale experiments have demonstrated the ability to obtain temperature and heat flux profiles on the ground. However, structures within the plume, including their interaction with the ground and evolution thereafter, are not yet available. Similarly, velocities within the plume are unattainable. These metrics are crucial for assessing surface survivability, stand-off distances for personnel and critical ground equipment, and for developing accurate computational models. However, they are difficult to acquire due to the large luminosity of the plume, density gradients within the plume, and, to a lesser extent, general size scales involved. For example, traditional and even next-generation Particle Image Velocimetry can only provide near-surface data due to the luminosity of the plume overcoming that of embedded particles [3, 4], and introduction of particles, especially not eroding the chamber throat, can be problematic and difficult. NASA's HiDyRS-X project was able to overcome the luminosity challenges but had limitations with temporal resolution making evolution studies difficult or impossible [5]. This topic seeks solutions which enable visualization of large structures and their interactions with the ground and/or the quantification of velocities within the plume before and after interaction with the ground. Temporal resolution must be sufficient to understand evolution as the plume contacts the landing site. To meet necessary acceleration of technology development and the demands of high-fidelity CFD, the methods must provide two- or three-dimensional data. Methods will be demonstrated on a small-scale, 1 klb thrust, kerosene-oxygen rocket chamber during Phase II. AFRL/RQRC will provide one week of testing time, up to ten tests a day, and the rocket chamber and ground simulant to carry out such a demonstration. AFRL/RQRC will also provide up to two black-and-white, high-speed cameras (Vision

Research Phantom) as necessary. Proposals should consider limitations for applications on larger rockets including a scale at which they would be untenable due to luminosity, size, or other complexity. Resolution and/or uncertainty estimates, as applicable to the measurement, should also be included.

PHASE I: Selected companies will establish the method overcoming complexities related to plumes. Verification can be a combination of reduced-scale demonstration (e.g., within bunsen-burner flame) and analysis. This verification, however established, will be documented and delivered as part of the Phase I work and will provide confidence that the system can be used successfully to collect data from a small-scale plume. Efforts should also quantify resolution and/or uncertainty of method, which will be documented as a deliverable. Companies will interact with CFD model developers to ensure needs are met. Data collected as part of verification will be provided to model developers as well as sufficient information regarding experimental set-up to allow data use in testing models.

PHASE II: If selected, companies will deliver necessary software and hardware prototype package to AFRL. Efforts will demonstrate the diagnostic technique with a 1 klbf, kerosene-oxygen engine plume impinging on a landing pad simulator. AFRL/RQRC will provide hot-fire testing with their 500-1000 lb thrust stand for such demonstrations, or an equivalent or larger system shall be used. Operation of the diagnostic will be shown across mixture ratios from 2.2 to 2.8 (at a minimum). Landing pad simulator will be located at a range of distances to be determined, but within the overall range of 18-72 inches. Air Force will be provided data package from demonstration to CFD modelers.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will scale the diagnostic to a 10 klbf thrust engine or larger and provide demonstration of efficacy and/or field prototype system for demonstration with medium or large rocket landing (to include dust and other environmental factors). This demonstration will necessarily involve commercial partners since the military does not manufacture nor purchase rockets.

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KEYWORDS: rockets; plumes; plume-ground interaction; plume-pad interaction; diagnostics

TECH FOCUS AREAS: Artificial Intelligence/Machine Learning

TECHNOLOGY AREAS: Sensors; Information Systems

OBJECTIVE: This topic seeks to develop new approaches to explainable AI (XAI) applicable to advanced radio frequency (RF) applications such as radar, electronic warfare (EW), ELINT and SIGINT. This would allow for adequate testing and evaluation (T&E) of deep learning networks (DLNs).

DESCRIPTION: The recent successes of deep learning applied to a variety of complex RF applications such as cognitive radar (CR) has prompted the need for new T&E methods to validate both performance and reliability, particularly for DoD applications. Explainable AI (XAI) is a branch of research focused on understanding "how and why" a DLN arrived at the response it did. However, for DoD applications, a very rigorous level of validation and reliability must be achieved in order to declare a system "operational". Thus, new XAI methods for DoD-specific applications are required that statistically: (1) quantify performance in an operationally relevant environment: and (2) quantify reliability (and thus availability). Methods are sought that do not require extensive (and expensive) field testing to obtain the relevant statistics.

PHASE I: Phase I efforts will pursue new XAI methods specifically addressing the DoD's needs for rigorous T&E to declare a warfighting system operational. In particular, rigorous XAI approaches are sought that can result in accurate statistical characterizations of both performance and reliability. These approaches should also minimize reliance on costly field experiments or testing. The feasibility of the proposed methods should be established in Phase I via a combination of analysis and computer simulation. Phase I should end with a clear technology development and transition roadmap for Phase II and beyond.

PHASE II: In Phase II, the methods developed in Phase I should be further developed and matured. One or more real-world focus applications will be selected to serve as the pathfinder for the new XAI approaches. Details of the new XAI procedures shall be delineated in a manner sufficient to transition to established DoD T&E organizations. The output of Phase II should be mature enough to enter low-rate initial production (LRIP) in Phase III.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will identify potential commercial and dual use applications. It is expected the inherent utility of the new XAI methods will be of immediate value to all commercial enterprises, incorporating advanced DL methods.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised

foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Help Desk:
usaf.team@afsbirsttr.us

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https://www.dau.edu/guidebooks/Shared%20Documents/Test_and_Evaluation_Mgmt_Guidebook.pdf

KEYWORDS: Artificial Intelligence; Explainable AI; Deep Learning; Cognitive Systems; RF modeling and simulation;

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: This topic seeks to develop energy deposition technologies for scramjet ignition and combustion augmentation using only on-board vehicle resources (e.g., vehicle fuel, air, and electrical power).

DESCRIPTION: The U.S. Air Force has invested in scramjet ignition technologies from both a fundamental [1–4] and applied perspective. Specifically, focus has been on Insensitive Munitions compliant ignition systems for missile platforms, which has allowed for accelerant-type systems to be used, such as pyrophorics/hypergolics, alternative oxidizers, etc., as well as consumables, such as compressed fuels or oxidizers. While many of these systems are suitable for packaging and application to expendable hypersonic systems, some are not ideal for reusable hypersonic platforms. In addition, moving away from systems with accelerants and other consumables would reduce the complexity in expendable systems. Therefore, there remains a desire to develop/mature scramjet ignition systems that only use on-board resources, such as the vehicle fuel (e.g., JP or RP-type), air, and electrical power. In addition to ignition, there is a desire to augment combustion processes in scramjet engines via energy deposition. By strategically depositing energy within an engine, combustion can be accelerated, therefore enhancing overall engine performance during off-design conditions. These “combustion enhancement” technologies also need to only use on-board vehicle resources but have the additional constraint of high duty cycle or continuous operation during certain portions of a flight profile. This topic seeks to produce new or mature existing energy deposition methods for scramjet ignition and combustion augmentation only using vehicle fuel and/or air and/or electrical power. It is envisioned the developed energy deposition technologies may be suitable for ignition or combustion augmentation, but do not have to be applicable to both because of the different operational requirements set. Specifically, ignition systems typically require operation for short duration (or order milliseconds to seconds) and should be focused on the spatial extent of influence from the electrical and/or chemical energy deposition. Combustion augmentation systems require long duration operation and, therefore careful considerations of power efficiency, thermal management, and repeated cycling. Specific focus on the applicable technology development should be placed in the areas of power and fluid requirements, as well as the spatial and temporal distribution of electrical and/or chemical energy. The energy deposition devices should try to avoid physical protrusions from the wall where it is expected to be inserted within a combustor (either in the subsonic flame holder region or in supersonic flow). Experience has shown protruding devices have limited cycle/lifetimes. Rather, it is desired any developed devices can either deposit the electrical and/or chemical energy in a large volume near the wall, or project it away from the wall by fluidic or other means. The larger the volume/region that the energy can be deposited, the greater chance of ignition success or combustion augmentation. If the developed systems are successful, the government may choose to test in relevant scramjet environments. The effort will culminate in an energy deposition system for hypersonic platforms that uses no consumables beyond the fuel and electrical power already on-board a vehicle and bleed and/or ram air. Proposals detailing systems that require/store additional fluids will not be considered.

PHASE I: Selected efforts will conceive and develop energy deposition technology and show capabilities versus baseline spark discharge systems, typically localized energy deposition of order of several Joules with specific parameters provided after award. The device requirements of power/energy, fuel and/or air pressure and flow rates, volume and mass packaging constraints, as well as the spatial and temporal distribution of the energy from the device need to be well documented. Phase I deliverables will include a final report containing the preliminary system design, estimated performance results, scaling to different device size or energy output, and/or proof-of-concept of the device operation.

PHASE II: Companies selected for Phase II will complete development of the energy deposition technology and perform bench testing of the system to demonstrate performance results. If successful, application and demonstration in a relevant scramjet environment at a government facility is desired depending upon testing availability and priority. Focus should be on validation of the system in harsh environments experienced by hypersonic vehicles and packaging to meet power, volume, and mass constraints. Phase II deliverables will include the energy deposition system and a final report that documents the demonstration results.

PHASE III DUAL USE APPLICATIONS: Phase III efforts would optimize the design of the energy deposition system for application to different engine types (reusable or expendable), different engine scales, or mission profiles. It would also involve performing engine testing of the packaged system in relevant scramjet environments to validate performance.

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KEYWORDS: scramjet ignition; turbine-based combined cycle; missile; hypersonic; ignition; combustion; air-breathing propulsion

TECH FOCUS AREAS: Autonomy

TECHNOLOGY AREAS: Air Platform

OBJECTIVE: The concept of runtime assurance (RTA) was first introduced in the 1990s and has been studied, developed, and applied to several specific systems since that time. However, if RTA applications are to be expanded for more operational uses and fielded in a wider range of platforms and systems (i.e., beyond R&D and flight-testing stages), then a number of technical hurdles will need to be addressed. Past and current R&D efforts in RTA have and are being conducted by both NASA and the Air Force Research Laboratory (AFRL). The near-term objective of this topic is to invest basic and applied research to build on accomplished R&D, address specific identified technical challenges, advance specific RTA design applications, and develop general design methods and approaches applicable to future Air Force, DoD and commercial systems. Far term objectives involve advanced technology development to construct RTA avionics packages, perform real-time hardware and flight testing of the RTA products, accomplish full V&V and certification of their intended uses, and manufacture and field the developed RTA systems in specific Air Force, DoD and commercial platforms.

DESCRIPTION: To address future Air Force strategic needs, an increasing number of advanced systems with intelligent autonomy are being envisioned. Intelligent autonomy is central to systems involving advanced automation, artificial intelligence, machine learning, and a wide range of intelligent adaptation, reconfiguration and autonomous decision making. However, a critical roadblock to the implementation and ultimate fielding of such systems are the required assurances that these advanced functions will always do the right thing. Advances in formal methods give new tools for design-time verification & validation (V&V) of these cutting-edge concepts. Yet, it is widely recognized that RTA will also be a necessary part of the overall solution towards trusted systems. This topic addresses the need for new approaches to realize implementation of RTA systems. RTA provides protection from errors in advanced functions not discovered during design-time V&V by 1) continually monitoring critical system states and parameters, 2) determining whether the system is safe and operating correctly, 3) if not, switching to a trusted, albeit less capable reversionary/backup function, and 4) allowing the reversionary system to recover to a safe/correct condition. The determination in step 2) is usually performed by observing if one or more system states have violated pre-defined boundaries. In general, this is denoted as the “switching condition” or the condition that determines when to switch to the reversionary/backup function. Original aerospace applications of RTA focused on protecting the inner-loop control and guidance systems from errors in advanced, adaptive controllers that could not be fully V&V’d to their required levels. However, there is now wide interest in expanding RTA applications to protect higher-level functions, including advanced intelligent-autonomy systems at the flight management and real-time mission planning/decision making functions in unmanned systems [1, 2]. There is also increasing interest in investigating how multiple interacting RTA systems should be designed for complex, multi-agent, distributed cyber-physical systems [3, 4]. Proposers can respond to one or more of the following sub-topics:

(1) **Physics-Based Switching Condition Accuracy:** Current fielded RTA systems have been beneficial for flight test research aircraft and have been termed “envelope protection systems,” employing physics-based switching condition boundaries (e.g., aerodynamic parameters, load factors, attitude rates, etc.). These research aircraft often perform iterative testing of experimental flight control code. At such design

stages, it is too time consuming and costly to perform extensive V&V analysis of this type of onboard code. However, the aircraft needs to remain safe during flight and if the human test pilot or remote operator cannot recognize an impending safety violation due to an error in the experimental code, the automated envelope protection system will detect the safety breach and immediately shut down the experiment, returning operation to the aircraft's production flight control system [5]. Current fielded RTA systems have also been beneficial for turbofan engine control. Engine protection systems monitor sensed physical states of the engine, such as fan and compressor speed, burner pressure and temperature, estimated surge margin, etc. If any of these parameters exceed their respective pre-defined bounds, then damage to the engine can occur or stable combustion lost. To prevent this, a reversionary fuel flow regulator takes over control of the engine and returns it to safe/stable operation [6]. Although beneficial, the envelope protection systems for flight test aircraft and the engine protection systems for turbofan controllers are broadly considered too conservative. Current allowable flight test operating envelopes are very restrictive to ensure safety of the pilots and aircraft, and the engine protection systems severely restrict the engine's transient performance. These systems are conservative because there are no practical methods to construct accurate physics-based switching conditions in an RTA system [5, 6]. Formal definitions of the switching condition boundaries that ensure safe operation were developed in [1]. However, these definitions involve complex control-theoretic conditions and do not provide realizable methods to construct the switching condition boundaries. For this reason, adding excessive safety margins seems to be the only current solution. For RTA to be broadly employed in operational applications, this problem needs to be solved. This need is not being currently addressed in NASA or AFRL R&D programs on RTA. This solicitation seeks proposals with innovative approaches to developing practical methods for the construction of accurate physics-based switching condition boundaries. Some approaches that could be considered are state reachability methods, targeted simulation methods, or other innovative, cutting-edge ideas. Successful outcomes would be demonstrated by reducing conservatism in currently fielded RTA systems, or in proving that advanced untrusted systems are allowed to operate throughout their defined envelopes as long as no software or design faults are detected. Performance should also be compared with baseline RTA methods that simply add additional safety margin to define the switching conditions.

(2) Integrated RTA – Monitoring for Both Hardware Failures and Software Errors: Another key enabling technology for advancing RTA operability is integration with hardware health monitoring and sensor redundancy management. This is related to the problem of information integrity. An RTA system that makes a decision to switch to its reversionary control function can do more harm than good if it is making that decision based on absent or incorrect information. An RTA system needs to know if observed anomalies are due to hardware malfunctions (e.g., control effector or sensor failures) or due to errors in the advanced system it is monitoring (due to software coding or algorithm design errors). The integration of RTA with hardware health monitoring has, to date, not been addressed. This solicitation seeks proposals that offer integrated software/hardware runtime assurance (integrated RTA) designs. Successful outcomes would demonstrate such integrated RTA systems, introducing seeded faults first in the advanced system's software, then seeded failures in control effectors and sensors. The integrated RTA system should respond appropriately in both cases, either shutting down the advanced system or allowing it to run, depending on the type of fault or failure determined. Comparisons should be made with RTA systems operating without hardware state knowledge showcasing the benefits of the integrated RTA approach.

(3) RTA Protection for Higher-Level Intelligent Autonomy in Complex Distributed Systems: Multiple interacting RTA functions within one platform have been studied in [1, 7]. It was determined that critical information needs to be passed between the interacting RTA modules involving current

operating conditions. Further, it was found that the complexity of the RTA designs grows rapidly with each introduction of another RTA protected module or subsystem. There is now wide interest in manned-unmanned teaming and other complex missions involving multiple unmanned agents operating in a cooperative command/control structure. Unmanned platforms possessing higher-level intelligent autonomy at the flight management or run-time mission planning levels will need RTA protection. This application of RTA is not currently being studied or addressed. Adding to the complexity of the problem, each platform will need to communicate with its neighboring fleetmates, negotiating tasks, deconflicting paths, etc., and coordinating current RTA operating states. For example, if one agent's RTA has switched to its less-capable reversionary flight management system, its lower-level performance could affect how it supports its fleetmates. This solicitation seeks proposals that offer design approaches and design considerations for RTA-protected platforms at the higher intelligent-autonomy levels involving functions that interact/communicate with teammates in a distributed, cooperative manner. The switching conditions of RTA systems at this level will not be checking physics-based criteria, but rather mission-based rules involving, for example, criteria that measure progress toward mission accomplishment, adherence of no-fly zones, optimality of teammate tasking, etc. Central to this effort will be to define/develop such mission-based RTA checks and to construct trusted reversionary flight management functions or procedures. Successful outcomes would demonstrate interacting RTA systems correctly keeping their ownships within defined operating parameters, and the team, as a whole, on course to successful mission completion. Reversionary operations should be demonstrated, including safe separation of a crippled vehicle from the fleet and its successful return to base.

(4) Other RTA Technology Advancements (General Topic): Proposals will also be considered that offer solutions to other technical hurdles, technology advancements or other innovative approaches that will broaden RTA application and improve RTA operability. Such topics include but are not limited to a) reversionary system design approaches that guarantee recovery anywhere in the operating envelope, b) approaches that reduce complexity in multiple, integrated RTA systems; b) improved approaches for design-time V&V and certification of RTA protected systems; c) integrated training of machine learning and other AI technologies with RTA switching conditions based on mission constraints.

PHASE I: In Phase I, focus should be on initial developments of proposed solutions to one or more of the aforementioned design challenges. Alternate solutions should be considered, and the most promising approaches identified. Feasibility studies should be conducted regarding proposed solution approaches. Initial design and analysis studies in desktop simulation environments should be performed. Based on initial analyses and experimental results, recommendations for further R&D and a Phase II technology development plan should be completed. Surrogate models representing Air Force platforms of interest can be used in Phase I. No government furnished data or equipment should be required. Air Force customers/stakeholders and specific Air Force technology applications of interest should be identified. These should be technologies in which advancements in RTA will provide significant benefit.

PHASE II: In Phase II, design details and experimental test plans should be significantly expanded. Development and analysis in higher fidelity desktop simulation environments with representative platform applications should be performed. Develop realistic use cases exercising RTA functionality and demonstrating benefits of RTA recovery processes. The RTA system should be agnostic of seeded faults in capstone demonstrations, proving its utility over a wide range of scenarios. Success will be defined by demonstrating the benefits of the advanced RTA technology as compared to current baseline RTA systems or platforms absent of RTA altogether. Develop real-time functionality and test/demonstrate the developed technologies in a software/hardware integration laboratory environment. Repeat some or all

of the capstone experiments performed in desktop simulations. Cost and schedule permitting, port developed real time code to flight processors and perform initial flight demonstrations with surrogate sUAS platform(s), again testing capstone experiments. Depending on contractual arrangements, government furnished data or equipment could be provided in the form of simulation models or equipment supporting laboratory or flight testing. At this stage, systems used to demonstrate the developed RTA technologies should closely align with Air Force programs of interest that employ advanced, adaptive and intelligent autonomy. Technology transfer plans should be constructed showing how the developed Phase II products can directly support such programs in preparations for Phase III efforts.

PHASE III DUAL USE APPLICATIONS: In Phase III, teaming arrangements should be made with airframe/avionics manufacturers to develop/finalize RTA system design(s) in a pre-production phase. Required V&V, safety analysis and testing for eventual certification should be performed. Phase III activities should directly support Air Force programs of interest with flight testing and demonstrations on full scale vehicles. One such potential effort is the current Skyborg Vanguard program. This program is integrating autonomous UAV technology with open missions systems to enable manned-unmanned teaming. A successful Skyborg program will deliver a prototype suite of technologies to enable autonomous UAVs with enhanced capabilities for Air Force missions. However, trust in the autonomy will be paramount for close-in manned-unmanned operations and RTA will be a key enabling technology to provide the required level of trust in the unmanned systems. Another potential program is Agility Prime, which is developing transformative technologies for urban/advanced air mobility (UAM/AAM). These vehicles are incorporating non-traditional electric or hybrid propulsion vertical takeoff and landing capabilities (eVTOL/hVTOL). These aircraft are being developed for both manned and unmanned operations, typically utilizing a single onboard pilot, remote pilot, or fully autonomous control. Mission applications include personnel recovery/delivery, medical evacuation, resupply/distribution, patrol, search and rescue, etc. Here too, trust in the onboard autonomy will be critical. Often the onboard pilot will have limited flight training (e.g., an EMT or first responder). This, along with operations over densely populated urban areas will require significant evidence that the autonomy will be bounded to safe/correct actions. Again, RTA will be a key enabling technology to provide this evidence. Follow-on Phase III activities should expand applications to other branches of the military and DoD customers. RTA technologies are not limited to military applications and there is substantial potential to expand the developed products to commercial markets. Clear applications include civil/commercial uses of UAVs/UAMs with use cases in law enforcement, civil air patrol, firefighting, disaster/humanitarian relief, border patrol, bridge/building/utility inspections, environmental services, agriculture, etc. RTA applications should be extended to ground vehicles, self-driving cars, and other autonomous modes of transportation. Other applications may include industrial systems, medical devices, robotic applications and any functions requiring assured intelligent autonomy.

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KEYWORDS: Runtime Assurance; Verification and Validation; Certification; Safety Assurance; Assured Intelligent Autonomy

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Space Platform

OBJECTIVE: This topic's objective is to develop machine learning (ML)-based analytic approaches and methods for autonomous detection and tracking of endo-atmospheric moving targets observed by EO/IR imaging sensors on LEO satellites.

DESCRIPTION: The DoD's intelligence, surveillance, and reconnaissance (ISR) enterprise seeks to bring to bear the tactical and strategic assets needed to detect, track, and target threats posed by potential adversaries. The development and integration of space-based, tactical ISR-enabling capabilities into a highly proliferated, hybrid space architecture is one critical element of employing the ISR enterprise for all-domain tactical operations. These capabilities are fundamental to ensuring that the ISR enterprise has timely and fully continuous tracking of tactical threats on a global scale in order to make warfighting decisions. One of the challenges to persistent ISR from space is having the sensing capabilities needed to collect and generate highly accurate indications of moving targets in order to convey timely actionable information across the integrated battlespace. In order to address this challenge and move beyond the current state-of-the art in detection, identification, and classification of mostly ground stationary targets, what is needed are transformative and disruptive technologies to outperform and re-conceive the function and operations of traditional space-based sensing systems and ground-based data processing, exploitation, and dissemination (PED) systems. One such transformative technology is autonomous space-based sensing for which this research topic seeks innovative autonomous data analytics that will enable highly agile sensing systems to create and deliver moving target information (MTI) as part of autonomous space architectures. The overarching goal and desired end state of this topic is an autonomous machine learning (ML)-based analytics architecture for autonomously detecting and tracking airborne moving tactical targets using MTI data that is derived from satellite EO/IR imagery and enables automatic and adaptive messaging and tasking of multi-domain assets. The objective of this research effort is to develop machine learning (ML)-based analytic approaches and computational methods for autonomous detection and tracking of endo-atmospheric moving targets observed by EO/IR imaging sensors on low earth orbit (LEO) satellites. This research effort specifically seeks to develop autonomous methods applicable to the generation of moving target information (MTI) for target flight profiles of varying altitude ranges and durations, including in-flight airborne vehicles.

The technology to be developed should focus on the need for innovative deep learning and other advanced ML methods that are not only automated and adaptive for surveillance of airborne tactical targets-of-interest from space, but also provide accurate and timely moving target information in the absence of large-scale data sets for model and algorithm training. Image simulation techniques that generate realistic training and test datasets containing moving target information are of interest, including data sets that are fully synthetic as well as those that are derived from real-world data. In addition, the research should focus on satellite imagery analytic capabilities needed for robust on-board and/or cloud-based autonomous sensing, including appropriate key performance parameters and metrics for evaluating the ability to correctly determine actual and predicted moving target information. Autonomous on-board analytics are of particular interest due to emerging data-intensive space-based

sensing concepts and the need for real-time MTI. ML approaches are also sought for generating/sharing moving target information to defense messaging and tasking systems that are local/distributed, including at the edge, as part of autonomous sensing grids.

PHASE I: Companies selected for Phase I will conduct a review and assessment of candidate ML-based analytic approaches and computational methods for autonomously processing large amounts of space-based EO/IR imagery for moving target information (MTI). Investigate the feasibility of potential image simulation techniques and models for creating training and test data sets for autonomous data analytics. Efforts will evaluate the challenges of real-time implementations of autonomous analytics on spacecraft processors.

PHASE II: Phase II efforts will design, develop, and implement a prototype autonomous analytics architecture for generating moving target information (MTI) using ML-based and other advanced data processing methods. They will demonstrate prototype architecture's autonomous functionality and operation using synthetically created data sets of LEO EO/IR imagery of in-flight aircraft and other militarily relevant targets over full flight profiles and trajectories. Additionally, demonstrations will be conducted on spacecraft processors, cloud-based platforms, and/or PC-platforms and assess trade-offs for different computational hardware with respect to MTI accuracy and latency. The demonstration's performance of the emulated autonomous end-to-end pipeline from data collection to MTI generation to MTI message preparation will be evaluated.

PHASE III DUAL USE APPLICATIONS: Phase III efforts would involve enhanced performance capabilities of the prototype autonomous analytics architecture implementation. They will demonstrate autonomous sensing capabilities as part of military exercises and other representative operational environments. Working with transition partners, they will identify and evaluate opportunities for implementation/integration in DoD and/or civilian applications requiring timely data for situational awareness.

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KEYWORDS: autonomous sensing (from space); machine learning analytics; EO/IR imagery; moving target information

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Electronics

OBJECTIVE: This topic seeks to identify and research signal processing techniques and/or algorithms improving anti-jam (AJ) performance over current MGUE capability and can be implemented in low size, weight, power, and cost (SWAP-C) military GPS M-code User Equipment utilized in multi-service operational applications.

DESCRIPTION: For nearly three decades, anti-jam (AJ) research and products for GPS User Equipment (UE) have largely been focused on high performance systems like adaptive antenna systems. The capabilities of these primarily hardware-based systems have steadily evolved to extend enhanced AJ performance to military applications with Size, Weight, and Power and Cost (SWaP-C) constraints. In addition, under the MGUE Increment 1 Resiliency and Software Assurance Modification (RSAM) effort, additional receiver-based AJ enhancement techniques were investigated and in part implemented in the MGUE Increment 1 products. Nonetheless, there are still additional challenges in addressing the ever-increasing GPS threats for those military applications and equipment with significant SWaP-C limitations such as handheld receivers, very small, unmanned aerial and ground vehicles, and diver underwater navigation systems where adaptive antenna systems may not be operationally suitable because of array size, high cost, and computational complexity. The objective of this SBIR is to develop and assess single antenna signal processing techniques and algorithms for SWaP constrained M-code capable receiver to enhance the AJ performance by at least 20 dB (30 dB objective) over the current AJ performance specified for the MGUE Increment 1 ground-based receiver in the presence of both narrowband and broadband jammers (e.g., CW, Pulsed CW, Swept CW, Matched Spectral, Gaussian noise). The tradeoffs between jammer suppression, implementation complexity, and SWaP impact should be assessed with respect to representative SWaP constrained military receiver applications and integrations. Evaluate the benefit of utilizing existing built-in sensors like an IMU that are typically integrated within a military diver navigation unit along with an M-code GPS receiver to further enhance jammer suppression. Offerors are encouraged to work with MGUE prime contractors and developers of low SWaP M-code- receiver based systems to help ensure applicability of their efforts and begin work towards technology transition. Offerors' proposals should clearly indicate what Government furnished property or information are required to conduct this effort.

PHASE I: Selected efforts will conduct a comprehensive comparative assessment and trade-offs of pre- and/or post correlation signal processing AJ enhancement algorithms and techniques for implementation with low SWAP-C M-code single antenna receivers and applications such as military underwater navigation systems which utilize various embedded sensors which can aid AJ implementation. Conduct analysis and simulations to demonstrate the level of AJ enhancement over the baseline MGUE Increment 1 AJ performance. Assess implementation complexity of candidate techniques and conduct trade-offs with respect to impact on SWAP-C, AJ performance, and operational suitability. Deliverables will be reporting of trade studies and accompanying analysis.

PHASE II: Companies selected for Phase II will design, implement, integrate, and test the most promising and effective low SWAP-C AJ signal processing/algorithmic techniques with a representative M-code based receiver prototype to demonstrate AJ implementation and performance applicable to evolving low SWaP M-code based receivers. Efforts will demonstrate measurable AJ performance with the prototype utilizing representative sensor inputs like those provided by an M-code receiver-based military underwater navigation system. Deliverables will include any software or hardware demonstrations used for analysis and reporting.

PHASE III DUAL USE APPLICATIONS: In cooperative efforts with one or more M-code-based receiver manufacturers and military underwater navigation system developers, integrate the proposed signal processing/algorithmic techniques with their respective products. Demonstrate the AJ performance, SWaP compatibility, and operational effectiveness of the algorithmic/signal processing enhancements in one or more upgraded products utilizing laboratory and field tests in representative operational and EW environments. Evaluate transition opportunities for utilization in approved Government civilian applications.

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KEYWORDS: GPS M-code; anti-jam; signal processing

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Space Platform

OBJECTIVE: The objective of this topic is to conceptualize, design, and develop a prototype of an on-orbit AI expert system for autonomous target track management by a proliferated constellation of LEO satellites. Additionally, this topic seeks to conceptualize, design, and develop a prototype of an on-orbit AI expert system for autonomous target track management in conjunction with autonomous tip & cue by a proliferated constellation of LEO satellites. This research effort specifically seeks to develop an expert system with an architecture consisting of an iterative knowledge base and an inference engine enabling autonomous track management of in-flight tactical aircraft and other airborne tactical targets. Since each satellite's expert system operates in a sensor/satellite network, technology development is also needed focusing on the potential efficiency to be gained by utilizing AI technology to enable on-orbit decisions that a) incorporate messaging traffic from other satellites in the constellation and b) allow for continuous track coordination and management across the entire constellation. AI concepts and methods are therefore also sought to facilitate and prioritize decision-making about what message content needs to be transmitted to which satellite(s) and when. Tipping & cueing all satellites in the constellation would be very inefficient and delay alerts to those satellites most likely to next view the target; however, some satellites might need a message which summarizes AMTI information whereas other satellites might need additional track information in order to fill gaps in partial or incomplete tracks.

DESCRIPTION: The DoD's all-domain intelligence, surveillance, and reconnaissance (ISR) enterprise is pursuing the development and integration of transformative capabilities needed to detect, track, and target current and future threats posed by potential adversaries. Autonomous sensing is one such innovative capability emerging as an integral technology enabler of space based tactical ISR in order to meet increasingly demanding target tracking challenges. This paradigm shift from traditional space-based surveillance systems and CONOPS to increasingly more autonomous mission operations depend on distributed and disaggregated space architectures controlled and supervised by on-orbit autonomous agents for data processing, information analysis, and course-of-action (COA) decision-making. Among these new space architectures being considered are proliferated LEO (pLEO) satellite constellations which will require many more satellites for coverage compared to other traditional orbit regimes and therefore will need to conduct mission operations in an entirely new way to minimize the large numbers of satellite operators otherwise needed to maintain the entire constellation, especially given tactical timelines requiring rapid on-orbit decision-making. One approach, therefore, to pLEO operations is for each satellite to have an onboard expert system, namely, an application using artificial intelligence (AI) to build a knowledge base which is then used to solve complex problems and make decisions without a human expert in the loop. In particular, on-orbit knowledge-based systems acting/reacting to events is central to decision-making for pLEO satellite constellations expected to coordinate and manage tipping & cueing operations among networked sensors and satellites for detecting and tracking targets. When and how an on-board expert, decision-making, system acts in response to a new observable or detected event is thus critical to the performance of autonomous tip & cue for target track management by a hybrid, multi-layered space architecture. In order to address this challenge, this research topic seeks innovative AI solutions to the design and development of an on-orbit expert system applying reasoning logic and processes to infer new information from a knowledge base of air moving target indication

(AMTI) data. The overarching goal and desired end state of this topic is an on-orbit expert system for autonomous target tracking by networked sensors/satellites in proliferated LEO constellations.

One of the challenges for on-orbit autonomous tip & cue is how to interpret data products and make dynamic decisions about courses of action while at the same time processing sensor data using trained machine learning algorithms. The technology to be developed should therefore focus on the need for innovative AI approaches and methods that enable an on-orbit autonomous expert system to make tip & cue decisions based on air moving target indication (AMTI) information that is a) characterized by statistical and probabilistic metrics for true positive/true negative classification outcomes as well as for false positive/false negative classification outcomes, b) then turned into partial track information, and c) then turned into complete tracks after processing track messages that received from other satellites that contain information on target position and velocity uncertainty. Integral to this technology development effort is the control and management of autonomous tips & cues by an expert system that acts on true target detections and disregards false alarms, but also takes into account predicted target trajectories based on a pattern of observed AMTI data. This topic thus seeks innovative AI methods which incorporate reasoning processes with feedback mechanisms that can generalize existing knowledge of the performance of the space architecture as well as incorporate new knowledge to facilitate the on-orbit decision-making process.

This topic includes research that utilizes airborne autonomous expert systems as a starting point for developing an expert system for autonomous target track management by pLEO satellite constellations. An important aim of this topic is to design and integrate technologies that make possible the decentralized operation of networked on-orbit expert systems since the convergence of sensor and communication capabilities within a proliferated constellation is a unique advantage of autonomous target tracking by hybrid space architectures being considered for tactical surveillance.

PHASE I: Phase I efforts will conduct a review and assessment of candidate AI approaches and methods for developing an expert system for autonomous target track management by proliferated space constellations. Selected companies will investigate reasoning rules/processes and develop a conceptual framework for a knowledge-based expert system with inference engine for making tip & cue decisions using knowledge of air moving target indication (AMTI) data. They will expand the conceptual framework to a preliminary design of an expert system for coordinating and managing target tracking across all satellites of a proliferated LEO constellation. Further, they will evaluate the mission challenges and impacts of implementing autonomous target track management on low-medium SWAP satellites.

PHASE II: Selected Phase II companies will finalize design of AI knowledge-based architecture and develop a prototype expert system for autonomous target track management by proliferated space constellations. Efforts will design and develop a simulated test environment for validating and demonstrating the autonomous functionality and operations of the prototype expert system. Assess performance of the prototype expert system against relevant benchmarks and metrics. They will investigate the feasibility of using digital engineering approaches to create a digital twin of a physical onboard expert system device.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will enhance performance capabilities of the prototype expert system and use the identified improvements to produce an expert system with autonomous decision-making capabilities for on-orbit tip & cue and target track management. They will demonstrate autonomous functionality and operations of the expert system as part of tabletop exercises,

simulated wargames and/or other representative operational-like environments. To the extent possible, they will develop a digital twin of the physical onboard expert system device. Working with commercial and government transition partners, companies will identify and evaluate opportunities for implementing/integrating the physical or digital expert system in DoD and/or civilian applications requiring autonomous, real-time decision-making for situations involving large, complex, and dynamic data sets for which actionable information can result in multiple courses of action with varying consequences and impacts. Commercial applications could include, for example, autonomous driving vehicles and robotic devices for household or business use requiring continuous monitoring of coordinated/collective tasks. Financial and manufacturing decisions might also benefit from an autonomous expert system. Additional DoD applications might include visual scene recognition in multi-domain common operating picture (COP) systems as well as mission operations for UAV/UAS swarms in environments with limited communications.

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KEYWORDS: AI expert systems; autonomous satellites; autonomous reasoning systems; machine learning methods for autonomy; networked autonomous systems; target tracking management

TECH FOCUS AREAS: Cybersecurity

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: This topic's objective is to develop, demonstrate and transition analytics to detect, classify and forecast the impact of information maneuvers (based on BEND information maneuvers framework) based on visual content (video, memes and pictures) and audio chat in order to support meaning making and decision-making regarding influence, course of action assessment and forecasting of behaviors, events. No BEND analytics currently exist for visual content. In fact, limited analytics for visual content exist at all -- they largely address activity detection, actor detection (akin to "entity detection" or "event detection") or characterization of affect. Likewise, there are not BEND (influence characterization) analytics for audio chat, as this is an emerging online discourse space. Current audio-based analytics focused on content, role taking within conversations ("politeness", etc.) could be leveraged to develop new analytics to characterize influence in this domain.

DESCRIPTION: Operating in the information environment today is highly challenging for military warfighters. Due to the difficulty in assessing influence in social media, a Social Digital Media playbook was developed to help characterize actions, events, and communications (Beskow and Carley, 2019). Specifically, the BEND framework accounts for how social media algorithms interact with different user activities. There are sixteen simple information maneuvers with half being community maneuvers and half being content maneuvers. Research is needed to extract the maneuvers from visual content (e.g., videos, memes) and also to better visualize the maneuvers. Additionally, research is needed on social media platforms beyond Twitter and with emerging platforms and capabilities such as voice chat (e.g., clubhouse). New analytics can assist planners, information operators, intelligence analysts with adaptive planning, triggering and cueing of sensors, strategic communication, etc. Further, by understanding the online behaviors and mechanisms of influence, it can help forecast behaviors offline (e.g., civil unrest leading to protests) which could lead to better military intervention strategies. Ideally, the approaches will include multiple parameter spaces to control for various knowledge topics, different events, varying network sizes, and different actors (including bots). Capabilities including non-English speaking contexts would particularly align with this topic. Approaches solely focused on disinformation (e.g., fake news, deepfakes) do not align with this topic. No government furnished materials, equipment, data, or facilities will be provided.

PHASE I: Develop software (analytic algorithms, models, and visualization) for characterizing the 16 BEND information maneuvers that are visual (e.g., images, memes, videos) and / or voice (e.g., voice chat). Proof of concept demonstration of the software for detection and classification of 4 BEND maneuvers from each type (content -- positive, negative, network -- positive, negative) across multiple types of visual content (videos, memes, pictures) and/or audio chat (e.g., Clubhouse). Deliverables are detection, classification, visualization software as well as full documentation of algorithms and characterization of algorithms (Receiver Operating Characteristic curves) for detection and classification software and narrative addressing proposed approach for expanding to all 16 BEND maneuvers in final report.

PHASE II: Companies selected for Phase II will apply the knowledge gained in Phase I to mature and integrate analytics and to further develop the interface, capabilities and training components needed to make the technologies transition to military customers, marketing, etc. Expand and develop the model to cope with real-time information flows and evolving information tactics. Demonstration of detection, classification of all (16) BEND maneuvers, including detection, classification of associated maneuvers in campaign (e.g., BOOST and BUILD maneuvers) in visual content (videos, memes, pictures) and/or audio chat. Anticipate/forecast impact on target audiences. Deliverables are software for detection, classification, visualization of both individual BEND maneuvers as well as associated maneuvers as well as a final report with full documentation of algorithms and characterization of algorithms (Receiver Operating Characteristic curves) for detection and classification software and narrative addressing proposed approach for visualization of influence campaigns, operationalization/transition to customers, including drill-down, supporting information to support meaning making by operators and anticipated/forecasted impact on target audiences. Additional deliverable is a software test dataset to be used to demonstrate the software/visualization to customers.

PHASE III DUAL USE APPLICATIONS: Phase IIIs will apply the knowledge gained in Phase II to further develop the interface, capabilities and training components needed to make the technologies transition to military customers, marketing, etc. They will expand and develop the model to cope with real-time information flows and evolving information tactics. Efforts will demonstrate ability to detect, classification of BEND maneuvers, including a campaign (associated BEND maneuvers) in visual content (videos, memes, pictures) and audio chat. Further, they will demonstrate capability for users to visualize maneuvers, drill down to data, and forecast impacts on target audiences, including the impacts of counter maneuvers.

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KEYWORDS: social-cyber data; social media analytics; network analytics; social media visualization; audio chat; voice chat; forecasting; classification; influence; actors; communities; networks; maneuvers; information maneuvers; influence; information operations; deep fakes; bots; information maneuver

TECH FOCUS AREAS: Artificial Intelligence/Machine Learning

TECHNOLOGY AREAS: Sensors; Air Platform

OBJECTIVE: This topic seeks to develop a software suite to analyze large time-dependent datasets by extracting insights with user-friendly statistical, decomposition, and system identification methods.

DESCRIPTION: Simulation-based evolution of military aircraft designs is increasingly dependent on computational techniques. High-fidelity unsteady databases of aircraft and sub-systems are becoming increasingly common. Suitable post-processing tools to analyze the large datasets produced have the potential to greatly speed up the evolution of optimal designs to fulfill different objectives. Experimental data acquisition has also reached maturity, and high-resolution volume data, comprising large data storage sizes, can increasingly be obtained very quickly. The ability of computational and experimental methods to generate large datasets has far exceeded analysis capabilities. Thus, only a small amount of the data is actually employed to generate insights, most frequently to determine integrated performance measures. The rich information encapsulated in the database is often neglected for lack of human resources required to perform tedious and systematic data exploration. Such information, including various phenomena of practical interest, such as flow separation, vortical structure formation, coherent structure dynamics and intermittent features among others, as well as methods to identify sensitivities of the flow-field, could not only accelerate development, but may provide significant guidance in the implementation of optimal control techniques or inform reduced-order-model development. This bottleneck must be overcome to aid design engineers and program managers in their quest for intelligent assessments of promising designs, ways to optimize this development, and to guide future simulations/experiments. A need exists to develop a suite of analytical tools capable of extracting key features from large databases, and their sensitivities, so as to provide meaningful and relevant information with minimal human involvement.

PHASE I: Phase I efforts will define and develop a concept for a software solution with ability to analyze large time-dependent data sets from computations and experiments with minimal human involvement. Efforts will define a methodology or approach for standardizing the data from disparate sources. The concept should include the initial design specifications and capabilities description to build a prototype solution in Phase II. Three Phase I solutions will be sought.

PHASE II: Based on the Phase I concept, selected efforts will design, develop, and deliver a prototype solution with the ability to analyze large unsteady data sets. The prototype must be capable of successfully demonstrating an ability to identify useful information to be used for decision making by designers and engineers. Efforts will demonstrate the tool capability with the relevant datasets. A Phase III qualification and transition plan is expected to be delivered at the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Based upon the success of Phase II, the developed product would be transitioned to DoD and integrated into its required software systems. Many commercial entities and non-DoD organizations may have interest in this technology.

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KEYWORDS: modal analysis; proper orthogonal decomposition; dynamic mode decomposition; resolvent analysis; stability analysis; feature extraction; reduced-order modeling; fluid dynamics; machine-learning

TECH FOCUS AREAS: Microelectronics

TECHNOLOGY AREAS: Sensors

OBJECTIVE: This topic seeks to model, design, and produce an asynchronous, event-based infrared read out integrated circuit (ROIC) with low power, medium array format, and digital outputs compatible with neuromorphic algorithms.

DESCRIPTION: Low power consumption is a persistent goal of military imaging systems. The power consumption is derived from three principal components: operate the imager, process the data, and transmit the image. Infrared imagers in particular must operate at low power levels (less than 500 mW), as power dissipation through the ROIC is more than doubled by the cryogenic cooling requirements, i.e., 1 W of dissipated power in the ROIC will require far more than 1 W of additional cooling capacity by the cryogenic cooler. A strong desire exists to reduce the power consumption in the ROIC and the data processing. Several groups have recently demonstrated low power, event-based sensors in the visible spectrum. These sensors are effectively asynchronous change detection circuits that only send data when the scene changes and produce a basic mapping of where light levels increased and where they decreased. Since a static scene produces no change in the circuit, the data rate and power consumption can be reduced dramatically. Furthermore, neuromorphic processing algorithms have been able to utilize this data directly to perform complicated tasks such as optical flow tracking, automatic target recognition, and stereo imaging. Recent designs have also featured grayscale imaging to enhance the user experience. The combination of both low power operation and processing has the potential to change the imaging paradigm for many systems but has only been demonstrated in the visible spectrum thus far. The goal of this program is (a) to model an event based infrared ROIC in Phase I, (b) to design, develop, and produce the ROIC in Phase II, and (c) to hybridize and demonstrate a full array with neuromorphic processing capabilities in Phase III. The basic requirements for meeting these goals are array formats of 320 x 256 or larger; pixel pitches of 40 microns or smaller; reset times of 10 microseconds or faster; an asynchronous, digital output capable of more than 1E9 events per second; grayscale imaging of 8 bits or greater; and static scene power consumption of 10 mW or less at 120 K. Preference will be given to systems run from commercial infrared camera test dewars with minimal modifications, as well as designs operating using detector material for SWIR (0.9-1.7 μm), MWIR (3-5 μm), or LWIR (8-12 μm). No government-furnished equipment, data, and/or facilities will be provided.

PHASE I: Selected Phase I efforts will develop a model for an event based infrared ROIC and imager using provided detector models. The model will be delivered in the form of code (e.g., Matlab, Python) for verification and future validation.

PHASE II: Companies selected for Phase II will design and produce an asynchronous ROIC based on the models at the desired array size and pixel pitch. Efforts will demonstrate low power operation under static scenes, as well as high speed operation. Both hybridized focalplane arrays and unhybridized ROICs will be delivered for testing, with supporting hardware interface control documentation and control software.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will demonstrate a fully packaged camera with a neuromorphic processing chip. Spiking neural network device technology is preferable. Efforts will leverage emerging event-based sensing algorithms to demonstrate.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Help Desk: usaf.team@afsbirsttr.us

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KEYWORDS: Neuromorphic imaging; event-based imager; read out integrated circuit; ROIC; infrared detector; infrared camera; asynchronous time-based image sensor

TECH FOCUS AREAS: Cybersecurity; Network Command, Control and Communications; Artificial Intelligence/Machine Learning

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: This topic seeks to develop an algorithmic approach and software framework for automated collection management across PAI sources, with the ability to generate RFIs for ISR sources, enabling improved relevance and accuracy in event discovery and threat forecasting

DESCRIPTION: Publicly Available Information (PAI) data sources are growing in volume and velocity and can provide critical and timely information about important events, such as changes in an adversary's threat posture. However, these datasets include significant irrelevant, incorrect, or incomplete information. Prioritization, verification, and supplementation are therefore essential to identify and analyze critical events. However, given the volume of data, much of this work must be automated. Previous research in "hard-soft fusion", combining PAI with traditional Intelligence, Surveillance, and Reconnaissance (ISR) sources, has shown promising strides toward identifying and verifying relevant events based on evidence spanning these disparate sources [1] [2]. Recent research in the intelligence community has also shown the potential to exploit disparate data sources to predict future threats in specific categories [3] [4]. However, a key enabler for such event discovery and threat forecasting capabilities is the ability to manage data collection to ensure detected events and threats are relevant to Air Force analysts and warfighters. While significant work in collection planning has been performed in single domains or for single INT sources such as satellite imagery [5], managing collection jointly across disparate PAI sources with coordinated cueing of more constrained ISR sources remains a challenging, unsolved problem.

The objective of this topic is to design and develop an algorithmic approach and software framework for automated collection management spanning disparate PAI sources and modalities, with support for cueing of traditional ISR or other non-PAI sources via Requests for Information (RFI) messaging. The framework should address the following specific challenges:

1. Prioritizing and optimizing PAI collection based on analysts' interests, to improve relevance of discovered events. A machine representation of analyst interests is an important aspect of this problem.
2. Prioritizing and cueing follow-up collection to gather additional information on discovered events, to improve characterization and understanding of the discovered events. This may include evidence from alternative PAI sources or modalities, as well as traditional ISR or non-PAI sources and modalities. As an example, a PAI MOVINT indication of troops massing at a border can be corroborated by satellite IMINT, providing both higher confidence and more actionable information about the event.
3. An additional challenge is that of prioritizing and organizing what is reported to analysts based on what is found by the automated collection and downstream event discovery and threat forecasting systems, to improve relevance of reported events. Addressing this challenge can leverage existing algorithms in these areas, simplified software approximating such algorithms, human judgment, or a combination of these methods.

For Phase I and II, developed software and data shall be unclassified. Generation of unclassified RFIs is sufficient for ISR sources and domains where the collected data itself is typically classified.

The resulting algorithmic framework will help “get the right decision quality data to the right decision-maker at the speed of relevance” [6]. It will also provide a useful foundation for transition into emerging hard-soft fusion analytics tool chains for military JADC2 decision-makers, with strong potential for applications in the commercial sector.

PHASE I: Phase I efforts will design algorithms to prioritize collection of PAI and cueing of supporting ISR data to support discovery of relevant events and threats spanning disparate sources and modalities. The algorithms should ingest PAI and incorporate at least two modalities in Phase I, and demonstrate generation of RFIs for at least one ISR or non-PAI source. The output should be ranked lists of events for Challenges 1 and 2 and formatted RFIs for additional data for Challenge 3. Programs should also demonstrate proof-of-concept for these algorithms on domain-relevant data sets and evaluate relevance of results.

PHASE II: Phase II efforts will develop a prototype system implementing the Phase I design and continue to thoroughly test and validate the Phase I algorithms by leveraging an expanded range of datasets. Phase II efforts will deliver software and support on-site integration and testing in customer environment.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will produce empirically validated methods for automated multi-modal collection management improving relevance, actionability, and collection efficiency of military intelligence. Commercial applications for these solutions would include public health and safety, law enforcement, and news reporting.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Help Desk: usaf.team@afsbirsttr.us

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KEYWORDS: ISR; Cyber; Algorithmic; Discovery; Forecasting; Collection Planning; PAI Sources

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Sensors; Electronics; Air Platform

OBJECTIVE: This topic seeks to develop a multi-channel 2-18 GHz receive-only RF personality subsystem to interface with conformal antenna arrays and the Zynq UltraScale+ RFSoc analog-to-digital system-on-chip devices. The developed receiver personality will leverage a commercial off the shelf open architecture approach to reduce cost and be form factored to integrate inside the size, weight, and power (SWaP) limitations of platforms such as the AgilePod(tm) and Valkyrie XQ58A nose cones.

DESCRIPTION: To operate effectively in highly contested environments, there is a critical need for distributed multi-function RF sensing capabilities on attributable platforms supporting integration into a dynamic battlefield environment within the sensing grid construct of the Air Battle Management System (ABMS). The Department of Defense (DoD) is developing the next generation of conformal phased array technologies with highly flexible, scalable, and reconfigurable RF digital backends, also known as digital receiver/exciter (DREX). These DREX modules operate over wide frequency bands and support many channels in a small SWaP form factor. Current multi-channel phased array receiver personalities, however, are still too expensive and have limited modularity for scaling capabilities in attributable-class platforms. In order to further reduce system life cycle costs and increase the ease of upgradability, next generation phase array technologies need to support common interfaces, such as Sensor Open Systems Architecture (SOSA), and modular subsystem integration approaches.

The goal of this topic area is to develop a modular and scalable receive-only RF personality directly connected with structurally integrated conformal antenna arrays and the Zynq UltraScale+ RFSoc for future SIGINT/ELINT, radar warning receiver (RWR), bistatic synthetic aperture radar, and bistatic ground moving target indicator radar capability demonstrations. Recent significant advances in commercially available RF electronics will enable performance improvements to a receiver's instantaneous bandwidth and sensitivity while lowering system costs.

The Air Force seeks a scalable receive-only 32-channel and 128-channel RF personality operating from 2-18 GHz (threshold requirement of 6-18 GHz) with a tunable bandwidth of 50-4000 MHz, spur free dynamic range of at least 90 dB, and Noise Figure better than 8 dB. The ADC sampling rate and effective number of bits (ENOB) will be defined by the Zynq UltraScale+ RFSoc, with further DREX subsystem and conformal antenna array interface details provided by the Air Force at the beginning of Phase 1. No other government materials, equipment, data, or facilities are required for successful program completion. The developed RF personality should adhere to the 3U OpenVPX form factor, which defines maximum size, weight, power, and cooling per slot (see ANSI/VITA 65-2017). Likewise, the design must include at least 16 channels per VPX card to support standard phase array system architectures. The developed personality architecture needs to be readily scalable beyond 128-channels in order to support future sensing needs. Additionally, the RF personality must include functionality to enable a hybrid analog/digital subarray beamforming architecture. Each RF path must incorporate phase and amplitude control to support this RF system architecture.

PHASE I: Phase I efforts will design a high-fidelity RF systems model of the receive-only RF personality to meet the performance objectives outlined in the description. Phase I companies will perform modeling, simulation and analysis trade-studies to identify the optimal approach and demonstrate concept feasibility of expected performance, size, weight, power consumption, and cooling considerations. The high-fidelity model will be delivered to the Air Force, as well as a Phase II work breakdown structure and dual-use strategy.

PHASE II: Phase II efforts will develop and deliver a prototype 32-channel and 128-channel receive-only RF personality meeting the topic performance requirements (TRL 4 demonstration criteria). Experimental measurements will be performed to verify performance. Additionally, an interface control document detailing aspects such as mechanical, electrical, and control interfaces will be delivered to the Air Force.

PHASE III DUAL USE APPLICATIONS: In Phase III, the company will assist the Air Force to adapt and transition the technology to the AgilePodtm program through Advanced Technologies Branch of the ISR Sensors Division (AFLCMC/WINA) and Kratos XQ-58 Valkyrie low-cost attritable strike demonstrator (LCASD) program. This technology has the potential to improve many other military systems across multiple agencies and other on-going small UAS programs. The company will actively engage with the Air Force to improve the TRL and adapt the technology to enhance future mission areas. Additionally, the developed technology may be readily adopted and commercialized in the rapidly growing satellite communications market for high data rate MIMO ground stations as well as the wireless mobile backhaul markets.

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KEYWORDS: Ultrawideband; High Dynamic Range; Digital Receiver; RF Personality

TECH FOCUS AREAS: Cybersecurity; Autonomy; Artificial Intelligence/Machine Learning

TECHNOLOGY AREAS: Sensors

OBJECTIVE: This topic seeks to develop and explore a software evolution workbench to remove malware from software/firmware, improve detection algorithms and malware understanding, and develop the means to provide software diversity to mitigate cyber-attacks.

DESCRIPTION: The ability to prevent, detect, and respond to avionics supply chain attacks and measure the effectiveness of existing cyber defense solutions remains an unsolved problem. Recent Solarwinds supply chain attacks compromising numerous U.S. government agencies highlight the impact of such a threat and the pressing, paramount need to develop solutions removing or detecting and responding to malware implanted in legitimate software and firmware. Several research efforts have proposed a variety of evolutionary approaches to address this problem.

For example, [1] argues introducing artificial software diversity into a potentially targeted program significantly decreases the probability of compromise since the evolved implementation is unknown to the attacker. In [2], a thorough survey of demonstrations where several attacks are mitigated using an automated software diversity approach is presented. The literature also includes optimizing the evolutionary process by identifying the target of diversification (e.g., instructions, basic blocks, loops) and the stage in the software life cycle for which diversification occurs (e.g., installation, loading, execution, updating) [2]. Many of the methods in the literature make use of Genetic Programming (GP) to carry out the evolutionary process [3,4]. In addition, software evolution has been used to automatically generate bug fixes [5]. Evolutionary-based diversification has therefore proven to be a useful tool in mitigating various attacks by attempting to create immune variations of programs and/or patching vulnerabilities. However, current evolutionary approaches are very inefficient as they produce non-functional mutations, not only due to the randomness in the approach but also brittleness of the computer language being evolved. In fact, 99.7% of all software mutations are found to be non-beneficial, making evolvability in existing languages computationally burdensome and very limited in producing acceptable results [6].

The goal of this topic is to develop and explore an evolvable software language and methodologies to overcome the above limitations. Specifically, this topic will focus in developing a methodology that yields fully executable programs and the means to yield the desired program functionality. The workbench will be used to 1) generate novel malware samples to evaluate and measure the effectiveness of avionics malware detection solutions against quantifiable metrics, 2) enhance existing malware detection tools, and 3) provide the means to eliminate supply chain malware by deliberately evolving the targeted legitimate software so as to “evolve out” any Trojan that may reside within that software. Additional requirements for malware generation include the ability of the evolved software to pass regression tests of the original program, avoid detection, and have the desired mission impact based on a user-configurable fitness function.

PHASE I: Phase I efforts will develop a software evolution workbench preliminary prototype demonstrating ability to evolve programs satisfying syntactic and semantic constraints. Use of

government materials, equipment and facilities are not required for this research effort. Deliverables for this phase include developed software i.e., evolvable software workbench, and manual/documentation.

PHASE II: Extend the workbench developed in Phase I to demonstrate that it can efficiently and effectively both generate novel malware that meets the above requirements and remove Trojans from legitimate software applications. Deliverables for the second phase include software of the comprehensive workbench, the generated malware samples, the successful demonstration of evolving out a Trojan from a legitimate application and corresponding documentation.

PHASE III DUAL USE APPLICATIONS: The final product will include a two-way automated translator that can ingest programs into the evolvable workbench and the evolved program can be translated back to the original instruction set architecture (e.g., 32-bit generation Intel microprocessor architecture [x86], Advanced Reduced Instruction Set Computing Machines [ARM]). Military applications include both manned and unmanned aerial vehicles, and advanced sensor systems. Commercial applications include embedded systems such as autonomous driving vehicles and Supervisory Control and Data Acquisition (SCADA) systems.

REFERENCES:

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KEYWORDS: Malware Detection and Response; Evolutionary Computing; Genetic Algorithms; Evolvable Software; Avionics Cyber Security

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Direct to Phase II (D2P2)
Proposal Submission Instructions
AMENDMENT 5
7 January 2022

The purpose of this amendment is to incorporate the following revisions:

1. Section II, Proposal Submission, second paragraph, is changed to read, “Phase II proposals require a comprehensive, detailed description of the proposed effort. AF D2P2 efforts are to be proposed in accordance with the DoD 22.1 SBIR BAA and the information in these instructions. The technical volume, Volume 2, shall be accomplished in accordance with the information found in the DoD 22.1 BAA Section 5.3.b, Format of Technical Volume (Volume 2). Performance Periods, Maximum SBIR Funding, and page limitations for required White Papers are detailed in Chart 1 (above) by Topic Number. Commercial and military potential of the technology under development is extremely important. Proposals emphasizing dual-use applications and commercial exploitation of resulting technologies are sought.”
2. Topic AF221-D002, Multi-Role Radio Frequency Sensing for GPS-degraded Navigation, is changed as follows:
 - a. The page count is changed from 7 to **15**.
 - b. The Phase II description, as previously amended, is deleted in its entirety and replaced with “Proposers with relevant hardware designs or prototypes, existing “classic” RF/SAR sensors and processing, i.e., GPS-enabled, and already developed non-GPS algorithms on real or representative simulated RF data are encouraged to propose. A successful Phase II effort will constitute the development of a hardware system and/or implementation and testing of real-time signal processing. Hardware development efforts will produce prototype hardware systems appropriate for (surrogate unmanned aerial vehicle (UAV)) flight environments and then demonstrate data acquisition (and potentially signal processing) on AFRL-lead UAV flights. Algorithm developers can be provided with a limited set of relevant government furnished equipment (GFE) data, but are encouraged to propose the use of their own relevant RF data (real or simulated), and will develop real-time code for signal processing which provides a navigation relevant output appropriate for an ASPN compliant navigator. Proposers considering both hardware and algorithmic development can assume hardware integration and flight testing support during the SBIR (i.e., if hardware development schedule allows, proposals can target AFRL lead flights starting at 12 months into the project) to facilitate data collections for use in algorithmic development.”

