DEPARTMENT OF DEFENSE SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM SBIR 21.1 Program Broad Agency Announcement (BAA)

AMENDMENT 2: February 26, 2021

The purpose of Amendment 2 is to:

- 1. Reopen the BAA for proposal submission on March 1, 2021 at 8:00 AM ET. Complete proposals must be certified in DSIP no later than March 4, 2021 12:00 PM ET.
- 2. All other BAA content, as previously amended, remains unchanged and in full effect.

AMENDMENT 1, REVISED: February 16, 2021

The purpose of Amendment 1 is to:

- 1. Replace Attachment 2: Foreign Disclosure Addendum with Attachment 2: Foreign Ownership or Control Disclosure, incorporate DFARS provision 252.209-7002 into this BAA, and remove the requirement to respond to the six questions concerning foreign involvement on the proposal cover sheet. The Amendment 1 changes are in the following BAA sections and subsections, and are also highlighted: 2.2; 5.1; 5.4(a); 5.4(c)(10); 5.4(f); 5.4(h); 8.1(x); and Attachment 2.
- 2. Extend the deadline for proposal receipt to February 24, 2021 at 12:00 PM ET.

December 08, 2020: DoD BAA issued for pre-release January 14, 2021: DoD begins accepting proposals March 4, 2021: Deadline for receipt of proposals no later than 12:00 p.m. ET

Participating DoD Components:

- Department of the Navy
- Department of the Air Force
- Defense Health Agency (DHA)
- Defense Logistics Agency (DLA)
- Defense Microelectronics Activity (DMEA)
- National Geospatial-Intelligence Agency (NGA)
- United States Special Operations Command (USSOCOM)

IMPORTANT

Deadline for Receipt: Complete proposals must be certified in DSIP no later than <u>12:00 PM</u> ET, March 4, 2021. Proposals submitted after 12:00 p.m. will not be evaluated. The final proposal submission includes successful completion of all firm level forms, all required volumes, and electronic corporate official certification.

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 <u>https://www.dodsbirstr.mil/submissions/login</u> and clicking "DSIP Listserv" located under Quick Links. <u>Help Desk:</u> If you have questions about the Defense Department's SBIR or STTR Programs, please call the DoD SBIR/STTR Help Desk at 1-703-214-1333, or email <u>DoDSBIRSupport@reisystems.com</u>. The Help Desk is available Monday through Friday, 9:00 a.m. to 5:00 p.m. ET.

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1.0 INTRODUCTION

The Army, Navy, Air Force, DHA, DLA, DMEA, NGA, 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, NGA, and USSOCOM are offering Direct to Phase II topics for the SBIR 21.1 BAA – see the Component-specific instructions for more information.

This BAA is for Phase I proposals only. 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. The initial measure being implemented for the SBIR program is to require proposers to self-report and disclose foreign ownership of, or control over, the proposer. 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.

RT&L Technology Focus Area Definitions

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 May 2, 2019. 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/SBIR-STTR Policy Directive 2019.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:

Performance Benchmarks for Progress toward Commercialization

In accordance with the SBA SBIR-STTR Policy Directive Sec 6(a)(7), DoD established a threshold for the application of a benchmark where it is applied only to Phase I applicants that have received more than twenty (20) awards over the prior five (5) fiscal years as determined by the Small Business Administration. The ratio of Phase II awards received to Phase I awards received during this period must be at least 0.25.

Additional information on performance benchmarking for Phase I applicants can be found at <u>https://www.sbir.gov/performance-benchmarks.</u>

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: <u>https://www.sbir.gov/tutorials/fraud-waste-abuse/tutorial-1</u>. 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, <u>http://www.ed.gov/about/offices/list/ocr/edlite-minorityinst.html</u>.

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).

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: <u>https://www.nsf.gov/statistics/ffrdclist/</u>.

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: <u>https://osp.od.nih.gov/wp-content/uploads/2016/05/NIH_Guidelines.pdf</u>. 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.

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 <u>two-thirds</u> 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 <u>primary employment</u> 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 <u>one-half</u> 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) <u>Phase I to Phase II Transition Rate</u>: 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) <u>Commercialization Benchmark</u>: 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 award for a period of one year from that date.
- Because this requirement only affects a company's eligibility for new Phase I 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 <u>www.sbir.gov.</u>
- In addition, SBA has posted a <u>Guide to SBIR/STTR Program Eligibility</u> 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 <u>https://www.sbir.gov/performance-benchmarks</u>.