All other content, as previously amended, remains unchanged and in full effect.

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Direct to Phase II (D2P2)
Proposal Submission Instructions
AMENDMENT 4
22 December 2021

The purpose of this amendment is to remove Air Force Direct to Phase II Topic AF221-D012, “Multiphysics Modeling Software for Directed Energy Bioeffects”, from the DoD 22.1 SBIR Broad Agency Announcement and associated Air Force-specific instructions. Proposals **will not** be accepted under this topic.

All other content, as previously amended, remains unchanged and in full effect.

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Direct to Phase II (D2P2)
Proposal Submission Instructions
AMENDMENT 3
20 December 2021

This amendment changes the following:

1. Chart 1: Air Force 22.1 SBIR Direct to Phase II Topic Information at a Glance, Technical Volume Content column information for each topic to read, “White Paper NTE XX **Pages**”. The maximum number of pages specified for each individual topic **is unchanged**.
2. Section III, Proposal Preparation Instructions and Requirements, last sentence, is changed to read, “There is no set format requirement for **white papers**.”

All other content, as previously amended, remains unchanged and in full effect.

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Direct to Phase II (D2P2)
Proposal Submission Instructions
AMENDMENT 2
2 December 2021

This amendment implements the following changes to **Topic AF221-D002, Multi-Role Radio Frequency Sensing for GPS-degraded Navigation**:

Phase I Summary section, current content is changed to read, “This is a Direct to Phase II topic; Phase I proposals will not be accepted in response to this topic. Direct to Phase II topics require detail regarding a “Phase I-like” feasibility study. This study would include initial hardware system design with suggested procurement/implantation plan and schedule and/or an initial algorithm development, with documentation of the algorithmic steps, associated hardware assumptions/requirements for RF sensor and signal processing, and expected run-time performance analysis.”

Phase II Summary section, “Proposers with relevant hardware prototypes, existing “classic” RF/SAR sensors and processing, i.e., GPS-enabled, and already developed non-GPS algorithms on real, or representative simulated, RF data are encouraged to propose,” **is added as the first sentence.**

All other content, as previously amended, remains unchanged and in full effect.

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Direct to Phase II (D2P2)
Proposal Submission Instructions
AMENDMENT 1
2 December 2021

The purpose of this amendment is to correct the following:

1. Chart 1: Air Force 22.1 SBIR Direct to Phase II Topic Information at a Glance, Max SBIR Funding column, the amounts for Topics AF221-D013 and AF221-D015 are changed from **\$830,000** to **\$1,250,000**.
2. Air Force 22.1 SBIR Direct to Phase II Topic Index, all Topic numbers are changed to reflect the following:

- AF221-D001** - Development of Adaptive Mesh Refinement for Hypersonic Reacting Flow Solvers
- AF221-D002** - Multi-Role Radio Frequency Sensing for GPS-degraded Navigation
- AF221-D003** - High Speed Particulate Erosion Capability
- AF221-D004** - RF Analog Imaging for Dual Multi-static Radar and Radar Warning Receivers
- AF221-D005** - Extremely High Temperature Aperture Materials Maturation and Manufacturing Development for High-Speed Systems
- AF221-D006** - Composite Laser Ablation for Surface Preparation (CLASP) Manufacturing Scale-Up
- AF221-D007** - NDE of Thick Scarf Repaired Composites and Related As-Manufactured Structures
- AF221-D008** - Self-Healing Fuel Tank Bladders for Reduced Aircraft Maintainability
- AF221-D009** - Material Advances for Aerospace Cognitive Monitoring
- AF221-D010** - AI for the Depot: Using ETAR for Digital Health Records
- AF221-D011** - Spatial Registration of Nondestructive Evaluation (NDE) Sensors in Enclosed or Constrained Access Locations
- AF221-D012** - Multiphysics Modeling Software for Directed Energy Bioeffects
- AF221-D013** - Innovations in Distributed Collaboration for Tactical Environments
- AF221-D014** - Peer-based Information Distribution in Contested Environments
- AF221-D015** - Mission Relevant ML Artifact Registry
- AF221-D016** - Digital Engineering at the Tactical Edge
- AF221-D017** - Imaging System for Real Time Observation of High Energy Laser Effects
- AF221-D018** - Multiple Sensor Platform for High Power Microwave Field Mapping
- AF221-D019** - Digital QuickStart
- AF221-D020** - Space-Based Sensing at the Tactical Edge
- AF221-D021** - Communications via Beat-Wave Excitation of ELF/VLF Waves in the Ionosphere
- AF221-D022** - High Sensitivity Tracking for Event Based LEO Moving Target Indication

3. All corresponding topics, i.e., **AF212-D001** through **AF212-D022**, are renumbered to **AF221-D001** through **AF221-D022**.
4. Government Technical Point of Contact (TPOC) information is changed as follows for **Topics AF221-D013, D015, and D016**:
 - a. AF221-D013, Innovations in Distributed Collaboration for Tactical Environments, TPOC is changed from **TPOC** to **TPOC**.
 - b. AF221-D015, Mission Relevant ML Artifact Registry, is changed from **TPOC** to **TPOC**.
 - c. AF221-D016, Digital Engineering at the Tactical Edge, is changed from **TPOC** to **TPOC**.
5. Topic AF221-D012, Multiphysics Modeling Software for Directed Energy Bioeffects, “Description” section, last paragraph, last sentence, is corrected to read,
“Examples of such mechanisms include but are not limited to light transport in turbid media coupled to thermal and acoustic solutions as well as sub-surface vaporization of materials in an elastic media **with the capacity for adaptive and dynamic meshing to account for highly variable and complex geometries.**”

All other content remains unchanged and in full effect.

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Direct to Phase II (D2P2)
Proposal Submission Instructions

AF Phase I proposal submission instructions are intended to clarify the Department of Defense (DoD) Broad Agency Announcement (BAA) as it applies to the topics solicited herein. **Firms must ensure proposals meet all requirements of the 22.1 SBIR BAA posted on the DoD SBIR/STTR Innovation Portal (DSIP) at the proposal submission deadline date/time.**

Complete proposals **must** be prepared and submitted via <https://www.dodsbirsttr.mil/submissions/> (DSIP) on or before the date published in the DoD 22.1 SBIR BAA. Offerors are responsible for ensuring proposals comply with the requirements in the most current version of this instruction at the proposal submission deadline date/time.

Please ensure all e-mail addresses listed in the proposal are current and accurate. The AF is not responsible for ensuring notifications are received by firms changing mailing address/e-mail address/company points of contact after proposal submission without proper notification to the AF. **If changes occur to the company mail or email addresses or points of contact after proposal submission, the information must be provided to the AF SBIR/STTR One Help Desk.** The message shall include the subject line, “22.1 Address Change”.

Points of Contact:

- General information related to the AF SBIR/STTR program and proposal preparation instructions, contact the AF SBIR/STTR One Help Desk at usaf.team@afsbirsttr.us.
- Questions regarding the DSIP electronic submission system, contact the DoD SBIR/STTR Help Desk at dodsbirsupport@reisystems.com.
- For technical questions about the topics during the pre-announcement and open period, please reference the DoD 22.1 SBIR BAA.
- Air Force SBIR/STTR Contracting Officers (CO):
 - Ms. Kristina Croake, kristina.croake@us.af.mil
 - Mr. James Helmick, james.helmick.2@us.af.mil

General information related to the AF Small Business Program can be found at the AF Small Business website, <http://www.airforcesmallbiz.af.mil/>. The site contains information related to contracting opportunities within the AF, as well as business information and upcoming outreach events. Other informative sites include those for the Small Business Administration (SBA), www.sba.gov, and the Procurement Technical Assistance Centers (PTACs), <http://www.ptacus.us.org>. These centers provide Government contracting assistance and guidance to small businesses, generally at no cost.

Chart 1: Air Force 22.1 SBIR Direct to Phase II Topic Information at a Glance

Topic Number	Performance Period	Max SBIR Funding	Technical Volume Contents
AF221-D001	18 months	\$1,250,000	White Paper NTE 20 Pages
AF221-D002	24 months	\$1,250,000	White Paper NTE 15 Pages
AF221-D003	27 months	\$1,500,000	White Paper NTE 15 Pages
AF221-D004	27 months	\$1,500,000	White Paper NTE 15 Pages
AF221-D005	27 months	\$1,250,000	White Paper NTE 15 Pages
AF221-D006	27 months	\$1,500,000	White Paper NTE 15 Pages
AF221-D007	27 months	\$1,250,000	White Paper NTE 15 Pages
AF221-D008	27 months	\$1,250,000	White Paper NTE 15 Pages
AF221-D009	27 months	\$1,500,000	White Paper NTE 15 Pages
AF221-D010	27 months	\$1,500,000	White Paper NTE 15 Pages
AF221-D011	27 months	\$1,500,000	White Paper NTE 15 Pages
AF221-D012	27 months	\$750,000	White Paper NTE 25 Pages
AF221-D013	27 months	\$1,250,000	White Paper NTE 25 Pages
AF221-D014	27 months	\$1,250,000	White Paper NTE 25 Pages
AF221-D015	27 months	\$1,250,000	White Paper NTE 25 Pages
AF221-D016	27 months	\$1,250,000	White Paper NTE 25 Pages
AF221-D017	27 months	\$750,000	White Paper NTE 25 Pages
AF221-D018	27 months	\$750,000	White Paper NTE 25 Pages
AF221-D019	27 months	\$1,500,000	White Paper NTE 15 Pages
AF221-D020	27 months	\$1,250,000	White Paper NTE 25 Pages
AF221-D021	27 months	\$1,250,000	White Paper NTE 20 Pages
AF221-D022	27 months	\$1,250,000	White Paper NTE 10 Pages

The AF recommends early submission, as computer traffic gets heavy near the proposal submission date/time and could slow down the system. **Do not wait until the last minute.** The AF is not responsible for incomplete proposal submission due to system lag or inaccessibility. Please ensure contact information, i.e., names/phone numbers/email addresses, in the proposal is current and accurate. The AF is not responsible for ensuring notifications are received by firms for which this information changes after proposal submission without proper notification. Changes of this nature shall be sent to the Air Force SBIR/STTR One Help Desk.

I. DIRECT TO PHASE II

15 U.S.C. §638 (cc), as amended by NDAA FY2012, Sec. 5106, and further amended by NDAA FY2019, Sec. 854, PILOT TO ALLOW PHASE FLEXIBILITY, allows DoD to make a SBIR Phase II award to a small business concern with respect to a project, without regard to whether the small business concern was provided an award under Phase I of an SBIR program with respect to such project. AF is conducting a "Direct to Phase II" implementation of this authority for these 22.1 SBIR topics and does not guarantee D2P2 opportunities will be offered in future solicitation. Each eligible topic requires documentation to determine whether the feasibility requirement described in the Phase I section of the topic has been met.

II. **INTRODUCTION**: Direct to Phase II proposals must follow the steps outlined below:

1. Offerors must create a Cover Sheet in DSIP; follow the Cover Sheet instructions provided in the DoD SBIR Program BAA. Offerors must provide documentation satisfying the Phase I feasibility requirement* to be included in the Phase II proposal. Offerors must demonstrate completion of research and development through means other than the SBIR/STTR Programs to establish the feasibility of the proposed Phase II effort based on the criteria outlined in the topic description.
2. Offerors must submit D2P2 proposals using the instructions below.

*NOTE: AF will not consider the offeror's D2P2 proposal if the offeror fails to demonstrate technical merit and feasibility have been established. It will also not be considered if it fails to demonstrate the feasibility effort was substantially performed by the offeror and/or the principal investigator (PI). Refer to the topics' Phase I descriptions for minimum requirements needed to demonstrate feasibility. Feasibility documentation MUST NOT be solely based on work performed under prior or on-going Federally funded SBIR and/or STTR work.

II. **PROPOSAL SUBMISSION**

The complete proposal must be submitted electronically through DSIP. Ensure the complete technical volume and additional cost volume information is included in this sole submission. The preferred submission format is Portable Document Format (.pdf). Graphics must be distinguishable in black and white. **VIRUS-CHECK ALL SUBMISSIONS.**

Complete proposals must include all of the following:

Volume 1: DoD Proposal Cover Sheet

Volume 2: Technical Volume

Volume 3: Cost Volume

Volume 4: Company Commercialization Report

Volume 5: Supporting Documents, e.g., SBIR/STTR Environment, Safety and Occupational Health (ESOH) Questionnaire; DoD Form 2345, Militarily Critical Data Agreement (if applicable); etc.

Volume 6: Fraud, Waste, and Abuse Training Completion

Phase II proposals require a comprehensive, detailed description of the proposed effort. AF D2P2 efforts are to be proposed in accordance with **the DoD 22.1 SBIR BAA and the information in these instructions. The technical volume, Volume 2, shall be accomplished in accordance with the information found in the DoD 22.1 BAA Section 5.3.b, Format of Technical Volume (Volume 2). Performance Periods, Maximum SBIR Funding, and page limitations for required White Papers are detailed in Chart 1 (above) by Topic Number.** Commercial and military potential of the technology under development is extremely important. Proposals emphasizing dual-use applications and commercial exploitation of resulting technologies are sought.

All D2P2 research or research and development (R/R&D) must be performed by the small business and its team members in the United States, as defined in the DoD SBIR 22.1 BAA. The Principal Investigator's (PI's) primary employment must be with the small business concern at the time of award and during the entire period of performance. Primary employment means more than one-half the PI's time is spent in the small business' employ. This precludes full-time employment with another entity.

Knowingly and willfully making false, fictitious, or fraudulent statements or representations may be a felony under 18 U.S.C. Section 1001, punishable by a fine up to \$250,000, up to five years in prison, or both.

III. **PHASE II PROPOSAL PREPARATION INSTRUCTIONS AND REQUIREMENTS**

See Chart 1 (above). Advocacy letters, if any; SBIR/STTR Environment, Safety and Occupational Health

(ESOH) Questionnaire; and the additional cost proposal itemized list, 17.a-j, should be included in Volume 5, Supporting Documentation. This documentation and the Cover Sheet will not count toward the technical volume limits. There is no set format requirement for **white papers**.

Please note the Fraud, Waste and Abuse Training **must** be completed prior to proposal submission. This is accomplished under Volume 6 within DSIP. When the training is complete and certified, DSIP will indicate so in the proposal, completing the Volume 6 requirement. **The proposal cannot be submitted until the training has been completed.** The complete proposal must be submitted via DSIP on or before the date published in the DoD 22.1 SBIR BAA. Submissions outside DSIP including, but not limited to, email, hardcopy, or other media will not be accepted.

Complete the SBIR/STTR Environment, Safety, and Occupational Health (ESOH) Questionnaire found at: https://www.afsbirsttr.af.mil/Portals/60/Pages/Overview/Air%20Force%20SBIR_STTR%20Environment%20Safety%20and%20Occupational%20Health_ESOH_Oct%202021_JSH.pdf . Include the completed document in the proposal under Volume 5, Other Documents.

A. **Proposal Requirements.** A Phase II proposal shall provide sufficient information to persuade the AF the proposed technology advancement represents an innovative solution to the scientific or engineering problem worthy of support under the stated criteria. All sections below count toward the page limit, unless otherwise specified.

B. **Proprietary Information.** Information constituting a trade secret, commercial/financial information, confidential personal information, or data affecting National Security must be clearly marked. It shall be treated in confidence to the extent permitted by law. Be advised, in the event of proposal selection, the Work Plan will be incorporated into the resulting contract by reference. Therefore, **DO NOT INCLUDE PROPRIETARY INFORMATION** in the work plan. See the DoD BAA regarding proprietary information marking.

C. **General Content.** Proposals should be direct, concise, and informative. Type shall be no smaller than 11-point on standard 8 ½ X 11 paper, with one-inch margins and pages consecutively numbered. Offerors are discouraged from including promotional and non-programmatic items. If included, such material will count toward the page limit.

D. **Proposal Format.** The technical proposal includes all items listed below in the order provided.

- (1) **Proposal Cover Sheet:** Complete the proposal Cover Sheet in accordance with the instructions provided via DSIP. The technical abstract should include a brief description of the program objective(s), a description of the effort, anticipated benefits and commercial applications of the proposed research, and a list of keywords/terms. The technical abstract of each successful proposal will be submitted to the Office of the Secretary of Defense (OSD) for publication and, therefore, **must not contain proprietary or classified information.** The term “Component” on the Cover Sheet refers to the AF organization requesting the Phase II proposal.
- (2) **Table of Contents:** A table of contents should be located immediately after the Cover Sheet.
- (3) **Glossary:** Include a glossary of acronyms and abbreviations used in the proposal.
- (4) **Milestone Identification:** Include a program schedule with all key milestones identified.
- (5) **Identification and Significance of the Problem or Opportunity:** Briefly reference the specific technical problem/opportunity to be pursued under this effort.

- (6) **Phase II Technical Objectives:** Detail the specific objectives of the Phase II work and describe the technical approach and methods to be used in meeting these objects. The proposal should also include an assessment of the potential commercial application for each objective.
- (7) **Work Plan:** The work plan shall be a separate and distinct part of the proposal package, using a page break to divide it from the technical proposal. It must contain a summary description of the technical methodology and task description in broad enough detail to provide contractual flexibility. The following is the recommended format for the work plan; begin this section on a new page. **DO NOT include proprietary information.**
- a) **1.0 – Objective:** This section is intended to provide a brief overview of the specialty area. It should explain the purpose and expected outcome.
 - b) **2.0 – Scope:** This section should provide a concise description of the work to be accomplished, including the technology area to be investigated, goals, and major milestones. The key elements of this section are task development and deliverables, i.e., the anticipated end result and/or the effort's product. This section must also be consistent with the information in Section 4.0 below.
 - c) **3.0 – Background:** The offeror shall identify appropriate specifications, standards, and other documents applicable to the effort. This section includes information or explanation for, and/or constraints to, understanding requirements. It may include relationships to previous, current, and/or future operations. It may also include techniques previously determined ineffective.
 - d) **4.0 – Task/Technical Requirements:** The detailed individual task descriptions for accomplishing proposed work are considered to be legally binding on the offeror. Therefore, it must be developed in an orderly progression with sufficient detail to establish overall program requirements and goals. The work effort must be segregated into major tasks and identified in separately numbered paragraphs.

Each numbered major task should delineate the work to be performed by subtask. The work plan MUST contain every task to be accomplished in definite, realistic, and clearly stated terms. Use “shall” whenever the work plan expresses a binding provision. Use “should” or “may” to express a declaration or purpose. Use “will” when no contractor requirement is involved, i.e., “... power will be supplied by the Government.”

- (8) **Deliverables:** Include a section clearly describing the specific sample/prototype hardware/software to be delivered, as well as data deliverables, schedules, and quantities. Be aware of the possible requirement for unique item identification IAW DFARS 252.211-7003, Item Identification and Valuation, for hardware. If hardware/ software will be developed but not delivered, provide an explanation. At a minimum, the following reports will be required under ALL Phase II contracts.
- a) **Scientific and Technical Reports:** Rights in technical data, including software, developed under the terms of any contract resulting from a SBIR Announcement generally remain with the contractor. The Government obtains SBIR/STTR data rights in all data developed or generated under the SBIR/STTR contract for a period of 20 years, commencing at contract award. Upon expiration of the 20-year SBIR/STTR license, the Government has Government purpose rights to the SBIR data.
 - i. **Final Report:** The draft is due 30 days after Phase II technical effort. The first

page of the final report will be a single-page project summary, identifying the work's purpose, providing a brief description of the effort accomplished, and listing potential result applications. The summary may be published by DoD. Therefore, it must not contain any proprietary or classified information. The

remainder of the report should contain details of project objectives met, work completed, results obtained, and technical feasibility estimates.

- ii. Status Reports: Status reports are due quarterly at a minimum.
- iii. Small Business Online Success Stories: Success Story submissions are due at the end of the technical effort via <http://launchstories.org>. If selected, refer to the Contract Data Requirements List (CDRL) in the contract for submission instructions.

- b) Additional Reporting: AF may require additional reporting documentation including:

- i. Software documentation and users' manuals;
- ii. Engineering drawings;
- iii. Operation and maintenance documentation
- iv. Safety hazard analysis when the project will result in partial or total development and delivery of hardware; and
- v. Updates to the commercialization results.

- (9) **Related Work**: Describe significant activities directly related to the proposed effort, including any previous programs conducted by the Principal Investigator, proposing firm, consultants, or others, and their application to the proposed project. Also list any reviewers providing comments regarding the offeror's knowledge of the state-of-the-art in the specific approach proposed.

(10) Company Commercialization Report (CCR)/Commercialization Potential:

- a) Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR Program BAA for full details on this requirement. Information contained in the CCR will not be considered by the Air Force during proposal evaluations.
- b) The DoD requires a commercialization plan be submitted with the Phase II proposal, specifically addressing the following questions:
 - i. What is the first planned product to incorporate the proposed technology?
 - ii. Who are the probable customers, and what is the estimated market size?
 - iii. How much money is needed to bring this technology to market and how will it be raised?
 - iv. Does your firm have the necessary marketing expertise and, if not, how will your firm compensate?
 - v. Who are the probable competitors, and what price/quality advantage is anticipated by your firm.
- c) The commercialization strategy plan should briefly describe the commercialization potential for the proposed project's anticipated results, as well as plans to exploit it. Commercial potential is evidenced by:
 - i. The existence of private sector or non-SBIR/STTR Governmental funding sources demonstrating commitment to Phase II efforts/ results.

- ii. The existence of Phase III follow-on commitments for the research subject.
- iii. The presence of other indicators of commercial technology potential, including the firm's commercialization strategy.

d) If awarded a D2P2, the contractor is required to periodically update the commercialization results of the project via SBA. These updates will be required at completion of the effort, and subsequently when the contractor submits a new SBIR/STTR proposal to DoD. Firms not submitting a new proposal to DoD will be requested to provide updates annually after the D2P2 completion.

(11) **Military Applications:** Briefly describe the existing/potential military requirement and the military potential of the SBIR/STTR Phase II results. Identify the DoD agency/organization most likely to benefit from the project. State if any DoD agency has expressed interest in, or commitment to, a non-SBIR, Federally funded Phase III effort. This section should include not more than one to two paragraphs. Include agency point of contact names and telephone numbers.

(12) **Relationship with Future R/R&D Efforts:**

- i. State the anticipated results of the proposed approach, specifically addressing plans for Phase III, if any.
- ii. Discuss the significance of the D2P2 effort in providing a basis for the Phase III R/R&D effort, if planned.

E. **Key Personnel:** In the technical volume, identify all key personnel involved in the project. Include information directly related to education, experience, and citizenship. A technical resume for the Principal Investigator, including publications, if any, must also be included. Concise technical resumes for subcontractors and consultants, if any, are also useful. Identify all non-U.S. citizens expected to be involved in the project as direct employees, subcontractors, or consultants. For these individuals, in addition to technical resumes, please provide countries of origin, type of visas or work permits held, and identify the tasks they are anticipated to perform.

Foreign Nationals (also known as Foreign Persons) means any person who is NOT:

- a. a citizen or national of the United States; or
- b. a lawful permanent resident; or
- c. a protected individual as defined by 8 U.S.C. § 1324b

ALL offerors proposing to use foreign nationals MUST follow the DoD 22.1 BAA and disclose this information regardless of whether the topic is subject to ITAR restrictions.

When the topic area is subject to export control, these individuals, if permitted to participate, are limited to work in the public domain. Further, tasks assigned must not be capable of assimilation into an understanding of the project's overall objectives. This prevents foreign citizens from acting in key positions, such as Principal Investigator, Senior Engineer, etc. Additional information may be requested during negotiations in order to verify foreign citizens' eligibility to perform on a contract awarded under this BAA.

The following will apply to all projects with military or dual-use applications developing beyond fundamental research (basic and applied research ordinarily published and shared broadly within the scientific community):

- (1) The Contractor shall comply with all U. S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and

the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in the performance of this contract. In the absence of available license exemptions/exceptions, the Contractor shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of (including deemed exports) hardware, technical data, and software, or for the provision of technical assistance.

- (2) The Contractor shall be responsible for obtaining export licenses, if required, before utilizing foreign persons in the performance of this contract, including instances where the work is to be performed on-site at any Government installation (whether in or outside the United States), where the foreign person will have access to export-controlled technologies, including technical data or software.
 - (3) The Contractor shall be responsible for all regulatory record keeping requirements associated with the use of licenses and license exemptions/exceptions.
 - (4) The Contractor shall be responsible for ensuring that these provisions apply to its subcontractors.
- F. **Facilities/Equipment:** Describe instrumentation and physical facilities necessary and available to carry out the D2P2 effort. Justify equipment to be purchased (detail in cost proposal). State whether proposed performance locations meet environmental laws and regulations of Federal, state, and local Governments for, but not limited to, airborne emissions, waterborne effluents, external radiation levels, outdoor noise, solid and bulk waste disposal practices, and handling and storage of toxic and hazardous materials.
- G. **Consultants/Subcontractors:** Private companies, consultants, or universities may be involved in the project. All should be described in detail and included in the cost proposal. In accordance with the Small Business Administration (SBA) SBIR Policy Directive, a minimum of 50% of the R/R&D must be performed by the proposing firm, unless otherwise approved in writing by the Contracting Officer. Signed copies of all consultant or subcontractor letters of intent must be attached to the proposal. These letters should briefly state the contribution or expertise being provided. Include statements of work and detailed cost proposals. Include information regarding consultant or subcontractor unique qualifications. Subcontract copies and supporting documents do not count against the Phase II page limit. Identify any subcontract/consultant foreign citizens per E above.
- H. **Prior, Current, or Pending Support of Similar Proposals or Awards:**
WARNING: While it is permissible, with proper notification, to submit identical proposals or proposals containing a significant amount of essentially equivalent work for consideration under numerous Federal program solicitations, it is unlawful to enter into contracts or grants requiring essentially equivalent effort. Any potential for this situation must be disclosed to the solicitation agency(ies) before award. If a proposal submitted in response to BAA is substantially the same as another proposal previously, currently, or in process of being funded by another Federal agency/DoD Component or the same DoD Component, the company must so indicate on the Cover Sheet and provide the following:
- a) The name and address of the Federal agency(ies) or DoD Component(s) to which proposals were or will be submitted, or from which an awarded is expected or has been received;
 - b) The proposal submission or award dates;
 - c) The proposal title;
 - d) The PI's name and title for each proposal submitted or award received; and
 - e) Solicitation(s) title, number, and date under which the proposal was or will be submitted, or under which an award is expected or has been received.
 - f) If award was received, provide the contract number.

- g) Specify the applicable topics for each SBIR proposal submitted or award received.

NOTE: If this section does not apply, state in the proposal, “No prior, current, or pending support for proposed work.”

- I. **Cost Proposal:** A detailed cost proposal must be submitted. Cost proposal information will be treated as proprietary. Proposed costs must be provided by both individual cost element and contractor fiscal year (FY) in sufficient detail to determine the basis for estimates, as well as the purpose, necessity, and reasonableness of each. This information will expedite award if the proposal is selected. Generally, firm fixed price contracts are appropriate for Phase II awards. In accordance with the SBA SBIR/STTR Policy Directive, Phase II contracts must include profit or fee.

Cost proposal attachments do not count toward proposal page limitations. The cost proposal includes:

- a) **Direct Labor:** Identify key personnel by labor category. Number of hours, actual hourly rates, labor overhead, and/or fringe benefits per contractor FY is also required.
- b) **Direct Materials:** Costs for materials, parts, and supplies must be justified and supported. Provide an itemized list of types, quantities, prices, and, where appropriate, purpose. If computer or software purchases are planned, detailed information such as manufacturer, price quotes, proposed use, and support for the need will be required.
- c) **Other Direct Costs:** This includes specialized services such as machining or milling, special test/analysis, and costs for temporary use/lease of specialized facilities/ equipment. Provide usage (hours) expected, rates, and sources, as well as brief discussion concerning the purpose and justification. Proposals including leased hardware must include an adequate lease versus purchase rationale. Special tooling/test equipment/material costs are acceptable but will be carefully reviewed to determine the need/appropriateness of the work proposed. The Contracting Officer must decide whether these purchases are advantageous to the Government and are directly related to the proposed effort. Title to property furnished by the Government will be vested with the AF unless determined to be more cost-effective for transfer to the contractor. The Government’s intention is not to directly fund purchase of general-purpose equipment.
- d) **Subcontracts:** Subcontract costs must be supported with copies of subcontract agreements. Agreement documents must adequately describe the work to be performed and cost bases. The agreement document should include a SOW, assigned personnel, hours and rates, materials (if any), and proposed travel (if any). A letter from the subcontractor agreeing to perform a task or tasks at a fixed price is not considered sufficient. The proposed total of all consultant fees, facility leases or usage fees, and other subcontract or purchase agreements may not exceed one-third of the total contract price, unless otherwise approved in writing by the Contracting Officer.

The prime contractor must accomplish price analysis, including reasonableness, of the proposed subcontractor costs. If based on comparison with prior efforts, identify the basis upon which the prior prices were determined reasonable. If price analysis techniques are inadequate or the FAR requires subcontractor cost or

pricing data submission, provide a cost analysis. Cost analysis includes but is not limited to, consideration of materials, labor, travel, other direct costs, and proposed profit rates.

- e) **Consultants:** For each consultant, provide a separate agreement letter briefly stating the service to be provided, hours required, and hourly rate, as well as a short, concise resume.
- f) **Travel:** Each effort should include, at a minimum, a kickoff or interim meeting. Travel costs must be justified as required for the effort. Include destinations, number of trips, number of travelers per trip, airfare, per diem, lodging, ground transportation, etc. Per Diem and lodging rates may be found in the Joint Travel Regulation (JTR), Volume 2, www.defensetravel.dod.mil.
- g) **Indirect Costs:** Indicate proposed rates' bases, e.g., budgeted/actual rates per FY, etc. The proposal should identify the specific rates used and allocation bases to which they are applied. Do not propose composite rates; proposed rates and applications per FY throughout the anticipated performance period are required.
- h) **Non-SBIR Governmental/Private Investment:** Non-SBIR Governmental and/or private investment is allowed. However, it is not required, nor will it be a proposal evaluation factor.
- i) **DD Form 2345:** For proposals submitted under export-controlled topics (either ITAR or EAR), a certified DD Form 2345, Militarily Critical Technical Data Agreement, or evidence of application submission, must be included. The form, instructions, and FAQs may be found at the US/Canada Joint Certification Program website, <http://www.dlis.dla.mil/jcp/>. DD Form 2345 approval will be verified if the proposal is selected for award.

J. Feasibility Documentation – Should be uploaded to Volume 5, Supporting Documents

- a. If appropriate, include a reference or works cited list as the last page.
- b. Feasibility efforts detailed must have been substantially performed by the offeror and/or the PI. If technology in the feasibility documentation is subject to intellectual property (IP) rights, the offeror must provide IP rights assertions. Provide a good faith representation all other IP utilized in the proposal is owned or possessed. Additionally, proposers shall provide a short summary for each item asserted with less than unlimited rights describing restriction's nature and intellectual property intended for use in the proposed research. Please see DoD SBIR 22.1 BAA for technical data rights information.
- c. DO NOT INCLUDE marketing material. Marketing material will NOT be evaluated and WILL be redacted.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

The Air Force does not participate in the Discretionary Technical and Business Assistance (TABA) Program. Proposals in response to Air Force topics should not include TABA.

IV. METHOD OF SELECTION AND EVALUATION CRITERIA

- A. **Introduction:** D2P2 proposals are evaluated on a competitive basis by subject matter expert (SME) scientists, engineers, or other technical personnel. Throughout evaluation, selection, and award, confidential proposal and evaluation information will be protected to the greatest extent possible.

D2P2 proposals will be disqualified and not evaluated if the Phase I equivalency documentation does not establish the proposed technical approach's feasibility and technical merit.

- B. Evaluation Criteria: Phase II proposals will be reviewed for overall merit based on the criteria discussed in the DoD 22.1 BAA.

NOTE: Restrictive notices notwithstanding, proposals may be handled for administrative purposes only, by support contractors: APEX, Peerless Technologies, Engineering Services Network, HPC- COM, Mile Two, REI Systems, MacB (an Alion company), and Infinite Management Solutions. In addition, only Government employees and technical personnel from Federally Funded Research and Development Centers (FFRDCs) MITRE and Aerospace Corporations working under contract to provide technical support to AF Life Cycle Management Center and Space Force may evaluate proposals. All support contractors are bound by appropriate non-disclosure agreements. **Contact the AF SBIR/STTR Contracting Officers with concerns about any of these contractors.**

V. CERTIFICATIONS

In addition to the standard Federal and DoD procurement certifications, the SBA SBIR/STTR Policy Directive requires the collection of certain information from firms at the time of award and during the award life cycle. Each firm must provide these certifications at the time of proposal submission, prior to receiving 50% of the total award amount, and prior to final payment.

VI. FEEDBACK

The PI and Corporate Official indicated on the Proposal Cover Sheet will be notified by email regarding proposal selection or non-selection. The small business will receive one notification for each proposal submitted. Please note the referenced proposal number and read each notification carefully. **If changes occur to the company mail or email addresses or points of contact after proposal submission, the information must be provided to the AF via AF SBIR/STTR One Help Desk.**

Feedback requests will be provided to offerors with proposals determined "Not Selectable" ONLY. The notification letter will include instructions for submitting a feedback request. Offerors are entitled to no more than one feedback per proposal. NOTE: Feedback is not the same as a FAR Part 15 debriefing. Acquisitions under this solicitation are awarded via "other competitive procedures." Therefore, offerors are neither entitled to nor will they be provided FAR Part 15 debriefs.

Refer to the DoD SBIR Program BAA for procedures to protest the Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: Air Force SBIR/STTR Contracting Officers.

AF 22.1 SBIR Direct to Phase II Topic Index

AF221-D001	Development of Adaptive Mesh Refinement for Hypersonic Reacting Flow Solvers
AF221-D002	Multi-Role Radio Frequency Sensing for GPS-degraded Navigation
AF221-D003	High Speed Particulate Erosion Capability
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AF221-D005	Extremely High Temperature Aperture Materials Maturation and Manufacturing Development for High-Speed Systems
AF221-D006	Composite Laser Ablation for Surface Preparation (CLASP) Manufacturing Scale-Up
AF221-D007	NDE of Thick Scarf Repaired Composites and Related As-Manufactured Structures
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AF221-D010	AI for the Depot: Using ETAR for Digital Health Records
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AF221-D001

TITLE: Development of Adaptive Mesh Refinement for Hypersonic Reacting Flow Solvers

TECH FOCUS AREAS: Artificial Intelligence/Machine Learning; General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Battlespace

OBJECTIVE: An unstructured grid based automatic mesh refinement capability is sought for predicting aerodynamic and aero-heating loads on reconfigurable and multi-body vehicles at hypersonic flight conditions.

DESCRIPTION: The accurate prediction of aerodynamic pressure and heating loads in high-speed reacting gas flows are paramount for the advancement of hypersonic vehicle design and analysis. Beyond the development of accurate, stable, and robust numerical schemes for hypersonic flow solvers is the construction of high-quality computational grids. The National Aeronautical and Space Administration computational fluid dynamics (CFD) Vision 2030 Study (Slotnick et al. 2014) identified CFD technology gaps and impediments which included mesh generation and adaptivity stating, "...the generation of suitable meshes for CFD simulations about complex configurations constitutes a principal bottleneck in the simulation workflow process." This statement is especially true in the hypersonic regime where flight conditions and shockwave locations must also be considered, i.e., grid adaptation is necessary to capture the complex shockwave structures around these vehicles leading to accurate boundary layer state, surface pressure, temperature, and heat flux predictions. Furthermore, full vehicle simulations require reconfigurable geometry for aerodynamic database generation dependent on flow conditions (i.e., Mach, Reynolds, angle-of-attack, angle-of-side slip), control surface deflections, and temporary geometric entities such as boosters or shrouds.

An Automatic Mesh Refinement (AMR) capability is sought to be implemented into an existing commercial or government-off-the-shelf (GOTS) unstructured grid flow solver to predict hypersonic vehicle performance. The flow solver chosen must have a proven history of accurate prediction of hypersonic flow fields around reconfigurable and multi-body geometries using monolithic grids. The AMR refinement criteria must be robust to changes in geometry and flight conditions across an entire vehicle trajectory or envelope resolving aeroheating and the high-temperature wake of these vehicles. A focus on scalability (including dynamic node balancing) and accuracy of the AMR methodology to non-axisymmetric 3D configurations and reacting flows is required. The AMR capability must also be compatible with restart/checkpoint capabilities and post-processing workflows of the selected solver. Any third-party library licenses must be compatible with U.S. DoD acquisition.

PHASE I: During Phase I, firms would determine Automatic Mesh Refinement (AMR) methodology and select a commercial or Government-Off-the-Shelf (GOTS) solver for implementation. Extensive literature surveys and prior research highlighting the advantages and limitations of the chosen approach are required.

PHASE II: A successful Phase II efficient and accurate predictions are required using legacy aerodynamic and aero heating databases including comparisons to monolithic grid solutions for the same validation cases. Documentation of the implementation including user manuals, theory manuals, examples, and source code with appropriate data rights is required. Examples must be demonstrated on U.S. Department of Defense High Performance Computing Modernization Program resources.

PHASE III DUAL USE APPLICATIONS: Phase III will consist of transitioning the software module proven in Phase II to existing code bases employed by the DoD and its prime contractors developing next-generation hypersonic vehicles. This transition will focus on user support or consulting to effectively deploy the software in a research & development or test and evaluation.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Help Desk: usaf.team@afsbirsttr.us

REFERENCES:

1. Slotnick, et al., "CFD Vision 2030 Study: A Path to Revolutionary Computational Aerosciences," NASA/CR-2014-218178, 2014.
2. Nemec, M., Aftosmis, M. J., Murmansk, S. M., Pulliam, T. H., "Adjoint Formulation for an Embedded-Boundary Cartesian Method," AIAA Paper 2005-0877, 43rd AIAA Aerospace Sciences Meeting & Exhibit, 2005.
3. Rodriguez, D. L., Aftosmis, M. J., Nemec, M., "Formulation and Implementation of Inflow/Outflow Boundary Conditions to Simulate Propulsive Effects," AIAA Paper 2018-0334, AIAA SciTech Forum, 2018.
4. Park, M.A., "Adjoint-Based, Three-Dimensional Error Projection and Grid Adaptation," AIAA-Paper 2002-3286, 32nd Fluid Dynamics Conference, 2002.
5. Park, M. A., Krakos, J. A., Michal, T., Loseille, A., Alonso, J. J., "Unstructured Grid Adaption: Status, Potential Impacts, and Recommended Investments Toward CFD Vision 2030," AIAA Paper 2016-3323, AIAA Aviation Forum, 2016.
6. Thompson, K. B., "Aerothermodynamic Design Sensitivities for a Reacting Gas Flow Solver on an Unstructured Mesh Using a Discrete Adjoint Formulation," Ph.D. Thesis, North Carolina State University, Aerospace Engineering, 2017.
7. Basore, K. D., "Reacting Gas Adjoint-Based Grid Adaptation in FUN3D," AIAA Paper 2019-1994, AIAA SciTech Forum, 2019.
8. Schwing, A. M., Nompelis, I., Candler, G. V., "Parallelization of Unsteady Adaptive Mesh Refinement for Unstructured Navier-Stokes Solvers," AIAA Paper 2014-3080, AIAA Aviation Forum, 2014.
9. McDaniel, D., Morton, S.A., "HPCMP CREATE-AV Kestrel Architecture, Capabilities, and Future Directions," AIAA Paper 2018-0025, AIAA SciTech Forum, 2018.

KEYWORDS: computational fluid dynamics; automatic mesh refinement; mesh adaptation; hypersonic; reacting flows

TECH FOCUS AREAS: Artificial Intelligence/Machine Learning; General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Air Platform; Battlespace

OBJECTIVE: Develop hardware and/or software for radio frequency (RF)-based navigation aiding on weapon systems. Hardware should be appropriate for both mid-course and terminal sensing, software/algorithm development should be focused on mid-course navigation aiding. Hardware and algorithms should be appropriate for a service-based open architecture approach for both terminal and mid-course applications.

DESCRIPTION: Weapon navigation in contested environments is a critical capability for the Air Force and DoD. Many weapon systems already employ radio frequency (RF) terminal seekers. It is desired to modify or replace these systems with multi-role sensing and processing capabilities. In addition to terminal functionality, these capabilities should also provide for navigation aiding in Global Positioning System (GPS)-denied or degraded scenarios. This effort seeks to develop or modify RF sensor payloads and/or RF signal processing capabilities in support of modular, service-based GPS-denied navigation capabilities.

Hardware: Hardware solutions should target weapon appropriate size, weight, and power (SWaP), provide direct access to in-phase and quadrature components (in-phase and quadrature (IQ) data) and other “raw” data sources, all necessary sensor metadata, act in a GPS-agnostic manner, and be operable with All Source Positioning and Navigation (ASPN) 2.0 or higher compliant interface control documents (ICDs) wherever feasible. Sensor development proposals specifically intended for research and development efforts may be larger SWaP, but should have a clear path to a refined footprint. Specific SWaP goals and details on ASPN ICDs will be provided to perspective proposers in a FAQ document. Proposals where sensor operation requires an inertial navigation solution (INS) input are appropriate; however, if that navigation solution is not GPS disciplined, the sensor must continue to function and the expected degradation of sensor performance as a function of INS uncertainty should be noted. The ability to leverage the sensor for both mid-course and terminal may require a wide field of regard, this may be achieved through digital or mechanical steering, a multi-antenna configuration, or other mechanisms within SWaP constraints. Hardware which provides the broader system with increased flexibility, e.g., frequency band options, multiple receive channels, or other properties that expand possible down-stream algorithm development, will be favored. Hardware focused proposals should also include base-line signal processing capabilities.

Algorithms/Software: Algorithm development should focus on RF signal processing capability aimed at providing explicit navigation feedback to an ASPN compliant navigator, i.e., the processed RF data should provide something akin to a direct measurement (and uncertainties) of position, velocity, or attitude or a bearing to known features in the environment. Other navigation relevant inputs are also acceptable, e.g., nonlinear feedback appropriate for particle filters, or other estimators/optimizers, that provide likelihoods with respect to position or other navigation states. Algorithms are intended to be real-time and appropriate for on-board processing on weapon system processors (no assumed down-link with external processing) and compatible with ASPN ICDs whenever feasible. Algorithms can assume access to high-rate inertial navigation system (INS) input, however, that input should not be assumed to be GPS disciplined. Systems which provide loosely coupled feedback are preferred, however tightly coupled systems, if ASPN compliant, are also acceptable when tight coupling significantly improves efficacy. Algorithm implementations may be “black box” in nature (the specific instantiation), however the algorithms itself must be detailed mathematically as part of the effort. Requirements and assumptions on input data should be explicit, and signal processing capabilities providing broader flexibility in input requirements (e.g., flexibility in band, look angles,

etc.) will be favored.

General: Hardware and software approaches that are agnostic to INS input errors, yet still produce relevant measurement inputs for a navigator, are highly desirable. Specifically, insensitivity to position error and heading error will be most advantageous. Velocities, roll, and pitch will be degraded, but still reasonably well known, however sensitivity to these states should be noted. The following references are an incomplete list example RF-based data products which could likely be leveraged as a navigation aid (with additional development) if they, or something highly similar could be produced without implicit or explicit reliance on GPS. Works of interest include, but are not limited to, multi-angle Synthetic Aperture Radar (SAR) imaging on a unified coordinate system (high-speed platform) [1], interferometric multimode SAR for high quality terrain mapping [2], SAR image retrieval from SAR databases [3], and SAR to EO image matching [4].

Additional, classic hardware and processing capabilities are also desirable. Real-time processing such as synthetic aperture radar image formation or other modalities in situations when GPS is available (or the INS solution is within a specified tolerance) would provide added value to a proposal but is considered secondary to non-GPS disciplined capabilities.

PHASE I: This is a Direct to Phase II topic; Phase I proposals will not be accepted in response to this topic. Direct to Phase II topics require detail regarding a “Phase I-like” feasibility study. This study would include initial hardware system design with suggested procurement/implantation plan and schedule and/or an initial algorithm development, with documentation of the algorithmic steps, associated hardware assumptions/requirements for RF sensor and signal processing, and expected run-time performance analysis.

PHASE II: Proposers with relevant hardware designs or prototypes, existing “classic” RF/SAR sensors and processing, i.e., GPS-enabled, and already developed non-GPS algorithms on real or representative simulated RF data are encouraged to propose. A successful Phase II effort will constitute the development of a hardware system and/or implementation and testing of real-time signal processing. Hardware development efforts will produce prototype hardware systems appropriate for (surrogate unmanned aerial vehicle (UAV)) flight environments and then demonstrate data acquisition (and potentially signal processing) on AFRL-lead UAV flights. Algorithm developers can be provided with a limited set of relevant government furnished equipment (GFE) data, but are encouraged to propose the use of their own relevant RF data (real or simulated), and will develop real-time code for signal processing which provides a navigation relevant output appropriate for an ASPN compliant navigator. Proposers considering both hardware and algorithmic development can assume hardware integration and flight testing support during the SBIR (i.e., if hardware development schedule allows, proposals can target AFRL lead flights starting at 12 months into the project) to facilitate data collections for use in algorithmic development.

PHASE III DUAL USE APPLICATIONS: Phase III will consist of transitioning sensor hardware and software to an operationally approved ASPN compliant navigation system on an operational UAV or weapon system.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with the

Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Help Desk: usaf.team@afsbirsttr.us

REFERENCES:

- [1] Chang, Wensheng et al. "A Novel Multi-Angle SAR Imaging System and Method Based on an Ultrahigh Speed Platform." *Sensors* (Basel, Switzerland) vol. 19,7 1701. 10 Apr. 2019, doi:10.3390/s19071701.
- [2] H. Yang, C. Chen, S. Chen, F. Xi and Z. Liu, "Interferometric Phase Retrieval for Multimode InSAR via Sparse Recovery," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 59, no. 1, pp. 333-347, Jan. 2021, doi: 10.1109/TGRS.2020.2994197.
- [3] L. Jiao, X. Tang, B. Hou and S. Wang, "SAR Images Retrieval Based on Semantic Classification and Region-Based Similarity Measure for Earth Observation," in *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, vol. 8, no. 8, pp. 3876-3891, Aug. 2015, doi: 10.1109/JSTARS.2015.2429137.
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KEYWORDS: SAR; RF; Navigation; GPS-denied; GPS-Degraded; Open Architecture; ASPN; Modular

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: To develop a mobile, high speed, high temperature particulate erosion capability for testing aerospace components and coatings in conjunction with laser heating for the Department of the Air Force (DAF). DAF equipment frequently operates in regions prone to airborne particulates, such as desert sands, volcanic ash, and pollution products. This capability will provide a rapid, low-cost testing capability for flight through atmospheres containing particulates. Applications include electromagnetic windows, leading edge materials, and coatings for supersonic and hypersonic weapon systems.

DESCRIPTION: Develop a new test capability to quantify resistance of aerospace materials to high velocity and high temperature particulate erosion. Existing sand and dust erosion techniques reach a maximum of approximately 225 m/s for continuous testing methods, with single shot testing methods such as gas guns providing a much more limited particulate loading. Long distance flight through dispersed particulate clouds results in high particulate loadings, requiring a new test method capable of similarly high particulate loadings at high speeds. Additionally, fast flight through atmosphere can generate high temperatures. The system should be able to maintain a specimen temperature of 500°C during testing. Further, a replaceable electromagnetic window should be provided which is transparent at 10.6 μm to allow for laser impingement of the specimen surface to generate higher temperatures. This window should be easily replaceable with a low-cost sacrificial window for testing that does not require a laser. The selected acceleration method should not melt the particulate, as angular particulates are required to generate effective surface erosion, and particulates will be solid when encountered during flight. The expected particulates are shattered quartz and volcanic glass, both of which will be highly angular and abrasive. The particulate used should be easily changeable, to allow for each test to use a different particulate mixture. The particulate velocity should be tunable to simulate different flight profiles. The minimum velocity should be 220 m/s or below, to allow comparison to the particle erosion test apparatus located at Wright Patterson Air Force Base. The maximum velocity should be at minimum 800 m/s, with an objective of 1400 m/s. The stream of particulates should be continuous, to allow for buildup to high mass loadings. The target area should be a minimum of 6"x6", with a target of 18"x18". This area may be covered by rastering either the nozzle or the specimen, provided that the entire area receives a uniform exposure. An alternative operation mode allowing a changeable exposure path would allow for reduced testing time for leading edges and is a desired feature. The target area should allow for customizable fixturing, to allow for both coupon and component tests. Finally, the test capability should be mobile. This may be as a palletized system utilizing a forklift. Utility water and power may be utilized at each operational site. The origin of this requirement is for movement between specialized laser test facilities and a permanent location for standard operations and storage.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a "Phase I-like" effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a "Phase I-like" effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve

product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

PHASE III DUAL USE APPLICATIONS: The contractor will pursue commercialization of the various technologies developed in Phase II for transitioning expanded mission capability to a broad range of potential government and civilian users and alternate mission applications. Direct access with end users and government customers will be provided with opportunities to receive Phase III awards for providing the government additional research & development, or direct procurement of products and services developed in coordination with the program.

REFERENCES:

<https://www.ues.com/lhmel>

MIL-STD-3033, DEPARTMENT OF DEFENSE TEST METHOD STANDARD: PARTICLE / SAND EROSION TESTING OF ROTOR BLADE PROTECTIVE MATERIALS (28-JUL-2010)

KEYWORDS: high temperature particulate erosion capability; testing aerospace components; coatings; laser heating; airborne particulates; desert sands; volcanic ash; pollution products

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Sensors; Electronics; Materials

OBJECTIVE: Fabrication of a first generation 32 element radar receiver that images for multi-static and bi-static applications with added functionality as a Signals Intelligence (SIGINT) and communication receiver if feasible within the program. The backend should be software defined and library loaded if in radar warning receiver (RWR) mode, with as large a beam bandwidth possible (within cost constraints, expandable upon enhanced funding and modular to 2-dimensions for further transition) demonstrating maximum bandwidth in at least 1 beam. Multi-static proof of principle demonstrated in laboratory or range, algorithm requirements at least road-mapped if not developed and implemented. Concept of Operations (CONOPS) and scheme.

DESCRIPTION: As use of the radio frequency (RF) spectrum by both red and blue forces continues to expand both to higher frequencies and in producing higher signal density of the environment, the next generation of communications and radar receiver systems will need more capability to route and process signals, and conventional electronic processors will struggle with the data flow especially if receivers are tasked with multiple missions in dense threat environments. Systems have been demonstrated using RF photonic techniques that provide real-time analog spatial and spectral processing of these high frequency signals within dense signal environments. Sorting of signals by analog imaging provides tremendous benefits including instantaneous direction finding and/or carrier frequency information, the relieving of the processors of beamforming thereby freeing up significant digital bandwidth so that processors can function solely as waveform analyzers. New generations of digitizers make extremely wideband receivers possible, putting even more emphasis on analog beam processing as a way to unburden already overstrained data pipelines. These new digitizers offer up to about 35GHz per beam instantaneous bandwidth, giving a huge potential >1TB/s beam-bandwidth product on a 1x32 receiver for instance, and sending that digital data flow to backend processors.

Data bottlenecks would remain; however, the problem is no longer bottlenecked at the same locations and by having data sorted by beam direction at least processors can sort threat directions if the instantaneous bandwidth needs to be large. Radar warning receivers in dense environments will probably also have to double as SIGINT receivers in order to deal with the large number of signals and more constrained Size, Weight, and Power (SWaP) environments on today's platforms. RF analog imaging offers avenues for this as again the backend digitizers may feed the same processors, but programmed for a different mission, or even multi-missions. This software defined backend, combined with analog beamforming, will in turn enable a much more agile and capable RF mission set on one phased array. RF Analog imaging is also an enabling technology for future multi-static radar systems as radar returns can come from anywhere in the field of view at any time, making wideband analog imaging extremely useful in that regard. Multi-static radar offers tremendous promise for future warfighting as large emitting radar platforms are increasingly becoming obsolete in high threat environments as expendable low-cost transmitters may be flown in forward of high value receivers. Multiple transmitters illuminate the forward area and therefore a staring imaging receiver is an attractive option for receiving the returns as there may be multiple signals at random directions and time delays. In the past, photonics has offered a way to perform this imaging by modulating received electronic signals onto optical carriers. This conversion is accomplished by means of an electro-optic modulator and the RF signals have been collected within a phased array and then imaged onto high data rate phototransistors. This generation of system can take advantage of advancements in the modulators recently.

PHASE I: This topic is intended for technology proven ready to move directly to Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

PHASE III DUAL USE APPLICATIONS: The contractor will pursue commercialization of the various technologies developed in Phase II for transitioning expanded mission capability to a broad range of potential government and civilian users and alternate mission applications. Direct access with end users and government customers will be provided with opportunities to receive Phase III awards for providing the government additional research & development, or direct procurement of products and services developed in coordination with the program.

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1. C. A. Schuetz et al., “A Promising Outlook for Imaging Radar Imaging Flash Radar Realized Using Photonic Spatial Beam Processing,” IEEE Microwave Magazine, vol. 19, no. 3, pp. 91–101, May 2018, doi: 10.1109/MMM.2018.2801639.

KEYWORDS: First generation 32 element radar receiver; multi-static and bi-static; SIGINT and communication receiver; radar warning receiver (RWR) mode; large a beam bandwidth; Multi-static proof of principle

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Sensors; Materials; Air Platform

OBJECTIVE: The objective is to provide material and process options for extremely high temperature aperture applications. Efforts may focus on development of new materials options and approaches, process improvement of existing but immature aperture materials, or manufacturing process development of well-established materials. The candidate material(s) should be validated through a range of mechanical, thermal, and electrical tests, at various times throughout the effort. For a material maturation focused effort, validation should include a demonstration of the ability to fabricate representative sized components (e.g., a 6" x 6" doubly curved panel, or 3" diameter hemisphere) by the end of the effort. The component should then be tested in a relevant environment. For a manufacturing focused effort, manufacturing of a full-scale relevant geometry aperture shall be performed to prove the process.

Testing should also assess the transient aerothermal and electromagnetic performance in a relevant environment. The resulting aperture technology will be validated under these efforts and data and concepts provided for transition to the programs of interest. To be viable, a component must not recess more than 1 mil/min during exposure to high heat flux tests which result in material temperatures well in excess of 1000°C. Electromagnetic properties such as signal transmittance must be measured and shown to be at least 80% of other state-of-the-art options. Ideally the improved manufacturing will also provide improved properties such as strength or erosion resistance as a result of reduction of variability due to controlled manufacturing processes.

DESCRIPTION: The Air Force must be able to operate effectively in anti-access, area-denial environments as well as be able to disseminate "real-time" intelligence, surveillance, and reconnaissance data. This requires current and next generation ground, air, and space platforms to have antenna and aperture systems with improved bandwidth, capability, functionality, selectivity, and performance. This need is accentuated for vehicle platforms that travel at hypersonic speeds due to the additional requirement for the apertures to survive in high temperature and high shear environments.

Hypersonic platforms represent an extremely challenging combination of design requirements for window and radome materials. Necessary attributes include oxidation resistance, desirable electrical performance over a wide wavelength range, sand and rain erosion resistance, stable performance over a wide temperature range, high strength and toughness, robust processing, reasonable cost, and the ability to be integrated into the vehicle platform. These apertures are most desirably placed at or near the front of the vehicle, where temperature can reach or exceed ~1800°C for short (~20-60 sec) times.

Commercial hypersonic platforms, assuming their successful development and the emergence of a viable business case, will require a range of apertures to meet various communications and sensing needs, but these can be placed in locations where they will experience much less extreme conditions, making extremely high temperature apertures a defense unique requirement. The high temperature composite and monolithic materials that are typical candidates for these types of applications have a long history of being expensive, poorly understood, slow and difficult to manufacture, and exhibiting significant lot-to-lot variability. A goal here is to identify new or improved materials and processes, mature the processing of the candidate material(s), and to increase the manufacturability, producibility, and reliability for current and next generation aperture systems. No single proposal will be able to accomplish all of this, so bidders should discuss the development status of their proposed material(s) and processing and clearly indicate where their focus lies – development of a new material

candidate, maturation of an existing material candidate, or manufacturing and producibility improvement of a well-established material and process.

The proposed aperture system can include Radio Frequency (RF), Electro-Optic (EO), Infrared (IR), or multispectral solutions. New and innovative material solutions may be proposed to provide new options for extreme temperature apertures. Potential candidates include but are not limited to advanced monolithic and composite material variants. Processing approaches could include any of the range of traditional ceramic and composite processing approaches, additive manufacturing, and other innovative and unique techniques. Established but immature aperture materials may be proposed with a focus on addressing outstanding processing issues. The goal here is to identify any process deficiencies (e.g., failure to control all of the key process parameters; failure to ensure the consistency and suitability of all constituents) and seek to remedy them. Tools such as Expert Elicitations and Designed Experiments should be used to solve such problems. Application of an in-process non-destructive evaluation (NDE) technique, or some new measurement may be necessary to gain the understanding needed to resolve such an issue. Well established materials and processes may be proposed with a focus on improving the manufacturability, producibility, and reliability for current and next generation aperture systems. The focus is on reducing cycle time, part count, touch labor, and ultimately reducing the cost of the components while at the same time reducing manufacturing variability.

An integrated manufacturing chain is required to overcome state-of-the-art geometric, material set, and part size limitations. To meet this need, advancements in areas that combine two or more aspects such as multi-material solutions, 3D printing techniques, innovative fiber preforming, engineered and localized property performance, automation, and improved densification techniques are sought. The work should be conducted with consultation or support from a hypersonics Prime vehicle manufacturer that can provide guidance on performance requirements and design considerations such as part size and relevant geometry. The proposal should clearly identify the current state of the art of the aperture system of interest including both technical and manufacturing readiness and how the proposed work will advance readiness for the proposed aperture concept.

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PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

PHASE III DUAL USE APPLICATIONS: The contractor will pursue commercialization of the various technologies developed in Phase II for transitioning expanded mission capability to a broad range of potential government and civilian users and alternate mission applications. Direct access with end users and government customers will be provided with opportunities to receive Phase III awards for providing the government additional research & development, or direct procurement of products and services developed in coordination with the program.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Help Desk:
usaf.team@afsbirsttr.us

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1. Harris, Daniel C. Materials for infrared windows and domes: properties and performance. Vol. 158. SPIE press, 1999. ISBN 0-8194-3482-5
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KEYWORDS: Extremely high temperature aperture applications; materials; manufacturing process; validated through a range of mechanical, thermal, and electrical tests; fabricate representative sized components (e.g. a 6" x 6" doubly curved panel, or 3" diameter hemisphere); relevant environment; transient aerothermal and electromagnetic performance; exposure to high heat flux; 1000°C; Electromagnetic properties; signal transmittance

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: The Composite Laser Ablation for Surface Preparation (CLASP) manufacturing scale-up objective is to take the one-off working handheld prototype and transform it into a set of production ready tools. Since these tools will be utilized on a manufacturing floor, they must be robust, easy to use, meet all governing safety regulations, and perform in a highly efficient and effective manner. They must be adapted for better handheld uses and for higher through put operations such as gantry type of set up where the CLASP tool is stationary and the part needing surface preparation moves under it. In addition, the scale up effort will improve prototype surface preparation time by 25%.

DESCRIPTION: CLASP manufacturing scale-up will refine the prototype handheld unit into a reliable production factory floor set of tools while enhancing its capability and improving its operating efficiency. Proper composite part surface preparation is critical in achieving a strong bond for structural capacity. The current surface preparation method is hand sanding which is extremely time consuming. In addition, the surface preparation is highly variable and thus, introduces structural integrity uncertainties into the bond between the composite parts. CLASP will improve the through put and surface quality for composite part bonding. The scale-up will redesign the handheld prototype into robust high-quality parts for assembly line type manufacture of the tool. The design will be highly ergonomic for handheld operations but also tailored for robotic or gantry type utilization for high output surface preparation. Disposal of ablated surface debris will be 100% contained as to not contaminate the just prepared clean surface. All fiber optic laser cables, debris removal hoses, power lines, user interface display cables and surface offset contact leads will be routed for ease of mobility and safety on the production floor.

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1. Palmieri, F.L., Ledesma, R. et al., "Optimized Surface Treatment of Aerospace Composites using a Picosecond Laser," Composites Part B: Engineering, 2019.
2. Belcher, M.A, Blohowiak, K.Y., Wohl, C.J., Connell, J.W. and Palmieri, F.L., "Laser Ablation Surface Preparation for Adhesive Bonding of Carbon Fiber Reinforced Epoxy," Int. Journal of Adhesion and Adhesives, 2016.
3. Cargill, R.L. and Wool, M.R., "Surface Preparation of Organic Matrix Composites (OMCs) for Structural Adhesive Bonding," AFRL-RX-WP-TR-2013-0178, March 2013.
4. AFD 2053 Invention Disclosure "Prepregs and Cured Composites Having Improved Surfaces and Processes of Making and Methods of Using Same" (Adam Hicks, copied here, has patent invention disclosure details)

KEYWORDS: Manufacturing scale-up; handheld unit; production factory floor set of tools; proper composite part surface preparation; tailored for robotic or gantry type utilization;

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: Develop novel non-destructive evaluation (NDE) tools and algorithms that facilitate rapid assessment of thick scarf repairs and joints, including those that do not have a plate-like geometry. The NDE tools and/or algorithms should detect delaminations 6 mm in diameter and larger plus porosity equal to and greater than two percent in the vicinity of the scarf. The capability must detect these flaws if the scarf includes multiple layers of composite lamina and should be readily integrated into common non-destructive testing (NDT) inspection equipment. Algorithms to assist in data interpretation and analysis must be prepared to enable easy update and maintenance by organic Air Force resources. The algorithms should not be based on brute force artificial intelligence / machine learning but needs to include the “human in the loop” using the preferred Intelligence Augmentation approach defined by the Air Force.

DESCRIPTION: Future concepts for composite aircraft include the use of bonded scarf joints either as part of the manufacture and assembly of the structure or repairs of manufacturing defects or damage experienced in service. These structures can be relatively thick when compared to current composite aerospace components, exceeding 50mm in total thickness. Typical NDT methods used for thinner composite structures include ultrasonic and thermographic-based techniques, where frequencies and diffusion fields are managed and analyzed by the trained inspector to provide the desired detection capability, nominally delaminations approximately 6 mm in diameter or porosity exceeding two percent of the local volume.

However, these methods are challenged when considering the geometry of a thick scarf repair, especially if multiple layers of composite components are joined together at the location and the scarf penetrates the multiple layers. As the signal becomes quite complex, the signal analysis and interpretation capability can exceed the skill of a typical Level 2 nondestructive inspector. Thus, the Air Force is seeking novel NDE approaches and/or the development of algorithms that assist and augment the inspection via interpretation of the complex signals that result from the interrogation of these types of structures.

It is important to note the Air Force is NOT interested in brute force Artificial Intelligence / Machine Learning approaches as they have been shown to not address the nuanced and outlier nature of the data of interest. The Air Force solution that has been successfully developed and implemented for metallic [ref] and composite [ref] structures use an approach called Intelligence Augmentation [ref] that combines the capabilities of statistical classifiers and other analytical algorithms with the human to optimize the decision-making process to detect features of interest emanating from defects. These algorithms eventually need to be integrated into commercially available NDT equipment to enable them to be supported by major equipment suppliers.

In addition, the NDT tools and algorithms should be developed in such a manner to accommodate changes and/or updates detection criteria and/or types of data being analyzed to enable organic Air Force maintenance of the implemented solution in its final state. Another desired capability is to inspect or facilitate inspection of complex geometry configurations typically found on military aircraft where such scarf repairs will occur. This includes variability in the geometry, lay-up, and substructure to the region of interest. The tools and algorithms must enable the assessment of these highly variable geometric configurations.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II.

Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

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PHASE III DUAL USE APPLICATIONS: The contractor will pursue commercialization of the various technologies developed in Phase II for transitioning expanded mission capability to a broad range of potential government and civilian users and alternate mission applications. Direct access with end users and government customers will be provided with opportunities to receive Phase III awards for providing the government additional research & development, or direct procurement of products and services developed in coordination with the program.

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1. Aldrin, J., C., Forsyth, D. S., and Welter, J. T., “Design and Demonstration of Automated Data Analysis Algorithms for Ultrasonic Inspection of Complex Composite Panels with Bonds,” 42nd Annual Review of Progress in QNDE, Incorporating the 6th European-American Workshop on Reliability of NDE, Vol. 1706, p. 120006, AIP Publishing, (2016)
2. Aldrin, J. C., Lindgren, E. A., and Forsyth, D. S., “Intelligence Augmentation in Nondestructive Evaluation,” 45th Annual Review of Progress in QNDE, AIP, 2102, p. 020028, (2019).

KEYWORDS: Composite aircraft; repair; manufacture; defects; damage; Structure; detection capability; delaminations; porosity; skill of a typical Level 2 nondestructive inspector; Non-destructive Evaluation; NDE; Artificial Intelligence / Machine Learning; tools and algorithms; highly variable geometric configurations.

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: To develop, produce, and transition a flexible, lightweight self-healing fuel tank bladder for military aircraft that can survive in-service fuel leaks. Fuel leaks from pinholes and seams in aircraft fuel cell bladders are a heavy maintenance burden, particularly for refueling aircraft such as the KC-135. Fuel leaks are a key factor in non-mission readiness for these aircraft. The self-healing function should be integral to the bladders and have weight increase of not greater than 3% (objective) or 10% (threshold). While self-healing materials previously have been developed for saltwater environments, currently there are none for aircraft fuels.

DESCRIPTION: To reduce the maintenance burden and expand the usable life of fuel cells, self-healing bladders are needed to detect and heal minor pinhole leaks and seeps from seams and/or around fittings. Self-healing bladders will reduce costs by reducing the amount of human interaction, system downtime, and the need for part replacement. In turn, the self-healing function will reduce maintainability and extend the mission. Currently there are no commercially available self-healing bladders. Requirements for the self-healing function include:

- (1) should be integral to the bladders and not reduce flexibility;
- (2) have weight gain of not greater than 3% (objective) or 10% (threshold);
- (3) should not alter the capability to contain fuel; and (4) should not hinder the installation nor the removal of the bladders.

The unique shapes and complexity of modern fuel cell bladders should be considered in any proposal, which should address all the requirements of MIL-DTL-6396, Type II. The self-healing capabilities of the bladders should be activated within 2 minutes of fuel leak initiation and be able to permanently seal (objective) or seal for at least 3 years (threshold). Concepts should be able to be readily integrated into the current manufacturing processes of aircraft fuel cell bladders.

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PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a "Phase I-like" effort predominantly separate from the SBIR Programs. Under the phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of

the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

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products and services developed in coordination with the program.

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2. Monk, R.; Ohnstad, T.; Henry, J.; "Projectile Barrier and Method", US Patent 7,169,452 ;
3. MIL-DTL-6396, Tanks, Fuel, Oil, Cooling Fluids, Internal, Removable Non-Self-Sealing

KEYWORDS: Fuel Bladders; Self-healing

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: AFRL recently assessed Food and Drug Administration (FDA) approved and/or commercially available products demonstrating reliability and validity for identifying alterations in cognitive ability as a function of various stressors. The assessment's goal was to target the most promising technologies capable of generating human performance metrics for real-time cognitive monitoring which could be compatible with the aerospace environment. Electrophysiological measurements (electro-oculogram (EOG), electromyography (EMG), and Electroencefalography (EEG)) were deemed highly relevant solutions for fatigue detection and potential avenues for rapid prototype development. These prototypes should leverage advances in dry electrode technology for sensor performance and long-term wearability. Additional challenges recording electrophysiological signals in the aerospace environments include:

- 1) Degradation from electrode instabilities,
- 2) Impedance mismatch from current electrode materials (must meet impedance levels equal to or better than standard wet electrodes),
- 3) Existing sensor limitations due to poor form factor/engineering,
- 4) Degradation due to motion artifacts and sensor decoupling,
- 5) Human factors challenges, and 6) Mission challenges for maintaining human monitoring in the cockpit.

AFRL seeks to identify solutions that may be low power, manufacturable at scale, wearable, and airworthy. Proposed solutions may include, but are not limited to, wearable, dry electrode EOG prototypes or on-eye contact lenses for fatigue detection with the ability to detect blinking and saccadic velocity metrics. Combined sensing capabilities within one proposed system is also of interest. Finally, proposed solutions may include, in isolation or in combination with a real-time monitoring solution, wearable, airworthy augmentation technology for neuromodulation. A long-term goal for this capability is to inform a closed-loop fatigue mitigation/augmentation capability to increase the long-endurance (>24 hours) operations capability for USAF.

DESCRIPTION: Fatigue is a pervasive problem during high tempo operations in many mission scenarios. The high-performance flight environment imposes unique causes of fatigue on pilots and aeromedical personnel and limits countermeasure capabilities. Flight-related fatigue may be due to consecutive missions, mental exertion, cognitive overload, and/or jetlag and can become chronic leading to reduced health and compounded stress.

Currently, the DoD does not require physiological monitoring of aircrew for the purpose of identifying decrements due to fatigue. However, steady decrements in performance in laboratory settings have been demonstrated (McIntire, et al., 2017) and counter fatigue measures have proven successful, such as transcranial direct current stimulation (tDCS) and noninvasive vagal nerve stimulation (nVNS). In fact, one 30-minute session of tDCS can improve accuracy and reaction times for up to 12 hours and shows this improvement above and beyond the effect of caffeine (McIntire, et al., 2017). In addition, the tDCS condition did not affect subjective mood, whereas performance in the caffeine condition showed a direct relationship (McIntire 2014 & 2017). While advances in cognitive monitoring technology for commercial, R&D, and personal health applications have rapidly advanced, they currently do not exist in flight. Current investigations across several U.S. bases identified 224 lives, \$11.6 billion, and 186 aircraft lost due to military aviation mishaps from 2013-2020. While these findings are devastating, the focus of mitigation lies at the investigation of Class C mishaps due to the ability to assess the factors involved. Nonfatal mishaps allow investigation boards to identify causes and establish standards to prevent further fatalities. The National Commission on

Military Aviation Safety (2020) determined that “judgement and decision-making errors” make up a majority of Class C mishaps. With cognitive degradations occurring in 24 hours and a need for optimal decision making to be sustained for multiple days, the unavailability of robust clinical devices for the aerospace environment poses a crucial gap and puts our AF missions at risk. As the Air Force drives towards the capability to sustain mission success in a potentially enduring fight, rapid assessment and augmentation of cognitive readiness and performance becomes crucial to maximize the warfighter’s potential and to inform the Joint Area Domain Command and Control (JADC2) network more effectively.

While physiological monitoring capabilities are rapidly being developed to meet the needs of the airborne environment, to date an airworthy, closed-loop, cognitive assessment and augmentation system currently does not exist to ensure medical readiness. This capability gap is largely due to poor signal continuity and reliability of many physiological monitoring technologies in high motion environments. In addition to human movement, the aerospace environment provides additional challenges due to high gravitational acceleration, vibration, ambient noise, and other potential electromagnetic interference. Size, weight, power and form factor become complicating factors. Several methods of detecting fatigue have been validated in a laboratory setting and include EEG/ERP, EOG, EMG, ECG, cerebral oxygenation (Lohani, Payne, & Stayer, 2019), facial recognition, eye tracking (Rozanowski, Bernat, & Kaminska, 2015), cognitive assessment (Basner et al., 2019), standard questionnaires, and various biometrics such as heart rate variability and blood pressure (Lohani, Payne, & Stayer, 2019). In a recent review to assess these validated metrics and their feasibility in a dynamic driving environment, it was recommended that ECG and thermal imaging yielded the most promise in terms of applicability to dynamic environments; however, oculomotion/pupilometry and electromyography can provide insight into user state if luminance can be controlled and measured (Lohani, Payne, & Stayer, 2019).

An additional review by the driving/trucking industry suggested that, among physiological signals, EOG is most suitable because of its simplicity, driver [user] friendliness and robustness against environmental factors such as ambient light and driver movement (Papadelis et al., 2007). Papadelis and colleagues presented clear evidence that eye-blinking statistics are sensitive to the driver's sleepiness and should be considered in the design of an efficient and driver-friendly sleepiness detection countermeasure device. In addition, several studies have demonstrated that saccade “peak” velocity is a sensitive indicator of cognitive fatigue. As time-on-task increases, the slope of saccadic peak velocity as a function of saccadic magnitude decreases. This relationship was validated by Di Stasi and colleagues when comparing air traffic control performance across time-on-task with longer duration times revealing a decreased slope (Di Stasi, et al., 2013b). Finally, in 2016, this relation was validated when comparing a short duration flight to a long duration flight with the longer duration (~2 hours) showing a decreased slope (Di Stasi, 2016). Camera-based eye tracking is widely adopted as a standard way to measure eye movements including saccadic velocity.

Current eye trackers are insufficient in the aerospace environment due to several factors including incompatibility with AFE/helmets, dynamic lighting or sunlight interference, and the requirement to illuminate the eyes with IR sources. In addition, video-based trackers tend to be bulky, slow and often produce a noisy signal. COTS eye trackers are rapidly advancing for aerospace simulation, but operational flight is still a challenge. EOG-based solutions may be more appropriate. In order to close the loop for cognitive monitoring and augmentation in the aerospace environment, such monitoring capabilities need to read into a validated technique for neuromodulation. As mentioned above, transcranial direct current stimulation (tDCS) has been shown to produce significant and sustained performance advantages when compared to a control condition as well as a caffeine condition (McIntire, et al., 2017). In addition, the method of noninvasive vagal nerve stimulation (nVNS) shows the same performance advantages compared to the control condition for multitask performance (McIntire, et al., 2014). These results are backed by significant differences in subjective fatigue. tDCS and nVNS are both highly reliable augmentation methodologies. The ability to administer tDCS

in the aerospace environment is challenging due to need for helmet integration; however, nVNS, which currently requires placement of a device on a specific area of the neck or ear, may prove feasible for the aerospace or austere environment with improvements in form factor for long-term wearability.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

PHASE III DUAL USE APPLICATIONS: The contractor will pursue commercialization of the various technologies developed in Phase II for transitioning expanded mission capability to a broad range of potential government and civilian users and alternate mission applications. Direct access with end users and government customers will be provided with opportunities to receive Phase III awards for providing the government additional research & development, or direct procurement of products and services developed in coordination with the program.

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KEYWORDS: Human performance; Aviation; Fatigue; Eye-tracking; Wearables; Pilots; Aeromedical Evacuation

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: This effort will deliver a prototype Digital Health Record application to provide all Engineering Technical Assistance Request (or ETAR) information, non-destructive inspection (NDI) results, Airworthiness information and 3D images to determine the health of each aircraft. The Digital health record application will provide an organized and indexed data for Artificial Intelligence & Machine Learning for disposition decisions/actions and contribute to predictive Maintenance.

DESCRIPTION: This project will include: 1. Designing and prototyping a Digital Health Record application to provide all ETAR information, NDI results, Airworthiness information and 3D images to determine the health of KC-135 2. Identify all relevant data sources and connect disparate data to create relationships to expand and operationalize AI/ML and 3. Use machine learning, historical performance data and contextual data to predict maintenance and alert for proactive identification of problem parts. While the data is currently being tracked, it is not analyzed to help make informed planning decisions- and this in this case KC-135 does not use the data to decide when to retire a plane. Engineering dispositions are burdened with repetitive assistance requests and responses, incorrect entry, lack of standards and quality. With increased data standards and quality, trending on historical mx actions it can result in faster/more accurate disposition. With the addition of technology and build out of the aircraft technical baseline (as sustained), the data can begin to be aggregated and analyzed to show predictive results.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

PHASE III DUAL USE APPLICATIONS: The contractor will pursue commercialization of the various technologies developed in Phase II for transitioning expanded mission capability to a broad range of potential government and civilian users and alternate mission applications. Direct access with end users and government customers will be provided with opportunities to receive Phase III awards for providing the government additional research & development, or direct procurement of products and services developed in coordination with the program.

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KEYWORDS: Artificial Intelligence (AI); Machine Learning (ML)

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: This effort will develop a sensor system to spatially register the location and orientation of non-destructive evaluation (NDE) sensors as an inspection is being accomplished. The sensor system must be sufficiently small to be integrated on current NDE sensors, such as ultrasonic transducers or eddy current pencil probes. The accuracy of the sensor positioning needs to be within 0.5 mm in x and y directions when on a surface and x, y, and z directions when in space. The sensor orientation should be tracked to within 3 degrees. The tracking system must operate inside confined and/or limited access areas where currently commercial systems based on optical, electromagnetic, or ultrasonic methods do not work due to internal reflections and/or interfering structures inside the aircraft. The system should have readily exportable digital data for integration into a display system to be determined and should include some form of software module that can be integrated into the overall display of the inspection process to enable near real-time feedback to the inspector regarding the area covered by the sensor and the orientation as the data was being collected. This can include both hand-held and robotic-assisted inspection processes.

DESCRIPTION: The Air Force has the desire to spatially track NDE sensors as inspections are performed. This includes spatial tracking accuracy of 0.5 mm in all available dimensions, e.g. x and y when the sensor is on a surface and x, y, and z if the sensor is in the air. In addition, this includes the angular orientation of the NDE sensor to within at least 3 degrees. The tracking capability needs to be provided in a small enough package to not interfere with the performance of an NDE assessment using current commercial sensors, such as hand-held ultrasonic transducers and/or eddy current pencil or specialty probes.

The intent of this tracking capability is to provide an inspector with near real-time feedback regarding the status of the inspection process. This includes ensuring the correct region of the inspection was covered and that the sensor in question was oriented correctly to ensure the inspection was performed in accordance with the intent of the inspection procedure. The feedback would enable the inspector to make any corrective actions before the inspection was marked as complete, greatly reducing the need to revisit and/or re-accomplish a completed inspection. In addition, it will simplify the completion of the inspection in case there are any interruptions as it was being performed to ensure the inspector continued the inspection at the location where the process was interrupted.

The significant challenge for this desired capability is the ability to track sensors inside a confined and/or constrained access location. Thus, current tracking methods, including such approaches as line-of-sight optical methods, electromagnetic positioning methods, and acoustic-based range finders, will not work in these applications due to the lack of access, interference from internal structures such as pipes, fittings, and other structural elements of the aircraft. Initial trials of typical commercial capabilities illustrated that these internal features, typically quite dense even in open bays, inhibit the accuracy and/or resolution of these commercial solutions. In addition to the size and resolution desired, the tracking data must be transmitted from the tracking sensors to a computerized system that will provide feedback to the inspector. Therefore, the data must be near real-time to enable the inspector to correct their processes and monitor their progress as they are accomplishing an inspection.

The preferred option for the display in which this information would be provided to the inspector is using some form of augmented reality or similar type interactive display. It is important that the data

stream from the tracking sensors is provided in a readily defined format to enable its simple integration into any type of display system. In addition to the sensor system, a desired capability is some form of image-based software that can illustrate to the inspector where the probe has been and what was its orientation as it was manipulated. This does not need to be a stand-alone software system but can be a capability that is readily integrated into displays that includes other inspection relevant information.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

PHASE III DUAL USE APPLICATIONS: The contractor will pursue commercialization of the various technologies developed in Phase II for transitioning expanded mission capability to a broad range of potential government and civilian users and alternate mission applications. Direct access with end users and government customers will be provided with opportunities to receive Phase III awards for providing the government additional research & development, or direct procurement of products and services developed in coordination with the program.

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KEYWORDS: NDE Spatial Registration; Confined Space; Probe Orientation;

AF221-D012

[TOPIC REMOVED]

TECH FOCUS AREAS: Network Command, Control and Communications; Autonomy; Artificial Intelligence/Machine Learning; General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Sensors; Electronics; Information Systems; Battlespace

OBJECTIVE: The Air Force Research Laboratory Information Directorate seeks innovation in a collaborative space augmenting the warfighter with tools and technology to safely, efficiently and accurately perform their duties. Examples of emerging technologies which could greatly enhance warfighter capability are voice interface to tactically deployed software systems, such as Android Tactical Assault Kit (ATAK), machine learning and/or artificial intelligence algorithms that leverage both currently deployed hardware and emerging commercial technologies, for revolutionary situational awareness and force collaboration.

DESCRIPTION: This topic seeks innovative technologies for distributed collaboration, using Tactical Assault Kit (TAK), for enhancing warfighter efficiency, safety, and accuracy. As distributed collaboration evolves on the battlefield, so do the possibilities for integration of modern sensors, systems and advanced technologies, including artificial intelligence and machine learning. Use cases for distributed collaboration are tremendously advancing in both the commercially and DOD-wide. Harnessing the power of innovation is often a cumbersome endeavor for the DOD, however the emergence of commonly deployed technology platforms has become exponentially beneficial. Successful development of innovative technologies for tactical collaboration not only benefit the end user of the technology but the larger enterprise, as well. The enhanced situational awareness and fortified software/hardware tool kit used by the tactical operator significantly impact the decision-making capabilities of connect leadership, through the chain of command. Additionally, there is a user community of 350k plus TAK users between commercial and federal users that could benefit from this technology.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a "Phase I-like" effort, including a feasibility study and customer discovery. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Proposals should include development, installation, integration, demonstration and/or test and evaluation of the proposed solution prototype system. This demonstration should evaluate the proposed solution against the proposed objectives; describe how the solution will fulfill the AF's requirements; identify the technology's transition path; specify the technology's integration; and describe the technology's sustainability. Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will focus on transitioning the developed technology to a working commercial or warfighter solution. If a viable business model for the developed strategy or algorithm(s) is demonstrated, the offeror or identified transition partners would be in a position to supply future processes to the Air Force and other DoD components as this new process is adopted.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any

proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Help Desk:

usaf.team@afsbirsttr.us

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KEYWORDS: TAK; ATAK; Artificial Intelligence; System Integration; Systems

TECH FOCUS AREAS: Cybersecurity; Network Command, Control and Communications; 5G

TECHNOLOGY AREAS: Sensors; Information Systems; Battlespace

OBJECTIVE: This topic will assess the ability of existing distributed file sharing protocols and applications to operate in relevant tactical scenarios with Android clients. It will evaluate the ability for selected peer-to-peer applications to support automatic directory synchronization. It will also investigate the feasibility of modifying the existing encryption on those applications to be compatible with DoD standards and the government-owned geospatial and situational awareness platforms. If evaluation proves promising, choose one of those candidates and replace the encryption, file/directory synchronization, and prioritization as appropriate.

DESCRIPTION: Distributed file sharing has broad applicability to the tactical domain, and fully distributed operating systems such as IPFS are likely too heavy weight for such applications. In particular, in an environment where we have large files, such as map imagery in a location with infrastructure (e.g., an Air or Tactical Operations Center (AOC/TOC)) and numerous users who need the information in a disadvantaged environment with low bandwidth to the AOC/TOC, but with substantial bandwidth to one another. This is often the case today with modern Mobile Ad Hoc Networking (MANET) radios, we can leverage a variation of an open-source, distributed, unidirectional file sharing approach to disseminate and store that tactical information in a secure, trusted manner based on prioritization to provide edge users with bandwidth-efficient information in a timely manner.

There are several distributed file replication protocols and applications (e.g. SyncThing, FolderSync, BitTorrent, or a half dozen similar tools) in popular use today. By emulating a disadvantaged tactical environment while concurrently using an existing distributed file client on Android, it's possible to quantify the potential gains that could result from the peer-to-peer architecture described. By modifying the existing open-source application to automatically synchronize files across the architecture, files can be pushed to edge devices whenever an update is available. Integrating such a distributed file distribution protocol with Tactical Assault Kit / Team Awareness Kit (TAK) ecosystem, either using DoD standard certifications in tandem with a Cursor on Target (CoT)-streaming server or using symmetric encryption for strictly peer-to-peer use, will likely make such file distribution exponentially more effective.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a "Phase I-like" effort, including a feasibility study and customer discovery. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Proposals should include development, installation, integration, demonstration and/or test and evaluation of the proposed technology. This demonstration should evaluate the proposed solution against the proposed objectives; describe how the solution will fulfill the AF's requirements; identify the technology's transition path; specify the technology's integration; and describe the technology's sustainability. Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will focus on transitioning the developed technology to a working commercial or warfighter solution. If a viable business model for the

developed solution is demonstrated, the offeror or identified transition partners would be in a position to supply future processes to the Air Force and other DoD components as this new technology is adopted.

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KEYWORDS: ATAK; Torrent; Low bandwidth; TAK

TECH FOCUS AREAS: Artificial Intelligence/Machine Learning

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The Air Force Research Laboratory Information Directorate seeks the development of a multi-domain, mission relevant ML artifact repository using the StreamlinedML framework developed by AFRL. The effort involves continuous implementation of state-of-the-art ML algorithms and supporting data sets defined by mission relevant use cases. Model development is to be implemented using AFRL's open-source Model Integration Software Toolkit (<https://mistkml.github.io/>)

DESCRIPTION: This topic seeks to develop mission relevant ML artifact repositories containing state-of-the-art algorithm implementations using StreamlinedML Model Integration Software Toolkit. Data driven AI/ML approaches are emerging as a dominant method for addressing problems too difficult to solve using formal methods. Industry, as well as the academic community, made great strides in successfully solving and demonstrating state-of-the-art solutions to many problems in technical and scientific domains using data driven approaches. In doing so, both of the communities make freely available a large corpus of research and reference implementations of such techniques as they relate to specific problems, such as sentiment analysis, natural language processing, and computer vision. As a result, subsequent research and development of these methods is made easier and less costly by enabling significant reuse and lessons learned of such applications in other domains. A similar approach within the DoD has the potential to bring similar benefits in terms of accelerated research, development, and application of data driven approaches towards a wide range of DoD problems.

Benefits - Successful development of a mission relevant ML artifact repository will provide the DoD with the first of its kind catalog of machine learning models and data sets, providing a number of benefits. It will significantly reduce duplication of work that requires expensive AI/ML expertise. It will allow for rapid experimentation and assessment of various techniques to new and existing problems. It will enable standardized life cycle management of ML artifacts based on a government owned platform. Finally, it will provide a simple method for deploying ML capabilities as stand-alone, self-contained micro-services to cloud-native DoD applications.

PHASE I: In Phase I, awardees will successfully deploy an instance of StreamlinedML into a relevant cloud environment. Conduct a survey of existing ML artifacts, such as models and data sets utilized in DoD applications and create a high-level taxonomy of applicable domains.

PHASE II: For Phase II, the awardee will develop reference implementations of ML models and associated data sets to be ingested into an instance of the StreamlinedML lifecycle management framework for AI/ML artifacts. Development to be done using the Model Integration Software Toolkit (MISTK) provided by StreamlinedML

PHASE III DUAL USE APPLICATIONS: In Phase III, future development of AI/ML capabilities will be significantly accelerated by utilizing the AI/ML artifact repository. This will include automated evaluation of live data against known models, ML workflow templates, and simple ML service deployment from the artifact repository running on StreamlinedML. The MISTK library is open sourced (DIST A) by the AF and is available for potential academic and industry collaborators.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related

material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Help Desk:

usaf.team@afsbirsttr.us

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KEYWORDS: Machine Learning; Artificial Intelligence; Data; Model Integration; Natural Language Processing; Computer Vision

TECH FOCUS AREAS: Cybersecurity; Network Command, Control and Communications

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: This topic's goal is implementation of a server for the Tactical Assault Kit / Team Awareness Kit (TAK) ecosystem supporting low resource usage and easy configuration for more efficient use at the tactical edge, especially where disconnected from the internet

DESCRIPTION: The TAK ecosystem including Android TAK (ATAK), Windows TAK (WinTAK), iOS TAK (iTAK), WebTAK and TAK Server has approximately 350-450,000 users, including Air Force, DoD, other Federal, state, local, international (military & civilian) government users. TAKServer handles enterprise users very well but requires significant resources to administer. Recently, an open source, easy-to-configure/use alternative, future TAKServer has appeared, developed from the ground up using “Digital Engineering” design methodologies has appeared and runs on an android device, Raspberry Pi or other low resource device. Future TAKServer is one of at least six such projects This open-source alternative has the potential to make the TAK ecosystem easily available users by lowering administration costs, however, it has not been fleshed out and developed for that task.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study and customer discovery. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Proposals should include development, installation, integration, demonstration and/or test and evaluation of the proposed technology. This demonstration should evaluate the proposed solution against the proposed objectives; describe how the solution will fulfill the AF’s requirements; identify the technology’s transition path; specify the technology’s integration; and describe the technology’s sustainability. Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will focus on transitioning the developed technology to a working commercial, civilian, or warfighter solution. If a viable business model for the developed strategy or software is demonstrated, the offeror or identified transition partners would be in a position to supply future processes to the Air Force and other DoD components as this new process is adopted.

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KEYWORDS: Android; Situational Awareness; ATAK, Servers; Collaboration; Digital Engineering

TECH FOCUS AREAS: Directed Energy

TECHNOLOGY AREAS: Bio Medical

OBJECTIVE: This topic seeks to model, design, build and install an imaging system enabling high energy laser operators to make real-time damage and hazard assessments during combat, utility and test operations.

DESCRIPTION: The use of high energy lasers (HEL) in military systems has several advantages (line-of-sight targeting, deep magazine, instantaneous engagement), but HEL effects are influenced by multiple factors that are not always predictable. Depending on the conditions, a HEL procedure may take several seconds or completely fail. During extended lasing procedures operators need feedback as to whether the procedure is having the desired effect. If so, the operator can confidently continue the HEL employment; if not, they can make a timely switch to a different course of action.

In addition, the chaotic, uncontrolled battlefield environment requires military HEL operators to make real-time risk determinations. Laser energy reflection modeling can be used to estimate hazard distances and probability of unintended exposure if the surface characteristics of the target are known. Unfortunately targets and their reflection patterns (diffuse, specular collimated, specular divergent) are not always known and are unpredictable. Video imaging of reflection patterns would allow HEL operators to better estimate the effectiveness and the hazards associated with continuing HEL operations. Providing the operator with imagery to support both laser effects and hazard assessments would allow for real-time, high-quality decisions about HEL use on the battlefield and other lasing scenarios including test and laser utility operations.

PHASE I: This topic is intended for technology proven ready to move directly into Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a "Phase I-like" effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential. The study will have:

- 1) created imaging models for both HEL damage and hazard assessments;
- 2) evaluated laser wavelength, power, divergence, lasing distance, target reflectance, ambient illumination, camera sensitivity, aperture, filtering and other factors as potential variables;
- 3) researched military HEL applications and near-term programs; and
- 4) design imaging system(s) for real time assessment of HEL operations for one military application.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a "Phase I-like" effort predominantly separate from the SBIR/STTR Programs. Build HEL imaging system(s), relevant to one military application. Demonstrate and evaluate the system(s) ability to image HEL performance under variety of operating conditions. Compare measured performance against model(s) predictions. Refine imaging models and redesign imaging system as necessary. Design workstation, including display, graphic user interface and controls, to optimize operator's decision making.

PHASE III DUAL USE APPLICATIONS: Integrate HEL imaging system into military HEL system. Evaluate HEL operator's ability to assess HEL effects and hazards.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related

material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Help Desk:

usaf.team@afsbirsttr.us

REFERENCES:

1. Final Report of Defense Science Board Task Force on Directed Energy Weapon Systems and Technology Applications, Office of the Under Secretary of Defense for Acquisition Technology and Logistics, December 2007 <http://www.acq.osd.mil/dsb/reports/ADA476320.pdf>;
2. Fiorino, S. et al. Effectiveness Assessment of Tactical Laser Engagement Scenarios in the Lower Atmosphere. Journal of Aerospace Information Systems. Vol. 10, No. 1, January 2013;
3. Sawatzky, C. High dynamic range imaging for laser weld monitoring. Industrial Laser Solutions for Manufacturing 09/04/2013
4. Lilley, K. Army, Air Force helps build laser-wielding MRAP to clear bombs. Army Times. July 6, 2015 <https://www.armytimes.com/story/military/tech/2015/07/06/rabdo-redstone-arsenal-air-force/29771333/>

KEYWORDS: Diffuse Reflection; Specular Reflection

AF221-D018

TITLE: Multiple Sensor Platform for High Power Microwave Field Mapping

TECH FOCUS AREAS: Directed Energy

TECHNOLOGY AREAS: Sensors

OBJECTIVE: This topic seeks to model, design, build and demonstrate a transportable, passive (non-field perturbing) pulsed Electromagnetic (EM) field measurement device with an array architecture expandable to 100 simultaneous nodes that can measure electric fields as low as 27.5 volts/meter up to air breakdown, magnetic fields as low as 0.0729 Amperes/meter up to air breakdown, a frequency bandwidth of 100 kiloHertz (kHz) to 20 GigaHertz (GHz) and a pulse width resolution as low as 1 nanosecond.

DESCRIPTION: High power electromagnetic field measurements are critical to characterizing transmitter output power, antenna pattern and temporal stability. A sensor system capable of non-perturbing (passive) measurement that can provide more than 100 sensor node spatially distributed measurements while achieving electric field sensitivity from 27.5 volts/meter up to air breakdown and magnetic fields from 0.0729 Amperes/meter up to air breakdown is required for this topic.

Additionally, the device should measure fields over a bandwidth of 100 kHz to 20 GHz with a pulse width resolution of 1 nanosecond. The sensor system should also be reasonably portable for transport to test facilities throughout the world. Previous experience has shown the difficulty of collecting field maps of test systems during routine developmental test activities. Extensive maps are critical to determine risk profiles for electromagnetic interference or bioeffects prediction. Deployment of a large number of simultaneous measurement nodes will allow collection of significant field maps during limited test shots.

PHASE I: This topic is intended for technology proven ready to move directly into Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a "Phase I-like" effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential. It must have validated the product-market fit between the proposed solution and a potential AF stakeholder. The offeror should have defined a clear, immediately actionable plan with the proposed solution and the AF customer. Offerors should demonstrate they have designed passive (non-perturbing) measurement equipment for use in an industrial or military environments and provide past test or modeling and simulation results as evidence they can meet the requirement of the topic.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a "Phase I-like" effort predominantly separate from the SBIR/STTR Programs. Offerors will build, test, and demonstrate a prototype system providing up to 100 measurement channels and meets the sensitivity requirements of the topic, as well as collaborate with the government to prove sensitivity of the measurement equipment in a laboratory environment.

PHASE III DUAL USE APPLICATIONS: Military applications of this technology will include profiling radar and communications emitters in a variety of environments. Commercial applications include mapping fields around Radiofrequency (RF) emitting equipment and mapping of static and gradient magnetic fields in MRI machines.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related

material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Help Desk:
usaf.team@afsbirsttr.us

REFERENCES:

1. IEEE C95.3TM-2002 - Measurements and Computations of Radio Frequency Electromagnetic Fields with Respect to Human Exposure to Such Fields, 100 kHz-300 GHz

KEYWORDS: Electric Field Detection; Magnetic Field Detection; Field Mapping; Electro-optic sensors

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: This topic seeks to establish the infrastructure and environment required for weapon systems and program offices to make digital data visible, accessible, understandable, linked, trustworthy, interoperable, and secure.

DESCRIPTION: B-52 has established the infrastructure and environment at the Engineering Research and Development Center (ERDC) Information Technology Laboratory (ITL) using DoD Defense Research and Engineering Network (DREN) connections to transfer large amounts of data. This provides the user an environment to access and control data. On this project this environment will be connected to DoD Platform One providing the users access from Non-classified Internet Protocol (IP) Router Network (NIPRNet). The implemented solution will be an easy-to-use web-based app so files can be transferred, information extracted, linked, and made available to users. Provide a platform and tools so that data stewards, data custodians and functional data managers are all able to make their data visible to authorized users by identifying, registering and exposing data in a way that makes it easily discoverable. Enable authorized users to obtain the data they need when they need it, including having data automatically pushed to interested and authorized users. This access requires that security controls are in place for credentialed users to ensure that access is permitted.

Understanding data is critical to enable enhanced, more accurate and timely decision-making. The ability to aggregate, compare and truly understand data adversely affects the ability of the Air Force to react and respond. Bringing together business and technology and applying a data-centric approach. Data-driven decisions requires data to be linked such that relationships and dependencies can be uncovered and maintained. Trust is required to deliver the needed value to the sustainment community and stakeholders. Lacking confidence in the data may result in less timely decision-making or consequently, no decision when one is warranted. Property exchanging data between systems and maintaining semantic understanding are critical for successful decision-making and military operations. The Air Force cannot afford to buy licensing from vendors for every document and data type provided as a deliverable to the Air Force. As per the DoD Cyber Risk Reduction Strategy, protected DoD data while at rest, in motion and in use (within applications, with analytics, etc.) is a minimum barrier to entry. Using and developing a data approach, such as attribute-based access control, across the enterprise allows the Air Force to maximize the use of data while, at the same time, employing the most stringent security standards to protect the American people.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a "Phase I-like" effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a "Phase I-like" effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

PHASE III DUAL USE APPLICATIONS: The contractor will pursue commercialization of the various technologies developed in Phase II for transitioning expanded mission capability to a broad range of potential government and civilian users and alternate mission applications. Direct access with end users and government customers will be provided with opportunities to receive Phase III awards for providing the government additional research & development, or direct procurement of products and services developed in coordination with the program.

REFERENCES:

1. Peixoto, R., Cruz, C., Silva, N. Adaptive learning process for the evolution of ontology-described classification model in big data context (2016) Proceedings of 2016 SAI Computing Conference, SAI 2016, art. no. 7556031, pp. 532-540. Cited 2 times. DOI: 10.1109/SAI.2016.7556031
2. 14th Extended Semantic Web Conference, ESWC 2017 (2017) Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 10250 LNCS, pp. 1-278.
3. Peixoto, R., Cruz, C., Silva, N. Semantic HMC: Ontology-described hierarchy maintenance in big data context (2015) Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 9416, pp. 492-501. Cited 2 times. DOI: 10.1007/978-3-319-26138-6_53
4. Boyles, R.R., Thessen, A.E., Waldrop, A., Haendel, M.A. Ontology-based data integration for advancing toxicological knowledge (2019) Current Opinion in Toxicology, 16, pp. 67-74. Cited 4 times. DOI: 10.1016/j.cotox.2019.05.005
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6. Conway, M., O'Connor, D. Social media, big data, and mental health: Current advances and ethical implications (2016) Current Opinion in Psychology, 9, pp. 77-82. Cited 47 times. DOI: 10.1016/j.copsyc.2016.01.004
7. Kim, Y., Lee, J., Lee, E.-B., Lee, J.-H. Application of Natural Language Processing (NLP) and Text-Mining of Big-Data to Engineering-Procurement- Construction (EPC) Bid and Contract Documents (2020) Proceedings - 2020 6th Conference on Data Science and Machine Learning Applications, CDMA 2020, art. no. 9044209, pp. 123-128. DOI: 10.1109/CDMA47397.2020.00027

KEYWORDS: Artificial Intelligence (AI); Machine Learning (ML)

TECH FOCUS AREAS: Artificial Intelligence/Machine Learning

TECHNOLOGY AREAS: Space Platform; Information Systems; Battlespace

OBJECTIVE: This topic seeks to build a cloud-based ecosystem continuously pulling multi-INT satellite sensor data, fuses and processes it through artificial intelligence (AI) to track vehicles and distributes actionable intelligence to mobile devices and analysts worldwide.

DESCRIPTION: Through the proliferation of commercial and military satellites populating Low Earth Orbit (LEO), it will soon be possible to perform certain time-critical sensing missions from space. To advance the state of the art, new methods are needed to exploit the increased availability of space imagery, to predict and to track vehicle movement robustly over tactical time scales, and to make this service accessible to a broad set of decision makers. The use of space-based sensors for procuring intelligence, surveillance, and reconnaissance (ISR) on tactically relevant timelines is expected to be a key enabling capability for the Air Force. Potential end-users for such a capability include pilots engaged in mission preparation, special-ops airmen active in the field, intelligence analysts searching for enemy launch sites, and base commanders monitoring threats to facilities. The goal of this effort is to develop an end-to-end software tool that aggregates opportunistic space-based capabilities and enables an efficient and reliable ecosystem for the request and delivery of data products.

The focus is on space-to-ground based tracking of vehicles (cars, trucks, military vehicles, mobile equipment, ships, maritime military assets, etc). The main deliverable will be a cloud based software app that incorporates full satellite tasking and access; builds artificial intelligence (AI) enabled automated target recognition (ATR) and processing, exploitation, and dissemination (PED) tools; extracts patterns and trends; simultaneously tracks multiple targets; merges space based sensor data with tracking tips from other sources; leverages the latest in human-machine interfaces; and an establishes a link to secure data distribution networks.

PHASE I: This topic is intended for technology proven ready to move directly into Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential. It must have validated the product-market fit between the proposed solution and a potential AF stakeholder. The offeror should have defined a clear, immediately actionable plan with the proposed solution and the AF customer. Relevant areas of demonstrated experience and success include: cloud-based data flows, AI for data curation, parsing and exploiting satellite imagery, effective operator interfaces, systems integration and test, etc.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR/STTR Programs. These efforts will include a working software prototype to include integration of features to aggregate space-based ISR collections, such as satellite tasking, automated target recognition (ATR), and tracking metrics. The prototype should additionally include analytics to recognize Pattern of Life (PoL) behavior, extract patterns and trends, predict vehicle position probabilities, and queue sensor collects. The prototype should feature an intuitive user interface (UI) amenable to use on a web browser or mobile device. The demonstration should use commercial space imagery, while later investments may involve both military and commercial imagery.

PHASE III DUAL USE APPLICATIONS: Phase III should include upgrades to the tool built in

Phase II, accounting for user feedback and results from test and evaluation. This phase should have a strong cyber security focus and allow for the distribution of actionable information from the cloud-based software tool out to the tactical edge for users to navigate, collaborate, and coordinate real-time mission planning and execution. Phase III could also address commercial applications, like global tracking of maritime and overland shipping.

REFERENCES:

- [1] A. Savakis, N. Nagananda, J. Kerekes, E. Ientillucci, R. Blue, W. Hicks, T. Rovito and E. Blasch, "Change Detection in Satellite Imagery with Region Proposal Networks," DSIAC Journal, vol. 6, no. 4, pp. 22-28, 2019. ;
- [2] E. Blasch, R. Cruise, A. Aved, U. Majumder and T. Rovito, "Methods of AI for Multimodal Sensing and Action for Complex Situations," AI Magazine, vol. 40, no. 4, pp. 50-65, 2019. ;
- [3] "The Space Force considers a new mission: tactical satellite imagery," 3 February 2021. [Online]. Available: https://www.c4isrnet.com/battlefield-tech/space/2021/02/03/the-space-force-is-considering-adopting-a-tactical-geoint-mission/?utm_source=Sailthru&utm_medium=email&utm_campaign=EBB%2002.04.21&utm_term=Editorial%20-%20Military%20-%20Early%20Bird%20Brief.

KEYWORDS: space-based sensing; machine learning; automated target recognition; data fusion; tracking

TECH FOCUS AREAS: Directed Energy; Network Command, Control and Communications

TECHNOLOGY AREAS: Space Platform; Battlespace

OBJECTIVE: The main objective of the proposed research is to predict optimal conditions for generation of extremely low frequency (ELF) and very low frequency (VLF) waves in the ionosphere F layer due to parametric beat wave interaction of two high frequency (HF) pump waves with different frequencies. The difference in the two HF transmissions should be in the ELF/VLF frequency range. The obtained results should define the necessary amplitudes of injected HF waves in the F-region ionosphere and the dimensions of the excitation region. The theoretical results will define the amplitude range of the excited ELF/VLF beat-waves and spatial localization as a function of the HF pump-wave amplitudes, frequencies, wave numbers, polarization, and incident angles. In particular:

- (1) Develop novel analytical models of parametric beat-wave excitation of ELF and VLF waves by HF waves propagating in inhomogeneous ionosphere plasma.
- (2) Create numerical code for solution of derived nonlinear equations for HF beat-wave excitation mechanism leveraging with the High-Performance Computers (HPC) capabilities. These models should allow to determine excited ELF/VLF wave amplitudes and spatial localization depending on the HF wave properties, such as frequency, wave number, polarization, amplitude, and incident angle with respect to the plasma density gradient and magnetic field orientation.
- (3) Collect unique experimental data on beat-wave excitation of ELF/VLF waves at the High-frequency Active Auroral Research Program (HAARP) facility and compare with theory.
- (4) Based on obtained data carry out comprehensive analysis of efficiency of radio frequency (RF) mixing mechanism for excitation of ELF/VLF waves in the F-layer of the ionosphere.
- (5) Investigate possibility of creation of frequency modulated and amplitude modulated ELF/VLF waves produced during a beat wave excitation process.
- (6) Develop commercialization strategy for developed new techniques and mitigation methods.

DESCRIPTION: Develop a novel comprehensive effort that incorporates theory, computer simulations, and field experiments, to investigate excitation of ELF and VLF waves in the F-region ionosphere and implementation of this method for secure communication on the ground and below sea level. The proposed research aims to explore the efficiency of the beat-wave excitation mechanism for generation of ELF and VLF waves. A beat-wave frequency will be created in the ionosphere due to parametric interaction of two HF pump waves launched from the ground. The proposed theory will be validated by means of controlled experiments. We will predict optimal conditions for the ELF/VLF excitation based on the HF wave characteristics and F-region ionosphere plasma parameters. We are interested in the development of analytical models supported by field experiments to demonstrate possibility of establishing reliable secure communications via ELF/VLF waves generated in the ionosphere F layer in the process of parametric interaction of HF electromagnetic waves from the MHz diapason launched from the ground.

PHASE I: D2P2 proposers should provide documentation that describes their analytic models with examples of numerical analysis for beat wave excitation of ELF/VLF waves by HF waves launched from the split array at the High-frequency Active Auroral Research Program (HAARP) facility. In addition to this, D2P2 proposers must formulate the problem correctly and derive equations that explain beat-wave excitation.

PHASE II: Conduct controlled experiments and collect data on generation of ELF/VLF waves in the F layer of the ionosphere, analyze experimental data and demonstrate that beat wave generation method can efficiently create ELF/VLF waves that can be detected on the ground. Beyond the current

government interest in VLF waves generation, there exists interest in the commercial sector to understand the ability of VLF waves penetrating in deep soil applications such as exploration of tunnels, mining and detection of natural resources. Present efficient commercialization strategy for newly developed techniques.

PHASE III DUAL USE APPLICATIONS: Design compact mobile HF radiation sources for generation of VLF waves for different applications using beat wave technology. Validate novel low-cost beat wave approach for applications such as ionospheric modification, over the horizon radar (OTHR) applications, secure VLF communications, underground structure detection (military or commercial use).

REFERENCES:

1. M. B. Cohen, R. C. Moor, M. Golkowski and N. G. Lehtinen, ELF/VLF wave generation from the beating of two HF ionospheric heating sources, *Journal of Geophysical Research*, vol. 117, no. A12310, 2012; \
2. V. A. Puchkov, Generation of Plasma Waves in the Ionospheric Plasma by Powerful Nonmonochromatic Microwave Beams, *Phys. Scr.*, vol. 78, no. 1, 2008; D. Main and V. Sotnikov, Parametric interaction between ELF and VLF waves, 3D LSP simulation results, *Phys. Plasmas* 27, 022304 (2020).

KEYWORDS: Ionosphere; Very low Frequency (VLF) waves; VLF communications; Parametric Wave Interaction

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Space Platform

OBJECTIVE: This topic seeks to design and develop an event-based sensing platform specifically optimized to the detection of ground moving targets from a small LEO payload.

DESCRIPTION: The DoD's interest in a proliferated and hybrid constellation architecture to execute intelligence, surveillance and reconnaissance (ISR) missions requires us to rethink traditional sensing modalities and mature those which scale well with large volumes of data, supporting true autonomous sensing development. Space-based EOIR imagery has reached very high spatial resolutions and sensitivities but requires high format sensors which output large unchanging data volumes not useful for the mission. This limits the amount of imagery collected and stored, therefore inhibiting the ability to collect video frames of particular interest in the moving target indication (MTI) field. These problems will be amplified when moving to a hybrid satellite architecture where SWAP C demands are greater but the requirement to process and relay data on the edge puts greater strains on space-borne systems. Event-based sensors rely on asynchronous pixel response which only report information when changes in scene dynamics occur. The result is a sparse stream of high time resolution data where each event is in the format (t, x, y, p) where t is the time of the event, x and y represent the position of the pixel reporting the change, and p is a polarity term indicating positive or negative going changes. This results in inherently sparse data which maintains high time resolution. Event-based sensors, which were first designed for the machine vision applications are then ideal for space-based ISR missions such as MTI. While current state of the art event cameras is improving and well-suited for machine vision applications, they are not optimized for unique space-based remote sensing challenges.

The goal of this research is the design and development of an event-based sensing platform specifically built and optimized to perform ground moving target indication (GMTI) from a small LEO platform ultimately well-suited for integration into a proliferated and hybrid satellite constellation. Successful design will require pixel-level considerations to maximize the trade-off between spatial resolution, field of view, and on pixel photon flux. The platform will also require robust GMTI algorithm development, leveraging the unique event camera dataset to monitor large numbers of targets while looking for anomalous behavior. This will be especially challenging in a constellation architecture, as persistent coverage requires handoff to maintain target tracks for meaningful time periods.

PHASE I: Phase I requires a discovery study to inform the critical design parameters specific to the space-based MTI problem applied to event-based sensors. This includes an examination of pixel design for currently available cameras and improvements to optimize mission specific performance. Phase I will result in a recommended sensor design to be digitally engineered in Phase II.

PHASE II: The Phase II will culminate in delivery of a full payload design including, optics, sensor, readout circuit and algorithms specific to event data for GMTI. Successful solutions will utilize digital engineering to the extent possible for the design process of a GMTI specific event-based sensing payload. Careful attention shall be paid to desired spatial resolution, and FOV required to accomplish the objectives from LEO. Sensor design should be informed by existing state of the art event-based sensors but specifically tailored to the scene dynamics associated with GMTI. Understanding scene background radiances and relevant contrasts for targets of interest will be key to the pixel design, optics selection, and success of developed algorithms. Payload and algorithm performance characterization will require high fidelity synthetic data use. Sensor design and performance will

require all models be validated against physical observables in both the field and laboratory.

PHASE III DUAL USE APPLICATIONS: The Phase III company will work with transition partners to identify mission specific use case. Build sensing payload into field and laboratory testable form factor. Use field and laboratory demonstration to evaluate MTI performance capability. Integrate tested payload into a small satellite form factor for flight demonstration. Further develop EBS exploitation algorithms for detection/tracking/counting of low contrast semi-resolved objects and generalize those methods for commercial applications.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Help Desk:
usaf.team@afsbirsttr.us

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1. G. Gallego et al., "Event-based Vision: A Survey," in IEEE Transactions on Pattern Analysis and Machine Intelligence, doi: 10.1109/TPAMI.2020.3008413.
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<https://doi.org/10.3390/s20061600>

KEYWORDS: Event Based Sensing; Neuromorphic Vision; Target Tracking

Defense Health Agency (DHA)
2022.1 Small Business Innovation Research Program (SBIR)
Proposal Submission Instructions

INTRODUCTION

The Defense Health Agency (DHA) SBIR Program seeks small businesses with strong research and development capabilities to pursue and commercialize medical technologies.

Broad Agency Announcement (BAA), topic, and general questions regarding the SBIR Program should be addressed according to the DoD SBIR Program BAA. For technical questions about a topic during the pre-release period, contact the Topic Author(s) listed for each topic in the BAA. To obtain answers to technical questions during the formal BAA period, visit <https://www.dodsbirsttr.mil/submissions/login>

The DHA Program participates in up to three DoD SBIR BAAs each year. Proposals not conforming to the terms of this BAA will not be considered. Only Government personnel will evaluate proposals with the exception of technical personnel from Odyssey Systems who will provide technical analysis in the evaluation of proposals submitted against DHA topic number:

- DHA221-001 - Prolonged Care: To Demonstrate a Medicated Combat Tourniquet Capable of Wound Infection Treatment Delivery.

Proposers responding to a topic in this BAA must follow all general instructions provided in the Department of Defense (DoD) SBIR Program BAA. DHA requirements in addition to or deviating from the DoD Program BAA are provided in the instructions below.

Specific questions pertaining to the administration of the DHA SBIR Program and these proposal preparation instructions should be directed to:

DHA SBIR Program Management Office (PMO)

Email - usarmy.detrick.medcom-usamrmc.mbx.dhpsbir@mail.mil

Phone - (301) 619-7296

PHASE I PROPOSAL GUIDELINES

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD SBIR Program BAA.

Technical Volume (Volume 2)

The technical volume is not to exceed 20 pages and must follow the formatting requirements provided in the DoD SBIR Program BAA. Do not duplicate the electronically-generated Cover Sheet or put information normally associated with the Technical Volume in other sections of the proposal as these will count toward the 20-page limit.

Only the electronically-generated Cover Sheet and Cost Volume are excluded from the 20-page limit. Technical Volumes that exceed the 20-page limit will be reviewed only to the last word on the 20th page. Information beyond the 20th page will not be reviewed or considered in evaluating the offeror's proposal. To the extent that mandatory technical content is not contained in the first 20 pages of the proposal, the evaluator may deem the proposal as non-responsive and score it accordingly.

Content of the Technical Volume

The Technical Volume has a 20-page limit including: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes) and any other attachments. Refer to the instructions provided in the DoD SBIR Program BAA for full details on content of the technical volume.

Cost Volume (Volume 3)

The Phase I Base amount must not exceed \$250,000. Costs for the Base must be clearly identified on the Proposal Cover Sheet (Volume 1) and in Volume 3.

Company Commercialization Report (CCR) (Volume 4)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR Program BAA for full details on this requirement. Information contained in the CCR will be considered by DHA during proposal evaluations.

Supporting Documents (Volume 5)

DHA SBIR will accept a Volume Five (Supporting Documents) as required under the DoD SBIR Program BAA.

Fraud, Waste, Abuse (Volume 6)

DHA SBIR will accept a Volume Six (Fraud, Waste, and Abuse) as required under the DoD SBIR Program BAA.

PHASE II PROPOSAL GUIDELINES

Phase II proposals may only be submitted by Phase I awardees. Phase II is the demonstration of the technology found feasible in Phase I. All DHA SBIR Phase I awardees from this BAA will be allowed to submit a Phase II proposal for evaluation and possible selection. The details on the due date, content, and submission requirements of the Phase II proposal will be provided by the DHA SBIR PMO. Submission instructions are typically sent toward the end of month five of the Phase I contract. The awardees will receive a Phase II window notification via email with details on when, how and where to submit their Phase II proposal.

Small businesses submitting a Phase II Proposal must use the DoD SBIR electronic proposal submission system (<https://www.dodsbirsttr.mil/submissions/login>). This site contains step-by-step instructions for the preparation and submission of the Proposal Cover Sheets, the Company Commercialization Report, the Cost Volume, the Technical Volume, Supporting Documents, and Fraud, Waste, and Abuse certificate.

The DHA SBIR Program will evaluate and select Phase II proposals using the evaluation criteria in the DoD SBIR Program BAA. Due to limited funding, the DHA SBIR Program reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

Small businesses submitting a proposal are required to develop and submit a Commercialization Strategy describing feasible approaches for transitioning and/or commercializing the developed technology in their Phase II proposal. This plan should be included in the Technical Volume.