4.3 Joint Ventures

Joint ventures and <u>limited partnerships</u> are permitted, provided that the <u>entity created</u> 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

Majority ownership in part by multiple venture capital, hedge fund, and private equity firms: Small businesses that are owned in majority part by multiple venture capital operating companies (VCOCs), 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 VCOCs, 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 VCOC, 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 (subawardee, 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 (subawardee, consultant) is providing SETA, A&AS, or similar support to any DoD Component office(s) under: (a) a current award or subaward; or (b) a past award or subaward 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 (subawardee, 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.

4.6 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 Security Service Web site at: <u>http://www.dss.mil/index.html.</u>

4.7 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.**

4.8 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.

4.9 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.

4.10 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.

4.11 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: <u>chrissandra.smith.civ@mail.mil</u>

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.

4.12 Phase I Award Information

All Phase I and Direct to Phase II 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; <u>it is therefore</u> <u>important for proposing firms to review Component-specific instructions regarding award size</u>.

d. **Timing**. The SBA SBIR 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. Normally proposing firms will be notified of selection or non-selection status for a Phase I award within 90 days of the closing date for this BAA.

4.13 Questions about this BAA and BAA Topics

a. General SBIR Questions/Information.

(1) Help Desk:

The DoD SBIR/STTR Help Desk is prepared to address general questions about this BAA, the proposal preparation and electronic submission process and other program- related areas. The Help Desk may be contacted from 9:00 a.m. to 5:00 p.m. ET Monday through Friday at:

- Phone: 1-703-214-1333
- E-mail: <u>DoDSBIRSupport@reisystems.com</u>

(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 (formerly SITIS)
- 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 <u>https://rt.cto.mil/rtl-small-business-resources/sbir-sttr/</u>, 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, you are invited to subscribe to our Listserv by emailing <u>DoDSBIRSupport@reisystems.com</u> or 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 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 <u>December 08, 2020 to January 14, 2021</u>, 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 (formerly SITIS). After this period questions must be asked through Topic Q&A as described below.

d. **Topic Q&A** (**formerly SITIS**). Once DoD begins accepting proposals on <u>January 14, 2021</u>, 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 <u>https://www.dodsbirsttr.mil/submissions/login</u>. 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 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, will not receive a response. Proposing firms may locate the topic to which they want to submit a technical question by using the Topic Search feature on this Web site. 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 <u>December 08, 2020</u> and closes to new questions on <u>February</u> <u>04, 2021 at 12:00 PM ET</u>. 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.

4.14 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, 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). If you were previously registered in CCR, your information has been transferred to SAM. However, it is in the firm's interest to visit SAM and ensure that all of the firm's data is up to date from SAM and other databases to avoid delay in award. SAM replaced the Central Contractor Registration (CCR), Online Representations and Certifications Application (ORCA), and the Excluded Parties List System (EPLS). SAM allows firms interested in conducting business with the federal government to provide basic information on business capabilities and financial information. To register, visit <u>www.sam.gov</u>.

Follow instructions found on the SAM Web site 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.

4.15 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.

4.16 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).

4.17 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 <u>http://www.dodig.mil/Components/Administrative-Investigations/DoD- Hotline/Hotline-Complaint/</u> 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.

4.18 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 <u>https://www.sbir.gov/state_services?state=105813#</u> 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.

4.19 Discretionary Technical and Business Assistance (TABA)

DoD has not mandated the use of TABA 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 TABA is being offered and follow specific proposal requirements for requesting TABA 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.

Since the guidance on allowable content may vary by Component, it is the proposing firm's responsibility to consult the Component-specific instructions for detailed guidance.

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 (REQUIRED)

Volume 5: Supporting Documents

- a. Contractor Certification Regarding Provision of Prohibited Video Surveillance and Telecommunications Services and Equipment (REQUIRED)
- 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 (REQUIRED)

NOTE: Beginning with the DoD 21.1 SBIR BAA, all proposers are required to submit Volume 4: Company Commercialization Report (CCR), Volume 5(a): Contractor Certification Regarding Provision of Prohibited Video Surveillance and Telecommunications Services and Equipment, Volume 5(b): Foreign Ownership or Control Disclosure (Proposers must review Attachment 2: Foreign Ownership or Control Disclosure to determine applicability), and Volume 6: Fraud, Waste and Abuse training.

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 <u>https://www.dodsbirsttr.mil/submissions/learning-support/firm-templates</u>.