The Cost Volume must contain a budget for the entire 24-month Phase II period not to exceed the maximum dollar amount of \$1,100,000. These costs must be submitted using the Cost Volume format (accessible electronically on the DoD submission site), and should be presented side-by-side on a single Cost Volume Sheet.

DHA SBIR Phase II Proposals have six Volumes: Proposal Cover Sheets, Technical Volume, Cost Volume, Company Commercialization Report, Supporting Documents, and Fraud, Waste, and Abuse. The Technical Volume has a 40-page limit including: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes) and any attachments. Do not include blank pages, duplicate the electronically-generated Cover Sheets or put information normally associated with the Technical Volume in other sections of the proposal as these will count toward the 40-page limit.

Technical Volumes that exceed the 40-page limit will be reviewed only to the last word on the 40th page. Information beyond the 40th page will not be reviewed or considered in evaluating the offeror's proposal. To the extent that mandatory technical content is not contained in the first 40 pages of the proposal, the evaluator may deem the proposal as non-responsive and score it accordingly.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

The DHA SBIR Program does not participate in the Technical and Business Assistance (formally the Discretionary Technical Assistance Program). Contractors should not submit proposals that include Technical and Business Assistance.

The DHA SBIR Program has a Technical Assistance Advocate (TAA) who provides technical and commercialization assistance to small businesses that have Phase I and Phase II projects.

EVALUATION AND SELECTION

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD SBIR Program BAA.

Proposing firms will be notified of selection or non-selection status for a Phase I award within 90 days of the closing date of the BAA.

Refer to the DoD SBIR Program BAA for procedures to protest the Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to:

Ms. Micaela Bowers
SBIR/STTR Contracting Officer
U.S. Army Medical Research Acquisition Activity
Phone: (301)-619-2173
Email: micaela.l.bowers.civ@mail.mil

AWARD AND CONTRACT INFORMATION

Phase I awards will total up to \$250,000 for a 6 month effort. Phase I contract awards will be awarded as Purchase Orders indicating the Technical Point of Contact. Phase II awards will be a Firm Fixed contract with the Contracting Officer Representative and other contracting staff identified.

ADDITIONAL INFORMATION

RESEARCH INVOLVING HUMAN SUBJECTS, HUMAN SPECIMENS/DATA, OR ANIMAL RESEARCH

The DHA SBIR Program highly discourages offerors from proposing to conduct Human Subjects, Human Specimens/Data, or Animal Research during Phase I due to the significant lead time required to prepare regulatory documentation and secure approval, which could substantially

delay the performance of the Phase I award. Prior to contract award when an IRB is indicated, proposers must demonstrate compliance with relevant regulatory approval requirements that pertain to proposals involving human subjects, human specimens, or research with animals. While technical evaluations will not be negatively impacted, evaluations requiring IRB approval may delay the start time of the Phase I award. If necessary approvals are not obtained within two months of notification of selection, the decision to award may be terminated.

Offerors are expressly forbidden to use, or subcontract for the use of, laboratory animals in any manner without the express written approval of the US Army Medical Research and Development Command (USAMRDC) Animal Care and Use Review Office (ACURO). Written authorization to begin research under the applicable protocol(s) proposed for this award will be issued in the form of an approval letter from the USAMRDC ACURO to the recipient. Modifications to previously approved protocols require re-approval by ACURO prior to implementation.

Research under this award involving the use of human subjects, to include the use of human anatomical substances or human data, shall not begin until the USAMRDC's Office of Research Protections (ORP) provides formal authorization. Written approval to begin a research protocol will be issued from the USAMRDC ORP, under separate notification to the recipient. Written approval from the USAMRDC ORP is also required for any sub-recipient that will use funds from this award to conduct research involving human subjects.

Research involving human subjects shall be conducted in accordance with the protocol submitted to and approved by the USAMRDC ORP. Non-compliance with any provision may result in withholding of funds and or termination of the award.

CYBERSECURITY CONSIDERATIONS

Appropriate cybersecurity considerations should be implemented at Phase III (or earlier if specified) for the potential transition of software and connected devices to be considered for future fielding. For initial information, please see the below reference to the *DoD Cybersecurity Reference and Resource Guide*.

DoD Cybersecurity Reference and Resource Guide

https://dodcio.defense.gov/Portals/0/Documents/Cyber/2019%20Cybersecurity%20Resource%20and%20Reference%20Guide_DoD-CIO_Final_2020FEB07.pdf

PHASE II ENHANCEMENTS

Through a Phase II Enhancement Program, the DHA SBIR Program provides matching SBIR funds to expand an existing Phase II contract able to attract investment funds from a DoD Acquisition Program, a non-SBIR government program, or eligible private sector investors. Phase II Enhancements allow an existing DHA SBIR Phase II contract to be extended for up to one year to perform additional research and development tasks. Phase II Enhancement matching funds will be provided on a dollar-for-dollar basis up to a maximum \$550,000 of SBIR funds. All Phase II Enhancement awards are subject to a review process, availability of funding, and the successful negotiation and award of a Phase II Enhancement contract modification.

WAIVERS

In rare situations, the DHA SBIR Program allows for a waiver to be incorporated allowing federal facility usage for testing/evaluation. A waiver will only be permitted when it has been determined that no applicable U.S. facility has the ability or expertise to perform the specified work. The DHA SBIR

Program has the right of refusal. If approved, the DHA SBIR PMO will assist in establishing the waiver for Program Manager and Contracting Officer approval. If approved, the proposer will subcontract directly with the federal facility and not a third party representative.

DHA SBIR 22.1 Phase I Topic Index

DHA221-001	Prolonged Care: To Demonstrate a Medicated Combat Tourniquet Capable of Wound Infection Treatment Delivery
DHA221-002	Scalable Multi-person Hearing Protection Device Fit-testing System
DHA221-003	Olfactory Neuroepithelium Functional Diagnostic Tool
DHA221-004	Blind 3D Kinematic Measurement of High-Rate Complex Surface Deformation

DHA221-001 TITLE: Prolonged Care: To Demonstrate a Medicated Combat Tourniquet Capable of Wound Infection Treatment Delivery

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: To reimagine the current fielded tourniquet beyond prevention of exsanguination and demonstrate next generation designs capable of delivering treatment for the prevention of infection in a prolonged care setting. The technology must retain or improve upon the original functionality and shall be in an easy-to-use format, require minimal instrumentation, lightweight, and compatible with prolonged care. The treatment delivery approach should enable deep tissue penetration of, but not limited to, antimicrobial agents post-compression towards the wound bed. The end goal for this effort is to assemble a system of systems to prevent the development of infection in an austere environment when the provision of surgical intervention is delayed over 72 hours (hrs).

DESCRIPTION: Multi-domain operations (MDO) of the future anticipate division-on-division combat operations with causality volumes and medical intervention times that mirror what was observed in WWI and WWII. In MDO, the deployment of anti-access and area denial (A2AD) technologies will not only limit evacuation to degrade the Golden Hour timeline for medical support but also constrain medical resupply, which will leave wounded Warfighters and first line medical support providers stranded in prolonged care (PC) scenarios for unknown durations. Furthermore, repeated events of mass casualty and greater dependency on PC (limited resources while being mobile) will increase the number of deaths from wounds as the infection rate will rise in wounds within 72hrs and beyond as was observed in previous conflicts. Here, the amount of wound dressings and antibiotics needed to prevent infection from polytraumatic wounds based on current US military medical doctrine designed for “Golden Hour” doctrine are untenable in PC scenarios. As a result, the need for innovative solutions that are massively scalable and distributive (i.e. affordable and for all combatants) focused on amplifying self/ buddy care (i.e. fire and forget solutions that enable less supply to be carried for longer duration or the ability of one medical provider to provide care for a high number of wounded casualties) is an urgent need. Furthermore, adding materials to the improved first aid kit (IFAK) or combat lifesaver (CLS) bag presents significant challenges. The critical need for wound infections and sepsis mitigation at point-of-care and Role 1 is to design alternative and/or adjunctive solutions that prevent infection within the first 72 hrs following injury. One approach is to reimagine components of the IFAK as a system of systems to prevent the development of infection in polytraumatic wounds by extending treatment options over 72 hrs to increase Warfighter survivability until surgical intervention. This topic explores the development of the tourniquet not only as hemorrhage control device but also as a new aspect of treatment, as a drug delivery device as well to specifically meet the need for immediate administration of infection treatment at point of injury to prevent infection in prolonged care settings.

Exsanguination (i.e. bleeding to death) and combat wound infection are the most common causes of death from survivable wounds in the history of combat. Tourniquets have been an effective means of controlling exsanguination of compressible trauma on the battlefield and in pre-hospital care to limit mortality and morbidity. Unfortunately, the evolution of tourniquets over time has been unremarkable relative to the many advances of modern medicine. According to the Tactical Combat Casualty Care (TCCC) guidelines, the initial response to penetrating battlefield trauma is to stop major hemorrhage with pressure, tourniquet, and wound packing. Wound packing includes hemostatic agents along with broad-spectrum, systemic battlefield antibiotics to prevent infection followed by casualty evacuation within the hour if the battlespace is mature. Studies have established prolonged application of tourniquets contributes to ischemic-reperfusion injury and microvascular dysfunction that accompanies altered trauma physiology such as shock and sepsis. Furthermore, prolonged tourniquet application significantly reduces

systemically administered antibiotics from penetrating soft-tissue further complicating the infection resolution process. Lessons both from OIF and OEF and from civilian trauma is that “brief” application of tourniquets is generally “safe”. Current research and development on tourniquets are focused on developing smart tourniquets with pressure sensors and describing “application” duration.

Another arm of the problem is that the timing of antibiotic treatment significantly correlated with infection development process. Animal studies of open fractures revealed that early antibiotic treatment and surgical debridement within two hours prevented infection, but delays in antibiotics and surgery after two hours significantly increased the development of infections. These observations were validated in retrospective clinical studies in civilian trauma involving open fractures and further studies have revealed that administering antibiotics immediately after traumatic injury reduced infection rates significantly (i.e. 7% of infection if treated within the hour to 28% if treated after 1.5 hours). This paradigm of casualty management was successful in recent operations where medical evacuation to a higher echelon of care was possible within hours of traumatic injury. However, the conceivable lack of a reasonable timeframe for medical evacuation in large scale combat operations requires the adaption of PC to the new operational environment to meet the balanced need for ease-of-use, scalability, longevity treatment, and efficiency of treatment delivery focused on point-of-care and Role 1 care.

The ultimate goal of the technology in this request is, but not limited to, to combine exsanguination prevention and antibiotic delivery in one-step at the earliest time possible after injury. In doing so, this convergent technology should prevent infection development as decolonization measure of the wound bed (maintain agents of infection below 10^5 threshold) by rapid treatment prior to ischemic-reperfusion injury (within 1.5hrs). This is not meant to replace systemic treatment upstream of tourniquet application according to current CPG.. The intent here is also to overcome compliance issues with combat wound medication packet (CWMP) usage, extend CWMP dose for later use, and ultimately increasing survivability for surgical intervention at point-of-injury and Role 1. The aim of this SBIR is to develop a technology with commercial viability that addresses the multidimensional problems of traumatized tissue biology and to accelerate the next generation of innovations that combine, but not limited to, sensors, treatment (i.e. small molecule-based antibiotics, tissue regeneration, pain management, immune modulators, monoclonal antibodies and/or bacteriophage) delivery features and sleeve/chamber features for bio-containment. When proposing a technology, it is paramount, but not limited to, to consider the factors below:

1. The starting technology must plan to have FDA or equivalent device clearance.
2. The original functionality of the tourniquet cannot be compromised or traded off for a new feature.
3. The original packing weight (2.7 oz) and dimensions (LxWxH- 6x2x1.5 in) should be at or near current fielded product but no more than 10% increase in weight or dimensions.
4. Modular designs with a library of medications incorporating exchangeable cartridges, microneedles, micropumps, catheters, gels... etc. are welcomed, but should describe a ruggedization plan and durability of design to include mechanical systems that require minimal logistical support.
5. Designs must have a manual fail-safe backup option for motorized or automated designs for active delivery.
6. Treatment of choice shall cover a wide array of infectious organisms but not limited to, small molecule-based antibiotics, metal ions, lantibiotics, natural products, bacteriophages, antibodies, polymers, nano-fibers/sponges, antimicrobial peptides, and or any pathogen agnostic treatment. Stable formulations with long shelf-life (18 month +) should be considered.
7. Other treatments such as analgesics for pain management, regenerative, and immune modulators are optional.
8. Modular designs to include bio-containment of wounds such as severed limbs in the form of a convertible sleeve or chamber are optional.

9. Built in sensors are optional.
10. Ease of applications, ability to withstand water, hot and cold temperatures and minimal storage conditions will be factored in the nomination process.
11. Engineering solutions overall should require minimum logistical support and should be compatible with applications in extreme environments including hot and cold temperature.

PHASE I: Given the short duration of Phase I and the high order of technology integration required, Phase I should focus on system design and development of proof-of-concept prototypes that address the treatment delivery requirement. Proposals may include different formulations of treatment. Prototypes may combine “classes” of applications into different “sets” of designs. At the end of this phase, fabricated prototypes should demonstrate feasibility, proof-of-concept and establish “release profile”, using relevant testing platforms for the proposed technology. This phase should down-select promising design as well as identify a pre-clinical animal model, such as, but not limited to, hemorrhagic shock, open fracture or soft tissue wounds with and without infection for use in Phase II. Evaluation of the product’s efficacy for controlling infection with antimicrobial activity must include data for the first 6, 24, 48, and 72 hours at a minimum, if not longer. The above time points do not represent tourniquet application on subjects but used as a bench mark and quantify duration of decolonization of wound bed and prevention of infection.

PHASE II: During this phase, the lead integrated system should be further refined from proof-of-concept into a viable product. Further optimization of the technology for deep penetration of treatments into the traumatized wound bed should be demonstrated during this phase. Qualitative and quantitative outcomes of product with regards to hemorrhage control, prevention of infection, and/or decolonization by invading organisms must be demonstrated as specific performance characteristics of the product compared to standard issued CAT. This testing should be controlled, and rigorous. Testing and evaluation of the prototype to demonstrate operational effectiveness in simulated environments shall be demonstrated. Stability of product in an austere environment should be evaluated to include extreme conditions (i.e. extreme heat, cold, wet environment). This phase should also demonstrate evidence of commercial viability of the product. Accompanying application instructions, simplified procedures, and training materials should be drafted in a multimedia format for use and integration of the product into market. Price estimate and comparison analysis for new design relative current fielded equipment and treatment shall be provided to forecast the potential cost of product. The offeror may develop a regulatory strategy for FDA clearance early to guide product development early on. Offeror may consider a pre-pre-submission communication with the FDA as an early communication for guidance.

PHASE III DUAL USE APPLICATIONS: The ultimate goal of this phase is to secure FDA clearance by developing non-DOD partnerships to demonstrate and commercialize a technology enabling the prevention of infection in wounded service members from infected traumatic combat wounds and control of hemorrhage under PC.. The global market for wilderness medicine and first responder technologies is worth over 100 billion dollars.. Appropriate partnerships to advance the technology above is encouraged at this stage to enable a commercial off-the-shelf solution for market analysis by USAMMDA WEMT or other DOD entities. Alternatively, further development, testing and evaluation of the medicated tourniquet product developed by phase II of this SBIR can be supported by CDMRP, JWMP, and other DOD opportunities and partnerships. This effort should seamlessly be integrated into the TCCC paradigm of initial response to trauma. Once developed and demonstrated, the technology can be used both commercially in civilian or military settings to save lives. The selected contractor shall make this product available to potential military and civilian users.. If product is transitioned into Acquisition Programs of Record, the Government may work with offeror to further refine and harmonize design with other relevant products.

REFERENCES:

1. Kragh JF Jr and Dubick MA. Battlefield tourniquets: lessons learned in moving current care toward best care in an army medical department at war. *US Army Med Depart J* 2016;29–36.
2. Penn-Barwell JG, et al. Early antibiotics and debridement independently reduce infection in an open fracture model. *J Bone Joint Surg Br* 2012;94:107–112.
3. Lack WD, et al. Type III open tibia fractures: immediate antibiotic prophylaxis minimizes infection. *J Orthop Trauma* 2015;29: 1–6.
4. Mangum LC, et al. Duration of extremity tourniquet application profoundly impacts soft-tissue antibiotic exposure in a rat model of ischemia-reperfusion injury. *Injury* 2019;50: 2203-2214.
5. Benov A, et al. Antibiotic treatment-what can be learned from point of injury experience. *Mil Med* 2018;183: 466–471.

KEYWORDS: MDO, tourniquets, drug delivery, wearable, trauma, prolonged care

DHA221-002 TITLE: Scalable Multi-person Hearing Protection Device Fit-testing System

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: Develop a system that can simultaneously fit-test multiple people with hearing protection devices (HPDs). The system should be usable in clinical and non-clinical settings to quickly test the fit of HPDs from various manufacturers.

DESCRIPTION: The Hearing Conservation Program is the largest occupational health program in the Department of Defense (DOD), crucial because the majority of military members are exposed to hazardous noise. Civilian personnel are also assigned to the program when subject to noise exposure associated with work such as aircraft, vehicle, or ship maintenance and other activities. One of the methods used to reduce noise exposure and prevent occupational hearing loss is the use of hearing protection devices (HPD). Until recently, the only way to ensure proper fit of hearing protection was to perform a real ear attenuation threshold (REAT) test in an audiometric booth. This type of testing is time- and labor-intensive. In recent years, commercial systems have been developed to enable HPD fit-testing outside of an audiometric booth. The Department of Defense Instruction 6055.12, Hearing Conservation Program, cites fit-testing as a best practice. Recent studies performed at Navy and Marine Corps accession points to determine the viability of large-scale HPD fit-testing on large numbers of recruits determined that testing at 500, 1000, and 2000 Hertz provided good fit-test results. However, these studies also found that on initial fitting, 55% of participants did not receive adequate protection; some (3.75%) new recruits could not achieve an adequate personal attenuation rating (PAR) with their issued HPDs and had to be offered alternative HPDs. Researchers concluded that adequate protection depends upon proper fit of the issued HPD as well as the quality of initial training (Federman & Duhon, 2016). A more recent study showed earplug PARs were highly variable across study participants; compared to participants with normal hearing, those with hearing loss had significantly lower PARs (Ullman et al., 2021). Other studies have shown that low levels of background noise do not affect PARs, which supports the feasibility of performing HPD fit-testing in the field (Gallagher et al., 2016). One study reported good results with fit-testing using modified ear cups for the Benson medical headphones (TDH-39) (Stefanson & Ahroon, 2019).

In 2018, the Acoustical Society of America (ASA) approved a national consensus standard (ANSI/ASA S12.71-2018) for field attenuation estimation systems (FAES) to measure HPD PAR. Various technical approaches can be used to determine attenuation, including non-audiometric booth REAT tests, field microphone in real ear tests, loudness balance tests, and audiometric booth REAT tests designed for multi-person booths. To date, only one FAES meets the ASA standard for individual HPD fit-testing, but the system can only be used to test one manufacturer's HPDs. The Department of Defense needs an HPD fit-test system that is scalable to allow testing of at least one person, with the ability to simultaneously fit-test multiple people (up to 100 or more). The device(s) should be portable to allow for testing in a variety of settings, including clinics, quiet office spaces, in the field, aboard ships, and with mobile audiometric testing platforms. The device(s) must be able to fit-test most commercially available earplugs. PAR should be calculated using 3, 5, or 7 frequencies, with an overall PAR and individual PAR values per octave band.

PHASE I: Phase I awardees will conceptualize and design an innovative system to rapidly fit-test multiple people at once and provide individualized PARs. The system must be usable in clinics, training classrooms, aboard ship, and in field locations such as firing ranges. Solution could include hardwired equipment or be an application (app) which uses existing methods to generate auditory signals. Designs should incorporate commercially available electronic and computer components. Software systems should

have capability to store and forward results for upload into occupational health records, safety records and military medical readiness systems. Individual files would include personally identifiable information but no personal health information. Data must be mineable and able to be packaged individually, by commands or bases for the military, and by company and work centers for industry. The system's power supply should use standard U.S. power and be designed to operate by battery with a minimum battery life of 4 hours and quick recharging capability. Batteries should not require specialized handling. Design should use standard ruggedization comparable to regular safety instruments such as sound level meters. Equipment should be able to operate in normal hot and cold environments, but does not need to be designed for extreme environments. Due to military constraints, wifi and Bluetooth-enabling should not be the only way to connect multiple individuals to the system.

Phase I deliverables: A concept and demonstration that the theoretical concept is valid for fit-testing hearing protection for multiple individuals simultaneously. Concepts will be evaluated on the number of individuals the system can test simultaneously, the speed of testing, and portability of any equipment.

PHASE II: Using results from Phase I, Phase II will develop, fabricate, and validate a prototype of the multi-person fit-testing system. Phase II initial goal will be to develop and fabricate a system capable of fit-testing multiple people at once. The second goal will be to validate the fit-testing system under an IRB-approved research protocol followed by HRPO-approval. Research does not need to be conducted at a DoD facility and can use a civilian IRB. A third goal will be to demonstrate system ability to conduct fit-testing in a variety of settings and with background noise. One fully functional prototype will constitute the fourth deliverable, accompanied by validation test reports and other relevant reports and designs. Factors used to assess the solution will be:

1. The number of people able to be tested at once where greater numbers are of higher value.
2. Speed of testing where faster is better.
3. Fidelity of test results where smaller levels of uncertainty are better.
4. Sensitivity and specificity where accuracy is valued more than precision.
5. Level of background noise under which the system can be used.

PHASE III DUAL USE APPLICATIONS: Implement any design changes from phase II. Develop production processes, training software, and manuals for the product system. Final product configuration should minimize footprint and weight for portability and ease of storage. The primary target users for the product are companies with large hearing conservation programs. The ability to test multiple people quickly and at the same time will increase the desirability of the product to industry. System would be further enhanced if it requires minimal training and can be used by non-medical personnel. This system could be marketed to many industrial, transportation, mining, and construction companies to improve their hearing conservation programs and increase compliance with the Occupational Safety and Health Administration and other regulatory requirements. In addition, the work may result in technology transition to an Acquisition Program managed by the Service Product Developers. The contractor can also propose product use to the military Services. Connectivity to DoD safety systems should be able to be accomplished as the system becomes GOTS/COTS. Utility of the product will be enhanced if the device is easily portable and requires minimal supervision to produce repeatable results. The capability to administer HPD fit-testing to large groups of people at once will ensure that personnel exposed to noise can be properly trained and fitted with HPDs in an efficient and effective manner.

REFERENCES:

1. ANSI/ASA S12.71-2018 Performance criteria for systems that estimate the attenuation of passive hearing protectors for individual users.
2. Federman J, Duhon C. The viability of hearing protection device fit-testing at navy and marine corps accession points. Noise Health [serial online] 2016 [cited 2017 Jan 5];18:303-311 <http://www.noiseandhealth.org/text.asp?2016/18/85/303/195806>.

3. Gallagher H, Murata TK, McKenna EA, et al. Personal Attenuation Ratings reported using Fit Check Solo: Is background noise a concern? 5th Joint Meeting of the Acoustical Society of American and the Acoustical Society of Japan 2016.
4. Stefanson EW, Ahroon WA. Computer-controlled audiometer's application as an earplug fit-testing tool. *The Journal of the Acoustical Society of America* 140, 3274 (2016).
5. Ullman ED, Smith LM, McCullagh MC, et al. Hearing loss as a predictor for hearing protection attenuation among miners. *Occup Environ Med* 2021;78:371–376.

KEYWORDS: hearing, hearing loss, hearing protection, noise, personal protective equipment, hearing protector fit testing, injury prevention, personal attenuation rating

DHA221-003 TITLE: Olfactory Neuroepithelium Functional Diagnostic Tool

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: To develop a non-invasive diagnostic device that can be used to determine the cellular and functional characteristics of olfactory neuroepithelium with limited or no anesthesia. The device should be able to determine thickness of mucus on top of the mucosa and then be able characterize important properties of the cellular layers of the olfactory cleft mucosa as has been demonstrated with optical coherence tomography (OCT) and confocal laser endomicroscopy (CLE) in the pulmonary tract. This would include proportion of supporting cells, fibrosis, and neuronal composition. The ability to assess olfactory neuroepithelium cellular structure enables assessment of the degree of insult from injury, leading to better treatment and improved patient outcomes. The resulting diagnostic device (medical product) will be employed at level III or IV care for diagnostic assessments after injury.

DESCRIPTION: Modern warfare exposes members to significant volatile inhalational injury risk. Many members return from deployments reporting a diminished sense of smell from burn pit exposure, oil field vapors, exposures to minute quantities of harmful battlefield chemicals, and other onsite/uncharacterized chemical exposures. The current COVID pandemic has significantly increased the number of permanent hyposmia/dysosmia cases occurring in active-duty personnel to the point of olfactory dysfunction becoming a concerning risk for duty limitation⁸. As a poignant example of this, Joint Base San Antonio Ear, Nose and Throat (ENT) referrals for active duty olfactory dysfunction have gone from a handful a year, to 2-3 per week. Modern testing techniques for olfactory dysfunction currently are very elementary and produce poor quality objective data on which to base treatments. These tests simply report a percent correct of common odors recognition with no insight regarding mechanism of injury. This ability to differentiate is critical to ensure optimal therapeutic strategy. For example, anosmia due to allergies or sinusitis responds to steroids and other anti-inflammatory therapies to reduce edema in the local microenvironment. This contrasts with COVID associated anosmia, which is due to injury to supporting cells, resulting in neuronal death. COVID associated anosmia does not respond to anti-inflammatory therapies and likely requires therapies targeting neuronal regeneration.

The primary role of olfaction in the military is for supporting “threat assessment.” The following career fields have expressed concerns to us over the years regarding loss of sense of smell: Military Police and Security Personnel (smell of alcohol on breath, vapors from an investigation scene), Firemen (smell of smoke, methane, other volatiles), Food Safety personnel (responsible for preventing food poisoning related to feeding vast numbers of personnel/trainees), Medical Workers (rely on sense of smell for sterility assessment, diagnostics), and Flight Line personnel (Jet Fuel leakage and other industrial chemical hazards). Outside of basic sense of smell tests and subjective questionnaires, there are no reliable imaging tools to assess any key characteristic of the sense of smell. We propose to develop a new technology for olfactory neuroepithelium assessment that will include an objective assessment of the health and viability of the olfactory cleft mucosa. Specifically, we desire a technology that can differentiate the following layers in terms of thickness, and other key material properties: mucus, epithelium, lamina propria, and potentially the olfactory bulb. We are impressed with the potential of both OCT (Optical Coherence Tomography) and CLE (Confocal Laser Endomicroscopy) technologies for this capability, and are open to new and novel technological solutions that may offer better solutions for improving patient outcomes. With this innovation, health care providers will be provided a tool to obtain essential objective data required to screen for disease and to recognize when treatments are having a subclinical effect.

PHASE I: During Phase one, determine and define the efficacy of the proposed technology that can determine layer thickness and material properties of the olfactory neuroepithelium. The proposed technology will have not have the potential to damage the mucosa or chemosensory structures being examined. Design/develop an innovative concept along with limited testing of potential materials. The product will be evaluated by Otolaryngologists, Allergists and Neurologists at role 3-4 clinical settings. Design requirements may include ease of use, minimal equipment or activation process and be delivered in a minimally invasive manner. It must be mobile, not cause pain or bleeding, able to be used without physically disturbing the structure it is measuring, have ease of storage (heat and cold tolerance) and be applied in vivo (no biopsy required to perform measurements). Demonstration of a prototype is desirable with some early in vitro data using rodent cultures. The product will report key histologic metrics to include: epithelial layer thickness, proportion of supporting cells, neuronal density and organization and inflammatory burden in the spectrum from normal olfaction to anosmia. The product should have function that meets existing output measures of similar technology applied to pulmonary respiratory mucosa.

PHASE II: Detail analysis of the selected device that will include optimal performance properties that are safe and perform according to the specifications listed below. The device should be designed to be utilized to minimize or avoid causing severe discomfort, bleeding, or mucosal disruption with use. In vivo efficacy will be established murine models of anosmia. Validation of efficacy will be gross histologic confirmation. The device will report key histologic metrics to include: epithelial layer thickness, proportion of supporting cells, neuronal density and organization and inflammatory burden in the spectrum from normal olfaction to anosmia. Validation of efficacy will be gross histologic confirmation. Clinical experts with insight into olfactory dysfunction and relevant patient populations should be consulted during optimization and animal validation.

PHASE III DUAL USE APPLICATIONS: Potential commercial and clinical partners for Phase III and beyond should be identified, and a detailed explanation should be provided for how the small business will obtain a monetary return on investment. Awardees will seek to develop a useable prototype for DOD role 3 and 4 environments. They will develop a strategy to lock in the final design (freeze and bridge the gap between laboratory-scale innovation and entry into a recognized FDA regulatory pathway leading to commercialization of the product that will be made available for purchase by the military health system and private sector. Close communication with military surgeons on the development on the product should be considered. Additional customers will likely be academic referral centers capable of validating a large number of patients with olfactory complaints. Functional prototypes will enable development and funding of clinical trials to assess efficacy of the devices and optimize functionality, performance, and safety. Small business should have a strategy in place to secure funding from the private sector and partnering with other medical device companies as needed to reduce costs and risk while improving product availability and capabilities. Imaging companies in the OCT space (e.g. OptoVue) are likely partners to streamline development and testing in humans. Given the worldwide impact of anosmia, funding should be sought from the World Health Organization (WHO).

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KEYWORDS: Olfactory Dysfunction, Anosmia, Hyposmia, Dysosmia, Burn Pit

DHA221-004 TITLE: Blind 3D Kinematic Measurement of High-Rate Complex Surface Deformation

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: Develop and demonstrate technologies capable of measuring complex surface response kinematics at the interface between the torso and body armor system.

DESCRIPTION: Body armor systems can be comprised of hard and soft materials which are designed to prevent ballistic projectile penetration into underlying surfaces and improve armor performance. Defeat of ballistic threats are typically accompanied with armor system back face deformation (BFD) into the underlying torso. Current armor system performance requirements include deformation depth limits, measured by the residual deformation impression in a clay substrate backing. While penetration of the ballistic threat may be stopped by the armor system, the ballistically induced BFD could induce injury to the wearer. Advanced material development advancements have produced armor systems capable of defeating increased threats, but with various BFD characteristics. Unfortunately, the backing material obscures visual observation of back face surfaces.

To establish human injury risk due to blunt insults, the Medical Research & Development Command research laboratories need the ability to accurately characterize the high-rate response surface kinematics which occur at the outer body armor system and underlying tissue interface when ballistic threats are defeated (i.e., no tissue penetration). An innovative approach is needed to measure and record these kinematics during ballistic exposures. This technical solution would provide medical researchers with a critical tool needed to define human injury mechanisms and tolerances associated with blunt exposures. The approach should be independent of backing material used, and should not influence the armor's performance or deformation response. The measurement system should provide a time-history surface deformation response along with associated kinematic parameters. The surface response parameters should include deformation depths, velocities, and accelerations, cross-sectional areas of deformations at variable deformation depths, deformation volumes, and their change rates. Analytical data post-processing techniques are required to extract and provide the response kinematic parameters and a computational visualization of data collected during dynamic test events.

Due to the high speed of ballistic induced insult onto the armor system, the data acquisition rate should be greater than 100 kilohertz (kHz). Deformation depth measurement resolution should be at least 1 millimeter (mm) with a sensitivity of 0.5 mm. The sensing surface should cover a minimum area of 400 by 400 mm; a single sensing array should cover the surface area of the armor systems. Sensing array spacing should be less than 5 mm. The sensing material should be flexible to account for the complex curvature of armor surfaces and backing materials. Unless the armor system fails to prevent ballistic threat penetration, the ideal measurement system should recover and be reusable. Current rigid armor testing protocols require ballistic impacts at three distinct locations. The deformation measurement system should capture these three events without need for removal. During exploratory and developmental testing, armor systems could be tested in more than three distinct locations. Methods to calibrate and verify system operation will be needed. If successful, this innovative technology will allow researchers to ascertain injury risk associated with individual armor system BFD during successful ballistic defeat. Use of this system could be employed in multiple medical research programs and armor systems research, development, and acquisition by the military, law enforcement organizations, etc.

PHASE I: The main goal of Phase I is a feasibility study in the development of a high-rate surface response sensor system. Initially, to prove feasibility, a physical, electronics, optical and circuit design of

the sensor system should be completed as the first deliverable. The electronic and circuit designs should include commercially available electronic, computer, and optical components, or components that can be fabricated easily and without extraordinary expense. The physical design of the surface response sensor should not exceed 2 mm thickness and cover a 400 mm by 400 mm area. The material should be lightweight and highly flexible in order to conform to complex and rapidly changing surface profiles, without altering the performance of armor systems and their deformations. The sensing array spacing within the sensor element should be less than 5 mm. A second deliverable is a data acquisition system and software capable of operating and sampling the surface response sensor system at a sample rate of 100 kilohertz. Appropriate anti-aliasing filters should be integrated into the data acquisition system. The associated software should provide ability to control power to the sensor system and provide data collection trigger options (manual, external source, and sensor threshold activated), and ability to store and view the collected data. A third deliverable is a data processing software capable of performing the needed post-processing of the sensor system data to extract the surface response kinematic metrics and provide imaging algorithms for displaying digital visualization animations of the surface response at various playback speeds. The response metrics include parameters such as, deformation distance, velocity, accelerations, strain rate, area, and volume at various surface points. The animation files should be easily recorded and exportable in commercial video formats to other commercial software programs. The post-processing software should provide a means for exporting the surface response kinematics data into commercially compliant software files. The fourth deliverable is a description of the surface response sensor system, the accompanying data acquisition system and supporting software systems. This is necessary because of the innovative technologies anticipated to accomplish the high-rate surface response data acquisition and associated data density. A detailed software schematic must be produced to indicate the computational path and logic in sensing, triggering, data acquisition, metric extraction, and data visualization algorithms. Specific existing software, or a plan to program new software, must be identified that can accomplish each step involved in the software path.

PHASE II: The overall objective of Phase II is to produce a fully operational prototype high-rate surface response sensor system, and required data acquisition and software system(s), capable of collecting high-rate surface response kinematics of a ballistically driven surface and through data post-processing, extract the surface response kinematic metrics and visually display response surface animations of the collected data. Testing of improvements and changes is then encouraged in order to take advantage of the state-of-the-art in electronics, optics, data acquisition technologies, computers, and software. At this early stage, data can be generated by testing with inanimate phantoms such as placing the sensor system over a heavily padded surface (flat and curved) and striking the sensor material with a blunt object of known and different surface geometries such as a baseball bat or other projectile. The aim is to mature the software programming and data post-processing algorithms to identify the known surface geometry and to test the robustness of the surface sensor technology and the required electrical wiring harnesses and connectors. This system and software should be tested extensively with inanimate phantoms. Modifications to the sensor system electronics, optics, data acquisition function, software and/or data post processing algorithms should be made at this point. Next, the focus should shift to the production of a fully functional prototype high-rate surface response sensor system in the desired form factor, complete with the computer software needed to perform data acquisition and all functions for collecting, archiving, retrieving the acquired data, extracting surface response kinematics, and data visualization animations. This system should be demonstrated to acquire high-rate surface response data (such as, deformation distance, velocity, accelerations, strain rate, area, and volume) collected with inanimate phantoms when struck by blunt surfaces of known surface geometries. The system data acquisition system and associated software should have the ability to detect sensor system faults and to verify system functionality prior to data collection events. Sensor calibration techniques should be investigated and demonstrated, and calibration hardware and methodologies developed. One fully functional prototype will constitute the third deliverable, accompanied by user manuals, calibration procedure, validation test reports and other relevant reports and designs.

PHASE III DUAL USE APPLICATIONS: During a Phase III award, the awardee will work towards maturing the technology, software and manuals for system commercialization. This product is envisioned to be a stand-alone sensor technology capable of being integrated with other test systems to record complex, high-rate surface deformations. The final product is envisioned to consist of three major components, the sensing element(s), the data acquisition module, and software. Users may require multiple sensing elements as they may sustain damage in harsh test environments. Along with the accompanying software, this data will be processed to provide surface response kinematics such as, distance, velocity, accelerations, strain rate, area, and volume. Commercially, this technology and capability could be utilized in the automotive testing and development market, by recording structural deformations during crash testing, seating system development to capture seat surface deformations for improved comfort, endurance, and to investigate chronic back pain in at-risk populations such as long distance truck drivers. New developments in anthropometric test dummies could utilize this technology to record surface deformations of various body regions (abdomen, chest, etc) to record deformations during automotive crash testing in order to document injury risks. Current test dummy instrumentation systems measure chest deformation in discrete locations. This technology is directly applicable to military medical research, such as the Military Operational Medicine Research Program at the Medical Research and Development Command in their research efforts on human tolerance, specifically blunt trauma, as well as utility in the Military materiel research, development, and acquisition in the areas of non-lethal weapon and personal protective equipment development. If this technology is successful, it could be embedded into procurement and testing requirements for the research, development, testing, and acquisition of body armor systems. As such, this technology could be adopted by the National Institute of Justice for integration into their performance specifications for body armor systems used by law enforcement personnel. Commercially, this technology would then be widely used by commercial industries that develop and produce personal armor systems for the military, law enforcement, and private citizens, as well as companies that produce protective equipment such as torso and chest protectors used in numerous sporting activities.

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KEYWORDS: Body armor, Back face deformation, Instrumentation, Kinematics, Complex surfaces, Dynamic response, Behind armor blunt trauma (BABT)

Defense Logistics Agency (DLA)
22.1 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

INTRODUCTION

The Defense Logistics Agency's (DLA) mission has three lines of effort the DLA Small Business Innovation Program (SBIP) supports. They include supporting the **NUCLEAR ENTERPRISE** by maintaining nuclear systems readiness, qualifying alternate sources of supply, improving the quality of consumable parts, and increasing materiel availability. **FORCE READINESS & LETHALITY** through Improvements to life cycle performance through technological advancement, innovation, and reengineering, mitigate single points-of-failure that threaten the readiness of weapons systems used by our Warfighters. **SUPPLY CHAIN INNOVATION & ASSURANCE** through improved lead times, reduced lifecycle costs, maintaining a secure and resilient supply chain, providing opportunities for the small business industrial base to enhance supply chain operations with technological innovations. Lastly supply chain assurance securing the microelectronics supply chain, development of a domestic supply chain for rare earth elements, the adoptions of industrial base best practices associated with counterfeit risk reduction.

Proposers responding to a topic in this BAA must follow all general instructions provided in the Department of Defense (DoD) SBIR Program BAA. DLA requirements in addition to or deviating from the DoD Program BAA are provided in the instructions below.

Specific questions pertaining to the administration of the DLA Program and these proposal preparation instructions should be directed to:

Defense Logistics Agency

Small Business Innovation Program (SBIP) Office DLA/J68

Email: DLASBIR2@DLA.mil

PHASE I PROPOSAL GUIDELINES

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD SBIR Program BAA.

Technical Volume (Volume 2)

DLA's objective for the Phase I effort is to determine the merit and technical feasibility of the concept. The technical volume is not to exceed twenty pages and must follow the formatting requirements provided in the DoD SBIR Program BAA. Any pages submitted beyond the 20-page limit within the Technical Volume (Volume 2) will not be evaluated. If including a letter(s) of support, they should be included in Volume 5, and they will not count towards the 20-page Volume limit. Any technical data/information that should be in the Volume 2 but is contained in other Volumes will not be considered.

Content of the Technical Volume

Refer to the instructions provided in the DoD Program BAA.

Cost Volume (Volume 3)

A list of topics currently eligible for proposal submission is included in these instructions, followed by full topic descriptions. These are the only topics for which proposals will be

accepted at this time. Refer to the topic for cost and duration structure. Proposers must utilize the excel cost volume provided during proposal submission on DSIP.

Company Commercialization Report (CCR) (Volume 4)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR Program BAA for full details on this requirement. Information contained in the CCR will not be considered by DLA during proposal evaluations.

Supporting Documents (Volume 5)

- Contractor Certification Regarding Provision of Prohibited Video Surveillance and Telecommunications Services and Equipment (required),
- Foreign Ownership or Control Disclosure (Proposers must review Attachment 2 in the DoD SBIR BAA: Foreign Ownership or Control Disclosure to determine applicability),
- Additional Cost information (optional),
- Letters of Support (optional),
- Any other supporting documents (optional),
- A qualified letter of support is from a relevant commercial or Government Agency procuring organization(s) working with DLA, articulating their pull for the technology (i.e., what DLA need(s) the technology supports and why it is important to fund it), and possible commitment to provide additional funding and/or insert the technology in their acquisition/sustainment program.
- Letters of support shall not be contingent upon award of a subcontract.

The standard formal deliverables for a Phase I are the:

- Plan of Action and Milestones (POAM) with sufficient detail for monthly project tracking.
- Initial Project Summary: one-page, unclassified, non-sensitive, and non-proprietary summation of the project problem statement and intended benefits (must be suitable for public viewing).
- Monthly Status Report. A format will be provided at the PAC.
- The TPOC and PM will determine a meeting schedule at the PAC. Phase I awardees can expect Monthly (or more frequent) Project Reviews.
- Draft Final Report including major accomplishments, business case analysis, commercialization strategy, transition plan with timeline, and proposed path forward for Phase II.
- Final Report including major accomplishments, business case analysis, commercialization strategy and transition plan with timeline, and proposed path forward for Phase II.
- Final Project Summary (one-page, unclassified, non-sensitive and non-proprietary summation of project results, high resolution photos or graphics intended for public viewing)
- Applicable Patent documentation
- Other Deliverables as defined in the Phase I Proposal
- Phase II Proposal is optional at the Phase I Awardee's discretion (as Applicable)

DIRECT TO PHASE II PROPOSAL GUIDELINES

There are no eligible DLA Topics using Direct to Phase II for this BAA.

PHASE II PROPOSAL GUIDELINES

Per SBA SBIR Phase II Proposal guidance, **all** Phase I awardees are permitted to submit a Phase II proposal for evaluation and potential award selection, without formal invitation. Details on the due date, format, content, and submission requirements of the Phase II proposal will be provided by the DLA SBIP

PMO on/around the midway point of the Phase I period of performance. Only firms who receive a Phase I award may submit a Phase II proposal.

DLA will evaluate and select Phase II proposals using the same criteria as Phase I evaluation. Funding decisions are based upon the results of work performed under a Phase I award and the scientific and technical merit, feasibility, and commercial potential of the Phase II proposal; Phase I final reports will not be reviewed as part of the Phase II evaluation process. The Phase II proposal should include a concise summary of the Phase I effort including the specific technical problem or opportunity addressed and its importance, the objective of the Phase I effort, the type of research conducted, findings or results of this research, and technical feasibility of the proposed technology.

Due to limited funding, DLA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

Phase II Proposals should anticipate a combination of any or all the following deliverables:

- Plan of Action and Milestones (POAM) with sufficient detail for monthly project tracking
- Initial Project Summary: one-page, unclassified, non-sensitive, and non-proprietary summation of the project problem statement and intended benefits (must be suitable for public viewing)
- Monthly Status Report. A format will be provided at the PAC.
- Meeting schedule to be determined by the Technical Point of Contact (TPOC) and PM at the PAC
- Phase II awardees expect Monthly (minimum) Project Reviews (format provided at the PAC)
- Draft Final Report including major accomplishments, commercialization strategy and transition plan and timeline.
- Final Report including major accomplishments, commercialization strategy, transition plan, and timeline.
- Final Project Summary (one-page, unclassified, non-sensitive and non-proprietary summation of project results, non-proprietary high-resolution photos, or graphics intended for public viewing)
- Applicable Patent documentation.
- Other Deliverables as defined in the Phase II Proposal.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

DLA is not authorizing TABA at this time.

EVALUATION AND SELECTION

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD SBIR Program BAA. DLA will evaluate and select Phase I and Phase II proposals using scientific review criteria based upon technical merit and other criteria as discussed in this Announcement document. DLA reserves the right to award none, one, or more than one contract under any topic. DLA is not responsible for any money expended by the offeror before award of any contract. Due to limited funding, DLA reserves the right to limit awards under any topic and only proposals considered to be of superior quality as determined by DLA will be funded.

Phase I proposals will be evaluated based on the criteria outlined below, including potential benefit to the DLA. Selections will be based on best value to the Government considering the following factors which are listed in descending order of importance:

- a) The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.

b) The qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the research and development but also the ability to commercialize the results.

c) The potential for commercial (Government or private sector) application and the benefits expected to accrue from its commercialization.

Please note that potential benefit to the DLA will be considered throughout all the evaluation criteria and in the best value trade-off analysis. When combined, the stated evaluation criteria are significantly more important than cost or price.

It cannot be assumed that reviewers are acquainted with the firm or key individuals or any referenced experiments. Technical reviewers will base their conclusions only on information contained in the proposal. Relevant supporting data such as journal articles, literature, including Government publications, etc., should be listed in the proposal and will count toward the applicable page limit.

Final Selection may require an oral presentation. This may include an in-person meeting or a Zoom.gov meeting.

The two-part evaluation process is explained below:

Part I: The evaluation of the Technical Volume will utilize the Evaluation Criteria provided in the DoD SBIR BAA. Once the initial evaluations are complete, all Offerors will be notified as to whether they were selected to present the slide deck portion of their proposal within 60 days of the BAA close date. Only proposals receiving a “Highly Acceptable” rating will receive an invitation to present orally.

Part II: If selected for an oral presentation, Offerors shall submit a slide deck not to exceed 15 PowerPoint slides to DLASBIR@dla.mil.

- There are no set format requirements other than the 15-page maximum page length.
- It is recommended (but not required) that more detailed information is included in the technical volume and higher-level information is included in the slide deck.

Selected Offerors will receive an invitation to present a slide deck (15-minute presentation time / 15-minute question and answer) in a technical question and answer forum to the DLA evaluation team via electronic media. This presentation will be evaluated by a panel against the criteria listed above and your overall presentation. DLA will evaluate the presentation for Business Acumen, and Core Business Capabilities (Customer Engagement / Presentation Skills). The rating of the presentation will be a Go/No-Go rating

Notification of the Go/No-Go rating decision will occur within 5 days of the presentation. Input on technical aspects of the proposals may be solicited by DLA from non-Government consultants and advisors who are bound by appropriate non-disclosure requirements.

Non-Government personnel will not establish final assessments of risk, rate, or rank Offeror's proposals. Further, these advisors are expressly prohibited from competing for DLA SBIR awards.

All administrative support contractors, consultants, and advisors having access to any proprietary data will certify that they will not disclose any information pertaining to this announcement, including any submission, the identity of any submitters, or any other information relative to this announcement; and shall certify that they have no financial interest in any submission. Submissions and information received

in response to this announcement constitutes the Offeror's permission to disclose that information to administrative support contractors and non-Government consultants and advisors.

The SBIP PMO will distribute selection and non-selection email notices to all firms who submit a SBIR/STTR proposal to DLA. The email will be distributed to the "Corporate Official" and "Principal Investigator" listed on the proposal coversheet. DLA cannot be responsible for notification to a company that provides incorrect information or changes such information after proposal submission. DLA will distribute the selection and non-selection notifications to all offerors within 90 days of the BAA close date.

DLA will provide written feedback to unsuccessful offerors regarding their proposals on the non-selection notification. Only firms that receive a non-selection notification are eligible for written feedback.

Refer to the DoD SBIR Program BAA for procedures to protest the Announcement. As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: DCSO Small Business Innovation Program SBIP.DCSO@dla.mil. This is the DLA Contracting Team workflow email address.

AWARD AND CONTRACT INFORMATION

Typically, the contract period of performance for Phase I should be up to twelve (12) months and the base award should not exceed \$100,000. However, each topic may have a different threshold. The DLA Contracting Office utilizes a Firm Fixed Price (FFP) Contract for DLA Phase I Projects

The expected budget for Phase II should not exceed \$1M unless preapproved by the DLA Program Manager, and the duration should not exceed 24 Months. The DLA Contracting Office utilizes a Firm Fixed Price Level of Effort (FFP/LOE) Contract for DLA Phase II Projects

Proposals not conforming to the terms of this Announcement will not be considered. DLA reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality as determined by DLA will be funded.

DLA reserves the right to withdraw from negotiations at any time prior to contract award.

Post Award, DLA may terminate any award at any time for any reason to include matters of national security (foreign persons, foreign influence or ownership, inability to clear the firm or personnel for security clearances, or other related issues).

Please read the entire DoD Announcement and DLA instructions carefully prior to submitting your proposal. Please go to <https://www.sbir.gov/about/about-sbir#sbir-policy-directive> to read the SBIR/STTR Policy Directive issued by the Small Business Administration.

Use of Support Contractors in the Evaluation Process

Only Government personnel with active non-disclosure agreements will evaluate proposals.

Non-Government technical consultants (consultants) to the Government may review and provide support in proposal evaluations during source selection.

Consultants may have access to the offeror's proposals, may be utilized to review proposals, and may provide comments and recommendations to the Government's decision makers. Consultants will not establish final assessments of risk and will not rate or rank offerors' proposals. They are also expressly

prohibited from competing for DLA SBIR awards in the SBIR topics they review and/or on which they provide comments to the Government.

All consultants are required to comply with procurement integrity laws. Consultants will not have access to proposals or pages of proposals that are properly labeled by the offerors as "FEDONLY." Pursuant to [FAR 9.505-4](#), DLA contracts with these organizations include a clause which requires them to

- (1) Protect the offerors' information from unauthorized use or disclosure for as long as it remains proprietary and
- (2) Refrain from using the information for any purpose other than that for which it was furnished. In addition, DLA requires the employees of those support contractors that provide technical analysis to the SBIR/STTR Program to execute non-disclosure agreements. These agreements will remain on file with the DLA SBIP PMO.

Non-Government consultants will be authorized access to only those portions of the proposal data and discussions that are necessary to enable them to perform their respective duties. In accomplishing their duties related to the source selection process, employees of the organizations may require access to proprietary information contained in the offerors' proposals.

USE OF FOREIGN NATIONALS (also known as Foreign Persons), GREEN CARD HOLDERS AND DUAL CITIZENS

If proposing to use foreign nationals (also known as foreign persons), they must be green card holders, and/or dual citizens. (No Student or Temporary Visa holders will be approved). The offeror must identify the personnel they expect to be involved on this project, the type of visa or work permit under which they are performing, country of origin and level of involvement.

You will be asked to provide additional information during negotiations to verify the foreign citizen's eligibility to participate on a SBIR contract. Supplemental information provided in response to this paragraph will be protected in accordance with the Privacy Act (5 U.S.C. 552a), if applicable, and the Freedom of Information Act (5 U.S.C. 552(b)(6)).

Proposals submitted to export control-restricted topics and/or those with foreign nationals, dual citizens, or green card holders listed will be subject to security review during the contract negotiation process (if selected for award).

DLA reserves the right to vet all uncleared individuals involved in the project, regardless of citizenship, who will have access to Controlled Unclassified Information (CUI) such as export controlled information. If the security review disqualifies a person from participating in the proposed work, the contractor may propose a suitable replacement.

In the event a proposed person and/or firm is found ineligible by the government to perform proposed work, the contracting officer will advise the offeror of any disqualifications but is not required to disclose the underlying rationale.

V. EXPORT CONTROL RESTRICTIONS

The technology within most DLA topics is restricted under export control regulations including the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR). ITAR controls the export and import of listed defense-related material, technical data and services that provide the United States with a critical military advantage. EAR controls military, dual-use and

commercial items not listed on the United States Munitions List or any other export control lists. EAR regulates export-controlled items based on user, country, and purpose. The offeror must ensure that their firm complies with all applicable export control regulations. Please refer to the following URLs for additional information: <https://www.pmddtc.state.gov/> and <https://www.bis.doc.gov/index.php/regulations/export-administration-regulations-ear>.

Most DLA SBIR topics are subject to ITAR and/or EAR. If the topic write-up indicates that the topic is subject to International Traffic in Arms Regulation (ITAR) and/or Export Administration Regulation (EAR), your company may be required to submit a Technology Control Plan (TCP) during the contracting negotiation process.

CLAUSE H-08 PUBLIC RELEASE OF INFORMATION (Publication Approval)

Clause H-08 pertaining to the public release of information is incorporated into all DLA SBIR contracts and subcontracts without exception. Any information relative to the work performed by the contractor under DLA SBIR contracts must be submitted to DLA for review and approval prior to its release to the public. This mandatory clause also includes the subcontractor who shall provide their submission through the prime contractor for DLA's review for approval.

FLOW-DOWN OF CLAUSES TO SUBCONTRACTORS

The clauses to which the prime contractor and subcontractors are required to comply include but are not limited to the following clauses:

- 1) DLA clause H-08 (Public Release of Information),
- 2) DFARS 252.204-7000 (Disclosure of Information),
- 3) DFARS clause 252.204-7012 (Safeguarding Covered Defense Information and Cyber Incident Reporting), and
- 4) DFARS clause 252.204-7020 (NIST SP 800-171 DoD Assessment Requirements). Your proposal submission confirms that any proposed subcontract is in accordance with the clauses cited above and any other clauses identified by DLA in any resulting contract.
- 5) DFARS Clause 252.223-7999 Ensuring Adequate COVID-19 Safety Protocols for Federal Contractors

OWNERSHIP ELIGIBILITY

Prior to award, DLA may request business/corporate documentation to assess ownership eligibility as related to the requirements of SBIR Program Eligibility. These documents include, but may not be limited to, the Business License; Articles of Incorporation or Organization; By-Laws/Operating Agreement; Stock Certificates (Voting Stock); Board Meeting Minutes for the previous year; and a list of all board members and officers.

If requested by DLA, the contractor shall provide all necessary documentation for evaluation prior to SBIR award. Failure to submit the requested documentation in a timely manner as indicated by DLA may result in the offeror's ineligibility for further consideration for award.

ADDITIONAL INFORMATION

Classified Proposals

Classified proposals **ARE NOT** accepted under the DLA SBIR Program. The inclusion of classified data in an unclassified proposal is grounds for the Agency to determine the proposal as non-responsive and the proposal not to be evaluated.

Contractors currently working under a classified contract must use the security classification guidance provided under that contract to verify new SBIR proposals are unclassified prior to submission.

Phase I contracts are not typically awarded for classified work. However, in some instances, work being performed on DLA SBIR/STTR contracts will require security clearances. If a DLA SBIR/STTR contract develops into or identifies classified work, the offeror must have a facility clearance, appropriate personnel clearances to perform the classified work and coordinate the DD254 with the Contract Officer and the service owning the classified data.

For more information on facility and personnel clearance procedures and requirements, please visit the Defense Counterintelligence and Security Agency Web site at: <https://www.dcsa.mil>.

Use of Acronyms

Acronyms should be spelled out the first time they are used within the technical volume (Volume 2), the technical abstract, and the anticipated benefits/potential commercial applications of the research or development sections. This will help avoid confusion when proposals are evaluated by technical reviewers.

Communication

All communication from the DLA SBIR/STTR PMO will originate from the DLASBIR2@DLA.mil email address. Please white list this address in your company's spam filters to ensure timely receipt of communications from our office.

ORGANIZATIONAL CONFLICTS OF INTEREST (OCI)

The basic OCI rules for Contractors which support development and oversight of SBIR topics are covered in FAR 9.5 as follows (the Offeror is responsible for compliance):

- (1) the Contractor's objectivity and judgment are not biased because of its present or planned interests which relate to work under this contract.
- (2) the Contractor does not obtain unfair competitive advantage by virtue of its access to non-public information regarding the Government's program plans and actual or anticipated resources; and
- (3) the Contractor does not obtain unfair competitive advantage by virtue of its access to proprietary information belonging to others.

All applicable rules under the FAR Section 9.5 apply.

If you, or another employee in your company, developed or assisted in the development of any SBIR requirement or topic, please be advised that your company may have an OCI. Your company could be precluded from an award under this BAA if your proposal contains anything directly relating to the development of the requirement or topic. Before submitting your proposal, please examine any potential OCI issues that may exist with your company to include subcontractors and understand that if any exist, your company may be required to submit an acceptable OCI mitigation plan prior to award.

PHASE III GUIDELINES & INSTRUCTIONS

Phase III is any proposal that "Derives From", "Extends" or completes a transition from a Phase I or II project. Phase III proposals will be accepted after the completion of Phase I and or Phase II projects.

There is no specific funding associated with Phase III, except Phase III is not allowed to use SBIR/STTR coded funding. Any other type of funding is allowed.

Phase III proposal Submission. Phase III proposals are emailed directly to DLASBIR2@dla.mil. The PMO team will set up evaluations and coordinate the funding and contracting actions depending on the outcome of the evaluations. A Phase III proposal should follow the same format as Phase II for the content, and format. There are, however, no limitations to the amount of funding requested, or the period of performance. All other guidelines apply. More specific Instructions may be available when a firm submits a Phase III proposal.

DLA 22.1 SBIR Phase I Topic Index

DLA221-001	Engaging the Manufacturing Industrial Base in Support of DLA's Critical Supply Chains
DLA221-002	Optimizing Lithium-Ion (Li-Ion) Battery Recovery Technology to Reclaim Cobalt and Nickel from Industrial and Defense Waste Streams

DLA221-001 TITLE: Engaging the Manufacturing Industrial Base in Support of DLA's Critical Supply Chains

OUSD (R&E) MODERNIZATION PRIORITY: Nuclear; General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Ground Sea; Nuclear; Weapons; Materials; Air Platform

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Expand the Small Business Manufacturer (SBM) base to address the Agency's need to develop qualified sources of supply to improve DLA product availability, provide competition for reduced lead time and cost, as well as address lifecycle performance issues. Through participation in DLA SBIR, SBMs will have an opportunity to collaborate with DLA Weapons System Program Managers (WSPMs) and our customer Engineering Support Activities (ESAs) to develop innovative solutions to DLA's most critical supply chain requirements. In the end, the SBM benefits from the experience by qualifying as a source of supply as well as from the business relationships and experience to further expand their product lines and readiness to fulfill DLA procurement requirements.

DESCRIPTION: Competitive applicants will have reviewed the parts list provided on DLA Small Business Innovation Program (SBIP) site, (Reference 4) as well as the technical data in the cFolders of DLA DiBBs, (Reference 3). Proposals can evolve in one of four ways depending on the availability of technical data and NSNs for reverse engineering as follows. Information on competitive status, RPPOB, and tech data availability will be provided on the website, (Reference 4).

- a. Fully Competitive (AMC/AMSC-1G) NSNs where a full technical data package is available in cFolders. The SBM proposal should reflect timeline, statement of work and costs associated with the manufacturing and qualification of a representative article.
- b. Other than (AMC/AMSC-1G) NSNs where a full Technical Data Package (TDP) is available in cFolders. These items may also require a qualification of a Representative Article. The SBM proposal should reflect timeline, statement of work, and costs associated with producing a Source Approval Request (SAR) and (if applicable) qualification of a Representative Article. Contact the TPOC if necessary. The scope and procedures associated with development of a SAR package are provided in Reference 1.
- c. Repair Parts Purchase or Borrow (RPPOB) may be an option for other than 1G NSNs where partial or no technical data is available in cFolders. NSNs, if available, may be procured or borrowed through this program for the purposes of reverse engineering. The instructions for RPPOB can be found on the websites, Reference 5. The SBM proposal should reflect timeline, statement of work and costs associated

with the procuring the part and reverse engineering of the NSN. Depending on complexity, producing both the TDP and SAR package may be included in Phase I.

d. Reverse Engineering (RE) without RPPOB is when the NSN will be provided as Government Furnished Material (GFM) if available from the ESA or one of our Service customers. In this case, contact the TPOC to discuss the availability of the NSN prior to starting the proposal. The SBM proposal should reflect timeline, statement of work and costs associated with the reverse engineering of the NSN and depending on complexity producing a TDP and SAR package in Phase I.

Specific parts may require minor deviations in the process dependent on the Engineering Support Activity (ESA) preferences and requirements. Those deviations will be addressed post award.

PROJECT DURATION and COST:

PHASE I: NTE 12 Months \$100,000,

- The project schedule should plan to complete the TDP and SAR in the first six months.

PHASE II: NTE 24 Months \$1,000,000

The Phase II proposal is optional for the Phase I awardee. Phase II selections are based on Phase I performance, Small Business Manufacturer innovation and engineering capability and the availability of appropriate requirements. Typically the goal of Phase II is to expand the number of NSNs and/or to build capability to expand capacity to better fulfill DLA requirements.

Participating small businesses must have an organic manufacturing capability and a Commercial and Government Entity (CAGE) code and be Joint Certification Program (JCP) certified in order to access technical data if available.

Refer to “link 2” below for further information on JCP certification. Additionally, small businesses will need to create a DLA’s Internet Bid Board System (DIBBS) account to view all data and requirements in C Folders.

Refer to “links 3 and 4” below for further information on DIBBS and C Folders. All available documents and drawings are located in the C Folder location “SBIR221A”. If the data is incomplete, or not available, the effort will require reverse engineering.

PHASE I: The goal of phase I is for the Small Business Manufacturer to qualify as a source of supply for the DLA NSN(s) to improve DLA NSN availability, provide competition for reduced lead time and cost, and address lifecycle performance issues. In this phase, manufacturers will request TDP/SAR approval from the applicable Engineering Support Activity (ESA), if required, for the NSN(s). At the Post Award Conference, the awardee will have the opportunity to collaborate with program, weapon system, and/or engineering experts on the technical execution and statement of work provided in their proposal. All Phase I Proposals should demonstrate an understanding of the NSN(s) and the general challenges involved in their manufacture. Proposals that fail to demonstrate knowledge of the part will be rejected.

PHASE II: The Phase II proposal is optional for the Phase I awardee. Phase II selections are based on Phase I performance, Small Business Manufacturer innovation and engineering capability and the

availability of appropriate requirements. Typically the goal of Phase II is to expand the number of NSNs and/or to build capability to expand capacity to better fulfill DLA requirements.

PHASE III DUAL USE APPLICATIONS: Phase III is any proposal that “Derives From”, “Extends” or completes a transition from a Phase I or II project. Phase III proposals will be accepted after the completion of Phase I and or Phase II projects.

There is no specific funding associated with Phase III, except Phase III is not allowed to use SBIR/STTR coded funding. Any other type of funding is allowed.

Phase III proposal Submission. Phase III proposals are emailed directly to DLA SBIR2@dla.mil. The PMO team will set up evaluations and coordinate the funding and contracting actions depending on the outcome of the evaluations. A Phase III proposal should follow the same format as Phase II for the content, and format. There are, however, no limitations to the amount of funding requested, or the period of performance. All other guidelines apply.

COMMERCIALIZATION: The SBM will pursue commercialization of the various technologies and processes developed in prior phases through participation in future DLA procurement actions on items identified but not limited to this BAA.

REFERENCES:

1. DLA Aviation SAR Package instructions. DLA Small Business Resources: <http://www.dla.mil/Aviation/Business/IndustryResources/SBO.aspx>
2. JCP Certification: <https://public.logisticsinformationservice.dla.mil/PublicHome/jcp>
3. Access the web address for DIBBS at <https://www.dibbs.bsm.dla.mil>, then select the “Tech Data” Tab and Log into c-Folders. This requires an additional password. Filter for solicitation “SBIR221A”
4. DLA Small Business Innovation Programs web site: <http://www.dla.mil/SmallBusiness/SmallBusinessInnovationPrograms>
5. DLA Aviation Repair Parts Purchase or Borrow (RPPOB) Program: <https://www.dla.mil/Aviation/Offers/Services/AviationEngineering/Engineering/ValueEng.aspx>

KEYWORDS: Nuclear Enterprise Support (NESO), Source Approval, Reverse Engineering

DLA221-002 TITLE: Optimizing Lithium-Ion (Li-Ion) Battery Recovery Technology to Reclaim Cobalt and Nickel from Industrial and Defense Waste Streams

OUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements (GWR)
TECHNOLOGY AREA(S): Materials

OBJECTIVE: The Defense Logistics Agency (DLA) seeks to provide responsive, best value supplies consistently to our customers. DLA continually investigates diverse technologies for manufacturing which would lead to the highest level of innovation in the discrete-parts support of fielded weapon systems (many of which were designed in the 1960's, 1970's and 1980's) with a future impact on both commercial technology and government applications. As such, advanced technology demonstrations for affordability and advanced industrial practices to demonstrate the combination of improved discrete-parts manufacturing and improved business methods are of interest. All these areas of manufacturing technologies provide potential avenues toward achieving breakthrough advances. Proposed efforts funded under this topic may encompass any specific discrete-parts or materials manufacturing or processing technology at any level resulting in a unit cost reduction.

Research and Development efforts selected under this topic shall demonstrate and involve a degree of risk where the technical feasibility of the proposed work has not been fully established. Further, proposed efforts must be judged to be at a Technology Readiness Level (TRL) 6 or less, but greater than TRL 3 to receive funding consideration.

TRL 3. (Analytical and Experimental Critical Function and/or Characteristic Proof of Concept)
TRL 6. (System/Subsystem Model or Prototype Demonstration in a Relevant Environment)

DESCRIPTION: DLA R&D is looking for a domestic capability that demonstrates a new and innovative lithium-ion battery element reclaiming technology, to retrieve nickel and cobalt from recovered batteries, which stem from defense or industrial waste streams. Li-Ion batteries are used in Defense weapon systems, these batteries contain cobalt and nickel; there is limited domestic production of these materials and therefore a risk of foreign reliance. Developing an economically viable, environmentally friendly process for enhancing the recovery of nickel and cobalt from Li-Ion batteries from existing waste feedstock could facilitate the establishment of a viable, competitive domestic supply chain.

R&D tasks include identifying feedstock sources in the existing domestic supply chain and developing processes for recovering nickel and cobalt from the Li-Ion batteries, that demonstrates a significant cost advantage versus standard processing. The process should be amenable to the scale of operation required in Li-Ion battery recycling, and will improve the economics of recovering the Nickel and Cobalt for DoD reuse, rather than recovery as downgraded materials for lower value uses.

PHASE I: Phase I – 6 Months \$100,000

Determine, insofar as possible, the scientific, technical, and commercial feasibility of the concept. Include a plan to demonstrate the innovative manufacturing process and address implementation approaches for near term insertion into the manufacture of Department of Defense (DoD) systems, subsystems, components, or parts.

PHASE II: Phase II – 24 Months \$1,000,000

Develop applicable and feasible process demonstration for the approach described, and demonstrate a degree of commercial viability. Validate the feasibility of the innovative process by demonstrating its use in the production, testing, and integration of items for DLA. Validation would include, but not be limited to, prototype quantities, data analysis, laboratory tests, system simulations, operation in test-beds, or

operation in a demonstration system. A partnership with a current or potential supplier to DLA, OEM, or other suitable partner is highly desirable. Identify commercial benefit or application opportunities of the innovation. Innovative processes should be developed with the intent to readily transition to production in support of DLA and its supply chains.

PHASE III DUAL USE APPLICATIONS: Technology transition via successful demonstration of a new process technology. This demonstration should show near-term application to one or more Department of Defense systems, subsystems, or components. This demonstration should also verify the potential for enhancement of quality, reliability, performance and/or reduction of unit cost or total ownership cost of the proposed subject. **Private Sector Commercial Potential:** Material manufacturing improvements, including development of domestic manufacturing capabilities, have a direct applicability to all defense system technologies. Material manufacturing technologies, processes, and systems have wide applicability to the defense industry including air, ground, sea, and weapons technologies. Competitive material manufacturing improvements should have leverage into private sector industries as well as civilian sector relevance. Many of the technologies under this topic would be directly applicable to other DoD agencies, NASA, and any commercial manufacturing venue. Advanced technologies for material manufacturing would directly improve production in the commercial sector resulting in reduced cost and improved productivity.

REFERENCES:

1. <https://www.nickelinstitute.org/about-nickel/nickel-in-batteries/>
2. <https://vtechworks.lib.vt.edu/handle/10919/92800>

KEYWORDS:

Defense Microelectronics Activity (DMEA)
22.1 Small Business Innovation Research (SBIR)
Proposal Submission Instructions

INTRODUCTION

The Defense Microelectronics Activity (DMEA) SBIR/STTR Program is implemented, administrated, and managed by the DMEA Office of Small Business Programs (OSBP). Proposers responding to a topic in this BAA must follow all general instructions provided in the Department of Defense (DoD) SBIR Program BAA. DMEA requirements in addition to or deviating from the DoD Program BAA are provided in the instructions below.

Specific questions pertaining to the administration of the DMEA SBIR/STTR Program and these proposal preparation instructions should be directed to the DMEA SBIR/STTR Program Manager (PM), Mr. Greg Davis, at osd.mcclellan-park.dmea.list.smbus@mail.mil.

PHASE I PROPOSAL GUIDELINES

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD SBIR Program BAA.

DMEA intends for Phase I to be only an examination of the merit of the concept or technology that still involves technical risk, with a cost not exceeding \$167,500 (excludes Discretionary Technical and Business Assistance (TABAs) amount). The technical period of performance for the Phase I effort should be no more than six (6) months.

A list of the topics currently eligible for proposal submission is included in this section followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics are directly linked to DMEA's core research and development requirements.

Please ensure that your e-mail address listed in your proposal is current and accurate. DMEA cannot be responsible for notification to companies that change their mailing address, e-mail address, or company official after proposal submission.

PROPOSAL VOLUMES:

Proposal Cover Sheet (Volume 1)

Required per the DOD SBIR Program BAA.

Technical Volume (Volume 2)

The technical volume is not to exceed 20 pages and must follow the formatting requirements provided in the DoD SBIR Program BAA.

Content of the Technical Volume

Read the DOD SBIR Program BAA for detailed instructions on proposal format and program requirements. When you prepare your proposal submission, keep in mind that Phase I should address the feasibility of a solution to the topic. Only UNCLASSIFIED proposals will be entertained.

DMEA will evaluate and select Phase I proposals using the evaluation criteria contained in Section 6.0 of the DOD SBIR Program BAA . Due to limited funding, DMEA reserves the right to limit awards under any topic, and only proposals considered to be of superior quality will be funded.

Cost Volume (Volume 3)

DMEA does not accept Phase I proposals exceeding \$167,500. DMEA will conduct a price analysis to determine whether cost proposals, including quantities and prices, are fair and reasonable. Contractors should expect that cost proposals will be negotiated. Costs must be separated and clearly identified on the Proposal Cover Sheet (Volume 1) and in Volume 3.

The on-line cost volume for Phase I and Phase II proposal submissions must be at a level of detail that would enable DMEA personnel to determine the purpose, necessity, and reasonability of each cost element. Provide sufficient information (a. through h. below) on how funds will be used if the contract is awarded. Include the itemized cost volume information (a. through h. below) as an appendix in your technical proposal. The itemized cost volume information (a. through h. below) will not count against the 20-page limit on Phase I and II proposal submissions.

a. Special Tooling and Test Equipment and Material: The inclusion of equipment and materials will be carefully reviewed relative to need and appropriateness of the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the government and relate directly to the specific effort. They may include such items as innovative instrumentation and/or automatic test equipment. Title to property furnished by the Government or acquired with Government funds will be vested with the DOD Component; unless it is determined that transfer of the title to the contractor would be more cost effective than recovery of the equipment by the DOD Component.

b. Direct Cost Materials: Justify costs for materials, parts, and supplies with an itemized list containing types, quantities, price, and where appropriate, purposes.

c. Other Direct Costs: This category of costs includes specialized services such as machining or milling, special testing or analysis, costs incurred in obtaining temporary use of specialized equipment. Proposals, which include leased hardware, must provide an adequate lease *versus* purchase justification or rationale.

d. Direct Labor: Identify key personnel by name if possible or by labor category if specific names are not available. The number of hours, labor overhead and/or fringe benefits and actual hourly rates for each individual are also necessary.

e. Travel: Travel costs must relate to the needs of the project. Break out travel cost by trip, with the number of travelers, airfare, and per diem. Indicate the destination, duration, and purpose of each trip.

f. Cost Sharing: Cost sharing is permitted. However, cost sharing is not required, nor will it be an evaluation factor in the consideration of a proposal.

g. Subcontracts: Involvement of university or other consultants in the planning and /or research stages of the project may be appropriate. If the offeror intends such involvement, describe the involvement in detail and include information in the cost proposal. The proposed total of all consultant fees, facility leases, or usage fees and other subcontract or purchase agreements may not exceed one-third of the total contract price or cost, unless otherwise approved in writing by

the Contracting Officer. Support subcontract costs with copies of the subcontract agreements. The supporting agreement documents must adequately describe the work to be performed (i.e., Cost Volume). At the very least, a statement of work with a corresponding detailed cost volume for each planned subcontract must be provided.

h. Consultants: Provide a separate agreement letter for each consultant. The letter should briefly state what service or assistance will be provided, the number of hours required, and the hourly rate.

Company Commercialization Report (CCR) (Volume 4)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR Program BAA for full details on this requirement. Information contained in the CCR will be considered by DMEA during proposal evaluations.

Supporting Documents (Volume 5)

Other than the Volume 5 requirements listed in the DoD SBIR Program BAA, supporting documents are not required and will not be evaluated.

Fraud, Waste and Abuse Training (Volume 6)

Fraud, Waste and Abuse (FWA) training is required for Phase I and Direct to Phase II proposals. Please refer to the DoD SBIR Program BAA for full details.

PHASE II PROPOSAL GUIDELINES

Phase II proposals may only be submitted by Phase I awardees. Phase II is the prototype/demonstration of the technology that was found feasible in Phase I. DMEA encourages, but does not require, partnership and outside investment as part of discussions with DMEA sponsors for potential Phase II efforts.

Phase II proposals may be submitted for an amount not to exceed \$1,100,000. The technical period of performance for the Phase II effort should be no more than twenty-four (24) months.

Phase I awardees may submit a Phase II proposal without invitation not later than sixty (60) calendar days following the end of the Phase I contract. The Phase II proposal submission instructions are identified in the Phase I contract, Part I – The Schedule, Section H, Special contract requirements, “SBIR Phase II Proposal Submission Instructions.”

All Phase II proposals must have a complete electronic submission per the Proposal Volumes area listed in Phase I. Your proposal must be submitted via the submission site on or before the DMEA-specified deadline or it will not be considered for award.

Due to limited funding, DMEA’s ability to award any Phase II, regardless of proposal quality or merit, is subject to availability of funds. Please ensure that your proposal is valid for 120 days after submission, and any extension to that time period will be requested by the contracting officer.

Any follow-on Phase II proposal (i.e., a second Phase II subsequent to the initial Phase II effort) shall be initiated by the Government Technical Point of Contact for the initial Phase II effort and must be approved by the DMEA SBIR/STTR Program Manager in advance.

DMEA SBIR PHASE II ENHANCEMENT PROGRAM

To encourage transition of SBIR into DOD systems, DMEA has a Phase II Enhancement policy. DMEA’s Phase II Enhancement program requirements include: up to one-year extension of existing Phase II, and

up to \$550,000 matching SBIR funds. Applications are subject to review of the statement of work, the transition plan, and the availability of funding. DMEA will generally provide the additional Phase II Enhancement funds by modifying the Phase II contract.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TAB A)

DMEA does not provide Discretionary Technical and Business Assistance (TAB A).

EVALUATION AND SELECTION

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD SBIR Program BAA. Proposing firms will be notified of selection or non-selection status for a Phase I or Phase II award within 90 days of the closing date of the BAA.

Refer to the DoD SBIR Program BAA for procedures to protest the Announcement. As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to:

DMEA SBIR/STTR Program Manager (PM):

- Name: Mr. Greg Davis
- Email: osd.mcclellan-park.dmea.list.smbus@mail.mil

DMEA SBIR Phase I Topic Index

DMEA221-001	Synthesizable Register Transfer Logic (RTL) Assertions
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DMEA221-001 TITLE: Synthesizable Register Transfer Logic (RTL) Assertions

OUSD (R&E) MODERNIZATION PRIORITY: Microelectronics

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop a library of practical synthesizable register transfer logic (RTL) assertions (System Verilog is highly preferred), investigate limitations of synthesizable assertions in both integrated circuit (IC) and field programmable gate array (FPGA) design and design verification flows using already existing EDA platforms, and develop a methodology for synthesizable RTL assertions and error reporting. Identify robust test vehicles and implement synthesizable RTL assertions in both an FPGA and an IC.

DESCRIPTION: In the design verification (DV) of digital circuit design, it is very common for the RTL coder to include assertions in their RTL code, commonly known as assertion-based verification (ABV). These assertions are non-synthesizable as their purpose is solely for design verification, and add nothing to the mission mode of the RTL. They are used in the design verification process to monitor that correct signals, timing and sequences are being maintained. However, for hardware assurance, it may be desirable in the mission mode to have additional circuitry that monitors that correct signals, synchronous timing and sequences are being maintained. Some prior research has been done and involve the creation of a novel synthesis compiler [1], or requiring the use of high level synthesis (HLS) compilers [2]. However, most digital designers will not have access to customer compilers or HLS compilers. And some prior research has been done [3-5] but not fully realized with practical digital design and digital design verification (DV) best practices for FPGA and digital IC development.

PHASE I: Perform a feasibility study that defines a commonly used IC electronic design application (EDA) platform, and a commonly used FPGA design platform for the investigation. The investigation will not involve creating a new synthesis tool or compiler, but to use industry standard EDA tools. Investigate and develop appropriate test vehicles, either organic or procured. Many practical assertions involve comparing signals at different RTL hierarchy modules. But for more efficient area, many times hierarchies are flattened during synthesis. Also, it would be desirable to be to have some assertions to be synthesized and some not. Investigate the practicality and any limitations of synthesizable RTL assertion code (System Verilog is highly preferred, research has already been done on synthesizable ANSI-C assertions [2]) in both IC and FPGA platforms regarding best practices in digital design and digital DV including (but not limited to): lint, clock domain crossing (CDC), reset domain crossing (RDC), synthesis design constraints (SDC), signal hierarchy, synthesis, scan chain insertion, area, logic equivalence check (LEC) and code coverage. Additionally, propose a practical methodology for how synthesizable assertions and error reporting are integrated into the digital design flow for both IC and FPGA development.

PHASE II: Phase II will result in building, testing and delivering a fully functional prototype or technology of the method developed in phase I. Identify robust test vehicles. Review lint, clock domain crossing (CDC) and reset domain crossing (RDC) reports. Review synthesis design constraints (SDC) file. Perform thorough design verification (DV) including (but not limited to): a functional verification matrix (FVM), a means of monitoring the progress and completion of the FVM, unified top-level test bench, definition of constrained random variables (CRV's), proper regression runs based on the state space of the CRV's, and code coverage reports. RTL code should have assertions, with some assertions monitoring signals at different levels of code hierarchy. Assertions need to be tested against false positives and false negatives. For the IC platform, review synthesis scripts. Perform synthesis with no assertions synthesized, and some chosen assertions synthesized in both IC and FPGA platforms with the hierarchy flattened. For the IC platform, insert a scan chain and enable clock gating during synthesis. For

the FPGA platform, continue through implementation phase (with and without synthesized assertions), and prove functionality of the FPGA. For the IC platform, review place and route scripts, review place and route reports, static timing analysis reports, LEC reports and perform automated test pattern generation (ATPG). Actual manufacturing of the IC would be ideal, but may not be practical.

PHASE III DUAL USE APPLICATIONS: Phase III will result in error monitoring that would be useful in commercial applications as part of built-in self-test BIST, having potential benefits of improved performance robustness and test time savings. During a Phase III program, offerors may refine the performance of the design and produce pre-production quantities for evaluation by the Government.

REFERENCES:

1. Y. Oddos, et al, "From Assertion-based Verification to Assertion-based Synthesis", 17th International Conference on Very Large Scale Integration, Oct 2009.
2. Mohamed Hammouda, et al, "A Design Approach to Automatically Synthesize ANSI-C Assertion During High-Level Synthesis of Hardware Accelerators" 2014 IEEE International Symposium on Circuits and Systems, June 2014.
3. Ivan Kastelan, Zoran Krajacevic, "Synthesizable SystemVerilog Assertions as a Methodology for SoC Verification", First IEEE Eastern European Conference of Computer Based Systems, 2009.
4. Sayantan Das, et al, "Synthesis of System Verilog Assertions" EDAA, 2006.
5. Omar Amin, et al, "System Verilog Assertions Synthesis Based Compiler" 17th International Workshop on Microprocessors and SOC Test and Verification", 2016.

KEYWORDS: FPGA; Digital ASIC; Design Verification; Hardware Assurance

Defense Microelectronics Activity (DMEA)
22.1 Small Business Innovation Research (SBIR)
Direct to Phase II Proposal Submission Instructions

INTRODUCTION

The Defense Microelectronics Activity (DMEA) SBIR/STTR Program is implemented, administrated, and managed by the DMEA Office of Small Business Programs (OSBP). Proposers responding to a topic in this BAA must follow all general instructions provided in the Department of Defense (DoD) SBIR Program BAA. DMEA requirements in addition to or deviating from the DoD Program BAA are provided in the instructions below.

Specific questions pertaining to the administration of the DMEA SBIR/STTR Program and these proposal preparation instructions should be directed to the DMEA SBIR/STTR Program Manager (PM), Mr. Greg Davis, at osd.mcclellan-park.dmea.list.smbus@mail.mil.

DIRECT TO PHASE II PROPOSAL GUIDELINES

15 U.S.C. §638 (cc), as amended by NDAA FY2012, Sec. 5106, and further amended by NDAA FY2019, Sec. 854, PILOT TO ALLOW PHASE FLEXIBILITY, allows the Department of Defense to make an award to a small business concern under Phase II of the SBIR program with respect to a project, without regard to whether the small business concern was provided an award under Phase I of an SBIR program with respect to such project. DMEA is conducting a "Direct to Phase II" implementation of this authority for this 22.1 SBIR Announcement and does not guarantee Direct to Phase II opportunities will be offered in future Announcements. Each eligible topic requires documentation to determine that Phase I feasibility described in the Phase I section of the topic has been met.

The DMEA SBIR Program reserves the right to not make any awards under this Direct to Phase II solicitation. The Government is not responsible for expenditures by the offeror prior to award of a contract. All awards are subject to availability of funds and successful negotiations.

The DMEA SBIR Direct to Phase II Proposals are different than traditional SBIR Phase I topics and proposals.

Direct to Phase II proposals must follow the steps outlined below:

STEP 1:

1. Offerors must create a Cover Sheet per the DOD SBIR 22.1 BAA instructions. Offerors must provide documentation that satisfies the Phase I feasibility requirement that will be included in the Supporting Documents (Volume 5) area of the Phase II proposal. Offerors must demonstrate that they have completed research and development through means other than the SBIR/STTR program to establish the feasibility of the proposed Phase II effort based on the criteria outlined in the topic description.

STEP 2:

1. Offerors must submit a Phase II proposal using the DMEA Phase II proposal instructions below.
2. The Phase II proposal must be submitted by the deadline as outlined in the the DOD SBIR 22.1 BAA instructions.

Offerors are required to provide information demonstrating that the scientific and technical merit and feasibility has been established. DMEA will not evaluate the offeror's related Phase II proposal if it determines that the offeror has failed to demonstrate that technical merit and feasibility has been

established or the offeror has failed to demonstrate that work submitted in the feasibility documentation was substantially performed by the offeror and/or the principal investigator (PI).

Refer to the Phase I description (within the topic) to review the minimum requirements that need to be demonstrated in the feasibility documentation. Feasibility documentation **MUST NOT** be based on work performed under prior or ongoing federally funded SBIR or STTR work.

PHASE II PROPOSAL GUIDELINES

Phase II is the prototype/demonstration of the technology that was found feasible in Phase I. DMEA encourages, but does not require, partnership and outside investment as part of discussions with DMEA sponsors for potential Phase II efforts.

Phase II proposals may be submitted for an amount not to exceed \$1,100,000 (excludes Discretionary Technical and Business Assistance (TAB) amount). The technical period of performance for the Phase II effort should be no more than twenty-four (24) months.

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD SBIR Program BAA. All Phase II proposals must have a complete electronic submission per the Proposal Volumes listed below.

Due to limited funding, DMEA's ability to award any Phase II, regardless of proposal quality or merit, is subject to availability of funds. Please ensure that your proposal is valid for 120 days after submission, and any extension to that time period will be requested by the contracting officer.

Any follow-on Phase II proposal (i.e., a second Phase II subsequent to the initial Phase II effort) shall be initiated by the Government Technical Point of Contact for the initial Phase II effort and must be approved by the DMEA SBIR/STTR Program Manager in advance.

A list of the topics currently eligible for proposal submission is included in this section followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics are directly linked to DMEA's core research and development requirements.

Please ensure that your e-mail address listed in your proposal is current and accurate. DMEA cannot be responsible for notification to companies that change their mailing address, e-mail address, or company official after proposal submission.

PROPOSAL VOLUMES:

Proposal Cover Sheet (Volume 1)

Required per the DOD SBIR Program BAA.

Technical Volume (Volume 2)

The technical volume is not to exceed 20 pages and must follow the formatting requirements provided in the DoD SBIR Program BAA.

Content of the Technical Volume

Read the DOD SBIR Program BAA for detailed instructions on proposal format and program requirements. When you prepare your proposal submission, keep in mind that Phase I should

address the feasibility of a solution to the topic. Only UNCLASSIFIED proposals will be entertained.

DMEA will evaluate and select Phase II proposals using the evaluation criteria contained in the DOD SBIR Program BAA. Due to limited funding, DMEA reserves the right to limit awards under any topic, and only proposals considered to be of superior quality will be funded.

Content of the Technical Volume should cover the items listed in section 5.3.c. of the DoD SBIR Program BAA.

Cost Volume (Volume 3)

DMEA does not accept Phase II proposals exceeding \$1,100,000. DMEA will conduct a price analysis to determine whether cost proposals, including quantities and prices, are fair and reasonable. Contractors should expect that cost proposals will be negotiated. Costs must be separated and clearly identified on the Proposal Cover Sheet (Volume 1) and in Volume 3.

The on-line cost volume for Phase II proposal submissions must be at a level of detail that would enable DMEA personnel to determine the purpose, necessity, and reasonability of each cost element. Provide sufficient information (a. through h. below) on how funds will be used if the contract is awarded. Include the itemized cost volume information (a. through h. below) as an appendix in your technical proposal. The itemized cost volume information (a. through h. below) will not count against the 20-page limit on Phase II proposal submissions.

a. Special Tooling and Test Equipment and Material: The inclusion of equipment and materials will be carefully reviewed relative to need and appropriateness of the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the government and relate directly to the specific effort. They may include such items as innovative instrumentation and/or automatic test equipment. Title to property furnished by the Government or acquired with Government funds will be vested with the DOD Component; unless it is determined that transfer of the title to the contractor would be more cost effective than recovery of the equipment by the DOD Component.

b. Direct Cost Materials: Justify costs for materials, parts, and supplies with an itemized list containing types, quantities, price, and where appropriate, purposes.

c. Other Direct Costs: This category of costs includes specialized services such as machining or milling, special testing or analysis, costs incurred in obtaining temporary use of specialized equipment. Proposals, which include leased hardware, must provide an adequate lease *versus* purchase justification or rationale.

d. Direct Labor: Identify key personnel by name if possible or by labor category if specific names are not available. The number of hours, labor overhead and/or fringe benefits and actual hourly rates for each individual are also necessary.

e. Travel: Travel costs must relate to the needs of the project. Break out travel cost by trip, with the number of travelers, airfare, and per diem. Indicate the destination, duration, and purpose of each trip.

f. Cost Sharing: Cost sharing is permitted. However, cost sharing is not required, nor will it be an evaluation factor in the consideration of a proposal.

g. Subcontracts: Involvement of university or other consultants in the planning and /or research stages of the project may be appropriate. If the offeror intends such involvement, describe the involvement in detail and include information in the cost proposal. The proposed total of all consultant fees, facility leases, or usage fees and other subcontract or purchase agreements may not exceed one-third of the total contract price or cost, unless otherwise approved in writing by the Contracting Officer. Support subcontract costs with copies of the subcontract agreements. The supporting agreement documents must adequately describe the work to be performed (i.e., Cost Volume). At the very least, a statement of work with a corresponding detailed cost volume for each planned subcontract must be provided.

h. Consultants: Provide a separate agreement letter for each consultant. The letter should briefly state what service or assistance will be provided, the number of hours required, and the hourly rate.

Company Commercialization Report (CCR) (Volume 4)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR Program BAA for full details on this requirement. Information contained in the CCR will be considered by DMEA during proposal evaluations.

Supporting Documents (Volume 5)

Other than the Volume 5 requirements listed in the DoD SBIR Program BAA, supporting documents will include the following:

Feasibility Documentation

a) Maximum page length for feasibility documentation is ten (10) pages. If you have references, include a reference list or works cited list as the last page of the feasibility documentation. This will count towards the page limit.

b) Work submitted within the feasibility documentation must have been substantially performed by the offeror and/or the principal investigator (PI). Technology in the feasibility documentation is subject to intellectual property (IP) rights, the offeror must provide IP rights assertions. Provide a good faith representation that you either own or possess appropriate licensing rights to all IP that will be utilized under your proposal. Additionally, proposers shall provide a short summary for each item asserted with less than unlimited rights that describes the nature of the restriction and the intended use of the intellectual property in the conduct of the proposed research. Please see the SBIR 22.1 BAA instructions for information regarding technical data rights.

Fraud, Waste and Abuse Training (Volume 6)

Fraud, Waste and Abuse (FWA) training is required for Phase I and Direct to Phase II proposals. Please refer to the DoD SBIR Program BAA for full details.

DMEA SBIR PHASE II ENHANCEMENT PROGRAM

To encourage transition of SBIR into DOD systems, DMEA has a Phase II Enhancement policy. DMEA's Phase II Enhancement program requirements include: up to one-year extension of existing Phase II, and up to \$550,000 matching SBIR funds. Applications are subject to review of the statement of work, the transition plan, and the availability of funding. DMEA will generally provide the additional Phase II Enhancement funds by modifying the Phase II contract.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TAB A)

DMEA does not provide Discretionary Technical and Business Assistance (TAB A).

EVALUATION AND SELECTION

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD SBIR Program BAA. Proposing firms will be notified of selection or non-selection status for a Phase II award within 90 days of the closing date of the BAA.

Refer to the DoD SBIR Program BAA for procedures to protest the Announcement. As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to:

DMEA SBIR/STTR Program Manager (PM):

- Name: Mr. Greg Davis
- Email: osd.mcclellan-park.dmea.list.smbus@mail.mil

DMEA SBIR 22.1 Direct to Phase II Topic Index

DMEA221-D01	Ultra High Voltage Silicon Carbide (SiC) Gated Devices
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DMEA221-D01 TITLE: Ultra High Voltage Silicon Carbide (SiC) Gated Devices

OUSD (R&E) MODERNIZATION PRIORITY: Microelectronics

TECHNOLOGY AREA(S): Electronics; Materials

OBJECTIVE: Development of high voltage gated semiconductor device process that leverages the enhanced power handling capability of SiC, and remediates the undesirable effects (threshold voltage instability, increased interface capacitance) associated with native SiO₂ growth from commercially available 4H-SiC and 6H-SiC polytypes. The process improvement and resultant performance enhancements gained will be validated by characterization of prototype devices

DESCRIPTION: Developmental work on wide bandgap materials has made substantial progress in recent years. The fundamental electrical properties of wide bandgap semiconducting materials are attractive to device designers due to the fact that wide bandgap devices hold the promise of substantial performance improvements over their silicon-based counterparts. In particular, Silicon Carbide (SiC) has emerged as the material-of-choice for high voltage/power applications due to its high thermal conductivity, a paramount factor for applications demanding high power dissipation. Additionally, native SiO₂ growth is possible on SiC substrates, making thermal oxidation steps on SiC substrates consistent with those in traditional silicon device fabrication. The potential to operate at higher temperatures, higher voltages, higher frequencies, and higher power densities make the utilization of SiC based devices highly desirable for future electronic systems in both commercial and defense applications.

A limiting factor in the development of gated high voltage devices (particularly MOSFETs), has the difficulties encountered in producing the required high quality gate dielectric. As mentioned above, SiO₂ growth is applicable to SiC substrates. However, the resultant SiC/SiO₂ interface contains many defects, trap states, and dangling bonds not found in the traditional Si/SiO₂ interface, due to the fact that SiO₂ grown on 4H, 6H, and 3C SiC polytypes has sufficient lattice mismatch to manifest in excessive interfacial defects. This has slowed the development and commercialization of gated SiC devices. The practical manifestation of interface defects in gated semiconductor devices is charge trapping. As carriers tunnel from the SiC conduction band edge to the oxide interface, charge becomes trapped wherever defects are present. Trapping at these sites degrades mobility, causes threshold voltage instability, and increases the surface capacitance at the boundary. Decreased mobility reduces drive current and impacts switching speed. Threshold voltage instability reduces design functional reliability, and excessive parasitic capacitance can drastically limit switching speed. In order to fabricate reliable high voltage gated devices on SiC substrates, the defect density at the SiC/SiO₂ interface must be reduced.

To date, formation of a high quality SiO₂ dielectric remains problematic for SiC polytypes. This is particularly true for 4H-SiC and 6H-SiC, which are anisotropic in crystal structure, which results in unfavorable oxidation kinetics and less uniformity in the resultant thin films. Reduction of interface defects in gated SiC devices would result in higher performance, and enhanced reliability. In particular, this is a critical criterion for high voltage devices utilized by the DoD in mission and safety-critical applications.

DIRECT TO PHASE II: DMEA will only accept Direct to Phase II proposals.

PHASE I: Perform a feasibility study on the selected fabrication approach to remediate the detrimental effects outlined in the preceding section of this document. The end result of Phase I is a feasibility study report, which demonstrates all the rational justifications for studying the proposed technique. The report will explicitly address the following items:

1. The proposed technique shall maximize the utilization of standard semiconductor tool classes (e.g. CVD, implants, etch/deposition). The feasibility study shall describe all required fabrication tools utilized to implement the proposed techniques.
2. The feasibility study shall describe and address the shortcomings described in prior art concerning the reduction of interface defects at the SiO₂/SiC interface.
3. The feasibility study shall address the impact of SiC polytype choice on the formed dielectric.
4. The feasibility study shall discuss the impact of growth rate on defect formation.
5. The feasibility study shall describe the methodology and analysis techniques required to characterize the structural and composition properties of produced thin films and material interfaces.
6. The feasibility study shall provide a detailed list of proposed follow-on tasks and technical objectives, including a proposed task schedule.
7. The feasibility study shall describe the utilization and role of modeling and simulation in the development of the proposed technique.
8. The feasibility study shall identify all prototype feature size limitations (e.g film thickness, gate width, minimum feature sizes).
9. The feasibility study shall address SiC crystal orientation and its potential impact on interface defect density.
10. The feasibility study shall address the impact of doping concentration on interface defect density.

Deliver a report fully describing the proposed techniques and characterization methodologies, including a notional list of fabrication tools, facility requirements and a program plan for follow-on phase development. If any of the above items cannot be fully addressed, the report must include relevant research and rationale that demonstrates their inapplicability to the proposed technique. If adhering to the above items is possible, but not financially feasible, the report must include relevant justification.

FEASIBILITY DOCUMENTATION: Offerors interested in participating in Direct to Phase II must include in their response to this topic Phase I feasibility documentation that substantiates the scientific and technical merit and Phase I feasibility described in Phase I above has been met (i.e. the small business must have performed Phase I-type research and development related to the topic, but from non-SBIR funding sources) and describes the potential commercialization applications. The documentation provided must validate that the proposer has completed development of technology as stated in Phase I above. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/results. Work submitted within the feasibility documentation must have been substantially performed by the offeror and/or the principal investigator (PI).

PHASE II: Based on the aforementioned study and applicable innovation, Phase II will result in producing fully functioning prototypes of an SiC MOSFET device incorporating the proposed methodology for reducing interface defects. The following table illustrates the minimum performance criteria for the prototype MOSFET devices. All parameters are assumed to be measured at nominal temperature (25C):

- Table 1: Minimum MOSFET Performance Criteria (Parameter, Condition, and Value)
- Parameter - Breakdown Voltage, Condition - VGS=0; ID=250μA, Value - 1300V
- Parameter - Drain Current, Condition - VGS=20V, Value - 40A
- Parameter - Threshold Voltage, Condition - ID=10mA; VDS=VGS, Value - 2.5V
- Parameter - Drain Source Leakage Current, Condition - VDS=1200V; VGS=0V, Value - 20μA
- Parameter - Gate Source Leakage Current, Condition - VGS=20V; VDS=0V, Value - 220nA
- Parameter - N-Channel Mobility, Value - >200 cm²/Vs

- Parameter - Threshold Voltage Stability, Condition - $V_{DD}=1V$; $I_D=100\mu A$; $V_{GS}=-8V$, Value - $<3\%$ over 100hrs

If the prototype does not meet the minimum requirements listed on Table 1, a rationale must be provided for each parameter specification not met, and a remediation strategy must be presented. Validated characterization results verifying that five (5) prototype devices met the specifications listed on Table 1 shall be and delivered along with at least five (5) untested samples for further testing and validation. Deliver a detailed final report that documents the manufacturing processes utilized, fabrication toolset required to perform the proposed techniques, all facility requirements, and all electrical characterization and all device design data (TCAD files, modeling/Simulation results. The final report shall contain sufficient technical detail such that an entity skilled in semiconductor fabrication can repeat the presented results.

PHASE III DUAL USE APPLICATIONS: There may be opportunities for further development of SiC MOSFETS for use in a specific military or commercial application. During a Phase III program, offerors may refine the performance of the design and produce pre-production quantities for evaluation by the Government. High voltage SiC MOSFET technology has commercial and Government applications. Government applications include reduced size, ultra-high voltage power modules. Commercial applications include electric vehicle charging devices/circuitry

REFERENCES:

1. Jaio, C, et al. Interface Trap Profiles in 4H-and 6H-SiC MOS Capacitors with Nitrogen-and Phosphorus-Doped Gate Oxides. Journal of Electronic Materials, 2017.
2. Anders, M.A, et al. Are Dangling Bonds Important Interface Traps in 4H-SiC Metal Oxide Semiconductor Field Effect Transistors? Applied Physics Letters 2016.
3. Cooper, J, et al. Fundamentals of Silicon Carbide Technology. Wiley 2014.
4. Shur, M, et al. SiC Materials and Devices. World Scientific 2006.

KEYWORDS: SiC, Traps; Defects; MOSFET; High Voltage; Semiconductor

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Missile Defense Agency (MDA) 22.1 Small Business Innovation Research (SBIR) Proposal Submission Instructions

INTRODUCTION

The Missile Defense Agency's (MDA) mission is to develop and deploy a layered Missile Defense System (MDS) to defend the United States, its deployed forces, allies, and friends from missile attacks in all phases of flight.

The MDA Small Business Innovation Research (SBIR) Program is implemented, administered, and managed by the MDA SBIR/Small Business Technology Transfer (STTR) Program Management Office (PMO), located within the Innovation, Science, & Technology (DV) directorate.

Offerors responding to a topic in this BAA must follow all general instructions provided in the Department of Defense (DoD) SBIR Program BAA. MDA requirements in addition to or deviating from the DoD Program BAA are provided in the instructions below.

Specific questions pertaining to the administration of the MDA SBIR Program and these proposal preparation instructions should be directed to:

**Missile Defense Agency
SBIR/STTR Program Management Office
MDA/DVR
Bldg. 5224, Martin Road
Redstone Arsenal, AL 35898**

**Email: sbirsttr@mda.mil
Phone: 256-955-2020**

Proposals not conforming to the terms of this announcement **may** not be considered. MDA reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality as determined by MDA will be funded. MDA reserves the right to withdraw from negotiations at any time prior to contract award. The Government may withdraw from negotiations at any time for any reason to include matters of national security (foreign persons, foreign influence or ownership, inability to clear the firm or personnel for security clearances, or other related issues).

Please read the entire DoD announcement and MDA instructions carefully prior to submitting your proposal. Please go to <https://www.sbir.gov/about#policy-directive> to read the SBIR/STTR Policy Directive issued by the Small Business Administration.

PHASE I PROPOSAL GUIDELINES

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. **Offerors** are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD SBIR Program BAA.

DSIP (available at <https://www.dodsbirsttr.mil>) will lead you through the preparation and submission of your proposal. Read the front section of the DoD announcement for detailed instructions on proposal format and program requirements. Proposals not conforming to the terms of this announcement **may** not be considered.

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MDA's objective for Phase I is to determine the merit and technical feasibility of the concept. The contract period of performance for Phase I is six (6) months.

Proposal Cover Sheet (Volume 1)

On DSIP at <https://www.dodsbirsttr.mil/submissions>, prepare the Proposal Cover Sheet.

Technical Volume (Volume 2)

The technical volume is not to exceed 15 pages and must follow the formatting requirements provided in the DoD SBIR Program BAA. Any pages submitted beyond the 15-page limit will not be evaluated.

Content of the Technical Volume

For technical volume format guidance, please refer to the "Format of Technical Volume" section within the DoD SBIR 22.1 BAA

If including a letter(s) of support and/or Technical and Business Assistance (TAB A) request, it must be included as part of Volume 5 and will not count towards the 15-page Technical Volume (Volume 2) limit. Any technical data/information that should be in the Technical Volume (Volume 2) but is contained in other Volumes will not be considered.

Cost Volume (Volume 3)

The Phase I Base amount must not exceed \$150,000 or not to exceed \$155,000 if TAB A is included. MDA does not utilize the Phase I Option.

Company Commercialization Report (CCR) (Volume 4)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR Program BAA for full details on this requirement. Information contained in the CCR will not be considered by MDA during proposal evaluations.

Supporting Documents (Volume 5)

MDA will only accept the following four documents as part of Volume 5:

1. Contractor Certification Regarding Provision of Prohibited Video Surveillance and Telecommunications Services and Equipment (Required).
2. Foreign Ownership or Control Disclosure (Offerors must review Attachment 2 in the DoD SBIR Program BAA to determine applicability.)
3. Request for TAB A using the MDA [Phase I TAB A form](#) (optional).
4. Letters of support (optional).

If including a request for TAB A, the MDA [Phase I TAB A Form](#) MUST be completed and uploaded using the "Other" category within Volume 5 of DSIP.

If including letters of support, they MUST be uploaded using the "Letters of Support" category within Volume 5 of DSIP. A qualified letter of support is from a relevant commercial or Government Agency procuring organization(s) working with MDA, articulating their pull for the technology (i.e., what MDS need(s) the technology supports and why it is important to fund it), and possible commitment to provide additional funding and/or insert the technology in their acquisition/sustainment program. Letters of support shall not be contingent upon award of a subcontract.

Any documentation other than the Prohibited Video Surveillance and Telecommunications Services and Equipment form, Foreign Ownership or Control Disclosure, letter(s) of support, or requests for TAB A included as part of Volume 5 WILL NOT be considered.

DIRECT TO PHASE II PROPOSAL GUIDELINES

MDA is not accepting Direct to Phase II proposals for the 22.1 SBIR BAA.

PHASE II PROPOSAL GUIDELINES

Phase II proposals may only be submitted by Phase I awardees. Details on the due date, format, content, and submission requirements of the Phase II proposal will be provided by the MDA SBIR/STTR Program Management Office during the fourth month of the Phase I period of performance.

MDA will evaluate and select Phase II proposals using the Phase II evaluation criteria listed in the DoD Program announcement. While funding must be based upon the results of work performed under a Phase I award and the scientific and technical merit, feasibility and commercial potential of the Phase II proposal, Phase I final reports will not be reviewed as part of the Phase II evaluation process. The Phase II proposal should include a concise summary of the Phase I effort including the specific technical problem or opportunity addressed and its importance, the objective of the Phase I effort, the type of research conducted, findings or results of this research, and technical feasibility of the proposed technology. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

All Phase II awardees must have a Defense Contract Audit Agency (DCAA) approved accounting system. It is strongly urged that an approved accounting system be in place prior to the MDA Phase II award timeframe. If you do not have a DCAA approved accounting system, this will delay/prevent Phase II contract award. Please visit <https://www.dcaa.mil/Customers/Small-Business> for more information on obtaining a DCAA approved accounting system.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

The [SBIR/STTR Policy Directive](#) allows agencies to enter into agreements with suppliers to provide technical assistance to SBIR and STTR awardees, which may include access to a network of scientists and engineers engaged in a wide range of technologies or access to technical and business literature available through on-line data bases.

All requests for TABA must be completed using the MDA SBIR/STTR Phase I TABA Form and included as a part of Volume 5 of the proposal package. MDA will not accept requests for TABA that do not utilize the MDA SBIR/STTR Phase I TABA Form or are not provided as part of Volume 5 of the Phase I proposal package.

A SBIR firm may acquire the technical assistance services described above on its own. Firms must request this authority from MDA and demonstrate in its SBIR proposal that the individual or entity selected can provide the specific technical services needed. In addition, costs must be included in the cost volume of the offeror's proposal. The TABA provider may not be the requesting firm, an affiliate of the requesting firm, an investor of the requesting firm, or a subcontractor or consultant of the requesting firm otherwise required as part of the paid portion of the research effort (e.g. research partner or research institution).

If the awardee supports the need for this requirement sufficiently as determined by the Government, MDA will permit the awardee to acquire such technical assistance, in an amount up to \$5,000 per year. This will be an allowable cost on the SBIR award. The per year amount will be in addition to the award and is not subject to any burden, profit or fee by the offeror. The per-year amount is based on the original contract period of performance and does not apply to period of performance extensions. Requests for TABA funding outside of the base period of performance (6 months) for Phase I proposal submission will not be considered.

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The purpose of this technical assistance is to assist SBIR awardees in:

1. Making better technical decisions on SBIR projects;
2. Solving technical problems that arise during SBIR projects;
3. Minimizing technical risks associated with SBIR projects; and
4. Developing and commercializing new commercial products and processes resulting from such projects including intellectual property protections.

The MDA Phase I TABA form can be accessed here:

(https://www.mda.mil/global/documents/pdf/SBIR_STTR_PHI_TABA_Form.pdf) and must be included as part of Volume 5 using the “Other” category.

EVALUATION AND SELECTION

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD SBIR Program BAA. Selections will be based on best value to the Government considering the evaluation criteria listed in the DoD SBIR Program BAA which are listed in descending order of importance.

MDA reserves the right to award none, one, or more than one contract under any topic. MDA is not responsible for any money expended by the offeror before award of any contract. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality as determined by MDA will be funded.

Please note that potential benefit to the MDS will be considered throughout all the evaluation criteria and in the best value trade-off analysis. When combined, the stated evaluation criteria are significantly more important than cost or price.

It cannot be assumed that reviewers are acquainted with the firm or key individuals or any referenced experiments. Technical reviewers will base their conclusions only on information contained in the proposal. Relevant supporting data such as journal articles, literature, including Government publications, etc., should be listed in the proposal and will count toward the applicable page limit.

AWARD AND CONTRACT INFORMATION

The MDA Contracting Office will distribute selection and non-selection email notices to all firms who submit an MDA SBIR proposal. Proposing firms will be notified of selection or non-selection status for a Phase I award within 90 days of the closing date of the BAA. The email will be distributed to the “Corporate Official” and “Principal Investigator” listed on the proposal coversheet and will originate from the sbirsttr@mda.mil email address. MDA cannot be responsible for notification to a company that provides incorrect information or changes such information after proposal submission.

MDA will provide written feedback to unsuccessful offerors regarding their proposals upon request. Requests for feedback must be submitted in writing to the MDA SBIR/STTR PMO within 30 calendar days of non-selection notification. Non-selection notifications will provide instructions for requesting proposal feedback. Only firms that receive a non-selection notification are eligible for written feedback. Refer to the DoD SBIR Program BAA for procedures to protest the announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to Tina Barnhill via email: sbirsttr@mda.mil.

AWARD AND CONTRACT INFORMATION

The Missile Defense Agency will issue all contract awards. The cognizant Government Contracting Officer is the only Government official authorized to enter into any binding agreement or contract on behalf of the Government.

Offeror Small Business Eligibility Requirements

Each offeror must qualify as a small business at time of award per the Small Business Administration's (SBA) regulations at [13 CFR 121.701-121.705](#) and certify to this in the Cover Sheet section of the proposal. Small businesses that are selected for award will also be required to submit a Funding Agreement Certification document and be registered ed with Supplier Performance Risk System <https://www.sprs.csd.disa.mil/> prior to award.

Ownership Eligibility

Prior to award, MDA may request business/corporate documentation to assess ownership eligibility as related to the requirements of SBIR/STTR Program Eligibility. These documents include, but may not be limited to, the Business License; Articles of Incorporation or Organization; By-Laws/Operating Agreement; Stock Certificates (Voting Stock); Board Meeting Minutes for the previous year; and a list of all board members and officers. If requested by MDA, the contractor shall provide all necessary documentation for evaluation prior to SBIR award. Failure to submit the requested documentation in a timely manner as indicated by MDA may result in the offeror's ineligibility for further consideration for award.

Performance Benchmark Requirements for Phase I Eligibility

MDA does not accept proposals from firms that are currently ineligible for Phase I awards as a result of failing to meet the benchmark rates at the last assessment. Additional information on Benchmark Requirements can be found in the DoD SBIR/STTR Program BAA.

References to Hardware, Computer Software, or Technical Data

In accordance with the SBIR/STTR Policy Directive, SBIR/STTR contracts are to conduct feasibility-related experimental or theoretical R/R&D related to described agency requirements. The purpose for Phase I is to determine the scientific and technical merit and feasibility of the proposed effort.

It is not intended for any formal end-item contract delivery and ownership by the Government of your hardware, computer software, or technical data. As a result, your technical proposal should not contain any reference to the term "Deliverables" when referring to your hardware, computer software, or technical data. Instead use the term: "Products for Government Testing, Evaluation, Demonstration, and/or possible destructive testing."

The standard formal deliverables for a Phase I are the:

- A001: Report of Invention(s), Contractor, and/or Subcontractor(s) // Patent Application for Invention
- A002: Status Report // Phase I Bi-monthly Status Report
- A003: Contract Summary Report // Phase I Final Report
- A004: Certification of Compliance // SBIR Funding Agreement Certification - Life Cycle Certification
- A005: Computer Software Product // Product Description
- A006: Technical Report - Study Services // Prototype Design and Operation Document

FAR 52.203-5 Covenant Against Contingent Fees

As prescribed in [FAR 3.404](#), the following [FAR 52.203-5](#) clause shall be included in all contracts awarded under this BAA:

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(a) The Contractor warrants that no person or agency has been employed or retained to solicit or obtain this contract upon an agreement or understanding for a contingent fee, except a bona fide employee or agency. For breach or violation of this warranty, the Government shall have the right to annul this contract without liability or to deduct from the contract price or consideration, or otherwise recover, the full amount of the contingent fee.

(b) Bona fide agency, as used in this clause, means an established commercial or selling agency, maintained by a contractor for the purpose of securing business, that neither exerts nor proposes to exert improper influence to solicit or obtain Government contracts nor holds itself out as being able to obtain any Government contract or contracts through improper influence.

"Bona fide employee," as used in this clause, means a person, employed by a contractor and subject to the contractor's supervision and control as to time, place, and manner of performance, who neither exerts nor proposes to exert improper influence to solicit or obtain Government contracts nor holds out as being able to obtain any Government contract or contracts through improper influence.

"Contingent fee," as used in this clause, means any commission, percentage, brokerage, or other fee that is contingent upon the success that a person or concern has in securing a Government contract.

"Improper influence," as used in this clause, means any influence that induces or tends to induce a Government employee or officer to give consideration or to act regarding a Government contract on any basis other than the merits of the matter.

ADDITIONAL INFORMATION

Federally Funded Research and Development Centers (FFRDCs) and Support Contractors

Only Government personnel with active non-disclosure agreements will evaluate proposals. Non-Government technical consultants (consultants) to the Government may review and provide support in proposal evaluations during source selection. Consultants may have access to the offeror's proposals, may be utilized to review proposals, and may provide comments and recommendations to the Government's decision makers. Consultants will not establish final assessments of risk and will not rate or rank offerors' proposals. They are also expressly prohibited from competing for MDA SBIR awards in the SBIR topics they review and/or on which they provide comments to the Government.

All consultants are required to comply with procurement integrity laws. Consultants will not have access to proposals or pages of proposals that are properly labeled by the offerors as "Government Only." Pursuant to [FAR 9.505-4](#), the MDA contracts with these organizations include a clause which requires them to (1) protect the offerors' information from unauthorized use or disclosure for as long as it remains proprietary and (2) refrain from using the information for any purpose other than that for which it was furnished. In addition, MDA requires the employees of those support contractors that provide technical analysis to the SBIR/STTR Program to execute non-disclosure agreements. These agreements will remain on file with the MDA SBIR/STTR PMO.

Non-Government consultants will be authorized access to only those portions of the proposal data and discussions that are necessary to enable them to perform their respective duties. In accomplishing their duties related to the source selection process, employees of the aforementioned organizations may require access to proprietary information contained in the offerors' proposals.

SBA Company Registry

Per the SBIR/STTR Policy Directive, all applicants are required to register their firm at SBA's Company Registry prior to submitting a proposal. Upon registering, each firm will receive a unique control ID to be

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used for submissions at any of the eleven (11) participating agencies in the SBIR or STTR program. For more information, please visit the SBA's Firm Registration Page: <http://www.sbir.gov/registration>.

Organization Conflicts of Interest (OCI) and Unfair Competitive Advantage

The basic OCI rules for Contractors which support development and oversight of SBIR topics are covered in FAR 9.5 as follows (the Offeror is responsible for compliance):

- (1) the Contractor's objectivity and judgment are not biased because of its present or planned interests which relate to work under this contract;
- (2) the Contractor does not obtain unfair competitive advantage by virtue of its access to non-public information regarding the Government's program plans and actual or anticipated resources; and
- (3) the Contractor does not obtain unfair competitive advantage by virtue of its access to proprietary information belonging to others.

All applicable rules under the FAR Section 9.5 apply.

If you, or another employee in your company, developed or assisted in the development of any SBIR requirement or topic, please be advised that your company may have an OCI. Your company could be precluded from an award under this Broad Agency Announcement (BAA) if your proposal contains anything directly relating to the development of the requirement or topic. Before submitting your proposal, please examine any potential OCI issues that may exist with your company to include subcontractors and understand that if any exist, your company may be required to submit an acceptable OCI mitigation plan prior to award.

In addition, FAR 3.101-1 states that Government business shall be conducted in a manner above reproach and, except as authorized by statute or regulation, with complete impartiality and with preferential treatment for none. The general rule is to avoid strictly any conflict of interest or even the appearance of a conflict of interest in Government-contractor relationships. An appearance of impropriety may arise where an offeror may have gained an unfair competitive advantage through its hiring of, or association with, a former Government official if there are facts indicating the former Government official, through their former Government employment, had access to non-public, competitively useful information. (See *Health Net Fed. Svcs*, B-401652.3; *Obsidian Solutions Group, LLC*, B-417134, 417134.2). The existence of an unfair competitive advantage may result in an offeror being disqualified and this restriction cannot be waived.

It is MDA policy to ensure all appropriate measures are taken to resolve OCI's arising under FAR 9.5 and unfair competitive advantages arising under FAR 3.101-1 to prevent the existence of conflicting roles that might bias a contractor's judgment and deprive MDA of objective advice or assistance, and to prevent contractors from gaining an unfair competitive advantage.

Use of Foreign Nationals (also known as Foreign Persons), Green Card Holders, and Dual Citizens

See the "Foreign Nationals" section of the DoD SBIR Program announcement for the definition of a Foreign National (also known as Foreign Persons).

ALL offerors proposing to use foreign nationals, green-card holders, or dual citizens, MUST disclose this information regardless of whether the topic is subject to export control restrictions. Identify any foreign nationals or individuals holding dual citizenship expected to be involved on this project as a direct employee, subcontractor, or consultant. For these individuals, please specify their

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country of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project. You may be asked to provide additional information during negotiations in order to verify the foreign citizen's eligibility to participate on a SBIR contract. Supplemental information provided in response to this paragraph will be protected in accordance with the Privacy Act (5 U.S.C. 552a), if applicable, and the Freedom of Information Act (5 U.S.C. 552(b)(6)).

Proposals submitted to export control-restricted topics and/or those with foreign nationals, dual citizens, or green card holders listed will be subject to security review during the contract negotiation process (if selected for award). MDA reserves the right to vet all un-cleared individuals involved in the project, regardless of citizenship, who will have access to Controlled Unclassified Information (CUI) such as export controlled information. If the security review disqualifies a person from participating in the proposed work, the contractor may propose a suitable replacement. In the event a proposed person and/or firm is found ineligible by the Government to perform proposed work, the contracting officer will advise the offeror of any disqualifications but is not required to disclose the underlying rationale.

Export Control Restrictions

The technology within most MDA topics is restricted under export control regulations including the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR). ITAR controls the export and import of listed defense-related material, technical data and services that provide the United States with a critical military advantage. EAR controls military, dual-use and commercial items not listed on the United States Munitions List or any other export control lists. EAR regulates export controlled items based on user, country, and purpose. The offeror must ensure that their firm complies with all applicable export control regulations. Please refer to the following URLs for additional information: <https://www.pmddtc.state.gov/> and <https://www.bis.doc.gov/index.php/regulations/export-administration-regulations-ear>.

Most MDA SBIR topics are subject to ITAR and/or EAR. If the topic write-up indicates that the topic is subject to ITAR and/or EAR, your company may be required to submit a Technology Control Plan (TCP) during the contracting negotiation process.

Flow-Down of Clauses to Subcontractors

The clauses to which the prime contractor and subcontractors are required to comply include, but are not limited to the following clauses: MDA clause H-08 (Public Release of Information), [DFARS 252.204-7000 \(Disclosure of Information\)](#), [DFARS clause 252.204-7012 \(Safeguarding Covered Defense Information and Cyber Incident Reporting\)](#), and [DFARS clause 252.204-7020 \(NIST SP 800-171 DoD Assessment Requirements\)](#). Your proposal submission confirms that any proposed subcontract is in accordance to the clauses cited above and any other clauses identified by MDA in any resulting contract. All proposed universities will need to provide written acceptance of the Flow-Down Clauses in both SBIR and STTR proposals.

MDA Clause H-08 Public Release of Information (Publication Approval)

MDA Clause H-08 pertaining to the public release of information is incorporated into all MDA SBIR contracts and subcontracts without exception. Any information relative to the work performed by the contractor under MDA SBIR contracts must be submitted to MDA for review and approval prior to its release to the public. This mandatory clause also includes the subcontractor who shall provide their submission through the prime contractor for MDA's review for approval.

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a. In addition to the requirements of National Industrial Security Program Operations Manual (DoD 5220.22-M), all foreign and domestic contractor(s) and its subcontractors are required to comply with the following:

1) Any official MDA information/materials that a contractor/subcontractor intends to release to the public that pertains to any work under performance of this contract, the Missile Defense Agency (MDA) will perform a prepublication review prior to authorizing any release of information/materials.

2) At a minimum, these information/materials may be technical papers, presentations, articles for publication, key messages, talking points, speeches, and social media or digital media, such as press releases, photographs, fact sheets, advertising, posters, videos, etc.

b. Subcontractor public information/materials must be submitted for approval through the prime contractor to MDA.

c. Upon request to the MDA Procuring Contracting Officer (PCO), contractors shall be provided the "Request for Industry Media Engagement" form (or any superseding MDA form).

d. At least 45 calendar days prior to the desired release date, the contractor must submit the required form and information/materials to be reviewed for public release to MDAPressOperations@mda.mil, and simultaneously provide courtesy copy to the appropriate PCO.

e. All information/materials submitted for MDA review must be an exact copy of the intended item(s) to be released, must be of high quality and are free of tracked changes and/or comments. Photographs must have captions, and videos must have the intended narration included. All items must be marked with the applicable month, day, and year.

f. No documents or media shall be publically released by the Contractor without MDA Public Release approval.

g. Once information has been cleared for public release, it resides in the public domain and must always be used in its originally cleared context and format. Information previously cleared for public release but containing new, modified or further developed information must be re-submitted

Rights in Noncommercial Technical Data and Computer Software – SBIR Program (DFARS 252.227-7018)

Use this link for full description of Data Rights:

<https://www.acquisition.gov/dfars/part-252-solicitation-provisions-and-contract-clauses#DFARS-252.227-7018>

Fraud, Waste, and Abuse

All offerors must complete the fraud, waste, and abuse training (Volume 6) that is located on DSIP (<https://www.dodsbirsttr.mil>). Please follow guidance provided on DSIP to complete the required training.

To Report Fraud, Waste, or Abuse, Please Contact:

MDA Fraud, Waste & Abuse

Hotline: (256) 313-9699

MDAHotline@mda.mil

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DoD Inspector General (IG) Fraud, Waste & Abuse
Hotline: (800) 424-9098
hotline@dodig.mil

Additional information on Fraud, Waste and Abuse may be found in the DoD Instructions of this announcement.

Proposal Submission

All proposals MUST be submitted online using DSIP (<https://www.dodsbirsttr.mil>). Any questions pertaining to the DoD SBIR/STTR submission system should be directed to the DoD SBIR/STTR Help Desk: DoDSBIRSupport@reisystems.com.

It is recommended that potential offerors email topic authors to schedule a time for topic discussion during the pre-release period.

Classified Proposals

Classified proposals **ARE NOT** accepted under the MDA SBIR Program. The inclusion of classified data in an unclassified proposal MAY BE grounds for the Agency to determine the proposal as non-responsive and the proposal not to be evaluated. Contractors currently working under a classified MDA SBIR contract must use the security classification guidance provided under that contract to verify new SBIR proposals are unclassified prior to submission. Phase I contracts are not typically awarded for classified work. However, in some instances, work being performed on Phase II contracts will require security clearances. If a Phase II contract will require classified work, the offeror must have a facility clearance and appropriate personnel clearances in order to perform the classified work. For more information on facility and personnel clearance procedures and requirements, please visit the Defense Counterintelligence and Security Agency Web site at: <https://www.dcsa.mil>.

Use of Acronyms

Acronyms should be spelled out the first time they are used within the technical volume (Volume 2), the technical abstract, and the anticipated benefits/potential commercial applications of the research or development sections. This will help avoid confusion when proposals are evaluated by technical reviewers.

Communication

All communication from the MDA SBIR/STTR PMO will originate from the sbirsttr@mda.mil email address. Please white-list this address in your company's spam filters to ensure timely receipt of communications from our office.

Proposal titles, abstracts, anticipated benefits, and keywords of proposals that are selected for contract award will undergo an MDA Policy and Security Review. Proposal titles, abstracts, anticipated benefits, and keywords are subject to revision and/or redaction by MDA. Final approved versions of proposal titles, abstracts, anticipated benefits, and keywords may appear on DSIP and/or the SBA's SBIR/STTR award site (<https://www.sbir.gov/sbirsearch/award/all>).

Approved for Public Release
21-MDA-11034 (20 Dec 21)

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MDA SBIR 22.1 Phase I Topic Index

MDA22-001	Advanced Manufacturing Technology for Coatings and Coating Systems
MDA22-002	Innovative Methodologies for Modeling of EO/IR Sensors in a Radiation Environment
MDA22-003	High Temperature Materials for Solid Propulsion Pintles
MDA22-004	Higher Performance Solid Propellants
MDA22-005	Substrates for High Temperature Electronics
MDA22-006	Object Detection, Tracking, and Identification in a Congested Environment Using Artificial Intelligence (AI) Enabled Algorithms
MDA22-007	Predictive Error Correction Algorithm for Hypersonic Applications
MDA22-008	Packaging High Temperature Electronics for Harsh Flight Environments
MDA22-009	Homeland Defense Interceptor Technologies
MDA22-010	Homeland Defense Weapon System Software Development Processes
MDA22-011	[TOPIC REMOVED]
MDA22-012	Ground Safing Enhancements
MDA22-013	Solid Propellant Oxidizer Alternative to Ammonium Perchlorate

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MDA22-001 TITLE: Advanced Manufacturing Technology for Coatings and Coating Systems

OUSD (R&E) MODERNIZATION PRIORITY: Space

TECHNOLOGY AREA(S): Materials

OBJECTIVE: Increase confidence in the surface treatments industrial base to provide critical coatings when necessary. Increase yield of coating processes and decrease human factors that degrade product quality.

DESCRIPTION: The Government utilizes coatings within its systems and for advanced manufacturing processes, however, coating procurement, such as electroplating, has presented risks due to the number of processing variables, the human touch-time factors, and sometimes environmental concerns. The industry struggles to advance in these areas as profit margins are often too small to justify manufacturing technology improvements.

The Government is interested in tools, techniques, systems, and/or material replacements to improve coatings manufacturing technology. Ideally, coating systems would be easier to control and environmentally safer than current market options. An example of space relevant coatings would include electroplating of precious metals. The solution would result in a higher availability of high quality coatings, either via coatings providers or as systems to be installed with Original Equipment Manufacturers (OEM)s.

One area of special interest are the dielectric or insulating coatings on tool-pieces used in electro-chemical machining (ECM). ECM appears to be a promising technique for micro-machining a large number of smooth narrow channels in the heat exchangers and injectors used in missile defense power electronic or aerospace systems. Improved coatings should not only improve the ECM precision but should also reduce ECM environmental impact by increasing tool lifetime and minimizing hazardous waste. These coatings should be very thin, uniform (without any breaks), well-adhered to the tool surface, and resistant to both applied voltages and the harsh/corrosive process environment. The Government currently envisions a non-exclusive R&D partnership between ECM suppliers and coating suppliers. ECM suppliers would provide requirements, fabricate the tool substrates, and test the coated tools during representative machining trials. Coating suppliers would prepare the tool surface, apply the coats, characterize the coats, and investigate any coating failures. Other arrangements would be considered. Advanced coatings for other micro-machining techniques that are similar to ECM would also be considered as long as it can be shown that these coatings would improve the technique's performance (for missile-defense applications), increase its commercialization prospects, and reduce its environmental footprint.

PHASE I: Establish the technical basis of the solution, with small scale validation and theoretical analysis of the effectiveness. The effort might include small scale design of experiments on test coupons and materials testing.

PHASE II: Down select any competing technologies and provide more extensive testing. If the solution purposes new apparatus, prototypes should be developed for technology demonstration.

PHASE III DUAL USE APPLICATIONS: Demonstrate the solution in relevant test environments, through collaboration with OEMs, or whoever the next higher tier user would be. The technology should be further developed for commercial applicability.

REFERENCES:

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1. <https://www.osti.gov/pages/biblio/1596174>.
2. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3928744>.
3. https://www.epa.gov/sites/default/files/2017-06/documents/electroplating_comm_info.pdf.
4. https://www.researchgate.net/publication/286774967_Study_of_coated_microtools_in_electrochemical_machining_ECM.
5. https://en.wikipedia.org/wiki/Electrochemical_machining.

KEYWORDS: Electrochemical Machining, Electro-Chemical Machining, ECM, PECM, Atomic Layer Deposition, ALD, Diamond-like Coatings, DLC, Electroplating, Metal Deposition

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MDA22-002 TITLE: Innovative Methodologies for Modeling of EO/IR Sensors in a Radiation Environment

OUSD (R&E) MODERNIZATION PRIORITY: Microelectronics; Space

TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop methodologies and techniques for first principles modeling of radiation effects on EO/IR materials in both a natural space environment and a man-made radiation environment.

DESCRIPTION: Seeking a modeling and simulation tool that will give an improved predictive capability for the assessment of microelectronic survivability in a radiation environment, in order to predict an average rate of defect formation, with the goal of determining the survivability of EO/IR detectors such as HgCdTe, or III-V materials, based on first principles. Modeling of defect formation in EO/IR detector materials in a radiation environment has been explored using molecular dynamics or density functional theory, and advances to these approaches are of interest, but new approaches may also be proposed. A methodology to bridge between analysis that can be done at very small (microscopic) length scales, and macroscopic or device-scale analysis, is also of interest.

PHASE I: Show feasibility of a modeling approach, especially the capability to predict the survivability of an EO/IR detector in a radiation environment.

PHASE II: Demonstrate a prototype modeling tool, benchmarked against test data.

PHASE III DUAL USE APPLICATIONS: Transition to defense applications modeling capabilities.

REFERENCES:

1. Schultz and Hjalmarsen, From first-principles defect chemistry to device damage models of radiation effects in III-V semiconductors, MMM 2018, Osaka, Japan, <https://www.osti.gov/biblio/1593578>.
2. Huang et al, Multi-Timescale Microscopic Theory for Radiation Degradation of Electronic and Optoelectronic Devices, American Journal of Space Science, 2015.
3. Nordland et al, Primary radiation damage: A review of current understanding and models, Journal of Nuclear Materials, 512 (2018) 450-479, <https://www.osti.gov/pages/biblio/1482433>.
4. Adams et al, The SIRE2 Toolkit, Space Weather, 18, e2019SW002364, <https://doi.org/10.1029/2019SW002364>.
5. Broberg et al, PyCDT: A Python toolkit for modeling point defects in semiconductors and insulators, Computer Physics Communications 226 (2018) 165-179.

KEYWORDS: Molecular dynamics, density functional theory, defect production in Silicon, III-V materials, HgCdTe

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MDA22-003 TITLE: High Temperature Materials for Solid Propulsion Pintles

OUSD (R&E) MODERNIZATION PRIORITY: Hypersonics

TECHNOLOGY AREA(S): Materials; Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop pintle shaft materials for use in higher temperature controllable solid propulsion systems.

DESCRIPTION: The Government desires solid propulsion systems with greater impulse and thrust for future systems. Increasing solid propellant burn temperatures, may achieve this goal but also creates thermal challenges for materials. Additionally, the combination of high temperature performance, low thermal conductivity, and high tensile strength significantly limits the selection of available materials for current pintles. This topic seeks improved materials for use in pintle shafts for controllable solid propulsion systems.

A current state of the art material used in pintles is needled carbon silicon carbide (C/SiC). Proposers may focus on improving C/SiC or propose other innovative materials, such as ceramics, metallics, multilayered composites of multiple materials, etc. This topic seeks to exceed tensile properties over existing materials while decreasing thermal conductivity. For composites, the tensile strength in the cross ply direction should be >8ksi at room temperature and >12ksi at 1,000°C. The cross ply thermal conductivity should be less than 20 W/mK at these temperatures. The material must be capable of production to at least 10cm thick. For other materials, the above properties must all be present in one direction, and the tensile strength in other directions must exceed the values stated above.

Proposers may assume that a separate material is used as a coating, cladding, or pintle tip to prevent excessive erosion of the pintle. Alternatively, unitary materials intended to make up the entire pintle shaft and tip are acceptable. Materials for coatings or claddings are outside of the scope of this topic.

PHASE I: Evaluate feasibility of proposed material concept by modeling and simulation and/or proof of concept testing. Material formulation and/or coupon fabrication is recommended to provide evaluation of critical properties. Work with solid propulsion system developers to understand environments.

PHASE II: Continue material and process development through design, analysis, and experimentation. Optimize processing parameters for yield and quality. Material testing should be conducted to validate material models and generate property databases. Demonstration in a representative environment is desired. Phase II should identify an insertion opportunity and conclude with a mature manufacturing process.

PHASE III DUAL USE APPLICATIONS: Work with a solid propulsion system manufacturer to iteratively design and fabricate prototype components for high-fidelity testing in a relevant solid rocket motor environment for current or future missile defense applications. A successful Phase III would provide the necessary technical data to transition the technology into a missile defense application.

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REFERENCES:

1. U.S. Missile Defense Agency. August 6, 2021. Missile Defense System. Retrieved from <http://www.mda.mil/index.html>.
2. George P. Sutton. 2010. "Rocket Propulsion Elements." 8th edition, John Wiley & Sons Inc.
3. James D. Beardsley. 1976. United States Patent #3,948,042, "System for Controlling the Nozzle Throat Area of a Rocket Motor."

KEYWORDS: Materials, Propulsion, Composites, Fiber Preforms

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MDA22-004 TITLE: Higher Performance Solid Propellants

OUSD (R&E) MODERNIZATION PRIORITY: Space

TECHNOLOGY AREA(S): Air Platform; Ground Sea; Materials

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop an energy dense and highly efficient solid propellant.

DESCRIPTION: Higher performing and efficient solid propellants will give maneuvering kill vehicles more delta-v for a successful intercept (in divert attitude control systems and other thrust vector control concepts) as well as faster boost phase velocities. Typical propellant performance limitations usually arise from incomplete aluminum combustion (for aluminized propellants), manufacturing casting techniques (casting voids/grain inconsistencies), total solids loading percent, and propellant ingredients. Potential propellant ingredient improvements can be in the form of binder, oxidizer, metallic fuel, catalysts or other additives, or the encompassing composition/manufacturing of the propellant. This topic seeks improvements in solid propellants for greater energy density. Applications could include multiple long-term storage environments such as ground, sea-based, or space environments. Proposers could apply improvements to propellants for traditional solid rocket boosters or high slope solid propellants for controllable systems. Proposers could offer solutions to improve traditional composite propellants or ideas in the development/exploration of non-traditional propellant chemistry (e.g. meta-stable solid propellants). Propellants should be classified as Department of Transportation (DOT) 1.3 or higher (cannot be DOT 1.1 or DOT 1.2) for safe storage on naval and air-based vessels. Propellant specific impulse should be greater than 270 seconds at sea level.

PHASE I: Evaluate feasibility of proposed propellant formulation and/or manufacturing techniques. Propellant formulation and/or coupon fabrication is recommended to provide evaluation of mechanical and performance properties to validate initial performance models. Small batches of propellant are expected to be produced and tested. Work with solid propulsion developers/experts to help further define and understand propellant requirements and performance needs.

PHASE II: Continue propellant characterization through experimentation and analysis. The contractor is expected to optimize propellant formulation and manufacturing based on experimentation results. Propellant batch sizes should be scaled up (relative to the Phase I effort) and tested. Phase II should include a hot fire test to demonstrate propellant performance parameters in a relevant environment. Phase II should identify an insertion opportunity and conclude with a matured propellant formulation/manufacturing process.

PHASE III DUAL USE APPLICATIONS: Work with solid propulsion system manufacturers/designers to implement the solid propellant formulation/manufacturing processes into a full-scale hot fire test. A successful Phase III would provide the necessary technical data to transition the technology into a missile defense application.

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REFERENCES:

1. <https://www.onlinelibrary.wiley.com/toc/15214087/2006/31/1> (Specifically pages 33-69).
2. <https://www.sciencedirect.com/science/article/abs/pii/S0010218020301735>.
3. <https://onlinelibrary.wiley.com/doi/abs/10.1002/prop.19810060502>.
4. <https://ntrs.nasa.gov/api/citations/20170012397/downloads/20170012397.pdf>.
5. <https://ntrs.nasa.gov/citations/19780005279>.

KEYWORDS: Propellant, Solid Propulsion, Chemistry, Propulsion, Space, Propellant Manufacturing

VERSION 3

MDA22-005 TITLE: Substrates for High Temperature Electronics

OUSD (R&E) MODERNIZATION PRIORITY: Hypersonics

TECHNOLOGY AREA(S): Air Platform; Sensors; Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop improved manufacturing or processing of substrate materials for high temperature electronics (HTE) to eliminate or reduce the need for cooling and all its accompanying requirements.

DESCRIPTION: Flight environments pose challenges for the state-of-the-art electronics required by missile-defense interceptors. Temperatures can surpass the MIL-STD-883 method 1011 upper range limit of 125°C. State of the art electronics are limited by the thermal capabilities of semiconductors, such as current silicon materials. Heat can have especially damaging effect on circuits that deal with higher frequencies like communications and sensors. These circuits can become distorted due to higher temperature altering impedance or interfering in other ways with functionality. A large portion of space and power is devoted to cooling or insulating the electronics. This need to cool circuits complicates designs, and can hamper performance. HTE would greatly reduce the size, weight, and power (SWaP) and complexity of the thermal management systems for these interceptors. However, integrated circuits that can withstand temperatures much higher than 125°C cannot be grown on bulk-silicon and must instead be grown on other substrates. Advanced substrate materials are very costly to grow and fashion into wafers. This topic seeks innovative ways to lower this cost in order to promote the wider adoption of HTE which would benefit the Government. Using substrate materials other than bulk-silicon would reduce the effects of heat on electronics and would be highly beneficial to many aspects of missile defense.

Proposed solutions should focus on the use of materials such as silicon carbide, gallium nitride, diamond, or high other temperature materials for wafer production in a new, innovative or novel method. Materials should be capable of operating at up to 300°C. Materials should also have improved radiation tolerance compared to current silicon material. The method should produce high yield to waste ratio, be affordable, and allow for fast wafer production methods.

PHASE I: Design and develop innovative solutions, methods, and concept for improved electronics temperature resilience. Produce paper studies, material fabrication, and/or simulations.

PHASE II: Complete a prototype substrate incorporating Government performance requirements, and demonstrate said prototype. Coordinate with the Government during prototype design and development to ensure that the delivered products will be relevant to ongoing missile defense architecture needs.

PHASE III DUAL USE APPLICATIONS: Use substrate design and or model complex electronics molded after state of the art Commercial Off-the-Shelf units.

REFERENCES:

1. “SiC Die Attach Metallurgy and Processes for Applications up to 500°C”, Ping Zheng and Wayne Johnson, IEEE Transactions on Electronics Packaging Manufacturing Technology, 2156–3950, Sep. 2011.
2. R. Wayne Johnson, Ping Zheng, Alberez Wiggins, Seymour and Leora Peltz, “High Temperature Electronics Packaging”, Proceedings of the HITEN, St Catherine's College, Oxford, UK, Sep. 17-19, 2007.
3. Virgil B. Shields, “Applications of Silicon Carbide for High Temperature Electronics and Sensors”, Mar 1, 1996, NASA Jet Propulsion Laboratory, Tech Briefs, 20, 3, P.55, ISSN 0145-319X.
4. Hypersonic Weapons and US National Security: A 21st Century Breakthrough. Speier, R., Nacouzi, G., Lee, C. A., & Moore, R. M. (2017).
5. United States, Air Force, Scientific Advisory Board. (2015, May). Technology Readiness for Hypersonic Vehicles.

KEYWORDS: Electronics, substrate, high temperature, semi-conductor, and radiation tolerance

VERSION 3

MDA22-006 TITLE: Object Detection, Tracking, and Identification in a Congested Environment Using Artificial Intelligence (AI) Enabled Algorithms

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence / Machine Learning; Network Command, Control and Communications

TECHNOLOGY AREA(S): Sensors

OBJECTIVE: Develop and validate AI-enabled algorithms and associated software capable of detecting, tracking, and identifying objects in a congested environment using data streams from radio frequency (RF) (e.g., passive, bi-static, synthetic aperture radar (SAR)) detection systems).

DESCRIPTION: This topic seeks to develop AI-enabled algorithms and associated software capable of using data streams and/or data collected by sensors to enable detection, tracking, and identification of targets in a congested environment. Software would be expected to determine position and velocity and track objects in the field of view (FOV) or field of regard (FOR) of the sensor(s). Data streams of interest are those other than the traditional RF radar sources. Applicable data streams could include commercially available data streams for example.

Ideally, the technology (AI-enabled algorithms and software) would be capable of establishing a fingerprint or signature for individual objects in a given environment through training or modeling in a controlled setting, i.e. in an area around an airport or a navigable waterway where cooperative objects are readily available and can be identified and tracked using online resources (e.g. <https://flightaware.com>, <https://www.adsbexchange.com>, and <https://www.marinetraffic.com>).

For missile defense applications, which can include air, sea, and space security around valued assets as well as defense against threats, the technology would require rapid adaptability to diverse environments and extrapolation of data available on cooperative, non-cooperative, or deliberately deceptive targets. Solutions should apply to sensors using RF data streams, such as passive, bi-static, or SAR detection systems.

PHASE I: Describe architecture and concept of operations applicable to missile defense applications and missions. Develop initial AI-enabled algorithms and describe their ability to distinguish between similar objects and to track objects of interest.

PHASE II: Develop prototype AI-enabled algorithms and associated software. Demonstrate ability of the algorithms to detect, track, and identify objects in a congested environment using available data streams, such as from commercial airport and seaport websites.

PHASE III DUAL USE APPLICATIONS: Implement the software into a missile defense relevant sensor system to demonstrate effectiveness. Sensors may be ground, sea, or space-based to detect, track, and identify threat in a congested environment. Additionally, post intercept assessment would be applicable to space-based sensors. Other civilian and commercial uses should be assessed.

REFERENCES:

1. P. Lang, X. Fu, M. Martorella, et.al, Comprehensive Survey of Machine Learning Applied to Radar Signal Processing, arXiv:2009.13702v1 [eess.SP].
2. W. M. Lees , A. Wunderlich , P. J. Jeavons, et.al, Deep Learning Classification of 3.5-GHz Band Spectrograms With Applications to Spectrum Sensing, IEEE Transactions on Cognitive Communications and Networking, Vol. 5, No. 2, June 2019.

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3. B. Yonel , E. Mason , and B. Yazici, Deep Learning for Passive Synthetic Aperture Radar, IEEE Journal of Selected Topics in Signal Processing, Vol. 12, No. 1, Feb. 2018.
4. S. Mahfouz, F. Mourad-Chehade, P. Honeine, et.al, Target tracking using machine learning and Kalman filter in wireless sensor networks, IEEE Sensors Journal, IEEE, 2014, 14 (10), pp.3715 – 3725.
5. F. Santi and D. Pastina, A Parasitic Array Receiver for ISAR Imaging of Ship Targets Using a Coastal Radar, Hindawi Publishing Corporation, International Journal of Antennas and Propagation, Vol. 2016, Art. ID 8485305. <http://dx.doi.org/10.1155/2016/8485305>.

KEYWORDS: Artificial intelligence, AI, machine learning, data fusion

VERSION 3

MDA22-007 TITLE: Predictive Error Correction Algorithm for Hypersonic Applications

OUSD (R&E) MODERNIZATION PRIORITY: Hypersonics

TECHNOLOGY AREA(S): Air Platform

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Determine best method to implement predictive algorithm for instantaneous error analysis and processing for hypersonic navigation applications.

DESCRIPTION: Hypersonic vehicles can have large inertial measurement errors due to their flight patterns and speeds. The need for rapid error correction or even predictive methods to apply adjustments in anticipation of accumulated errors is necessary to ensure flight accuracy. Use of Kalman filters is a common state of the art approach. This topic seeks software improvements beyond state of the art that can be applied to existing IMUs. Proposed solutions could focus on new algorithms, improved Kalman filter, applications of machine learning, or artificial intelligence to hypersonic navigation that would allow for more precise use of hypersonic applications in defense schemas.

Solution should be a stand-alone algorithm or solution that can be incorporated into future missile defense hardware. Solutions should increase error correction estimates by greater than 25%. Solutions should also maintain accuracy for at least 200s without GPS input at 200Hz sampling rate or higher.

PHASE I: Design and develop innovative solutions, methods, and concepts to correct or mitigate current and anticipated error in hypersonic inertial measurement units in real time. The solutions should capture the key areas for new development, suggest appropriate methods and algorithms to minimize the time intensive processes, and incorporate new technologies researched during the design and development.

PHASE II: Complete/refine a detailed algorithm incorporating Government performance requirements and current leading edge methods. Coordinate with the Government during design and development to ensure that the delivered products will be relevant to an ongoing missile defense architecture and data types and structures.

PHASE III DUAL USE APPLICATIONS: Adapt the capability from the prototype utilizing the new technologies and/or algorithms developed in Phase II into a mature, full scale, fieldable capability. Work with missile defense integrators to integrate the advancement into a missile defense system level test-bed and test in a relevant environment.

REFERENCES:

1. Dutta, P. and R. Bhattacharya. "Nonlinear Estimation of Hypersonic State Trajectories in Bayesian Framework with Polynomial Chaos." *Journal of Guidance Control and Dynamics* 33 (2010): 1765-1778.

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2. Sun, Tao & Xin, Ming. (2014). (Hypersonic Entry Vehicle State Estimation Using High-degree Cubature Kalman Filter). AIAA AVIATION 2014 -AIAA Atmospheric Flight Mechanics Conference. 10.2514/6.2014-2383.
3. G. Hu, L. Ni, B. Gao, X. Zhu, W. Wang and Y. Zhong, "Model Predictive Based Unscented Kalman Filter for Hypersonic Vehicle Navigation With INS/GNSS Integration," in IEEE Access, vol. 8, pp. 4814-4823, 2020, doi: 10.1109/ACCESS.2019.2962832.
4. C. Shen et al., "Seamless GPS/Inertial Navigation System Based on Self-Learning Square-Root Cubature Kalman Filter," in IEEE Transactions on Industrial Electronics, vol. 68, no. 1, pp. 499-508, Jan. 2021, doi: 10.1109/TIE.2020.2967671.

KEYWORDS: Kalman, filter, IMU, inertial, artificial intelligence, machine learning, algorithm, navigation error, navigation, IMU

VERSION 3

MDA22-008 TITLE: Packaging High Temperature Electronics for Harsh Flight Environments

OUSD (R&E) MODERNIZATION PRIORITY: Hypersonics; Microelectronics

TECHNOLOGY AREA(S): Materials; Sensors; Electronics; Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: This topic seeks improved materials, techniques, and processes for integrating high temperature semiconductor dies into packages and higher levels of assembly. The packaged electronics should be robust and reliable enough to operate at 300°C or greater in the very harsh flight environment experienced by a missile defense interceptor.

DESCRIPTION: The electronics onboard a missile-defense interceptor must operate in a harsh environment. In particular, these electronics could reach high temperatures due to aero-heating, self-heating, and/or proximity to a propulsion system. High temperatures degrade electrical performance and weaken the ability to withstand mechanical and chemical stresses. Conventional silicon-based electronics fail above a certain temperature. Insulation, isolation, and/or cooling could help protect these electronics, but these protective measures also complicate the interceptor's design and increases its size, weight, and power (SWaP). There are, however, emerging solutions that could extend the upper limit of operating temperature in order to minimize the need for these protective measures.

This topic seeks to contribute towards the larger goal of advancing high temperature electronics (HTEs). Numerous advancements are needed in order to further mature HTEs and promote its wider adoption for MDA applications. Of these advancements, this topic specifically focuses on the challenge of packaging HTEs for harsh flight environments.

Of particular interest is the ability to attach and connect a high-temperature die to its package. Higher levels of integration are also of interest, but to a lesser extent. There are many complex integration challenges that must be overcome in order to maintain suitable thermal, mechanical, and electrical connections across a wide range of operating temperatures.

The exact mission and application is not specified in this topic and is open to suggestion. Examples include remote sensing, control, and actuator electronics located near heat-sources such as rocket engines, divert and attitude control systems, and aero-heated control surfaces. Examples also include power transistors and radiofrequency amplifiers that self-heat and are attached to a rapidly warming heat sink. Other suggestions would be considered but should be relevant to interceptor electronics.

For the purposes of this topic, MDA seeks packaged HTEs that can operate at temperatures greater than 300°C. This temperature is assumed to be near the practical upper limit for silicon-on-insulator (SOI) electronics. SOI electronics operating at 300°C or greater would be responsive to this topic. There is a desire to operate at even higher temperatures, using advanced semiconductor materials such as silicon carbide (SiC), if suitable dies and packages are available and affordable enough to support Phase I-III goals. The packaged HTEs might be concurrently exposed to high temperatures, shock (>100 g at lower

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frequencies and >1000 g at higher frequencies), vibration (>20 g-rms), and acceleration (>50 g). Depending on the application, the HTEs might also be exposed to air, propellant, oxidizer, and/or exhaust gases. They might start at sub-zero pre-launch temperatures, at sea-level, and then rise to high temperatures at near-vacuum pressures as the interceptor rapidly ascends. The HTEs might be exposed to natural and manmade radiation. Mission durations are <30 minutes and the interceptors are not reused afterward. These requirements seem very different than commercial HTE applications and even seem more stressing than space launches.

The following questions (among others) should be considered: What is the current state of the practice for HTE and associated packaging? How is the proposed approach innovative? What are its advantages and disadvantages compared to competing alternatives? What are its limitations? What are the developmental risks and contingency plans? How would the technology be commercialized in accordance with the Phase III goals? What high-demand applications, if any, have similar requirements? What other Government-funded efforts (to mature HTEs) could this SBIR augment?

Please note that the references listed below (in no particular order) were helpful for understanding the challenges of packaging HTEs. They should not be misconstrued as describing a preferred approach, organization, or technology. They should also not be misconstrued as describing the boundaries within which proposed solutions must fall. They may, however, be used as a benchmark to compare your proposed approach against.

Please also note that the technical objectives described within this topic are negotiable and may be adjusted based on pre-release feedback.

PHASE I: The objectives of Phase I are as follows: (1) Demonstrate the feasibility and benefit of the proposed approach compared to competing approaches. (2) Build a high-fidelity model of the proposed solution and simulate its electrical performance and robustness in the intended environment. (3) Develop a detailed and executable plan for experimentation and process development in Phase II. This includes creating a complete list and schedule of all of the experiments that would be performed during Phase II. It also includes gathering quotes (with lead-times) for all required materials, equipment, and services (to include back-up suppliers). Phase I is anticipated to be mostly labor, although a small amount may go to materials in order to measure basic properties (to inform models), gain early hands-on experience, and/or demonstrate proof-of-concept. No travel to Government facilities would be required during Phase I.

PHASE II: The objectives of Phase II are as follows: (1) Execute the plan developed during Phase I. (2) Continue to improve the fidelity of the model and your capabilities to simulate performance and robustness in harsh conditions. (3) Begin developing a workflow for packaging electronics (and screening for workmanship) that could be commercialized in Phase III. The overall approach should be to produce a large number of samples and take a large number of measurements with which to validate model predictions and inform the next steps. Start simple and incrementally add complexity as confidence in the model and processes increases. Likewise, electrical and environmental tests should start as simple measurements and then progress to flight-representative functional testing during exposure to concurrent environments. Near the end of the program, quantify the limits of the technology by testing to failure. Investigate failures and determine causes. The spend rate should start at Phase I levels and increase linearly to a maximum near the end of Phase II. Major equipment purchases should be deferred until needed in order to continue progress.

PHASE III DUAL USE APPLICATIONS: The goal of Phase III is to stand-up a sustainable service to package HTEs for missile defense applications, missile defense contractors, and other US-based customers. It is unlikely that the production volumes needed for missile defense would be large enough to sustain this capability after Phase III ends. Therefore, the offeror should consider (and identify)

commercial and/or other defense applications that have similar requirements but that require larger volumes. Another possibility might be to down-market the product in order to meet the price point of customers with less stressing requirements. It is preferable that the offeror intends to provide this service themselves rather than selling or licensing the technology to another company. It is also worth noting that the focus of this SBIR is on integration, rather than the dies or packages themselves. Therefore, it would be acceptable (and in some ways preferable) for the offeror to source these items from other (preferably U.S.-based) suppliers. Other arrangements would be considered. The first flight of this technology would likely be as a redundant and nonessential component onboard a test vehicle, as part of that test vehicle's non-tactical instrumentation (i.e. telemetry package). Therefore, low SWaP and low electromagnetic emissions are crucial to avoid interfering with mission-critical systems and for allowing the packaged HTE to be collocated near existing components with which results could be compared against. Other transition pathways are possible and would be considered.

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1. P. Hagler, P. Henson and R. W. Johnson, "Packaging Technology for Electronic Applications in Harsh High-Temperature Environments," in IEEE Transactions on Industrial Electronics, vol. 58, no. 7, pp. 2673-2682, July 2011, doi: 10.1109/TIE.2010.2047832.
2. Liang-Yu Chen, Robert S. Okojie, Philip G. Neudeck, Gary W. Hunter, and Shun-Tien T. Lin, "Packaging of High Temperature SiC Based Electronics", Accessed here: <https://nepp.nasa.gov/docuploads/4AEA6FF5-2264-449C-AA1532A7EDFC931F/LiangyuChenLinks701Article.pdf>.
3. B. Hunt and A. Tooke, "High temperature electronics for harsh environments," 18th European Microelectronics & Packaging Conference, 2011, pp. 1-5.
4. McCluskey, F. Patrick; Podlesak, Thomas; Grzybowski, Richard. (1997) "High Temperature Electronics". CRC Press.

KEYWORDS: Electronics, high temperature, HTE, packaging, packages, die, attach, integration, silicon-on-insulator, SOI, silicon carbide, SiC, gallium nitride, GaN, wide bandgap, semiconductors

VERSION 3

MDA22-009 TITLE: Homeland Defense Interceptor Technologies

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence/ Machine Learning; 5G; Autonomy; Cybersecurity; Network Command, Control and Communications; Microelectronics; Space; Quantum Sciences

TECHNOLOGY AREA(S): Materials; Sensors; Electronics; Battlespace; Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop innovative interceptor technologies, capabilities, and capacity to pace present and emerging threats.

DESCRIPTION: The Government faces a growing threat of ballistic missiles and needs future interceptor missiles to quickly respond and defeat them. The goal for missile defense is to provide the capability to pace the threat. To support this goal, improved and enhanced interceptor technologies, including booster and kill vehicle component technologies such as advanced materials, structures, propulsion and controls, seeker technology, guidance and navigation, and communications are desired. The innovative technologies include methods to decrease weight and improve fabrication methods that will improve capabilities and increase flight velocity and range. In order to meet the desired performance, these technologies will need to withstand natural and nuclear environments as well as dynamic and thermal environmental requirements.

This topic seeks technologies that improve reliability, lethality, sustainability, and survivability. Note survivability includes lightning, radiation, and thermal protection. In the midcourse when reentry vehicles, penetration aids, and decoys are deployed, discrimination is key. Technologies or capabilities which provide enhanced discrimination and reduce the number of called lethal objects are desired.

PHASE I: Develop conceptual, technical approaches that improve the reliability, lethality, sustainability, and survivability of booster and kill vehicle components and increase interceptor capability and capacity to mitigate threats. Perform trades and analysis to support the proposed design solutions. Perform bench-level testing to demonstrate the concept and an understanding of the new, innovative technology.

PHASE II: Develop and refine the proposed solution. The Phase I concept will be validated by development and demonstration tests to ensure performance objectives are met. The effort should result in a solution that can be transitioned in Phase III and/or can show substantial commercialization potential.

PHASE III DUAL USE APPLICATIONS: Conduct engineering and manufacturing development, test, evaluation in a realistic system environment or in a system level test-bed. The various technologies and models should have applicability to the defense industry as well as other application such as commercial space flight.

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1. R. Lloyd. 2001. "Physics of Direct Hit and Near Miss Warhead Technology." American Institute of Aeronautics and Astronautics.
2. National Research Council of the National Academies. 2012. "Making Sense of Ballistic Missile Defense: An Assessment of Concepts and Systems for U.S. Boost-Phase Missile Defense in Comparison to Other Alternatives."
3. Department of Defense. December 10, 2007. MIL-STD-461F, Department of Defense Interface Standard: Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment.
4. James R. Schwank, Marty R. Shaneyfelt, and Paul E. Dodd, "Radiation Hardness Assurance Testing of Microelectronic Devices and Integrated Circuits: Radiation Environments, Physical Mechanisms, and Foundations for Hardness Assurance," IEEE Transactions on Nuclear Science, Vol. 60, No. 3, June 2013.

KEYWORDS: Cybersecurity, LWIR, Long-wave, Infrared, FPA, Detector, Solid Propulsion, Propulsion Components, Solid Component Geometries, Additive Manufacturing, Electronics Testing, Metamaterial, Power, Converter, DC-DC, Space, Radiation, Rad Hard, Reliability, Radi

VERSION 3

MDA22-010 TITLE: Homeland Defense Weapon System Software Development Processes

OUSD (R&E) MODERNIZATION PRIORITY: Network Command, Control and Communications; Autonomy

TECHNOLOGY AREA(S): Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a software development approach that leverages modernized tools, methods and technology that is efficient, repeatable and streamlined to meet mission goals in a Development, Security and Operations (DEVSECOPS) environment.

DESCRIPTION: The goal for missile defense is to provide capabilities to pace the threat and support new threat classes. To meet this goal, the Government is seeking innovative software development concepts to apply to future homeland defense weapon system software development processes to include enhanced automated software development qualification testing capabilities for rapid deployment of high quality and cyber-secured capabilities to the warfighter. A conceptual approach that leverages modernized tools, methods and technology that is efficient, repeatable and streamlined to meet mission goals is desired. The concept would need to include all supporting assumptions and documentation.

PHASE I: Develop conceptual technical approaches for conducting DEVSECOPS when there are weapon system performance requirements. This will include assumptions and conceptual architecture to inform how weapon system performance testing can be accomplished via DEVSECOPS automated tests.

PHASE II: Develop and refine the proposed solution. Validate by development and demonstration tests to ensure performance objectives are met. The effort should result in a solution that can be transitioned in Phase III.

PHASE III DUAL USE APPLICATIONS: Refine the phase II solution. Conduct software engineering and demonstrate automated test and evaluation in a realistic system environment for related performance requirements.

REFERENCES:

1. DOD-Enterprise-DEVSECOPS-2.0-Strategy-Guide: <https://software.af.mil/wp-content/uploads/2021/05/DoD-Enterprise-DevSecOps-2.0-Strategy-Guide.pdf>.
2. DOD Enterprise DEVSECOPS Reference Design Version 1.0 12 August 2019: https://dodcio.defense.gov/Portals/0/Documents/DoD%20Enterprise%20DevSecOps%20Reference%20Design%20v1.0_Public%20Release.pdf.

KEYWORDS: Development, Security, Operations

MDA22-011 [TOPIC REMOVED]

VERSION 3

MDA22-012 TITLE: Ground Safing Enhancements

OUSD (R&E) MODERNIZATION PRIORITY: Network Command, Control and Communications; Autonomy

TECHNOLOGY AREA(S): Information Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop innovative technologies, capabilities, and capacity to provide ground safing alternatives for the interceptor to allow remote enabling/disabling of the missile fields while maintaining physical inhibit and safety requirements.

DESCRIPTION: The Ground Safing Device (GSD) provides the physical inhibit required to prevent unintended arming of the interceptor stage 1 motor. The GSD is a separate, physically isolated system from the operational command and control system. Currently the GSD requires a warfighter who is physically located at the readiness and control center at each site to manually enable/disable the GSD to allow for launch/safing of an interceptor complex. Safety also requires that the GSD remain in the last selected state after failure of any GSD system component or power loss. This presents operational concerns for the warfighter. An analysis into possible enhancements to the current GSD Concept of Operations (CONOPS) and design is needed. Enhancements should consider increasing reliability of the present system, allowing for remote enabling of the GSD at all sites from each Mission Operator command center (Fort Greely Alaska and Colorado Springs) and investigating methods for ensuring interceptor launch capability in the event of a GSD failure.

PHASE I: Develop conceptual, technical approaches that provide alternatives to present GSD CONOPS while maintaining safety considerations regarding inadvertent launch (i.e.; one physical launch inhibit). Improve the availability of the GSD by incorporating Mission Operator desire for remote GSDenabling at the Command and Control centers and to investigate methods for ensuring GSD failures do not preclude ability to launch. Perform trades and analysis to support the proposed design solutions. Perform bench-level testing to demonstrate the concept and an understanding of the new, innovative technology.

PHASE II: Develop and refine the proposed solution. The Phase I concept will be validated by development and demonstration tests to ensure performance objectives are met. The effort should result in a solution that can be transitioned in Phase III and/or can show substantial commercialization potential.

PHASE III DUAL USE APPLICATIONS: Conduct engineering and manufacturing development, test, evaluation in a realistic system environment or in a system level test-bed. The various technologies and models should have applicability to the defense industry as well as other applications for related missile defense and offense programs.

REFERENCES:

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1. Air Force Space Command Manual 91-710, Volume 3, 15 May 2019. Range Safety User Requirements Manual Volume 3 – Launch Vehicles, Payloads, And Ground Support Systems Requirements.
2. Military Standard System Safety Program Requirements MIL-STD-882C 19 Jan 1993.

KEYWORDS: Safety, Inhibit, Ground Safing Device

VERSION 3

MDA22-013 TITLE: Solid Propellant Oxidizer Alternative to Ammonium Perchlorate

OUSD (R&E) MODERNIZATION PRIORITY: Hypersonics

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Identify, develop, and demonstrate a solid propellant oxidizer alternative to Ammonium Perchlorate (AP).

DESCRIPTION: State-of-the-art composite solid propellants commonly use AP as an oxidizer. An alternative oxidizer to AP is needed to address potential future supply chain risk, and provide future missile systems increased performance while meeting Insensitive Munitions (IM) requirements set forth by 10 USC § 2389.

This topic seeks to develop and demonstrate an alternative oxidizer to AP in a solid propellant formulation with equal or greater performance (e.g. density-specific impulse) when compared to a typical AP/hydroxyl-terminated polybutadiene/aluminum composite propellant. Solutions must primarily address an AP alternative, but may also include changes to other constituents of the propellant formulation to compensate for performance differences associated with the oxidizer, if any.

Propellants formulated with the developmental oxidizer must achieve Hazard Classification 1.3C or better (less sensitive) and be able to pass the following standardized IM test parameters and passing criteria as defined by MIL-STD-2105D and associated NATO Standardization Agreement (STANAG): Fast Cook-off (STANAG 4240); Slow Cook-off (STANAG 4382); Bullet Impact (STANAG 4241); High-Velocity Fragment Impact (STANAG 4496); Sympathetic Detonation (STANAG 4396).

PHASE I: Develop a proof-of-concept solution; identify candidate oxidizer and conduct analyses for predicted performance and sensitivity for both the individual oxidizer ingredient and a composite propellant utilizing the candidate oxidizer. Perform initial sensitivity screening (electrostatic discharge, friction, shock, etc.) for the oxidizer. Results will be documented for Phase II.

PHASE II: Expand on Phase I results by producing oxidizer in sufficient quantity to fully characterize oxidizer sensitivity (making sure to consider potential increased sensitivity as a function of particle size), and formulate into a composite solid propellant. Demonstrate performance of propellant (via strand-burn burn rate and small scale motor hot-fire test). Demonstrate ability of propellant cast into a motor to pass the aforementioned IM tests, specifically slow cook-off and bullet impact. Manufacturing and quality control processes should be identified to minimize batch-to-batch variability.

PHASE III DUAL USE APPLICATIONS: The developed solution should have direct insertion potential into missile defense systems. Conduct engineering and manufacturing development, test, evaluation, qualification. Demonstration would include, but not limited to, demonstration in a real system or operation in a system level test-bed with insertion planning for a missile defense interceptor.

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REFERENCES:

1. US Insensitive Munitions Policy Update, DTIC.
2. MIL-STD-2105D.
3. Yang, Brill, and Ren, “Solid Propellant Chemistry Combustion and Motor Interior Ballistics.”
4. George P. Sutton, “Rocket propulsion Elements; Introduction to Engineering of Rockets” 7th edition, John Willey & Sons, 2001.

KEYWORDS: Insensitive Munitions, Propellant, Oxidizer, Propulsion, cook-off, bullet impact

(Topics) Approved for Public Release
21-MDA-10965 (21 Sep 21)

VERSION 2

NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY (NGA) 22.1 Small Business Innovation Research (SBIR) Phase I Proposal Submission Instructions

INTRODUCTION

The National Geospatial-Intelligence Agency (NGA) has a responsibility to provide the products and services that decision makers, warfighters, and first responders need, when they need it most. As a member of the Intelligence Community and the Department of Defense, NGA supports a unique mission set. We are committed to acquiring, developing and maintaining the proper technology, people and processes that will enable overall mission success.

Geospatial intelligence, or GEOINT, is the exploitation and analysis of imagery and geospatial information to describe, assess and visually depict physical features and geographically referenced activities on the Earth. GEOINT consists of imagery, imagery intelligence and geospatial information.

With our unique mission set, NGA pursues research that will help guarantee the information edge over potential adversaries. Additional information pertaining to the National Geospatial-Intelligence Agency's mission can be obtained by viewing the website at <http://www.nga.mil/>.

Proposers responding to a topic in this BAA must follow all general instructions provided in the Department of Defense (DoD) SBIR Program BAA. NGA requirements in addition to or deviating from the DoD Program BAA are provided in the instructions below.

Specific questions pertaining to the administration of the SBIR Program and these proposal preparation instructions should be directed to:

National Geospatial-Intelligence Agency
Attn: SBIR Program Manager, RA, MS: S75-RA
7500 GEOINT Dr., Springfield, VA 22150-7500
Email: SBIR@nga.mil

PHASE I PROPOSAL GUIDELINES

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD SBIR Program BAA.

Technical Volume (Volume 2)

The technical volume is not to exceed 20 pages and must follow the formatting requirements provided in the DoD SBIR Program BAA. The Government will not consider pages in excess of the page count limitations. Number all pages of your proposal consecutively.

Content of the Technical Volume

Refer to the DoD SBIR Program BAA for detailed instructions on the content of the technical volume.

Cost Volume (Volume 3)

The Phase I Base amount must not exceed \$100,000 over a period of performance not exceeding 9 months.

VERSION 2

Company Commercialization Report (CCR) (Volume 4)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR Program BAA for full details on this requirement. Information contained in the CCR will not be considered by NGA during proposal evaluations.

Supporting Documents (Volume 5)

In addition to the Volume 5 requirements listed in the DoD SBIR Program BAA, the vendor may submit supporting documents (Volume 5) but that material WILL NOT be reviewed by the evaluation team as part of the proposal evaluation. Items that may go into, not all inclusive, are additional cost proposal information, advocacy letters, etc.

PHASE II PROPOSAL GUIDELINES

Phase II proposals may only be submitted by Phase I awardees. Phase II is the demonstration of the technology found feasible in Phase I. All NGA SBIR Phase I awardees from this BAA will be allowed to submit a Phase II proposal for evaluation and possible selection. To minimize the gap between the Phase I and Phase II, it is suggested that the vendor submit their proposal during month 7 of the Phase I award.

The NGA SBIR Program is committed to minimizing the funding gap between Phase I and Phase II activities. Phase I awardees may submit a Phase II proposal without invitation; However, it is strongly encouraged that an UNCLASSIFIED Phase II proposal not be submitted until sufficient Phase I progress can be evaluated and assessed based on results of the Phase I proof-of-concept/feasibility study Work Plan. Therefore, it is highly recommended to submit your UNCLASSIFIED proposal 60 days prior to the end date of their Phase I contract in order to be considered for funding. All NGA SBIR Phase II proposals will receive a timely review.

Due to limited funding, the NGA SBIR Program reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

NGA typically provides a firm fixed price contract as a Phase II award. The type of contract is at the discretion of the Contracting Officer.

Initial Phase II proposals shall be limited to \$1,000,000 over a two-year period with a Period of Performance not exceeding 24 months.

Small businesses submitting a Phase II Proposal must use the DoD SBIR electronic proposal submission system (<https://www.dodsbirsttr.mil/submissions/>). This site contains step-by-step instructions for the preparation and submission of the Proposal Cover Sheets, the Company Commercialization Report, the Cost Volume, and how to upload the Technical Volume. For general inquiries or problems with proposal electronic submission, contact the DoD SBIR/STTR Help Desk at DoDSBIRSupport@reisystems.com.

The Phase II Technical Volume has a 40-page limit including: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes) and any attachments. Do not include blank pages, duplicate the electronically generated Cover Sheets or put information normally associated with the Technical Volume in other sections of the proposal as these will count toward the 40-page limit.

- **Proposal Cover Sheet (Volume 1):** The Cover Sheet must include a brief technical abstract of no more than 200 words that describes the proposed R&D project with a discussion of anticipated benefits and potential commercial applications. Do not include proprietary or classified information in the Proposal Cover Sheet. If your proposal is selected for award, the technical abstract and discussion of anticipated benefits may be publicly released.

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- **Format of Technical Volume (Volume 2):** The Technical Volume must be a single Portable Document Format (PDF) file, including graphics. Perform a virus check before uploading the Technical Volume file. If a virus is detected, it may cause rejection of the proposal. Do not lock or encrypt the uploaded file. Do not include or embed active graphics such as videos, moving pictures, or other similar media in the document. The length of each part of the technical volume is limited to 40 pages. The Government will not consider pages in excess of the page count limitations. Number all pages of your proposal consecutively. Font size should not be smaller than 12 pitch Times New Roman font, with at least a one-inch margin on top, bottom, and sides, on 8½” by 11” paper. The header on each page of the Technical Volume should contain your company name, topic number, and proposal number assigned by DSIP when the Cover Sheet was created. The header may be included in the one-inch margin.
 - (1) Significance of the Problem. Define the specific technical problem or opportunity addressed and its importance.
 - (2) Phase II Technical Objectives. Enumerate the specific objectives of the Phase II work, and describe the technical approach and methods to be used in meeting these objectives.
 - (3) Phase II Statement of Work. The statement of work should provide an explicit, detailed description of the Phase II approach, indicate what is planned, how and where the work will be carried out, a schedule of major events and the final product to be delivered. The methods planned to achieve each objective or task should be discussed explicitly and in detail. This section should be a substantial portion of the total proposal. Include how and where the work will be carried out, a schedule of major events and the final product to be delivered. The methods planned to achieve each objective or task should be discussed explicitly and in detail.
 - (4) Section 508 Compliance: The contractor shall ensure that all systems, hardware, software, software engineering, and information technology associated with this effort is made in a manner that is accessible for people with the standards for people with disabilities as directed in the NGA Instruction 8400.4 and Section 508 of the Rehabilitation Act of 1973 as amended in 1998 (Section 508). Specifically, all Information and Communications Technology (ICT) associated with this contract, may use the Web Content Accessibility Guidelines (WCAG) 2.1 to comply with the Section 508 or use alternative designs or technologies which result in substantially equivalent or greater access to and use of the product for people with disabilities. Furthermore, the contractor shall pursue human centered design and usability guidelines in order to ensure that all services associated with this Topic Area are accessible by as many users as possible and as a means to drive modernization, innovation, and enhance mission support. **As part of the vendor’s proposal, the vendor should include an outline specifically how Section 508 compliance will be achieved in the design of the ICT product. The proposal for Phase 2 should provide an explicit, detailed description of the approach, indicate what is planned, how and where the work will be carried out, a schedule of major events, how the solution will be Section 508 Compliant, and the final product to be delivered. The methods planned to achieve each objective or task should be discussed explicitly and in detail. If a determination is made that a Section 508 exception request is justified, the rationale for the exception request must be made and submitted as a part of the proposal.**
 - (5) Related Work. Describe significant activities directly related to the proposed effort, including any conducted by the Principle Investigator (PI), the proposer, consultants or others. Describe how these activities interface with the proposed project and discuss any planned coordination with outside sources. The proposal must persuade reviewers of the proposer's awareness of the state of the art in the specific topic. Describe previous work not directly related to the proposed effort but similar. Provide the following: (1) short

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- description, (2) client for which work was performed (including individual to be contacted and phone number) and (3) date of completion.
- (6) Relationship with Future Research or Research and Development. State the anticipated results of the proposed approach if the project is successful. ii. Discuss the significance of the Phase II effort in providing a foundation for Phase III research and development or commercialization effort.
 - (7) Key Personnel. Identify key personnel who will be involved in the Phase II effort including information on directly related education and experience. A concise resume of the PI, including a list of relevant publications (if any), must be included. All resumes count toward the page limitation.
 - (8) Foreign Citizens. Identify any foreign nationals you expect to be involved on this project.
 - (9) Facilities/Equipment. Describe available instrumentation and physical facilities necessary to carry out the Phase I effort. Items of equipment to be purchased (as detailed in the cost proposal) shall be justified under this section. If proposing to perform classified activities during the period of performance you need to provide the following: 1) Will the information include controlled unclassified information (CUI) and; 2) What unclassified IT systems will be required.
 - (10) Subcontractors/Consultants. Involvement of a university or other subcontractors or consultants in the project may be appropriate. If such involvement is intended, it should be identified and described according to the Cost Breakdown Guidance. Please refer to section 4.2 of this BAA for detailed eligibility requirements as it pertains to the use of subcontractors/consultants.
 - (11) Prior, Current or Pending Support of Similar Proposals or Awards. If a proposal submitted in response to this is substantially the same as another proposal that was funded, is now being funded, or is pending with another Federal Agency, or another or the same DoD Component, you must reveal this on the Proposal Cover Sheet and provide the following information: a) Name and address of the Federal Agency(s) or DoD Component to which a proposal was submitted, will be submitted, or from which an award is expected or has been received. b) Date of proposal submission or date of award. c) Title of proposal. d) Name and title of the PI for each proposal submitted or award received. e) Title, number, and date of BAA(s) or solicitation(s) under which the proposal was submitted, will be submitted, or under which award is expected or has been received. f) If award was received, state contract number. g) Specify the applicable topics for each proposal submitted or award received. Note: If this does not apply, state in the proposal "No prior, current, or pending support for proposed work."
 - (12) Commercialization Strategy. NGA is equally interested in dual use commercialization of SBIR/STTR projects that result in products sold to the U.S. military, the private sector market, or both. NGA expects explicit discussion of key activities to achieve this result in the commercialization strategy part of the proposal. The Technical Volume of each Direct to Phase I proposal must include a commercialization strategy section. The Phase I commercialization strategy shall not exceed 5 pages. The commercialization strategy should include the following elements:
 - a) Problem or Need Statement. Briefly describe what you know of the problem, need, or requirement, and its significance relevant to a Department of Defense application and/or a private sector application that the SBIR/STTR project results would address.
 - b) Description of Product(s) and/or System Application(s). Identify the commercial product(s) and/or DoD system(s), or system(s) under development, or potential new system(s). Identify the potential DoD end users, Federal customers, and/or private sector customers who would likely use the technology.

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- c) Business Model(s)/Procurement Mechanism(s). Discuss your current business model hypothesis for bringing the technology to market. Describe plans to license, partner, or self-produce your product. How do you plan to generate revenue? Understanding NGA's goal of creating and sustaining a U.S. military advantage, describe how you intend to develop your product and supply chains to enable this differentiation.
 - d) Target Market. Describe the market and customer sets you propose to target, their size, their growth rate, and their key reasons they would consider procuring the technology. Describe competing technologies existent today on the market as well as those being developed in the lab.
 - e) Funding Requirements. Describe your company's funding history. How much external financing have you raised? Describe your plans for future funding sources (internal, loan, angel, venture capital, etc.).
 - f) Commercialization Risks. Describe the major technology, market and team risks associated with achieving successful transition of the NGA funded technology. NGA is not afraid to take risks but we want to ensure that our awardees clearly understand the risks in front of them.
 - g) Expertise/Qualifications of Team/Company Readiness. Describe the expertise and qualifications of your management, marketing/business development and technical team that will support the transition of the technology from the prototype to the commercial market and into government operational environments. Has this team previously taken similar products/services to market? If the present team does not have this needed expertise, how do you intend to obtain it? What is the financial history and health of your company (e.g., availability of cash, profitability, revenue growth, etc.)?
- **Format of Cost Volume (Volume 3):** The Cost Volume (and supporting documentation) DOES NOT count toward the page limit of the Technical Volume. Some items in the Cost Breakdown Guidance below may not apply to the proposed project. If such is the case, there is no need to provide information on each and every item. ALL proposed costs should be accompanied by documentation to substantiate how the cost was derived. For example, if you proposed travel cost to attend a project-related meeting or conference, and used a travel website to compare flight costs, include a screen shot of the comparison. Similarly, if you proposed to purchase materials or equipment, and used the internet to search for the best source, include your market research for those items. You do not necessarily have to propose the cheapest item or supplier, but you should explain your decision to choose one item or supplier over another. It's important to provide enough information to allow contracting personnel to understand how the proposer plans to use the requested funds. If selected for award, failure to include the documentation with your proposal will delay contract negotiation, and the proposer will be asked to submit the necessary documentation to the Contracting Officer to substantiate costs (e.g., cost estimates for equipment, materials, and consultants or subcontractors). It is important to respond as quickly as possible to the Contracting Officer's request for documentation. Cost Breakdown Guidance:
 - List all key personnel by name as well as by number of hours dedicated to the project as direct labor.
 - Special tooling and test equipment and material cost may be included. The inclusion of equipment and material will be carefully reviewed relative to need and appropriateness for the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the Government and should be related directly to the specific topic. These may include such items as innovative instrumentation and/or automatic test equipment. Title to property furnished by the Government or acquired with Government funds will be vested with NGA; unless it is

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determined that transfer of title to the contractor would be more cost effective than recovery of the equipment by NGA.

- Cost for travel funds must be justified and related to the needs of the project.
- Cost sharing is permitted for proposals under this announcement; however, cost sharing is not required nor will it be an evaluation factor in the consideration of a proposal.
- All subcontractor costs and consultant costs must be detailed at the same level as prime contractor costs in regard to labor, travel, equipment, etc. Provide detailed substantiation of subcontractor costs in your cost proposal. The Supporting Documents Volume (Volume 5) may be used if additional space is needed. For more information about cost proposals and accounting standards, see the DCAA publication titled “Audit Process Overview – Information for Contractors” available at: <http://www.dcaa.mil>.
- **Company Commercialization Report (Volume 4):** See DoD SBIR Instructions on Company Commercialization Report. This material WILL NOT be reviewed by the evaluation team as part of the proposal evaluation.
- **Supporting Documents (Volume 5):** The vendor may submit supporting documents (Volume 5) but that material WILL NOT be reviewed by the evaluation team as part of the proposal evaluation. Items that may go into, not all inclusive, are additional cost proposal information, Completed Form SF326, advocacy letters, etc.
- **Fraud, Waste and Abuse Training (Volume 6):** See DoD SBIR Instructions on Fraud, Waste and Abuse Training. This material WILL NOT be reviewed by the evaluation team as part of the proposal evaluation.

Selection of Phase II proposals will be in accordance with the evaluation procedures and criteria discussed in this BAA (refer to Section 6.0 of the BAA). As part of subfactor c in the evaluation criteria, the vendor will be evaluated on how it addresses the following five questions on the overall commercialization strategy:

- (1) What is the first product that this technology will go into?
- (2) Who will be the customers, and what is the estimated market size?
- (3) How much money will be needed to bring the technology to market, and how will that money be raised?
- (4) Does the company contain marketing expertise and, if not, how will that expertise be brought into the company?
- (5) Who are the proposing firm’s competitors, and what is the price and/or quality advantage over those competitors?

A work breakdown structure that shows the number of hours and labor category broken out by task and subtask, as well as the start and end dates for each task and subtask, shall be included.

Phase II contracts shall include a requirement to produce a monthly status and financial reports, an interim report not later than 12 months after contract award, a prototype demonstration not later than 23 months after contract award and a final report not later than 24 months after contract award. These reports shall include the following sections:

- A summary of the results of the Phase II research to date
- A summary of the Phase II tasks not yet completed with an estimate of the completion date for each task
- A statement of potential applications and benefits of the research.
- A summary of any risks or issues

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The interim and final report shall be prepared single spaced in 12 pitch Times New Roman font, with at least a one-inch margin on top, bottom, and sides, on 8½” by 11” paper. The pages shall be numbered.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

NGA will not provide any TABA.

EVALUATION AND SELECTION

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD SBIR Program BAA. Selection of Phase I proposals will be in accordance with the evaluation procedures and criteria discussed in this BAA. As part of subfactor c in the evaluation criteria, the vendor will be evaluated on how it addresses the following five questions on the overall commercialization strategy:

- (1) What is the first product that this technology will go into?
- (2) Who will be the customers, and what is the estimated market size?
- (3) How much money will be needed to bring the technology to market, and how will that money be raised?
- (4) Does the company contain marketing expertise and, if not, how will that expertise be brought into the company?
- (5) Who are the proposing firm's competitors, and what is the price and/or quality advantage over those competitors?

Proposals not conforming to the terms of this BAA, and unsolicited proposals, will not be considered. Awards are subject to the availability of funding and successful completion of contract negotiations.

The NGA SBIR Program reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality in the judgment of the technical evaluation team will be funded. The offeror must be responsive to the topic requirements, as solicited.

Proposing firms will be notified of selection or non-selection status for a Phase I award within 90 days of the closing date of the BAA. The individual named as the Corporate Official on the Proposal Cover Sheet will receive an email for each proposal submitted from the Government Contracting Officer/Specialist with their official notification of proposal selection or non-selection. The notices will be binned into 3 categories: (1) proposals selected for award, (2) proposals selected for award, if additional funding becomes available, and (3) proposals not selected for award. Proposals with the award designation of 'Award if Additional Funding Becomes Available' will receive consideration for award 12 months from the BAA close date. An unsuccessful offeror has 3 days after notification that its proposal was not selected to submit a written request for a debriefing to the Contracting Officer (CO). Those offerors who get their written request in within the allotted timeframe above will be provided a debriefing.

Refer to the DoD SBIR Program BAA for procedures to protest the Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: Viphalac Dickover at Viphalac.C.Dickover@nga.mil.

AWARD AND CONTRACT INFORMATION

Federally Funded Research and Development Contractors (FFRDC) and other government contractors, whom have signed Non-Disclosures Agreements, may be used in the evaluation of your proposal. NGA typically provides a firm fixed price payable milestone contract for Phase I awards. The type of contract is at the discretion of the Contracting Officer.

Phase I contracts will include a requirement to produce monthly status reports, a more detailed interim report not later than 7 months after award, a final report no later than 9 months after award and any

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software/algorithms/documentation from items developed in Phase I. These reports shall include the following sections:

- A summary of the results of the Phase I research to date
- A summary of the Phase I tasks not yet completed, with an estimated completion date for each task
- A statement of potential applications and benefits of the research.
- A summary of any risks or issues

The interim report (draft final report) and final report shall be prepared single spaced in 12 pitch Times New Roman font, with at least a one-inch margin on top, bottom, and sides, on 8½” by 11” paper. The pages shall be numbered.

ADDITIONAL INFORMATION

USE OF FOREIGN NATIONALS

Due to the nature of our business, only US Nationals are permitted to work on NGA topics, unless the vendor proposes the work as Fundamental Research and indicates it as such in the proposal. The use of non-US National on a NGA contract is PROHIBITED, unless the work is scoped as Fundamental Research. If the effort is Fundamental Research, the PI must be a US National. ALL offerors proposing to use non-US Nationals (which has not been determined as Fundamental Research) on the effort will be ineligible for award. This includes the use at universities or any other subcontractor. In the event it is determined to be Fundamental Research, non-US Nationals will be ineligible to receive controlled unclassified information as described below.

CONTROLLED UNCLASSIFIED INFORMATION (CUI)

Controlled Unclassified Information (CUI) is information that requires safeguarding or dissemination controls pursuant to and consistent with applicable law, regulations, and government-wide policies but is not classified under Executive Order 13526 or the Atomic Energy Act, as amended.

Executive Order 13556 "Controlled Unclassified Information" (the Order), establishes a program for managing CUI across the Executive branch and designates the National Archives and Records Administration (NARA) as Executive Agent to implement the Order and oversee agency actions to ensure compliance. The Archivist of the United States delegated these responsibilities to the Information Security Oversight Office (ISOO).

32 CFR Part 2002 "Controlled Unclassified Information" was issued by ISOO to establish policy for agencies on designating, safeguarding, disseminating, marking, decontrolling, and disposing of CUI, self-inspection and oversight requirements, and other facets of the Program. The rule affects Federal executive branch agencies that handle CUI and all organizations (sources) that handle, possess, use, share, or receive CUI—or which operate, use, or have access to Federal information and information systems on behalf of an agency.

During performance of this contract, if the government provides the vendor a dataset that is not publicly released, the vendor must be CUI Compliant to receive it. For more information on this compliance please see DFARS Clause 252.204-7012, NIST Special Publication SP 800-171 and the National Archives and Records Administration (NARA) website (<https://www.archives.gov/cui/about>).

CERTIFICATE PERTAINING TO FOREIGN INTERESTS

Offers must submit a SF-328 in Volume 5 in order to be considered for award. If after review of the form, the offeror may be found ineligible for award if the offerors foreign interest are found to be

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unacceptable. The form can be found at <https://www.gsa.gov/forms-library/certificate-pertaining-foreign-interests>.

DISCLOSURE OF INFORMATION

(a) The Contractor shall not release to anyone outside the Contractor's organization any unclassified information, regardless of medium (e.g., film, tape, document), pertaining to any part of this contract or any program related to this contract, unless-

(1) The Contracting Officer has given prior written approval;
(2) The information is otherwise in the public domain before the date of release; or
(3) The information results from or arises during the performance of a project that involves no covered defense information (as defined in the clause at DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting) and **has been scoped and negotiated by the contracting activity with the contractor and research performer and determined in writing by the contracting officer to be fundamental research* (which by definition cannot involve any covered defense information)**, in accordance with National Security Decision Directive 189, National Policy on the Transfer of Scientific, Technical and Engineering Information, in effect on the date of contract award and the Under Secretary of Defense (Acquisition, Technology, and Logistics) memoranda on Fundamental Research, dated May 24, 2010, and on Contracted Fundamental Research, dated June 26, 2008 (available at DFARS PGI 204.4).

(b) Requests for approval under paragraph (a)(1) shall identify the specific information to be released, the medium to be used, and the purpose for the release. The Contractor shall submit its request to the Contracting Officer at least 10 business days before the proposed date for release.

(c) The Contractor agrees to include a similar requirement, including this paragraph (c), in each subcontract under this contract. Subcontractors shall submit requests for authorization to release through the prime contractor to the Contracting Officer.

***Note: This must be negotiated prior to award of the contract. A request for determination after award will not be entertained and will result in the clause being pushed down to all subcontracts. Non-performance could result in cancelation of contract.**

5X252.204-7000-90 PUBLIC RELEASE OF INFORMATION

(a) Except as provided in paragraph (b) of this clause, information pertaining to this contract shall not be released to the public unless authorized by the Contracting Officer in accordance with DFARS 252.204-7000, Disclosure of Information. Requests for approval to release information pertaining to this contract shall be submitted to the Contracting Officer by means of NGA Form 5230-1, National Geospatial-Intelligence Agency Request for Clearance for Public Release.

(b) The contractor may provide past performance information regarding this contract, without Contracting Officer approval, to the Office of the Director of National Intelligence (ODNI), the Central Intelligence Agency (CIA), the National Reconnaissance Office (NRO), the National Security Agency (NSA), the Defense Intelligence Agency (DIA), and NGA to support source selections at those agencies. The contractor is responsible for the proper classification and handling of such information and shall provide a copy of the information provided to the Contracting Officer.

5X52.227-9000 UNAUTHORIZED USE OF NGA NAME, SEAL AND INITIALS

(a) As provided in 10 U.S.C. Section 425, no person may, except with the written permission of the Director, National Geospatial-Intelligence Agency, knowingly use the words "National Geospatial-Intelligence Agency", National Imagery and Mapping Agency" or "Defense Mapping Agency", the

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initials “NGA”, “NIMA” or “DMA”, the seal of the National Geospatial-Intelligence Agency, National Imagery and Mapping Agency or the Defense Mapping Agency, or any colorable imitation of such words, initials, or seal in connection with any merchandise, retail product, impersonation, solicitation, or commercial activity in a manner reasonably calculated to convey the impression that such is approved, endorsed, or authorized by the Director, NGA.

(b) Whenever it appears to the U.S. Attorney General that any person is engaged or about to engage in an act or practice which constitutes or will constitute conduct prohibited by paragraph (a), the Attorney General may initiate a civil proceeding in a district court of the United States to enjoin such act or practice. Such court shall proceed as soon as practicable to hearing and determination of such action and may, at any time before such final determination, enter such restraining orders or prohibition, or take such other action as is warranted, to prevent injury to the United States, or to any person or class of persons whose protection the action is brought.

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NGA SBIR 22.1 Phase I Topic Index

OSD221-001	Scene Geometry Aided Automatic Target Recognition (ATR) for Radar
OSD221-002	Automatic Labeling of Multiple Target Synthetic Aperture Radar (SAR) Imagery for Automatic Target Recognition (ATR)
OSD221-003	Rapid Object Detector Development from Limited Labelled Data

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OSD221-001 TITLE: Scene Geometry Aided Automatic Target Recognition (ATR) for Radar

OUSD (R&E) MODERNIZATION PRIORITY: Artificial intelligence/machine learning (AI/ML), autonomy

TECHNOLOGY AREA(S): Information systems, sensors, electronics

OBJECTIVE: Develop and demonstrate synthetic aperture radar (SAR) ATR that reduces false alarm rates by incorporating modern artificial intelligence and geometry of the imaged area.

DESCRIPTION: The focus of this research incorporates geometry (building, tree, and road networks, etc.) of the imaging scene for radar ATR so that false alarms can be reduced. When an area of interest has been interrogated with SAR, the imagery includes the targets' signature, layover, and signatures of surrounding objects. All of the unwanted signatures (other than the targets' signature) contribute to false alarms. Hence, the goal of this research is to investigate novel radar ATR that reduces false alarms.

Radar ATR technologies have evolved over time from one-dimensional signal (range profile) to three-dimensional (3D) signal (i.e., 3D imagery) or even four-dimensional information. ATR has also evolved from a template-based approach to modern AI/ML—that is, deep learning–based recognition. During ATR technology evolution, we have also seen significant improvement in classification accuracy. In particular, it was shown that target variations, articulations, and various operating conditions are problematic for the template-based ATR approach because this approach relied heavily on correlation templates. In a sense, the template-based approach works best when thousands of target templates are provided. Recent deep learning techniques overcame many of the shortcomings of the template-based approach. However, ATR technology with reduced a false alarm rate (FAR) is very important for precision target engagement. Along with advanced sensors (high resolution, multiple polarizations, etc.) and AI/ML technology, the foundation of the imaging scene may provide additional information to reduce FAR.

It is important that researchers of this topic have significant experiences in SAR imaging (two-dimensional (2D) and 3D imaging), layover issue, moving target signature, radar clutter mitigation, and deep learning-based target classification. Understanding SAR datasets such as the Gotcha radar data from the Air Force Research Laboratory (AFRL), moving and stationary target acquisition and recognition (MSTAR) datasets, and implementing deep learning techniques to MSTAR targets will be helpful. As needed, the Government will work with the performer to find relevant synthetic and measured datasets.

PHASE I: Research, develop, and demonstrate concepts for deep learning and scene geometry aided (SGA) ATR that contribute to reducing false alarms.

PHASE II: Implement geometry-aided ATR algorithms using synthetic aperture radar datasets and imaging scenes. Evaluate performance of SGA ATR and quantify false alarm reduction.

PHASE III DUAL USE APPLICATIONS: Transition SGA ATR technology by implementing the algorithms on relevant measured SAR datasets.

REFERENCES:

1. John F. Gilmore, "Knowledge-based target recognition system evolution," Optical Engineering 30(5), 1 May 1991. <https://doi.org/10.1117/12.55829>.
2. B. Bhanu, "Automatic target recognition: State of the art survey," in IEEE Transactions on Aerospace and Electronic Systems, vol. AES-22, no. 4, pp. 364–379, July 1986, doi: 10.1109/TAES.1986.310772.

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3. U. K. Majumder, E. P. Blasch, and D. A. Garren, Deep Learning for Radar and Communications Automatic Target Recognition. Norwood, MA, USA: Artech House, 2020.
4. Timothy D. Ross, Steven W. Worrell, Vincent J. Velten, John C. Mossing, and Michael Lee Bryant. "Standard SAR ATR evaluation experiments using the MSTAR public release data set," Proceedings SPIE 3370, Algorithms for Synthetic Aperture Radar Imagery V, 15 September 1998.

KEYWORDS: Automatic target recognition (ATR), synthetic aperture radar (SAR), false alarm rate (FAR), deep learning, artificial intelligence/machine learning (AI/ML), scene geometry, knowledge-based ATR

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OSD221-002 TITLE: Automatic Labeling of Multiple Target Synthetic Aperture Radar (SAR) Imagery for Automatic Target Recognition (ATR)

OUSD (R&E) MODERNIZATION PRIORITY: Artificial intelligence/machine learning (AI/ML), autonomy

TECHNOLOGY AREA(S): Information systems; sensors; electronics

OBJECTIVE: Develop novel algorithms for labeling multiple target classes in Synthetic Aperture Radar (SAR) imagery to expedite training of SAR Automatic Target Recognition (ATR) algorithms.

DESCRIPTION: The focus of this research will be the automatic labeling of multiple-target target classes in SAR imagery for deep learning-based SAR ATR. A critical first step for AI/ML-based target classification involves providing a large amount of labeled data to train deep neural networks (DNN). As of now, there is no automated approach to label the training data (i.e., multiple target input SAR imagery). Currently, after SAR data collection and image formation, data labeling is conducted manually. As a result, the development and deployment of AI/ML-based algorithms can be greatly delayed. For each data collection or mission, labeling thousands of images manually is costly in terms of time and money. Hence, research should be conducted to develop novel algorithms to expedite the labeling process.

Currently, some research efforts attempt to apply active learning techniques to label single targets in SAR imagery (i.e., an image chip). [4]

Other approaches have developed labelling methods for imagery other than SAR. One approach is a graph-based technique that labels a few images covering multiple target types, learns the features, and applies these features to label unlabeled imagery. This technique, sSemi-supervised learning (SSL), shows some success. [1-3] Researchers also tried other approaches such as Core-set to label non-radar imagery. [5]

The critical issue is that if a SAR image contains multiple targets multiple targets, which can be vehicles, bright vegetation, buildings, or unknown clutter, making labeling each detected object a difficult problem. Moreover, if the targets are heterogeneous in size, detection and labeling is further complicated. The goal of this research is to develop automated labeling algorithms that can label multiple classes of target without a human in-the-loop.

Research in this area requires significant experience in SAR imaging (2D, 3D imaging), clutter reduction, constant false alarm rate (CFAR) based detection, region-based detection, only-look-once detection, and deep learning-based target classification. An understanding of SAR datasets such as the AFRL Gotcha radar data, Moving and Stationary Target Acquisition and Recognition (MSTAR) dataset, and implementation of various deep learning techniques to MSTAR datasets will also be helpful. As needed, the government will work with the performer to find relevant synthetic and measured datasets.

PHASE I: Research, develop, and demonstrate an automated algorithm framework to label multiple target classes in radar imagery. Provide a baseline technique to automatically label multiple target classes in the open (separable targets surrounded by benign clutter such as cut grass, desert, etc.) in SAR imagery.

PHASE II: Implement automated SAR image labeling for complex targets scenarios. Evaluate performance of labeling and performing ATR on targets embedded in complex clutter (e.g., trees, etc.) using relevant datasets. Demonstrate an end-to-end ATR system that include the automated labeling of multiple target classes in SAR imagery, training, testing and ATR classification.

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PHASE III DUAL USE APPLICATIONS: Adapt algorithms from Phase II to other mission relevant datasets.

REFERENCES:

1. Z. Meng, E. Merkurjev, A. Koniges, and A. L. Bertozzi, "Hyperspectral image classification using graph clustering methods," *Image Processing On Line*, vol. 7, pp. 218–245. 2017.
2. K. Miller, H. Li, and A. L. Bertozzi, "Efficient graph-based active learning with probit likelihood via Gaussian approximations," *arXiv preprint arXiv:2007.11126*, 2020.
3. C. Garcia-Cardona, E. Merkurjev, A. L. Bertozzi, A. Flenner, and A. G. Percus, "Multiclass data segmentation using diffuse interface methods on graphs," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 36, no. 8, pp. 1600–1613, 2014.
4. U. K. Majumder, E. P. Blasch, and D. A. Garren, *Deep Learning for Radar and Communications Automatic Target Recognition*. Norwood, MA, USA: Artech House, 2020.
5. O. Sener, Silvio Savarese, "Active learning for convolutional neural networks: A core-set approach," *ICLR* 2018.

KEYWORDS: Automatic target recognition (ATR), synthetic aperture radar (SAR), data labeling, active learning, deep learning, artificial intelligence/machine learning (AI/ML), constant false alarm rate (CFAR)

OSD221-003 TITLE: Rapid Object Detector Development from Limited Labelled Data

OUSD (R&E) MODERNIZATION PRIORITY: Artificial Intelligence / Machine Learning

TECHNOLOGY AREA(S): Information Systems Technology- Modeling and Simulation Technology; Computing and Software Technology

OBJECTIVE: Develop methods and science to rapidly produce object detectors for overhead imagery starting from a limited pool of hand-labeled data.

DESCRIPTION: NGA utilizes deep learning detectors to automatically find objects in overhead satellite imagery. Creating machine learning datasets for overhead imagery is particularly challenging and expensive because the area of each image is typically large, the total number of objects present in each image can be enormous, and the number of unique classes of objects is likewise very large. Lacking the benefit of existing large, labeled datasets of overhead imagery, detector developers often train a rudimentary detector beginning with a small pool of hand-labeled data. This initial detector is used to locate additional object examples in new, unlabeled imagery that are then confirmed by a human reviewer. These new, confirmed detections are then added to the original training data, together with (confirmed) incorrect detections serving as negative training examples in an iterative process sometimes referred to as bootstrapping.

This procedure has many flaws, including bias induced by a poor choice of the initial pool of labeled data and inefficient use of labeler time spent confirming correct but uninformative detections. One often overlooked concern is that the initial detector, and those improved iterative versions, may never be informed by the undetected false negatives, where an object of interest (OOI) has failed to be detected and hence fails to be added to the corpus of confirmed-positive training data. Indeed, undetected OOIs (false positives) effectively become unintentional incorrect negative training data, ensuring that the resultant detector algorithm will never find these objects. Despite these weaknesses and inefficiencies, this iterative bootstrapping method often produces effective and useful detectors that have value that exceeds the cost of developing exhaustively labeled and vetted training, test, and evaluation datasets.

NGA welcomes proposals for methods to improve this bootstrapping procedure and investigatory science to quantify the limitations introduced by undetected false negatives unintentionally introduced as negative training examples. Methods employed may include, but are not limited to, active learning [1] or semi-supervised learning [2]. Proposals should detail which publicly available datasets of labeled overhead electro-optic (EO) imagery are to be utilized in this work. Non-published datasets can also be proposed, but must be provided as a deliverable to the Government without restriction. Proposers should include a detailed explanation of metrics intended to show performance of both detectors and the quality of their resultant bootstrapped datasets.

PHASE I: Proposers will develop a bootstrapping process to create object detectors on EO satellite imagery, model the efficiency of that process, and theoretically quantify the impact of unintentional false negative detections on detector performance. As part of this process, proposers shall produce an unclassified, bootstrapped labeled data set from unlabeled satellite imagery provided as Government-furnished information. Proposers may additionally expand on existing labeled datasets to include new object classes that were not included in the original dataset labeling. Any datasets developed under Phase I shall be provided to the Government as a deliverable without restriction.

PHASE II: Proposers will refine their bootstrapping methodology and evaluation techniques resulting in a practical system as a deliverable. Focus should be on the acceleration and efficiency of the process, while minimizing the need for human-assisted review of iterative detector results without compromising

detector performance. Any datasets developed under Phase II shall be provided to the Government as a deliverable without restriction.

PHASE III DUAL USE APPLICATIONS: Follow-on activities are expected to be aggressively pursued by the offeror, namely, in seeking opportunities to create object detectors for a variety of imagery applications quickly, efficiently, and cost effectively.

REFERENCES:

1. Active learning: <http://burrsettles.com/pub/settles.activelearning.pdf>.
2. Semi-supervised learning: <https://arxiv.org/abs/2103.00550>.

KEYWORDS: Land use, land cover, land use change, remote sensing, computer vision, machine learning, deep learning, segmentation

NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY (NGA)
22.1 Small Business Innovation Research (SBIR) Direct to Phase II
Proposal Submission Instructions

INTRODUCTION

The National Geospatial-Intelligence Agency (NGA) has a responsibility to provide the products and services that decision makers, warfighters, and first responders need, when they need it most. As a member of the Intelligence Community and the Department of Defense, NGA supports a unique mission set. We are committed to acquiring, developing, and maintaining the proper technology, people and processes that will enable overall mission success.

Geospatial intelligence, or GEOINT, is the exploitation and analysis of imagery and geospatial information to describe, assess and visually depict physical features and geographically referenced activities on the Earth. GEOINT consists of imagery, imagery intelligence and geospatial information.

With our unique mission set, NGA pursues research that will help guarantee the information edge over potential adversaries. Additional information pertaining to the National Geospatial-Intelligence Agency's mission can be obtained by viewing the website at <http://www.nga.mil/>.

Proposers responding to a topic in this BAA must follow all general instructions provided in the Department of Defense (DoD) SBIR Program BAA. NGA requirements in addition to or deviating from the DoD Program BAA are provided in the instructions below.

Specific questions pertaining to the administration of the SBIR Program and these proposal preparation instructions should be directed to:

National Geospatial-Intelligence Agency
Attn: SBIR Program Manager, RA, MS: S75-RA
7500 GEOINT Dr., Springfield, VA 22150-7500
Email: SBIR@nga.mil

DIRECT TO PHASE II PROPOSAL GUIDELINES

NGA has developed topics to which small businesses may respond to in this fiscal year 2022 SBIR Direct to Phase II iteration. These topics are described on the following pages. **The maximum amount for a Direct to Phase II award is \$1,000,000, and the maximum period of performance for a Direct to Phase II is 24 months.** While NGA participates in the majority of SBIR program options, NGA does not participate in either the Commercialization Readiness Program (CRP), Technical and Business Assistance (TABAs) or Phase II Enhancement programs.

The entire SBIR proposal submission must be submitted electronically through the DoD SBIR/STTR Proposal Submission system located at <https://www.dodsbirsttr.mil/ehb-app/home> for it to be evaluated.

- **Proposal Cover Sheet (Volume 1):** The Cover Sheet must include a brief technical abstract of no more than 200 words that describes the proposed R&D project with a discussion of anticipated benefits and potential commercial applications. Do not include proprietary or classified information in the Proposal Cover Sheet. If your proposal is selected for award, the technical abstract and discussion of anticipated benefits may be publicly released.
- **Format of Technical Volume (Volume 2):** The Technical Volume must include two parts, PART ONE: Feasibility Documentation and PART TWO: Technical Proposal. The Technical Volume must be a single Portable Document Format (PDF) file, including graphics. Perform a

virus check before uploading the Technical Volume file. If a virus is detected, it may cause rejection of the proposal. Do not lock or encrypt the uploaded file. Do not include or embed active graphics such as videos, moving pictures, or other similar media in the document. The length of each part of the technical volume are as follows: Feasibility Documentation is limited to 20 pages and Technical Proposal is limited to 40 pages. The Government will not consider pages in excess of the page count limitations. Number all pages of your proposal consecutively. Font size should not be smaller than 12 pitch Times New Roman font, with at least a one-inch margin on top, bottom, and sides, on 8½” by 11” paper. The header on each page of the Technical Volume should contain your company name, topic number, and proposal number assigned by DSIP when the Cover Sheet was created. The header may be included in the one-inch margin.

- **Content of the Technical Volume (Volume 2) PART ONE: Feasibility**

Documentation: Provide documentation to substantiate that the scientific and technical merit and feasibility described in the Phase I section of the topic has been met and describes the potential commercial applications. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/results. Maximum page length for feasibility documentation is 20 pages. If you have references, include a reference list or works cited list as the last page of the feasibility documentation. This will count towards the page limit. Work submitted within the feasibility documentation must have been substantially performed by the proposer and/or the Principle Investigator (PI). If technology in the feasibility documentation is subject to Intellectual Property (IP), the proposer must either own the IP, or must have obtained license rights to such technology prior to proposal submission, to enable it and its subcontractors to legally carry out the proposed work. Documentation of IP ownership or license rights shall be included in the Technical Volume of the proposal. Include a one-page summary on Commercialization Potential addressing the following: i. Does the company contain marketing expertise and, if not, how will that expertise be brought into the company? ii. Describe the potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization. **DO NOT INCLUDE** marketing material. Marketing material will **NOT** be evaluated.

- **PART TWO: Technical Proposal:**

- (1) Significance of the Problem. Define the specific technical problem or opportunity addressed and its importance.
- (2) Phase II Technical Objectives. Enumerate the specific objectives of the Phase II work and describe the technical approach and methods to be used in meeting these objectives.
- (3) Phase II Statement of Work. The statement of work should provide an explicit, detailed description of the Phase II approach, indicate what is planned, how and where the work will be carried out, a schedule of major events and the final product to be delivered. The methods planned to achieve each objective or task should be discussed explicitly and in detail. This section should be a substantial portion of the total proposal. Include how and where the work will be carried out, a schedule of major events and the final product to be delivered. The methods planned to achieve each objective or task should be discussed explicitly and in detail.
- (4) Section 508 Compliance: The contractor shall ensure that all systems, hardware, software, software engineering, and information technology associated with this effort is made in a manner that is accessible for people with the standards for people with disabilities as directed in the NGA Instruction 8400.4 and Section 508 of the Rehabilitation Act of 1973 as amended in 1998 (Section 508). Specifically, all Information and Communications Technology (ICT)

associated with this contract, may use the Web Content Accessibility Guidelines (WCAG) 2.1 to comply with the Section 508 or use alternative designs or technologies which result in substantially equivalent or greater access to and use of the product for people with disabilities. Furthermore, the contractor shall pursue human centered design and usability guidelines to ensure that all services associated with this Topic Area are accessible by as many users as possible and to drive modernization, innovation, and enhance mission support. **As part of the vendor's proposal, the vendor should include an outline specifically how Section 508 compliance will be achieved in the design of the ICT product. The proposal for Phase 2 should provide an explicit, detailed description of the approach, indicate what is planned, how and where the work will be carried out, a schedule of major events, how the solution will be Section 508 Compliant, and the final product to be delivered. The methods planned to achieve each objective or task should be discussed explicitly and in detail. If a determination is made that a Section 508 exception request is justified, the rationale for the exception request must be made and submitted as a part of the proposal.**

- (5) Related Work. Describe significant activities directly related to the proposed effort, including any conducted by the PI, the proposer, consultants, or others. Describe how these activities interface with the proposed project and discuss any planned coordination with outside sources. The proposal must persuade reviewers of the proposer's awareness of the state of the art in the specific topic. Describe previous work not directly related to the proposed effort but similar. Provide the following: (1) short description, (2) client for which work was performed (including individual to be contacted and phone number) and (3) date of completion.
- (6) Relationship with Future Research or Research and Development. State the anticipated results of the proposed approach if the project is successful. ii. Discuss the significance of the Phase II effort in providing a foundation for Phase III research and development or commercialization effort.
- (7) Key Personnel. Identify key personnel who will be involved in the Phase II effort including information on directly related education and experience. A concise resume of the PI, including a list of relevant publications (if any), must be included. All resumes count toward the page limitation.
- (8) Foreign Citizens. Identify any foreign nationals you expect to be involved on this project.
- (9) Facilities/Equipment. Describe available instrumentation and physical facilities necessary to carry out the Phase II effort. Items of equipment to be purchased (as detailed in the cost proposal) shall be justified under this section. If proposing to perform classified activities during the period of performance, you need to provide the following: 1) Highest Level of Classification of the Research; 2) Where the classified work will be performed; 3) Will the information include controlled unclassified information (CUI); 4) What classified/unclassified IT systems will be required and; 5) CAGE Code for Facility Clearance (FCL) Validation
- (10) Subcontractors/Consultants. Involvement of a university or other subcontractors or consultants in the project may be appropriate. If such involvement is intended, it should be identified and described according to the Cost Breakdown Guidance. Please refer to section 4.2 of this BAA for detailed eligibility requirements as it pertains to the use of subcontractors/consultants.

- (11) Prior, Current or Pending Support of Similar Proposals or Awards. If a proposal submitted in response to this is substantially the same as another proposal that was funded, is now being funded, or is pending with another Federal Agency, or another or the same DoD Component, you must reveal this on the Proposal Cover Sheet and provide the following information: a) Name and address of the Federal Agency(s) or DoD Component to which a proposal was submitted, will be submitted, or from which an award is expected or has been received. b) Date of proposal submission or date of award. c) Title of proposal. d) Name and title of the PI for each proposal submitted or award received. e) Title, number, and date of BAA(s) or solicitation(s) under which the proposal was submitted, will be submitted, or under which award is expected or has been received. f) If award was received, state contract number. g) Specify the applicable topics for each proposal submitted or award received. Note: If this does not apply, state in the proposal "No prior, current, or pending support for proposed work."
- (12) Commercialization Strategy. NGA is equally interested in dual use commercialization of SBIR/STTR projects that result in products sold to the U.S. military, the private sector market, or both. NGA expects explicit discussion of key activities to achieve this result in the commercialization strategy part of the proposal. The Technical Volume of each Direct to Phase II proposal must include a commercialization strategy section. The Phase II commercialization strategy shall not exceed 5 pages. The commercialization strategy should include the following elements:
 - a) A summary of transition and commercialization activities conducted during Phase I, and the Technology Readiness Level (TRL) achieved. Discuss how the preliminary transition and commercialization path or paths may evolve during the Phase II project. Describe key proposed technical milestones during Phase II that will advance the technology towards product such as: prototype development, laboratory and systems testing, integration, testing in operational environment, and demonstrations.
 - b) Problem or Need Statement. Briefly describe what you know of the problem, need, or requirement, and its significance relevant to a Department of Defense application and/or a private sector application that the SBIR/STTR project results would address.
 - c) Description of Product(s) and/or System Application(s). Identify the commercial product(s) and/or DoD system(s), or system(s) under development, or potential new system(s). Identify the potential DoD end users, Federal customers, and/or private sector customers who would likely use the technology.
 - d) Business Model(s)/Procurement Mechanism(s). Discuss your current business model hypothesis for bringing the technology to market. Describe plans to license, partner, or self-produce your product. How do you plan to generate revenue? Understanding NGA's goal of creating and sustaining a U.S. military advantage, describe how you intend to develop your product and supply chains to enable this differentiation.
 - e) Target Market. Describe the market and customer sets you propose to target, their size, their growth rate, and their key reasons they would consider procuring the technology. Describe competing technologies existent today on the market as well as those being developed in the lab.

- f) Funding Requirements. Describe your company's funding history. How much external financing have you raised? Describe your plans for future funding sources (internal, loan, angel, venture capital, etc.).
- g) Commercialization Risks. Describe the major technology, market and team risks associated with achieving successful transition of the NGA funded technology. NGA is not afraid to take risks, but we want to ensure that our awardees clearly understand the risks in front of them.
- h) Expertise/Qualifications of Team/Company Readiness. Describe the expertise and qualifications of your management, marketing/business development and technical team that will support the transition of the technology from the prototype to the commercial market and into government operational environments. Has this team previously taken similar products/services to market? If the present team does not have this needed expertise, how do you intend to obtain it? What is the financial history and health of your company (e.g., availability of cash, profitability, revenue growth, etc.)?
- i) Anticipated Commercialization Results. Include a schedule showing the anticipated quantitative commercialization results from the Phase II project at one year after the start of Phase II, at the completion of Phase II, and after the completion of Phase II (i.e., amount of additional investment, sales revenue, etc.).
- **Format of Cost Volume (Volume 3):** The Cost Volume (and supporting documentation) DOES NOT count toward the page limit of the Technical Volume. Some items in the Cost Breakdown Guidance below may not apply to the proposed project. If such is the case, there is no need to provide information on each and every item. ALL proposed costs should be accompanied by documentation to substantiate how the cost was derived. For example, if you proposed travel cost to attend a project-related meeting or conference, and used a travel website to compare flight costs, include a screen shot of the comparison. Similarly, if you proposed to purchase materials or equipment, and used the internet to search for the best source, include your market research for those items. You do not necessarily have to propose the cheapest item or supplier, but you should explain your decision to choose one item or supplier over another. It's important to provide enough information to allow contracting personnel to understand how the proposer plans to use the requested funds. If selected for award, failure to include the documentation with your proposal will delay contract negotiation, and the proposer will be asked to submit the necessary documentation to the Contracting Officer to substantiate costs (e.g., cost estimates for equipment, materials, and consultants or subcontractors). It is important to respond as quickly as possible to the Contracting Officer's request for documentation. Cost Breakdown Guidance:
 - List all key personnel by name as well as by number of hours dedicated to the project as direct labor.
 - Special tooling and test equipment and material cost may be included. The inclusion of equipment and material will be carefully reviewed relative to need and appropriateness for the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the Government and should be related directly to the specific topic. These may include such items as innovative instrumentation and/or automatic test equipment. Title to property furnished by the Government or acquired with Government funds will be vested with NGA; unless it is determined that transfer of title to the contractor would be more cost effective than recovery of the equipment by NGA.
 - Cost for travel funds must be justified and related to the needs of the project.

- Cost sharing is permitted for proposals under this announcement; however, cost sharing is not required, nor will it be an evaluation factor in the consideration of a proposal.
- All subcontractor costs and consultant costs must be detailed at the same level as prime contractor costs in regard to labor, travel, equipment, etc. Provide detailed substantiation of subcontractor costs in your cost proposal. The Supporting Documents Volume (Volume 5) may be used if additional space is needed. For more information about cost proposals and accounting standards, see the DCAA publication titled “Audit Process Overview – Information for Contractors” available at: <http://www.dcaa.mil>.
- **Company Commercialization Report (Volume 4):** Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR Program BAA for full details on this requirement. Information contained in the CCR will not be considered by NGA during proposal evaluations.
- **Supporting Documents (Volume 5):** In addition to the Volume 5 requirements listed in the DoD SBIR Program BAA, the vendor may submit supporting documents (Volume 5), but that material WILL NOT be reviewed by the evaluation team as part of the proposal evaluation. Items that may go into, not all inclusive, are additional cost proposal information, Completed Form SF326, advocacy letters, etc.
- **Fraud, Waste and Abuse Training (Volume 6):** The Fraud, Waste and Abuse (FWA) training is required for Direct to Phase II proposals. Refer to the DoD SBIR Program BAA for full details.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

NGA will not provide TABA.

EVALUATION AND SELECTION

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD SBIR Program BAA. Selection of Direct to Phase II proposals will be in accordance with the evaluation procedures and criteria discussed in this BAA. As part of subfactor c in the evaluation criteria, the vendor will be evaluated on how it addresses the following five questions on the overall commercialization strategy:

- (1) What is the first product that this technology will go into?
- (2) Who will be the customers, and what is the estimated market size?
- (3) How much money will be needed to bring the technology to market, and how will that money be raised?
- (4) Does the company contain marketing expertise and, if not, how will that expertise be brought into the company?
- (5) Who are the proposing firm’s competitors, and what is the price and/or quality advantage over those competitors?

NGA will not continue evaluating the Offeror's related Phase II proposal if it determines that the Offeror failed to demonstrate that feasibility has been established or the Offeror failed to demonstrate work submitted in the feasibility documentation was substantially performed by the Offeror and/or the Principal Investigator.

Due to limited funding, the NGA SBIR Program reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality in the judgment of the technical evaluation team will be funded. The offeror must be responsive to the topic requirements, as solicited.

Federally Funded Research and Development Contractors (FFRDC) and other government contractors, who have signed Non-Disclosures Agreements, may be used in the evaluation of your proposal.

NGA typically provides a firm fixed price payable milestone contract for Direct to Phase II awards. The type of contract is at the discretion of the Contracting Officer.

Proposing firms will be notified of selection or non-selection status for a Phase I award within 90 days of the closing date of the BAA. The individual named as the Corporate Official on the Proposal Cover Sheet will receive an email for each proposal submitted from the Government Contracting Officer/Specialist with their official notification of proposal selection or non-selection. The notices will be binned into 3 categories: (1) proposals selected for award, (2) proposals selected for award, if additional funding becomes available, and (3) proposals not selected for award. Proposals with the award designation of 'Award if Additional Funding Becomes Available' will receive consideration for award 12 months from the BAA close date. An unsuccessful offeror has 3 days after notification that its proposal was not selected to submit a written request for a debriefing to the Contracting Officer (CO). Those offerors who get their written request in within the allotted timeframe above will be provided a debriefing.

Refer to the DoD SBIR Program BAA for procedures to protest the Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: Viphalac Dickover at Viphalac.C.Dickover@nga.mil.

AWARD AND CONTRACT INFORMATION

Direct to Phase II contracts will include a requirement to produce one-page monthly status reports and a more detailed interim report not later than 12 months after award. These reports shall include the following sections:

- A monthly summary of the results of the Phase II research to date
- A monthly summary of the Phase II tasks not yet completed, with an estimated completion date for each task
- A statement of potential applications and benefits of the research.
- An interim report no later than 12 months after award describing finding to date and continued way forward, not to be all-inclusive.
- A final report no later than 24 months after award
- A demonstration of the prototype no later than 23 months after award
- Final delivery of the prototype and associated documentation no later than 24 months after award.

The interim report and final report shall be prepared single spaced in 12 pitch Times New Roman font, with at least a one-inch margin on top, bottom, and sides, on 8½" by 11" paper. The pages shall be numbered. Each report must have the proper DTIC distribution statement on it.

ADDITIONAL INFORMATION USE OF FOREIGN NATIONALS

Due to the nature of our business, only US Nationals are permitted to work on NGA topics, unless the vendor proposes the work as Fundamental Research and indicates it as such in the proposal. The use of non-US National on a NGA contract is PROHIBITED, unless the work is scoped as Fundamental Research. If the effort is Fundamental Research, the PI must be a US National. ALL offerors proposing to use non-US Nationals (which has not been determined as Fundamental Research) on the effort will be ineligible for award. This includes the use at universities or any other subcontractor. In the event it is determined to be Fundamental Research, non-US Nationals will be ineligible to receive controlled unclassified information as described below.

CONTROLLED UNCLASSIFIED INFORMATION (CUI)

Controlled Unclassified Information (CUI) is information that requires safeguarding or dissemination controls pursuant to and consistent with applicable law, regulations, and government-wide policies but is not classified under Executive Order 13526 or the Atomic Energy Act, as amended.

Executive Order 13556 "Controlled Unclassified Information" (the Order), establishes a program for managing CUI across the Executive branch and designates the National Archives and Records Administration (NARA) as Executive Agent to implement the Order and oversee agency actions to ensure compliance. The Archivist of the United States delegated these responsibilities to the Information Security Oversight Office (ISOO).

32 CFR Part 2002 "Controlled Unclassified Information" was issued by ISOO to establish policy for agencies on designating, safeguarding, disseminating, marking, decontrolling, and disposing of CUI, self-inspection and oversight requirements, and other facets of the Program. The rule affects Federal executive branch agencies that handle CUI and all organizations (sources) that handle, possess, use, share, or receive CUI—or which operate, use, or have access to Federal information and information systems on behalf of an agency.

During performance of this contract, if the government provides the vendor a dataset that is not publicly released, the vendor must be CUI Compliant to receive it. For more information on this compliance please see DFARS Clause 252.204-7012, NIST Special Publication SP 800-171 and the National Archives and Records Administration (NARA) website (<https://www.archives.gov/cui/about>).

CERTIFICATE PERTAINING TO FOREIGN INTERESTS

Offers must submit a SF-328 in Volume 5 in order to be considered for award. If after review of the form, the offeror may be found ineligible for award if the offerors foreign interest are found to be unacceptable. The form can be found at <https://www.gsa.gov/forms-library/certificate-pertaining-foreign-interests>.

DISCLOSURE OF INFORMATION

(a) The Contractor shall not release to anyone outside the Contractor's organization any unclassified information, regardless of medium (e.g., film, tape, document), pertaining to any part of this contract or any program related to this contract, unless-

(1) The Contracting Officer has given prior written approval;

(2) The information is otherwise in the public domain before the date of release; or

(3) The information results from or arises during the performance of a project that involves no covered defense information (as defined in the clause at DFARS 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting) and **has been scoped and negotiated by the contracting activity with the contractor and research performer and determined in writing by the contracting officer to be fundamental research* (which by definition cannot involve any covered defense information)**, in accordance with National Security Decision Directive 189, National Policy on the Transfer of Scientific, Technical and Engineering Information, in effect on the date of contract award and the Under Secretary of Defense (Acquisition, Technology, and Logistics) memoranda on Fundamental Research, dated May 24, 2010, and on Contracted Fundamental Research, dated June 26, 2008 (available at DFARS PGI 204.4).

(b) Requests for approval under paragraph (a)(1) shall identify the specific information to be released, the medium to be used, and the purpose for the release. The Contractor shall submit its request to the Contracting Officer at least 10 business days before the proposed date for release.

(c) The Contractor agrees to include a similar requirement, including this paragraph (c), in each subcontract under this contract. Subcontractors shall submit requests for authorization to release through the prime contractor to the Contracting Officer.

***Note: This has to be negotiated prior to award of the contract. A request for determination after award will not be entertained and will result in the clause being pushed down to all subcontracts. Non-performance could result in cancelation of contract.**

5X252.204-7000-90 PUBLIC RELEASE OF INFORMATION

(a) Except as provided in paragraph (b) of this clause, information pertaining to this contract shall not be released to the public unless authorized by the Contracting Officer in accordance with DFARS 252.204-7000, Disclosure of Information. Requests for approval to release information pertaining to this contract shall be submitted to the Contracting Officer by means of NGA Form 5230-1, National Geospatial-Intelligence Agency Request for Clearance for Public Release.

(b) The contractor may provide past performance information regarding this contract, without Contracting Officer approval, to the Office of the Director of National Intelligence (ODNI), the Central Intelligence Agency (CIA), the National Reconnaissance Office (NRO), the National Security Agency (NSA), the Defense Intelligence Agency (DIA), and NGA to support source selections at those agencies. The contractor is responsible for the proper classification and handling of such information and shall provide a copy of the information provided to the Contracting Officer.

5X52.227-9000 UNAUTHORIZED USE OF NGA NAME, SEAL AND INITIALS

(a) As provided in 10 U.S.C. Section 425, no person may, except with the written permission of the Director, National Geospatial-Intelligence Agency, knowingly use the words "National Geospatial-Intelligence Agency", "National Imagery and Mapping Agency" or "Defense Mapping Agency", the initials "NGA", "NIMA" or "DMA", the seal of the National Geospatial-Intelligence Agency, National Imagery and Mapping Agency or the Defense Mapping Agency, or any colorable imitation of such words, initials, or seal in connection with any merchandise, retail product, impersonation, solicitation, or commercial activity in a manner reasonably calculated to convey the impression that such is approved, endorsed, or authorized by the Director, NGA.

(b) Whenever it appears to the U.S. Attorney General that any person is engaged or about to engage in an act or practice which constitutes or will constitute conduct prohibited by paragraph (a), the Attorney General may initiate a civil proceeding in a district court of the United States to enjoin such act or practice. Such court shall proceed as soon as practicable to hearing and determination of such action and may, at any time before such final determination, enter such restraining orders or prohibition, or take such other action as is warranted, to prevent injury to the United States, or to any person or class of persons whose protection the action is brought.

NGA SBIR 22.1 Direct to Phase II Topic Index

OSD221-D04

High Resolution Near Real Time Land Use and Land Use Change

OSD221-D04 TITLE: High Resolution Near Real Time Land Use and Land Use Change

OUSD (R&E) MODERNIZATION PRIORITY: Artificial intelligence/machine learning

TECHNOLOGY AREA(S): Information systems, modeling and simulation technology

OBJECTIVE: Develop a high-resolution fully automated land use and land use change (LULUC) map of the globe, updated daily, using commercial or publicly available satellite imagery. Identify mission-specific types of change in near real-time across broad areas.

DESCRIPTION: NGA produces timely, accurate, and actionable geospatial intelligence (GEOINT) to support national policymakers on matters of national security and to support federal agencies responding to humanitarian and disaster relief efforts. Many of NGA's GEOINT products begin with LULUC maps detailing environmental conditions and changes relating to human activities and natural phenomena. Time series of LULUC maps enable deeper analysis and the development of follow-on predictive analytics relating to broad topics in environmental security and national security.

Recent advances in deep learning have dramatically improved the state-of-the-art (SoTA) for techniques such as large-scale semantic segmentation and change detection, which may be applied to accurately and efficiently produce LULUC maps [1]. Concurrently, the volume of available satellite imagery has grown tremendously, including commercial imagery products that image the entirety of the earth every day at high resolution. Together, these advancements in deep learning and imagery availability may be used to produce highly accurate LULUC maps of the globe, enhancing NGA's GEOINT capabilities (e.g., [2]).

Only direct to Phase II proposals are being accepted under this topic. A direct to Phase II proposal must demonstrate the proposer's possession of an existing prototype LULUC capability that is at a minimum equivalent to the Phase I deliverables below. Performers should improve upon the SoTA for LULUC mapping by (1) increasing the resolution and accuracy of LULUC segmentation maps and (2) decreasing the time required to produce LULUC maps and associated GEOINT products to at least weekly and ideally daily (weather conditions and imagery collection allowing).

PHASE I: A successful Phase 1 will result in a 10-30 m resolution, 6+ land use class LULUC mapping capability covering at least 60% of the landmass of the globe, which can be updated automatically on demand with <3 days of combined human effort and compute time. A >1500 km² LULUC example should be made available for demonstration covering at least two separate dates at the same areas.

PHASE II: In addition to specifying the performer's existing Phase I capability, the performer must identify the SoTA for LULUC mapping and its plan for surpassing the SoTA supported by sound scientific and engineering principals. A successful Phase II will result in a <10 m resolution, 10+ land use class LULUC mapping capability, which can be updated daily if weather conditions and imagery collection allow. 6+ significant change types, at least three of which are directly anthropogenic, must be automatically identified. Performers will be expected to provide comprehensive reports detailing technical advancements and performance metrics, which will be provided to NGA and submitted to an academic journal or conference. LULUC maps and associated products produced during the period of performance shall be delivered to NGA without further use restrictions. Collaboration with a program of record at NGA (e.g., SAFFIRE) for potential integration at the end of Phase II is preferred.

PHASE III DUAL USE APPLICATIONS: Accurate, timely, and high-resolution LULUC products are a critical source of monitoring global change caused by environmental factors and human activities. GIS analysts across a variety of Government and commercial sectors rely on these mapping products to

improve understanding on topics such as land use planning, hydrology, food and environmental security, and resource allocation and management.

REFERENCES:

1. Khan S., Alarabi L., and Basalamah S., “Deep hybrid network for land cover semantic segmentation in high-spatial resolution satellite images,” *Information* 2021, 12, 230.
doi.org/10.3390/info12060230.
2. “A new land cover map of the world,” ArcGIS StoryMaps,
storymaps.arcgis.com/stories/486cd2ae2016454f951c97f802f125b3, accessed 24 September 2021.

KEYWORDS: Land use, land cover, land use change, remote sensing, computer vision, machine learning, deep learning, segmentation

VERSION 2

**Office of the Under Secretary of Defense for Research and Engineering
Defense Research and Engineering for Research and Technology (DDRE(RT))
C5ISREW – Quantum Science Topics
22.1 Small Business Innovation Research (SBIR)
Phase I Proposal Submission Instructions**

INTRODUCTION

The Office of the Undersecretary of Defense, Research and Engineering (OUSD(R&E)) Command, Control, Computers, Communications, Cyber, Intelligence, Surveillance, Reconnaissance and Electronic Warfare (C5ISREW) Office in partnership with the Director of Defense Research & Engineering for Modernization (DDRE(M)) Quantum Science Office seeks to advance scientific discoveries in alignment with the USD(R&E) Quantum Science Roadmap and provide a mechanism to further scientific development, maturation, and commercialization of quantum science technologies. The C5ISREW SBIR program aims to stimulate technological innovation, strengthen the role of small business in meeting DoD research and development needs, foster and encourage participation by minority and disadvantaged persons in technological innovation, and increase the commercial application of DoD-supported research or research and development results. **The C5ISREW SBIR program solicits approaches that combine high-risk with potential for high-reward to address scientific challenges described in the topics below.**

Proposers responding to a topic in this BAA must follow all general instructions provided in the Department of Defense (DoD) SBIR Program BAA. C5ISREW requirements in addition to or deviating from the DoD Program BAA are provided in the instructions below.

Specific questions pertaining to the administration of the C5ISREW SBIR/STTR Program and these proposal preparation instructions should be directed to: Dr. Karl Dahlhauser, karl.j.dahlhauser.civ@mail.mil.

PHASE I PROPOSAL GUIDELINES

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD SBIR/STTR Program BAA.

Technical Volume (Volume 2)

The technical volume is not to exceed 15 pages of Times New Roman size 11 font and must follow the formatting requirements provided in the DoD SBIR/STTR Program BAA. Any pages in the technical volume over 15 pages will not be considered in proposal evaluations.

Cost Volume (Volume 3)

Phase I projects may have a period of performance up to 12 months and a funding level up to \$250,000. Costs must be clearly identified on the Proposal Cover Sheet (Volume 1) and in Volume 3.

Company Commercialization Report (CCR) (Volume 4)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR/STTR Program BAA for full details on this requirement. Information contained in the CCR will be considered by C5ISREW during proposal evaluations.

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Supporting Documents (Volume 5)

Supporting documents will be accepted/required as indicated in each topic.

PHASE II PROPOSAL GUIDELINES

Phase II proposals may only be submitted by Phase I awardees. Phase II projects may have a period of performance up to 36 months, including option years, and a funding level up to \$1,700,000.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

The DDRE(RT) C5ISREW Office will not participate in the Technical and Business Assistance.

EVALUATION AND SELECTION

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD SBIR/STTR Program BAA.

Proposing firms will be notified of selection or non-selection status for a Phase I award within 90 days of the closing date of the BAA.

Refer to the DoD SBIR/STTR Program BAA for procedures to protest the Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: Dr. Karl Dahlhauser, karl.j.dahlhauser.civ@mail.mil.

VERSION 2

C5ISREW SBIR 22.1 Phase I Topic Index

OSD221-006	Stand-alone multi-axis compact portable quantum accelerometer
OSD221-007	High yield atomic vapor cell manufacturing and packaging for atomic clocks and magnetometers

VERSION 2

OSD221-006 TITLE: Stand-alone multi-axis compact portable quantum accelerometer

OUSD (R&E) MODERNIZATION PRIORITY: Quantum Science

TECHNOLOGY AREA(S): Sensors, Electronics and Electronic Warfare

OBJECTIVE: Build a compact portable 3-axis quantum-based accelerometer and demonstrate on a moving platform.

DESCRIPTION: A significant portion of quantum IMU development has focused on single-axis inertial sensors. Of these, the majority have been gyroscopes and gravimeters instead of full-scale accelerometers. Although some approaches measure both rotation and acceleration simultaneously, the resulting measurements are of limited use to practical systems. The DoD seeks the development of a stand-alone multi-axis quantum accelerometer that can simultaneously offer competitive sensitivity, bandwidth, full-scale range, bias error, and scale factor performance as compared to conventional accelerometers. A realistic pathway must be established towards a portable version that can be flown on an aerial vehicle in a GPS-denied environment. The accelerometer can be purely quantum or a hybrid combination of classical and quantum sensors. The pathway to demonstration will be required, and development of optical and electronic systems must have a clear and direct purpose towards meeting that goal.

PHASE I: Demonstration of a compact 3-axis quantum-based accelerometer on a moving platform that promises pathway towards miniaturization which will be undertaken in Phase II.

PHASE II: Demonstration of a 3-axis quantum-based accelerometer on a DoD-provided aerial platform with the following minimum characteristics:

- Full Acceleration Vector Output Rate >100 Hz
- White Noise $<1 \times 10^{-5} \text{ g}/\sqrt{\text{Hz}}$
- Bias Stability $<5 \times 10^{-6} \text{ g}$
- Scale Factor Stability <10 ppm
- Full-Scale Range $>\pm 10 \text{ g}$
- Volume (including all electronics and optical systems) $<0.3 \text{ m}^3$

PHASE III DUAL USE APPLICATIONS: Military applications for a 3-axis quantum-based accelerometer include inertial navigation of ships, spacecraft, aircraft, and undersea/underground vehicles that operate in GPS-degraded environments. Further commercial applications include gravity mapping, natural resource exploration, earthquake monitoring, and detection of underground tunnels.

REFERENCES:

1. P Cheiney, et al., Navigation-Compatible Hybrid Quantum Accelerometer Using a Kalman Filter. Phys. Rev. Applied 10, 034030. 17 September 2018. Phys. Rev. Applied 10, 034030 (2018) - Navigation-Compatible Hybrid Quantum Accelerometer Using a Kalman Filter (aps.org).
2. X Wu, et al., Multiaxis atom interferometry with a single-diode laser and a pyramidal magneto-optical trap. Optica 4, 12. 20 December 2017. OSA | Multiaxis atom interferometry with a single-diode laser and a pyramidal magneto-optical trap (osapublishing.org).
3. X Wang, et al., Enhancing Inertial Navigation Performance via Fusion of Classical and Quantum Accelerometers. ArXiv 2103.09378. 17 March 2021. [2103.09378] Enhancing Inertial Navigation Performance via Fusion of Classical and Quantum Accelerometers (arxiv.org).
4. B Barrett, et al. Inertial quantum sensors using light and matter. Physica Scripta 91, 5. 13 April 2016. Inertial quantum sensors using light and matter – IOPscience.

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5. R Geiger, et al., Detecting inertial effects with airborne matter-wave interferometry. Nature Communications 2, 474. 20 September 2011. Detecting inertial effects with airborne matter-wave interferometry | Nature Communications.

KEYWORDS: Quantum; Accelerometer; Inertial Navigation; Atom; Sensor

VERSION 2

OSD221-007 TITLE: High yield atomic vapor cell manufacturing and packaging for atomic clocks and magnetometers

OUSD (R&E) MODERNIZATION PRIORITY: Quantum Science

TECHNOLOGY AREA(S): Sensors, Electronics and Electronic Warfare; Materials / Processes

OBJECTIVE: Develop a manufacturing process which allows greater yield (>80%) per wafer batch on vapor cell wafer runs to support quantum clocks and magnetometers.

DESCRIPTION: Over the last decade, quantum sensor technology (including atomic clocks and atomic magnetometers) have accelerated in performance to provide new and important capabilities for the DoD. While the performance of these quantum devices has improved significantly, the ability to deploy them for DoD missions is still lacking due to inadequate processing and manufacturing capabilities, specifically at capacities needed to meet the SWaP-C requirements for DoD deployable systems. One area of improvement lies at the heart of these quantum devices - the atomic vapor cell. Even with commercialized atomic clocks and magnetometers, manufacturing techniques to fabricate vapor cells and thermal packages have proved elusive, often resulting in low yield and considerable added expense to the device. The fabrication of these vapor cells typically requires high heat and high voltage in a process called anodic bonding which complicates the manufacturing process and leads to inconsistency in the final product. We are seeking a microfabrication technique for parallel, batch manufacturing of vapor cells that does not rely on anodic bonding for the final seal. The technology should be capable of scaling to high volumes with production yields that exceed 80 percent and a path towards producing hundreds of thousands of vapor cells per year. Proposing companies should also include compact packaging techniques that provide thermal stability and power reduction. These advances will allow for quantum devices to be produced at significantly lower cost, with the goal to achieve significantly wider dissemination across the DoD. We are looking for vapor cell manufacturing and packaging technologies that accelerate manufacturing, produce greater quantity per batch, provide reduced part-to-part variation (greater consistency), improve SWAP (size, weight, and power), and provide overall cost reductions for quantum sensors like atomic clocks and atomic magnetometers.

PHASE I: A successful Phase I will demonstrate the production of vapor cells with yield greater than 70 percent on a substrate having a cavity array of 5x5 and using a non-anodic bonding technique. The cells must demonstrate a judicious proportion of alkali gas, buffer gas, and leak proof vapor cell manufacturing. A design for packaging the cells should also be included.

PHASE II: Phase II will advance the phase I techniques to successfully demonstrate manufacturing runs on a full wafer-scale substrate while achieving a production yield that exceeds 80 percent. The packaging solution should be demonstrated in a prototype device. A sample of vapor cells should be substantiated by using them to demonstrate either an atomic clock or an atomic magnetometer.

PHASE III DUAL USE APPLICATIONS: Commercial applications include smaller, more affordable atomic clocks for use in navigation and enhanced cellular timing holdover, and magnetometers for geological surveying and mineral prospecting. DoD applications involving magnetometers like magnetic anomaly detection can benefit from inexpensive sensors that are low enough powered to fly on small UAS.

REFERENCES:

1. S. Knappe, V. Gerginov, P. D.D. Schwindt, V. Shah, H. G. Robinson, L. Hollberg, and J. Kitching, "Atomic vapor cells for chip-scale atomic clocks with improved long-term frequency stability," Opt. Lett. 30, 2351-2353 (2005).

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2. Yanjun Zhang, Yunchao Li, Xuwen Hu, Lu Zhang, Zhaojun Liu, Kaifang Zhang, Shihao Mou, Shougang Zhang, and Shubin Yan, "Micro-fabrication process of vapor cells for chip-scale atomic clocks," Chin. Opt. Lett. 17, 040202- (2019).
3. John Kitching , "Chip-scale atomic devices", Applied Physics Reviews 5, 031302 (2018)
<https://doi.org/10.1063/1.5026238>.

KEYWORDS: Vapor Cell Manufacturing; Atomic Clocks; Atomic Magnetometer; high Yield

Office of the Under Secretary of Defense for Research and Engineering
Defense Research and Engineering for Research and Technology (DDRE(RT))
C5ISREW – Quantum Science Topics
22.1 Small Business Innovation Research (SBIR)
Direct to Phase II (DP2) Proposal Submission Instructions

INTRODUCTION

The Office of the Undersecretary of Defense, Research and Engineering (OUSD(R&E)) Command, Control, Computers, Communications, Cyber, Intelligence, Surveillance, Reconnaissance and Electronic Warfare (C5ISREW) Office in partnership with the Director of Defense Research & Engineering for Modernization (DDRE(M)) Quantum Science Office seeks to advance scientific discoveries in alignment with the USD(R&E) Quantum Science Roadmap and provide a mechanism to further scientific development, maturation, and commercialization of quantum science technologies. The C5ISREW SBIR program aims to stimulate technological innovation, strengthen the role of small business in meeting DoD research and development needs, foster and encourage participation by minority and disadvantaged persons in technological innovation, and increase the commercial application of DoD-supported research or research and development results. **The C5ISREW SBIR program solicits approaches that combine high-risk with potential for high-reward to address scientific challenges described in the topics below.**

Proposers responding to a topic in this BAA must follow all general instructions provided in the Department of Defense (DoD) SBIR Program BAA. C5ISREW requirements in addition to or deviating from the DoD Program BAA are provided in the instructions below.

Specific questions pertaining to the administration of the C5ISREW SBIR/STTR Program and these proposal preparation instructions should be directed to: Dr. Karl Dahlhauser, karl.j.dahlhauser.civ@mail.mil.

DIRECT TO PHASE II (DP2) PROPOSAL GUIDELINES

15 U.S.C. §638 (cc), as amended by NDAA FY2012, Sec. 5106, and further amended by NDAA FY2019, Sec. 854, PILOT TO ALLOW PHASE FLEXIBILITY, allows DoD to make a SBIR Phase II award to a small business concern with respect to a project, without regard to whether the small business concern was provided an award under Phase I of the SBIR program with respect to such project. C5ISREW will conduct a "Direct to Phase II" implementation of this authority for select topics under this BAA, as specified in these instructions.

Each eligible topic requires that proposers provide documentation to demonstrate feasibility described in the Phase I section of the topic has been met. **Feasibility documentation cannot be based upon or logically extend from any prior or ongoing federally funded SBIR or STTR work.** Work submitted within the feasibility documentation must have been substantially performed by the proposer and/or the PI. If technology in the feasibility documentation is subject to Intellectual Property (IP), the proposer must either own the IP, or must have obtained license rights to such technology prior to proposal submission, to enable it and its subcontractors to legally carry out the proposed work.

If the proposer fails to demonstrate technical merit and feasibility equivalent to the Phase I level as described in the associated topic, the related Phase II proposal will not be accepted or evaluated.

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other

means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD SBIR/STTR Program BAA.

A complete proposal consists of the following:

Volume 1: Proposal Cover Sheet

Volume 2: Technical Volume

Volume 3: Cost Volume

Volume 4: Company Commercialization Report

Volume 5: Supporting Documents

- a. Contractor Certification Regarding Provision of Prohibition on Contracting for Certain Telecommunications and Video Surveillance Services or Equipment (DoD Program BAA Attachment 1)
- b. Foreign Ownership or Control Disclosure (Proposers must review DoD Program BAA Attachment 2: Foreign Ownership or Control Disclosure to determine applicability.)
- c. Other supporting documentation (Refer to topic description for additional Volume 5 requirements)

Volume 6: Fraud, Waste and Abuse Training

Follow the instructions and guidance provided in section 5.3 of the DoD Program BAA for completing these proposal volumes.

Technical Volume (Volume 2)

The technical volume for DP2 proposals consist of two parts:

- **PART ONE: Feasibility Documentation:** Provide documentation to substantiate that the scientific and technical merit and feasibility described in the Phase I section of the topic has been met and describes the potential commercial applications. Documentation should include all relevant information including, but not limited to: technical reports, test data, prototype designs/models, and performance goals/results. **Maximum page length for feasibility documentation is 10 pages.** If you have references, include a reference list or works cited list as the last page of the feasibility documentation. This will count towards the page limit. Work submitted within the feasibility documentation must have been substantially performed by the proposer and/or the PI. If technology in the feasibility documentation is subject to Intellectual Property (IP), the proposer must either own the IP, or must have obtained license rights to such technology prior to proposal submission, to enable it and its subcontractors to legally carry out the proposed work. Documentation of IP ownership or license rights shall be included in the Technical Volume of the proposal. **DO NOT INCLUDE** marketing material. Marketing material will NOT be evaluated.
- **PART TWO: Technical Proposal:** Content of the Technical Volume should cover the items listed in section 5.3.c. of the DoD SBIR Program BAA. **The maximum page length for the technical proposal is 15 pages.**

Cost Volume (Volume 3)

For topic OSD221-D05, the Base amount must not exceed \$1,000,000 for a 12-month period of performance and the Option amount must not exceed \$700,000 for a 12-month period of performance.

For topic OSD221-D08, the Base amount must not exceed \$900,000 for an 18-month period of performance and the Option amount must not exceed \$800,000 for an 18-month period of performance.

Costs for the Base and Option must be separated and clearly identified on the Proposal Cover Sheet (Volume 1) and in Volume 3.

Company Commercialization Report (CCR) (Volume 4)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR/STTR Program BAA for full details on this requirement. Information contained in the CCR will be considered by C5ISREW during proposal evaluations.

Supporting Documents (Volume 5)

Supporting documents will be accepted/required as indicated in each topic.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TAB A)

The DDRE(RT) C5ISREW Office will not participate in the Technical and Business Assistance.

EVALUATION AND SELECTION

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD SBIR/STTR Program BAA.

Proposing firms will be notified of selection or non-selection status for a Phase I award within 90 days of the closing date of the BAA.

Refer to the DoD SBIR/STTR Program BAA for procedures to protest the Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: Dr. Karl Dahlhauser, karl.j.dahlhauser.civ@mail.mil.

C5ISREW SBIR 22.1 Direct to Phase II Topic Index

OSD221-D05	Networked quantum sensor for geolocation of anomalous underground ferrous sources
OSD221-D08	Open environment nuclear quadrupole magnetic resonance detection

OSD221-D05 TITLE: Networked quantum sensor for geolocation of anomalous underground ferrous sources

OUSD (R&E) MODERNIZATION PRIORITY: Quantum Science

TECHNOLOGY AREA(S): Sensors, Electronics and Electronic Warfare

OBJECTIVE: Detect and geo-locate subterranean tunneling activities by using a quantum networked magnetometer.

DESCRIPTION: In challenging environments, the DoD needs the capability to distinguish hidden threats in subsurface environments. These threats manifest as hidden, dynamic, and ferrous materials violating the perimeters of sovereignty. Quantum magnetic sensors have surpassed conventional sensors in demonstrating higher sensitivity and lower SWaP. However, these sensors have yet to convincingly demonstrate a relevant DoD mission in terms of geolocation and detection at a judicious range. The DoD recognizes that one stand-alone sensor is not adequate to detect these anomalies, but rather an array of sensors working in unison is required. Therefore, DoD seeks networked sensors with algorithms and signal-processing techniques demonstrating real-time geolocation, identification, and dynamic tracking of threats. Of particular interest is harbor defense, FOB protection, and border security. This effort is not intended to fund magnetometer development but rather experimental demonstrations that isolate signals of interest from noise to ascertain geolocation from the surface within 10% error underground and/or undersea. Furthermore, limits of range of detection given configuration of an array is of high interest to the DoD. Pathway towards further development to a much bigger network of sensors globally should be addressed at the conclusion of this work.

PHASE I: To qualify for Direct to Phase II, sufficient evidence of a previous externally funded effort that specifically addresses detection of underground activities is needed. Any final reports, findings, publications must be included in the proposal.

PHASE II: In order for this project to be successful, detected signals from tool movement inside a tunnel must be processed and adapted to the inverse propagation model with accurate geo-location. This effort does not repeat sensor development, but rather focuses on algorithm development and system integration to increase the technology readiness level (TRL). To accommodate algorithm development, it is desirable to set up a prototype system at a remote tunnel site for continual collection of data to verify and fine tune the physics model for geo-location. Although the geo-location algorithms worked in previous testing for simple sources with predictable magnetic fields, geo-location of hand tools was not as successful. The Phase II effort should significantly extend the system's ability to detect the use of hand tools in a subterranean environment. We are also looking to find ways to minimize sensor deployment but maximize detection range.

PHASE III DUAL USE APPLICATIONS: If the project is successful, Phase III can be extended to undersea for port surveillance, PBIED detection, and border protection for illegal drug movement underground (between US/Mexico border etc.)

REFERENCES:

1. L. G. Stolarczyk, R. Troublefield, J. Battis. "Detection of Underground Tunnels with a Synchronized Electromagnetic Wave Gradiometer", Proceedings of SPIE Vol. 5778, doi: 10.1117/12.609623.
2. L. Chen, Y. Feng, P. Wu, W. Zhu and G. Fang, "An Innovative Magnetic Anomaly Detection Algorithm Based on Signal Modulation," in IEEE Transactions on Magnetics, vol. 56, no. 9, pp. 1-9, Sept. 2020, Art no. 6200609, doi: 10.1109/TMAG.2020.3005896.

KEYWORDS: quantum sensor; atomic magnetometer; tunnel detection; networked quantum sensor

OSD221-D08 TITLE: Open environment nuclear quadrupole magnetic resonance detection

OUSD (R&E) MODERNIZATION PRIORITY: Quantum Science

TECHNOLOGY AREA(S): Sensors, Electronics and Electronic Warfare

OBJECTIVE: Develop a quantum magnetometer that is widely tunable between 100 Hz and 10 MHz to detect and distinguish RF signals with sensitivity near 1 fT/Hz^{1/2}. The sensor system should be simple and easily adapted to any system that uses an antenna in this frequency range. The sensor shall also possess the properties necessary to support nuclear quadrupole resonance (NQR) detection in an outdoor open environment.

DESCRIPTION: Quantum magnetic sensing has been continuously advancing performance down below the femtotesla level. Whereas previously applications that utilize such sensitivity such as magnetoencephalography required shielded environments, now modern quantum magnetic sensors are offering the same sensitivity in the open environment. For various DoD-related missions, there is a need to detect down to 1 fT/rtHz in open environments at a wide range of frequencies below 10 MHz. This requires pushing the limits of even the best magnetic sensors to mitigate noise, be robust to electromagnetic disturbance, and detect faint magnetic fields. The objective of this project is to develop a practical and versatile high-performance radiofrequency quantum magnetometer that can be used in a variety of commercial and defense applications. The sensor system should be specifically but not exclusively engineered to detect weak NQR signals at standoff, which could give significant asymmetric warfighter advantage as well as domestic security.

PHASE I: Previous proposer experience with rf atomic magnetometers of any type can support a Direct to Phase II proposal, including reports and data from proposer's previous sensor prototype operation and/or previous proposer laboratory measurements. Any final reports, findings, publications must be included in the proposal.

PHASE II: The Phase II may include a base program of up to 18 months and an Option program of up to 18 months to develop a prototype quantum antenna.

In the Base program, the project shall develop a versatile and automated atomic rf magnetometer system that is widely tunable from 100 Hz to 10 MHz with sensitivity better than 10 fT/rtHz. The program shall develop fully automated operation, with the user specifying the center frequency and the sensor supplying the signal at that frequency with a ≥ 1 kHz bandwidth. The outputs shall be both the raw analog signal via coaxial connector and the digitally demodulated signal via a data port such as USB. Multiple sensors must be synchronized and calibrated to achieve common mode rejection ratio (CMRR) > 100 . An array of 4 sensors should be constructed and demonstrated measuring an RF tensor field and also demonstrated for common mode interference rejection.

The sensor shall offer two operating modes; the unit shall support continuous wave (CW) operation in the Base program and develop pulsed mode operation in the Option period. In the Option period, the sensor sensitivity shall be improved to 1 fT/rtHz. The sensor hardware shall furthermore be hardened to survive typical NQR excitation pulse without damage. The pulsed mode operation shall rapidly recover operation after electromagnetic disturbance such as a typical NMR or NQR excitation pulse in time to receive an NMR echo signal. The prototype should be developed as a potential drop-in replacement for a typical NQR coil and offer an appropriate interface for an NMR/NQR spectrometer such as the Tekmag Redstone.

At the end of the program, a final sensor prototype deliverable shall be smaller than 5x5x15 cm³ and consume less than 10 W power.

PHASE III DUAL USE APPLICATIONS: Describe one or more potential commercial applications, and one or more potential DoD/military applications for the technology that may be pursued by the firm post Phase II. Phase III refers to work that derives from, extends, or completes an effort made under prior SBIR/STTR funding agreements, but is funded by sources other than the SBIR/STTR Program.

There are numerous compelling commercial and defense applications for a tunable RF atomic magnetometer: With the addition of an excitation pulse, the RF magnetometer can detect NMR and NQR signals. The NMR capabilities can enable higher sensitivity for low field magnetic resonance imaging. Measurement of the RF tensor field can enable source tracking and location. Measurement of oilfield NMR can be enhanced by a high performance magnetic sensor. Underwater, underground, and surface-to-cave communications can be uniquely enabled by a portable, ultrasensitive magnetic sensor.

REFERENCES:

1. I. M. Savukov, S. J. Seltzer, M. V. Romalis and K. L. Sauer. "Tunable Atomic Magnetometer for Detection of Radio-Frequency Magnetic Fields." *Phys. Rev. Lett.* 95, 063004 (2005).
2. I. M. Savukov, S. J. Seltzer, and M. V. Romalis. "Detection of NMR signals with a radio-frequency atomic magnetometer." *Journal of Magnetic Resonance.* 185, 214 (2007).
3. S.-K. Lee, K. L. Sauer, S. J. Seltzer, O. Alem, and M. V. Romalis. "Subfemtotesla radio-frequency atomic magnetometer for detection of nuclear quadrupole resonance." *Appl. Phys. Lett.* 89, 214106 (2006).
4. Robert J. Cooper, David W. Prescott, Peter Matz, Karen L. Sauer, Nezih Dural, Mike Romalis, Elizabeth L. Foley, Thomas W. Kornack, Mark Monti, and Jeffrey Okamitsu. "Atomic Magnetometer Multisensor Array for rf Interference Mitigation and Unshielded Detection of Nuclear Quadrupole Resonance." *Physical Review Applied* 6, 064014 (2016).
5. Orang Alem, "Spin-damping in an ultra-sensitive tunable rf atomic magnetometer" Dissertation, George Mason University (2011).

KEYWORDS: Quantum sensors; magnetic resonance detection; RF, atomic magnetometer, optical magnetometer, NMR, NQR, SLF, ULF, VLF, LF, MF

VERSION 2

UNITED STATES SPECIAL OPERATIONS COMMAND 22.1 Small Business Innovation Research (SBIR) Phase I Proposal Submission Instructions

Introduction:

The United States Special Operations Command (USSOCOM) seeks small businesses with strong research and development capabilities to pursue and commercialize technologies needed by Special Operations Forces through the Department of Defense (DoD) SBIR 22.1 Program Broad Agency Announcement (BAA). A thorough reading of the “Department of Defense Small Business Innovation Research (SBIR) Program, SBIR 22.1 Program Broad Agency Announcement (BAA)” prior to reading these USSOCOM instructions is highly recommended. These USSOCOM instructions explain certain unique aspects of the USSOCOM SBIR Program that differ from the DoD Announcement and its instructions. The Offeror is responsible for ensuring that their proposal complies with the requirements in the most current version of these instructions. Prior to submitting your proposal, please review the latest version of these instructions as they are subject to change before the submission deadline.

Table 1: Consolidated SBIR Topic Information

Topic	Technical Volume (Vol 2)	Additional Info. (Vol 5)	Period of Performance	Award Amount	Contract Type
<i>Phase I</i> SOCOM221-001	Not to exceed 5 pages	15-page PowerPoint	Not to exceed 6 months	NTE \$150,000.00	Firm-Fixed-Price

Contract Awards:

SBIR awards for topic SOCOM221-001 may be made under the authority of National Defense Authorization Act for Fiscal Year 2020, Section 851, PILOT PROGRAM FOR DEVELOPMENT OF TECHNOLOGY-ENHANCED CAPABILITIES WITH PARTNERSHIP INTERMEDIARIES. USSOCOM may use a partnership intermediary to award SBIR contracts and agreements to small business concerns. SOCOM213-003 SBIR contract awards may be done through SOFWERX and result in a commercial contract between the firm and DEFENSEWERX. The Government will evaluate and select for award all SOCOM221-001 proposals.

Proposal Submission:

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD SBIR Program BAA.

Proposal Documents Titles: We have encountered issues while downloading proposals due to lengthy file names. The contractor shall not use more than 50 characters to include spaces in any of the proposal documents titles.

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Proposal Volumes: Proposal Volumes are key in the qualification of the proposal. Offerors shall complete each of the following volumes. Those volume are (1) Cover Page, (2) Technical Volume, (3) Cost Volume, (4) Company Commercialization Report, (5) Pitch Day Presentation, and (6) Fraud, Waste and Abuse Training.

Volume 1: Cover Page is created as part of the DoD Proposal Submissions process.

Volume 2: Technical Volume

The technical volume is **not to exceed 5 pages** and recommended to follow the formatting requirements provided in the DoD SBIR Program BAA

The identification of foreign national involvement in a USSOCOM SBIR topic is needed to determine if a firm is ineligible for award on a USSOCOM topic that falls within the parameters of the United States Munitions List, Part 121 of the International Traffic in Arms Regulation (ITAR). A firm employing a foreign national(s) (as defined section titled "Foreign Nationals" of the DoD SBIR 22.1 Announcement) to work on a USSOCOM ITAR topic must possess an export license to receive a SBIR Phase I contract.

Volume 3: Cost Volume

Companies submitting a Phase I proposal under this BAA must complete the USSOCOM Phase I Cost excel spreadsheet, with a base **not to exceed \$150,000.00**.

A minimum of two-thirds of the research and/or analytical work in Phase I must be conducted by the proposing firm. The percentage of work is measured by both direct and indirect costs as a percentage of the total contract cost.

Volume 4: Company Commercialization Report (CCR)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR Program BAA for full details on this requirement. Information contained in the CCR will be considered by USSOCOM during proposal evaluations.

Volume 5: Supporting Documents (Pitch Day Presentation and Section K)

In addition to the documentation outlined in the DoD SBIR Program BAA, the following must also be included with Volume 5 consists of three documents: (1) the Pitch Day presentation and (2) Section K.

(1) Pitch Day Presentation: Potential Offerors shall submit a slide deck **not to exceed 15 PowerPoint slides (inclusive of the cover sheet)**. There is no set format for this document. It is recommended (but not required) that more detailed information is included in the technical volume and higher-level information is included in the slide deck suitable for the 30 minutes presenting. Refer to the "Phase I Evaluations" Section of this instruction for more details.

(2) Section K: If Section K is not submitted with the proposal, the proposal will not be considered non-responsive, but, the completed Section K shall be required at the time of award.

(3) Resumes: Include resumes as required.

Volume 6: Fraud, Waste and Abuse Training

Fraud, Waste and Abuse (FWA) training is required for Phase I and Direct to Phase II proposals. Please refer to the DoD 22.1 SBIR BAA for full details.

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Phase I proposals shall NOT include:

- 1) Any travel for Government meetings. All meetings with the Government will be conducted via electronic media.
- 2) Government furnished property or equipment.
- 3) Priced or Unpriced Options.
- 4) A Technical Volume exceeding five pages. USSOCOM will only evaluate the first five pages of the Technical Volume. Additional pages will not be considered or evaluated.
- 5) "Basic Research" (or "Fundamental Research") defined as a "Systematic study directed toward greater knowledge or understanding of the fundamental aspects of phenomena and/or observable facts without specific applications toward processes or products in mind."
- 6) Human or animal studies.
- 7) Discretionary Technical and Business Assistance

Technical Inquiries:

During the Pre-release and Open periods of the DoD SBIR 22.1 Program BAA, all questions must be submitted to the online Defense SBIR/STTR Innovation Portal (DSIP) Topic Q&A. All questions and answers submitted to DSIP Topic Q&A will be released to the general public. USSOCOM does not allow inquirers to talk directly or communicate in any other manner to the topic authors (differs from the DoD SBIR 22.1 Program BAA instructions).

Site visits will not be permitted during the Pre-release and Open Periods of the DoD SBIR 22.1 Program BAA.

Phase I Evaluations:

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD SBIR Program BAA with the following exceptions:

1. Proposals missing any of the six stated volumes or does not comply with the 2/3rd rule will not be evaluated. Likewise, proposals that exceed the maximum price allowed as per Table 1 of these instructions will be considered to be non-responsive.
2. The technical evaluation will utilize the Evaluation Criteria provided in DoD SBIR 22.1 BAA. The Technical Volume and slide deck will be reviewed holistically. The technical evaluation is performed in two parts:

Part I: The evaluation of the Technical Volume will utilize the Evaluation Criteria provided of the DoD SBIR 22.1 BAA. Once the evaluations are complete, all Offerors will be notified as to whether they were selected to present the slide deck portion of their proposal.

Part II: Selected Offerors **may** receive an invitation to present their slide deck (30 minute presentation time / 30 minute Government question and answer period) to the USSOCOM technical evaluation team, using virtual teleconference. This will be a technical presentation only of the proposed solution and the key personnel listed in the proposal should be conducting the presentation and responding to the questions of the evaluation team. This presentation is NOT intended for business development personnel, it is purely technical. Selected Offerors shall

DISTRIBUTION A: Approved for public release

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restrict their Pitch Day presentations to only the 15-page PowerPoint presentations that were submitted with their respective proposals. There will be no changes or updates to the presentations from what was proposed. All selected firms will be required to provide teleconference information for the presentation. This presentation will complete the evaluation of the proposal the panel did against the criteria listed in the DoD SBIR 22.1 BAA. Notifications of selection/non-selection for Phase I award will be completed within a timely manner.

3. The Cost Volume (Volume 3) evaluation:

For this Phase I, the award amount is set at a not to exceed (NTE) amount and a technical evaluation of the proposal cost will be completed to assess price fair and reasonableness. Proposals above the established NTE for the Phase I effort will not be considered for award. The team will assess the technical approach presented for the effort based on the number of labor hours by labor categories, the key personnel level of involvement, materials, subcontractors and consultants (scope of work, expertise, participation and proposed effort), and other direct cost as proposed.

Additionally, input on technical aspects of the proposals may be solicited by USSOCOM from non-Government consultants and advisors who are bound by appropriate non-disclosure requirements. Non-Government personnel will not establish final assessments of risk, rate, or rank Offeror's proposals. These advisors are expressly prohibited from competing for USSOCOM SBIR awards. All administrative support contractors, consultants, and advisors having access to any proprietary data will certify that they will not disclose any information pertaining to this announcement, including any submission, the identity of any submitters, or any other information relative to this announcement; and shall certify that they have no financial interest in any submission. Submissions and information received in response to this announcement constitutes the Offeror's permission to disclose that information to administrative support contractors and non-Government consultants and advisors.

Selection Notifications:

For topic SOCOM221-001, the Defensewerx (also known as SOFWERX) may notify each Offeror whether they have been selected for award. Otherwise, the notifications will be sent out by the Government Contracting Officer. The e-mail notification will be sent to the Corporate Official (Business) identified by the Offeror.

Informal Feedback:

A non-selected Offeror can make a written request to their respective contracting officer within 30 calendar days of receipt of notification of non-selection, for informal feedback. The respective Contracting Officer will provide informal feedback in response to an Offeror's written request rather than a debriefing as specified in the DoD SBIR 22.1 Announcement.

Protest Procedures

Refer to the DoD SBIR Program Announcement for procedures to protest the Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to the Contracting Officer (KO) from which the notice was generated and sent from.

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USSOCOM SBIR Program Point of Contact:

Inquiries concerning the USSOCOM SBIR Program and these proposal preparation instructions should be addressed to sbir@socom.mil.

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USSOCOM SBIR 22.1 Phase I Topic Index

SOCOM221-001	Low SWaP Tactical Ultra-Secure Communications System
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SOCOM221-001

TITLE: Low SWaP Tactical Ultra-Secure Communications System.

TECHNOLOGY FOCUS AREAS: Network Command, Control and Communications

TECHNOLOGY AREAS: Sensors; Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense-related material and services. Offerors must disclose any proposed use of foreign nationals, their country of origin, and what tasks each would accomplish in the statement of work in accordance with section 5.4.c.(8) of the solicitation. Additionally, Offerors will describe compliance mechanisms offerors have in place or will put in place to address any ITAR issues that arise during the course of agreement administration.

OBJECTIVE: In the face of a rising near-peer threat to electronic communications, USSOCOM is looking for advances in ultra-secure communications systems, including Low Probability of Detection (LPD) / Low Probability of Intercept (LPI) features at the tactical level. Tactical teams are increasingly burdened with large Size, Weight, and Power (SWaP) footprints but still require secure communications. The objective of this topic is to develop applied research toward an innovative capability to develop low SWaP Tactical Ultra-secure Communication Systems to allow operators to communicate safely in modern contested environments.

DESCRIPTION:

As a part of this feasibility study, the proposers shall address all viable overall system design options with a focus on developing a means of ultra-secure communications for the purpose of providing operators a low SWaP system to communicate safely in modern contested environments. The resultant solution must consider that the prime purpose of the system is to provide high bandwidth (>1Gbps) and reliable communications at the secure level while on the move. The communications system shall include at a minimum point to point terrestrial communication at a range of 3 miles and SATCOM communications. The feasibility study should consider various methods and techniques of LPD and LPI (including frequency agility, frequency aggregation; simultaneous bands; wide band, etc.) or features to accomplish secure communication while maintaining low SWaP. Low SWaP is considered < 500 grams with battery and antennas included. Proposers shall consider frequency coverage in the microwave and millimeter bands. If other bands are determined to be advantageous by the proposers, they should provide supporting information and will be assessed for their potential capability to enhance operator communication versatility while maintaining LPI/LPD.

PHASE I: Conduct a feasibility study to assess what is in the art of the possible that satisfies the requirements specified in the above paragraphs entitled "Objective" and "Description."

The objective of this USSOCOM Phase I SBIR effort is to conduct and document the results of a thorough feasibility study ("Technology Readiness Level 3") to investigate what is in the art of the possible within the given trade space that will satisfy a needed technology. The feasibility study should investigate all options that meet or exceed the minimum performance parameters specified in this write up. It should also address the risks and potential payoffs of the innovative technology options that are investigated and recommend the option that best achieves the objective of this technology pursuit. The funds obligated on the resulting Phase I SBIR contracts are to be used for the sole purpose of conducting a thorough feasibility

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study using scientific experiments and laboratory studies as necessary. Operational prototypes will not be developed with USSOCOM SBIR funds during Phase I feasibility studies. Operational prototypes developed with other than SBIR funds that are provided at the end of Phase I feasibility studies will not be considered in deciding what firm(s) will be selected for Phase II.

PHASE II: Develop, install, and demonstrate a prototype system determined to be the most feasible solution during the Phase I feasibility study on a Low Size, Weight, and Power (SWaP) Tactical Ultra-Secure Communications System.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military applications where secure communications are required.

REFERENCES:

1. Department of Defense Instruction (DoDI) 8523.01 Communications Security (COMSEC)

<https://safe.menlosecurity.com/doc/docview/viewer/docN2184A57DE9A63a334b4f908c8ad7307002d8d209aa9726dc4a60cad75dddcf141ec11f087cb7>

2. DoD Information Security Program: Protection of Classified Information 5200.01, Volume 3

https://www.dodig.mil/Portals/48/Documents/Policy/520001_vol3.pdf

KEYWORDS: Low Probability of Intercept; Low Probability of Detection; SATCOM; satellite communications; ultra-secure communications

UNITED STATES SPECIAL OPERATIONS COMMAND

22.1 Small Business Innovation Research (SBIR)

Direct to Phase II Proposal Submission Instructions

Introduction:

The United States Special Operations Command (USSOCOM) 22.1 Direct to Phase II proposal submission instructions cover Direct to Phase II proposals only and change/append the Department of Defense (DoD) instructions for Phase II submissions as they apply to USSOCOM Direct to Phase II requirements. The Government will only evaluate responsive proposals.

A thorough reading of the “Department of Defense Small Business Innovation Research (SBIR) Program, SBIR 22.1 Program Broad Agency Announcement (BAA)”, located at <https://rt.cto.mil/rtl-small-business-resources/sbir-sttr/>, prior to reading these USSOCOM instructions is highly recommended. These USSOCOM instructions explain certain unique aspects of the USSOCOM SBIR Program that differ from the DoD Announcement and its instructions. The Offeror is responsible for ensuring that their proposal complies with the requirements in the most current version of these instructions. **Prior to submitting your proposal, please review the latest version of these instructions as they are subject to change before the submission deadline.**

These USSOCOM instructions explain USSOCOM specific aspects that differ from the DoD Announcement and its instructions.

Table 1: Consolidated SBIR Topic Information

Topic	Technical Volume (Vol 2)	Additional Info. (Vol 5)	Period of Performance	Award Amount
<i>Direct to Phase II SOCOM221-D002</i>	Not to exceed 10 pages not including Feasibility Appendix	15-page PowerPoint	Maximum 12 months	Not to Exceed \$889,000.00
<i>Direct to Phase II SOCOM221-D003</i>	Not to exceed 10 pages not including Feasibility Appendix	15-page PowerPoint	Maximum 12 months	Not to Exceed \$1,483,000.00
<i>Direct to Phase II SOCOM221-D004</i>	Not to exceed 10 pages not including Feasibility Appendix	15-page PowerPoint	Maximum 12 months	Not to Exceed \$1,188,000.00

Contract Awards:

SBIR awards for the Direct to Phase II topics SOCOM221-D002, SOCOM221-D003, and SOCOM221-D004 will be awarded as a fixed price (level of effort type), Other Transactions Agreements (OTA). Successful completion of the prototype under an OTA may result in a follow-on production OTA or contract. Successful completion of the prototype is defined as meeting one or more threshold requirements. Firms may download the template at <https://www.socom.mil/SOF-ATL/Pages/SBIR-22-1.aspx>. The general terms and conditions are included in the draft OTA template provided in this solicitation. The terms and conditions of the Template OTA and the latest version of the OTA may be revised prior to execution. The document deliverables required for the effort are listed in the uploaded Statement of Objectives (SOO) for each topic. The OTA template uploaded is a basic draft and not tailored to the specific topic and is not the final document to be use in the award. Offerors must review these documents to develop their proposal.

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The OTA template needs to be completed by only those Offerors selected for award and will be submitted directly to the Agreements Officer identified in the notification. The specific OTA template for each topic will be sent to those selected to present the slide deck. Providing the completed OTA for those invited to present, is desirable but not required.

Those selected for award would be required to enter their company information, expected milestones (Attachment 1), and provide a non-proprietary Statement of Work (SOW) following the format of the Statement of Objectives (SOO) (Attachment 3).

Proposal Submission:

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD SBIR Program BAA.

USSOCOM does not provide Discretionary Technical and Business Assistance for Direct to Phase II awards.

Proposal Documents Titles: We have encountered issues with proposals due to lengthy file names. The contractor shall not use more than 50 characters to include spaces in any of the proposal documents titles.

Proposal Volumes:

Volume 1: Cover Sheet is created as part of the DoD Proposal Submissions process.

Volume 2: Technical Volume

The technical volume is not to exceed 10 pages and must follow the formatting requirements provided in the DoD SBIR Program BAA. Required items are under the DoD SBIR Program BAA **Phase I** Technical Volume instructions. Any additional pages will be deleted from the proposal prior to evaluation, only the first 10 pages will be evaluated.

The technical proposal shall include a Statement of Work (SOW) with the planned tasks and descriptions to meet the Statement of Objectives (SOO) goals detailed. Do not upload the whole SOO as your SOW with your proposal. The SOO and CDRL are provided to help the Offerors consider the required goals, scope, and deliverables when developing the proposal. It is an Offeror's responsibility to provide fully responsive, complete, and clear submissions. Exceptions to the requirements need to be identified/explained. The SOO, with the list of CDRLs are provided and can be downloaded from <https://www.socom.mil/SOF-ATL/Pages/SBIR-22-1.aspx>.

If an Offeror is selected for award, the Offeror will be required to submit a separate non-proprietary SOW with the planned tasks and descriptions from the proposal and all other applicable sections of the SOO and it shall include no proprietary information, data, or marking. The provided SOW will become Attachment 3 of the resulting OTA, incorporating any agreed upon changes if necessary.

Note: The Phase I feasibility Appendix (Appendix A) is required for the Direct to Phase II proposal and is specified in **Volume 5**.

Volume 3: Cost Volume

Offerors must complete the cost volume using the Phase II OTA Cost Proposal template posted on the USSOCOM Portal at <https://www.socom.mil/SOF-ATL/Pages/SBIR-22-1.aspx>, and read instructions

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before completing it. The Cost Proposal information (PDF format) shall be appended to and submitted in Volume 3. Those recommended for award shall submit the original cost proposal in Excel format.

For the Direct to Phase II topic in this announcement, the total price limit to provide a testable prototype is listed in Table 1 titled "Consolidated SBIR Topic Information". **Any proposal submitted with a total price above the provided limit will not be evaluated or considered for award.**

The final negotiated price of a USSOCOM Phase II SBIR contract will result from a determination of price fairness and reasonableness commensurate with the magnitude and complexity of the required research and development effort. The resulting agreement will be a firm priced agreement.

Proposal information should include the itemized listing (a-h) specified below. The proposal information must include a level of detail that would enable the Government personnel to determine the purpose, necessity, and reasonability of the proposal and show an understanding of the scope of the work. It is requested that a breakdown of labor hours per labor category and other associated costs be provided **by task**. The Agreements Officer may request additional information to support price analysis or understand the approach if needed.

a. Special Tooling and Test Equipment and Material: The inclusion of equipment and materials will be carefully reviewed relative to need and appropriateness of the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the Government and relate directly to the specific effort. They may include such items as innovative instrumentation and/or automatic test equipment. The reason for the requirement and the intention of offeror on disposition of the special material / equipment shall be documented in the proposal as well as the reason on why said equipment is charge directly to the effort rather than in the indirect cost of the business.

b. Direct Cost Materials: Justify costs for materials, parts, and supplies with an itemized list that includes item description, part number, quantities, and price.

c. Other Direct Costs: This category of costs includes specialized services such as machining or milling, special testing or analysis, and costs incurred in obtaining temporary use of specialized equipment. Proposals that include leased hardware must provide an adequate lease vs. purchase justification or rationale.

d. Direct Labor: For each individual, include the number of hours, and loaded rate to include all indirect costs. Identify key personnel by name if possible and labor category.

e. Travel: Travel costs must relate to the needs of the project. Proposed travel cost must be in accordance with the Federal Travel Regulation (FTR).

1. Per Diem Rates can be obtained at: <http://www.gsa.gov/perdiem>

2. The following information is documented –

- (i) Date (estimated), length and place (city, town, or other similar designation) of the trip;
- (ii) Purpose of the trip; and
- (iii) Number of personnel included in the estimate.

f. Cost Sharing: Cost sharing is permitted. However, cost sharing is not required, nor will it be an evaluation factor in the consideration of a proposal. Please note that cost share contracts do not allow fees/profit.

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g. Subcontracts: Involvement of university or other consultants in the planning and/or research stages of the project may be appropriate. If the Offeror intends such involvement, describe in detail and include information in the cost proposal. The proposed total of all consultant fees, facility leases or usage fees, and other subcontract or purchase agreements may not exceed one-half of the total contract price or cost, unless otherwise approved in writing by the Agreements Officer.

Support subcontract costs with copies of the subcontract agreements. The supporting agreement documents must adequately describe the work to be performed (i.e., cost proposal) or provide a statement of work with a corresponding detailed proposal for each planned subcontract.

h. Consultants: Provide a separate agreement letter for each consultant. The letter should briefly state what service or assistance will be provided, the number of hours required and hourly rate.

Volume 4: Company Commercialization Report

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR Program BAA for full details on this requirement. Information contained in the CCR will be considered by USSOCOM during proposal evaluations.

Volume 5: Supporting Documents

In addition to the documentation outlined in the DoD SBIR Program BAA, the following must also be included in Volume 5: the (1) Slide deck, (2) Feasibility Study, (3) section K and (4) resumes.

- (1) Slide Deck: Potential Offerors shall submit a slide deck with the proposed technical solution **not to exceed 15 PowerPoint slides (includes introductory first slide)**. Must be separate and clearly marked. Any additional slides will not be evaluated, only slide 1-15 will be evaluated. It is recommended (but not required) that more detailed information is included in the technical volume and higher-level information is included in the slide deck suitable for the 30 minutes presenting. Refer to the “Direct to Phase II Evaluations” Section of this instruction for more details.
- (2) Feasibility Study: Offerors must provide documentation to satisfy the Phase I feasibility requirement as specified in the Phase I topic write-up. The documentation shall be included as a Feasibility Appendix in this volume. Offerors are required to provide sufficient information to determine, to the extent possible, the scientific, technical, and commercial merit and feasibility of ideas submitted, and that the feasibility assessment was performed by the Offeror and/or the Principal Investigator. **If the Offeror fails to demonstrate the scientific and technical merit, feasibility, and/or the source of the work, USSOCOM will not continue to evaluate the Offeror's proposal.** Refer to the topic's Phase I description under the Direct to Phase II topic to review the minimum requirements needed to demonstrate feasibility. There is no minimum or maximum page limitation for the Feasibility Appendix (Appendix A).
- (3) Section K: The proposal must also include a completed Section K which does not count toward the page limit and should be uploaded with this volume. The identification of foreign national involvement in a USSOCOM SBIR topic is required to determine if a firm is ineligible for award on a USSOCOM topic that falls within the parameters of the United States Munitions List, Part 121 of the International Traffic in Arms Regulation (ITAR). A firm employing a foreign national(s) (as defined in paragraph 3.7 entitled “Foreign Nationals” of the DoD SBIR 22.1 Announcement) to work on a USSOCOM ITAR topic must possess an export license to receive a SBIR Phase II contract.
- (4) Resumes as required

Volume 6: Fraud, Waste and Abuse Training

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Fraud, Waste and Abuse (FWA) training is required for Phase I and Direct to Phase II proposals. Please refer to the DoD SBIR Program BAA for full details.

Technical Inquiries:

During the Pre-release and Open Periods of the DoD SBIR Program BAA, all questions must be submitted to the online Defense SBIR/STTR Innovation Portal (DSIP) Topic Q&A. All questions and answers submitted to DSIP Topic Q&A will be released to the general public. USSOCOM does not allow inquirers to communicate directly in any manner to the topic authors (differs from the DoD SBIR Program BAA instructions). **All inquiries must include the topic number in the subject line of the e-mail.**

Site visits will not be permitted during the Pre-release and Open Periods of the DoD SBIR Program BAA.

Direct to Phase II Evaluations:

The Government will evaluate only responsive proposals.

USSOCOM evaluates Direct to Phase II proposals using the evaluation criteria specified in DoD SBIR Program BAA with the following exceptions/clarifications:

1. Proposals missing technical volume, feasibility appendix, cost volume, or slide deck will not be evaluated or those that exceed the maximum price allowed as per Table 1 of this instructions. Those proposals will be considered non-responsive.
2. Feasibility determination. The Feasibility Appendix to the Phase II proposal will be evaluated first to determine that the Offerors demonstrated they have completed research and development to establish the feasibility of the proposed Phase II effort based on the criteria outlined in the topic description of Phase I. **USSOCOM will not continue evaluating the Offeror's related Phase II proposal if it determines that the Offeror failed to demonstrate that feasibility has been established or the Offeror failed to demonstrate work submitted in the feasibility documentation was substantially performed by the Offeror and/or the Principal Investigator.** Refer to the Phase I Topic description included in the Direct to Phase II topic to review the minimum requirements that need to be demonstrated in the feasibility documentation.
3. The technical evaluation will utilize the Evaluation Criteria provided in the DoD SBIR Program BAA instructions. The Technical Volume and slide deck will be reviewed holistically. The technical evaluation is performed in two parts:

Part I: The evaluation of the Technical Volume will utilize the Evaluation Criteria provided in the DoD SBIR Program BAA instructions. Once the evaluations are completed, all Offerors will be notified as to whether they were selected to present their slide deck portion of their proposal.

Part II: Selected Offerors will receive an invitation to present their slide deck (30-minute presentation time / 30-minute question and answer) to the USSOCOM technical evaluation team, using a virtual teleconference. This will be a **technical presentation** only of the proposed solution and the key personnel listed in the proposal should be conducting the presentation and responding to the questions of the evaluation team. This presentation is NOT intended for business development people but purely technical exchange. The technical approach and key personnel knowledge involved in the project will be considered. This presentation will complete the panel's evaluation of the proposal against the criteria listed in the DoD SBIR Program BAA instructions. Notifications of selection/non-selection for Phase II award will be completed in a timely manner.

4. The Cost Volume (Volume 3) evaluation:

For these direct to Phase II efforts, the award amount is set with not to exceed (NTE) amount. Technical evaluation of the proposals costs will be completed to assess the probability of success to obtain a working prototype. Proposals above the set NTE for the effort **will not** be considered for award. The team will assess the probability of success of the technical approach, presented for the efforts. The technical team will assess number of labor hours, labor categories, key personnel expertise and level of involvement, materials, equipment, subcontractors and consultants (scope of work, expertise, participation and proposed effort), travel and other direct cost to successfully complete the effort as proposed.

The resulting award/s will be a fixed price OTA prototyping agreement and a successful prototype may lead to follow on production. Follow on production awards may be FAR based, Fixed Price or Cost-Plus Fixed Fee contracts. A Defense Contracts Audit Agency approved accounting system will be required to issue a Cost-Plus Fixed Fee contract.

Additionally, input on technical aspects of the proposals may be solicited by USSOCOM from non-Government consultants and advisors who are bound by appropriate non-disclosure requirements. Non-Government personnel will not establish final assessments of risk, rate, or rank Offeror's proposals. These advisors are expressly prohibited from competing for USSOCOM SBIR awards. All administrative support contractors, consultants, and advisors having access to any proprietary data will certify that they will not disclose any information pertaining to this announcement, including any submission, the identity of any submitters, or any other information relative to this announcement; and shall certify that they have no financial interest in any submission. Submissions and information received in response to this announcement constitutes the Offeror's permission to disclose that information to administrative support contractors and non-Government consultants and advisors.

Selection Notifications:

The USSOCOM Contracting Office will notify the Offeror by e-mail of selection/non-selection for award. The e-mail notification will only be sent to the Corporate Official identified by the Offeror during proposal submission. The Government will also notify the Offerors if their proposal is considered non-responsive (disqualified).

Informal Feedback:

A non-selected Offeror can make a written request to the Contracting Officer, within 30 calendar days of receipt of notification of non-selection, for informal feedback. The Contracting Officer will provide informal feedback after receipt of an Offeror's written request rather than a debriefing as specified in the DoD SBIR Program BAA instructions.

Protest Procedures

Refer to the DoD SBIR Program Announcement for procedures to protest the Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to the Contracting Officer (KO) from which the notice was generated and sent from.

USSOCOM SBIR Program Point of Contact:

Inquiries concerning the USSOCOM SBIR Program and these proposal preparation instructions should be addressed to sbir@socom.mil.

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USSOCOM SBIR 22.1 Direct to Phase II Topic Index

SOCOM221-D002	Ultra-Compact Long Range Machine Gun Optic
SOCOM221-D003	Miniature Aiming Ranging Laser
SOCOM221-D004	Advanced Precision-Variable Power Scope

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SOCOM221-D002 TITLE: Ultra-Compact Long Range Machine Gun Optic

OUUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements

TECHNOLOGY AREA(S): Sensors; Weapons; Human Systems; Battle Space; Direct View Optics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: The objective of this topic is to develop applied research toward an innovative capability that will allow operators to detect and engage targets for 0-2000 meters and beyond in day-night mounted and dismounted machine gun engagements. The intent of this optic is to provide a compact direct view optic to the operator that will not interfere with the operation of the machinegun, which includes immediate and remedial corrective actions. This capability shall meet the requirements in the description below.

DESCRIPTION: With the advent of highly accurate and long range lightweight medium machine guns (LWMMG) weapon systems as well as the existing family of machine guns, a direct view sighting system is required to allow the operator to detect and engage targets at the effective range of those weapons. Existing direct view MGOs, while compact, provide limited overmatch as they do not have adequate magnification to detect and engage targets at the standoff distances of all enemy weapons. Due to the limited mounting space, a very specific and ultra-compact direct view MGO is required that is very short to properly mount and interface with these LWMMG weapons without interfering with machinegun operation. This topic is seeking information regarding advanced technology pertaining to advancements in materials, miniaturization, weight reduction, weapon shock and environmental durability, and direct view detect/recognize/identify performance.

PHASE I: Conduct a feasibility study to assess what is in the art of the possible that satisfies the requirements specified in the above paragraphs entitled "Objective" and "Description". The objective of this USSOCOM Phase I SBIR effort is to conduct and document the results of a thorough feasibility study to investigate what is in the art of the possible within the given trade space that will satisfy a needed technology. The feasibility study should investigate all known options that meet or exceed the minimum performance parameters specified in this write up. It should also address the risks and potential payoffs of the innovative technology options that are investigated and recommend the option that best achieves the objective of this technology pursuit. The funds obligated on the resulting Phase I SBIR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments and laboratory studies as necessary. Operational prototypes will not be developed with USSOCOM SBIR funds during Phase I feasibility studies. Operational prototypes developed with other than SBIR funds that are provided at the end of Phase I feasibility studies will not be considered in deciding what firm(s) will be selected for Phase II.

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PHASE II: Develop, install, and demonstrate up to 12 prototype systems determined to be the most feasible solution during the Phase I feasibility study on a Ultra-Compact Long Range Machine Gun Optic (UCLR-MGO) unit that will allow operators to detect and engage targets for 0-2000 meters and beyond in day-night mounted and dismounted machine gun engagements. This capability shall meet the requirements in the description above. The testing and demonstration will contain scenarios, environments, and test objectives to demonstrate program and operational objectives.

PHASE III DUAL USE APPLICATIONS: This UCLR-MGO could be used for fire control for lightweight medium and heavy machine guns as well as potentially squad and designated marksman rifles in a broad range of military, law enforcement, and homeland security applications

REFERENCES:

1. TC 3-22.249 LIGHT MACHINE GUN M249 Series May 2017
(<https://atiam.train.army.mil/catalog/dashboard>).
2. MIL-STD-810H DEPARTMENT OF DEFENSE TEST METHOD STANDARD ENVIRONMENTAL ENGINEERING CONSIDERATIONS AND LABORATORY TESTS
(<https://quicksearch.dla.mil/ImageRedirector.aspx?token=5755401.35978>).
3. MIL-STD-1913 NOTICE 1 MILITARY STANDARD DIMENSIONING OF ACCESSORY MOUNTING RAIL FOR SMALL ARMS WEAPONS
(https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=115317).

KEYWORDS: Optics; Direct View Optics; Machine Gun Optics; Target Engagement

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SOCOM221-D003 TITLE: Miniature Aiming Ranging Laser

OUUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements

TECHNOLOGY AREA(S): Sensors; Electronics; Battle Space; Human Systems; Weapons; Lasers

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: The objective of this topic is to develop applied research toward an innovative capability that will allow operators to illuminate, and detect human targets from 0-900 meters, vehicle targets from 0-3,000 meters and beyond when using the PVS-31 or PVS-31A Binocular Night Vision Device (BNVD). The system shall allow operators to successfully range a man size target from 0-900 meters. The system capability shall meet the requirements in the description below.

DESCRIPTION: The Special Operations Forces (SOF) Operator is faced with a dynamic battlefield and evolving enemy. In order to maintain the advantage and increase the survivability and lethality of the operator on the battlefield, a compact, lightweight, ranging, aiming, pointing, and illuminating laser is required to allow the operator to range, detect, and engage targets at the effective range at night when using the Binocular Night Vision Device (BNVD). Existing squad weapon mounted lasers do not have the power output nor ranging capabilities required to provide suitable stand-off and engagement ranges in the compact size that is required. This topic is seeking information regarding advanced technology pertaining to advancements in materials, miniaturization, weight reduction, weapon shock and environmental durability, and laser ranging/aiming/illuminating performance.

PHASE I: Conduct a feasibility study to assess what is in the art of the possible that satisfies the requirements specified in the above paragraphs entitled "Objective" and "Description". The objective of this USSOCOM Phase I SBIR effort is to conduct and document the results of a thorough feasibility study to investigate what is in the art of the possible within the given trade space that will satisfy a needed technology. The feasibility study should investigate all known options that meet or exceed the minimum performance parameters specified in this write up. It should also address the risks and potential payoffs of the innovative technology options that are investigated and recommend the option that best achieves the objective of this technology pursuit. The funds obligated on the resulting Phase I SBIR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments and laboratory studies as necessary. Operational prototypes will not be developed with USSOCOM SBIR funds during Phase I feasibility studies. Operational prototypes developed with other than SBIR funds that are provided at the end of Phase I feasibility studies will not be considered in deciding what firm(s) will be selected for Phase II.

PHASE II: Develop, install, and demonstrate up to 12 prototype systems determined to be the most feasible solution during the Phase I feasibility study on a Miniature Aiming Ranging Laser (MARL) unit that will allow operators to illuminate and detect targets when using the PVS-31 or PVS-31A Binocular

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Night Vision Device (BNVD). This capability shall meet the requirements in the description above. The testing and demonstration will contain scenarios, environments, and test objectives to demonstrate program operational objectives.

PHASE III DUAL USE APPLICATIONS: The MARL could be used for rapid target acquisition of compact rifles (CR's), assault rifles (AR's), lightweight medium machine guns (LWMMG), Designated Marksmen Rifles (DMR's) along with pulse features utilized for signaling in both day and night environments in a broad range of military, law enforcement, and homeland security applications.

REFERENCES:

1. MIL-STD-810H DEPARTMENT OF DEFENSE TEST METHOD STANDARD ENVIRONMENTAL ENGINEERING CONSIDERATIONS AND LABORATORY TESTS
(<https://quicksearch.dla.mil/ImageRedirector.aspx?token=5755401.35978>).
2. MIL-STD-1913 NOTICE 1 MILITARY STANDARD DIMENSIONING OF ACCESSORY MOUNTING RAIL FOR SMALL ARMS WEAPONS
(https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=115317).
3. Interface Control Document (ICD) for Weapon Mounted Ballistic Calculators and Micro-Displays Revision D or current. (Requests for this document shall be referred to U.S. Army ARDEC, ATTN: RDAR-WSF-N, Picatinny Arsenal, NJ 07806.)

KEYWORDS: Optics; Laser; Target Engagement; Ranging; Ballistics

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SOCOM221-D004 TITLE: Advanced Precision-Variable Power Scope

OUUSD (R&E) MODERNIZATION PRIORITY: General Warfighting Requirements

TECHNOLOGY AREA(S): Sensors; Weapons; Human Systems; Battle Space; Direct View Optics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: The objective of this topic is to develop applied research toward an innovative capability that will allow operators to detect and engage targets from 50-1500 meters and beyond in sniper rifle engagements while simultaneously viewing laser rangefinder, wind, and ballistic data in the optic's field of view.

DESCRIPTION: The Advanced Precision-Variable Power Scope (AP-VPS) will allow operators to detect and engage targets from 50-1500 meters and beyond in mounted sniper rifle engagements while simultaneously viewing laser rangefinder, wind, and ballistic data in the optic's field of view. The AP-PVS shall have the same capabilities of the Precision-Variable Power Scope (P-VPS, SU-295/SU-296), but will also incorporate a micro data display to display firing solution, range finding, ballistics offsets, and other engagement data within the optic's field of view. These AP-VPS will upgrade the Family of Sniper Weapon Systems (FSWS) family of sniper scopes previously fielded as part of the sniper weapon system. This topic is seeking information regarding advanced technology pertaining to advancements in materials, miniaturization, weight reduction, weapon shock and environmental durability, Laser Range Finder interface, and direct view detect/recognize/identify performance.

PHASE I: Conduct a feasibility study to assess what is in the art of the possible that satisfies the requirements specified in the above paragraphs entitled "Objective" and "Description". The objective of this USSOCOM Phase I SBIR effort is to conduct and document the results of a thorough feasibility study to investigate what is in the art of the possible within the given trade space that will satisfy a needed technology. The feasibility study should investigate all known options that meet or exceed the minimum performance parameters specified in this write up. It should also address the risks and potential payoffs of the innovative technology options that are investigated and recommend the option that best achieves the objective of this technology pursuit. The funds obligated on the resulting Phase I SBIR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments and laboratory studies as necessary. Operational prototypes will not be developed with USSOCOM SBIR funds during Phase I feasibility studies. Operational prototypes developed with other than SBIR funds that are provided at the end of Phase I feasibility studies will not be considered in deciding what firm(s) will be selected for Phase II.

PHASE II: Develop, install, and demonstrate up to 4 prototype systems determined to be the most feasible solution during the Phase I feasibility study on a AP-VPS unit that will allow operators to detect and engage targets for 50-1500 meters and beyond in day-night mounted sniper rifle engagements

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while simultaneously viewing laser rangefinder, wind, and ballistic data in the optic's field of view. This capability shall meet the requirements in the description above. The testing and demonstration will contain scenarios, environments, and test objectives to demonstrate program and operational objectives.

PHASE III DUAL USE APPLICATIONS: This AP-VPS could be used for observation, fire control, and target engagement for SOF Sniper weapons as well as potentially designated marksman rifles in a broad range of military, law enforcement, and homeland security applications.

REFERENCES:

1. MIL-STD-810H DEPARTMENT OF DEFENSE TEST METHOD STANDARD ENVIRONMENTAL ENGINEERING CONSIDERATIONS AND LABORATORY TESTS
(<https://quicksearch.dla.mil/ImageRedirector.aspx?token=5755401.35978>).
2. MIL-STD-1913 NOTICE 1 MILITARY STANDARD DIMENSIONING OF ACCESSORY MOUNTING RAIL FOR SMALL ARMS WEAPONS
(https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=115317).
3. Interface Control Document (ICD) for Weapon Mounted Ballistic Calculators and Micro-Displays Revision D.

KEYWORDS: Optics; Direct View Optics; Sniper; Target Engagement; Micro-Display