Detailed guidance on registering in DSIP and using DSIP to submit a proposal can be found at <u>https://www.dodsbirsttr.mil/submissions/learning-support/training-materials</u>. 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 Summary of Component Programs

The tables below are provided for your convenience. Information provided in the Component instructions take precedence over any figures listed below. Please refer to the Component instructions for the topic of interest prior to proposal submission.

DoD Component	Cost	Duration	Phase I Option	Technical and Business Assistance	Technical Volume Page Limits
Army	Base NTE \$111,500 + Phase I Option NTE \$56,000	6 Month Base + 4 Month Phase I Option	Required	\$5,000	20 pages
Navy	Base NTE \$140,000 + Phase I Option NTE \$100,000	6 Month Base + 6 Month Phase I Option	Required	\$6,500	10 pages
Navy Direct to Phase II	See Component-Specific Instructions	See Component-Specific Instructions	See Topics/Context Instructions	\$25,000	30 pages
Air Force Direct to Phase II	NTE \$1.705M			Not Available	15 Pages
DHA	NTE \$250,000	6 Months		Not Available	20 pages
DLA	See Topics/Context Instructions	See Topics/Context Instructions	See Topics/Context Instructions	Not Available	20 pages
NGA Direct to Phase II	Base: \$1,000,000	24 Months		Not Available	60 pages
OSD/DMEA	NTE \$167,500	6 Months		Not Available	20 pages
USSOCOM	Base \$150,000	6 Month Base	Not Applicable	\$6,500	5 pages
USSOCOM Direct to Phase II	Base NTE \$1,500,000	Typically 18 Month	Not Applicable	\$50,000	10 pages

5.3 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.

5.4 Phase I Proposal Instructions

a. **Proposal Cover Sheet (Volume 1)**

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

Beginning in January 2021, proposers will be required to disclose foreign involvement. The DSIP Firm Admin must review the below questions to determine if the Foreign Ownership or Control Disclosure (BAA Attachment 2) needs to be submitted with the proposal. The DSIP Firm Admin will either certify that the questions do not apply, or certify that the questions do apply and that the Foreign Ownership or Control Disclosure will be uploaded to Volume 5 as part of the proposal submission.

The questions below regarding disclosure of foreign involvement in the firm certifications section of the proposal submission are no longer required and responses to these questions will NOT be considered. Due to system requirements, however, these questions cannot be removed from the submission portal and answers to these questions must be provided in the submission portal for a proposal to be submitted. Proposers are therefore advised to answer "No" to these questions and should understand that these answers will be neither reviewed nor considered. Those proposers that have previously answered these questions are not required to revise or change their answers now and are advised that their previous answers will not be reviewed or considered.

- 1. Does your company currently employ any foreign nationals?
- 2. Does/did your company or employees have relationships with any foreign academic institutions, research centers, or affiliated academic organizations over the past seven years?
- 3. Has your company received investment or financing from any foreign-based entity?
- 4. Has your company received investment or financing from any foreign-owned entity domiciled in the US?
- 5. Has your company received investment or financing from a US entity that manages or receives foreign sources of capital?
- 6. Does your company have any substantial business operations in other countries?

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 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 <u>not</u> 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 oneinch 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 according to the <u>Cost Breakdown Guidance</u>. 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. Foreign disclosure requirements flow down to all subcontractors and consultants.
- (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:
 - 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 principal investigator 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 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 Guidance 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.

- (1) List all key personnel by name as well as by number of hours dedicated to the project as direct labor.
- (2) 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.
- (3) Cost for travel funds must be justified and related to the needs of the project.
- (4) 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.
- (5) A Phase I Option (if applicable) should be fully costed separately from the Phase I (base) approach.
- (6) 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. Enter this information in the Explanatory Material section of the on-line cost proposal form. The Supporting Documents Volume (Volume 5) 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 http://www.dcaa.mil. Click on "Guidance" and then click on "Audit Process Overview Information for Contractors."

e. Company Commercialization Report (Volume 4)

The Company Commercialization Report (CCR) allows companies to report funding outcomes resulting from prior SBIR and STTR awards. Completion of Volume 4: Company Commercialization Report in DSIP is required for all proposal submissions. During proposal submission, proposing firms with no prior DoD or non-DoD SBIR/STTR awards can select "No" for the question "Do you have a new or revised Company Commercialization Report to upload?".

Proposing firms with prior DoD and/or non-DoD Phase I and/or Phase II SBIR/STTR awards must complete the CCR, regardless of whether the project has any commercialization to date, by logging into their account at <u>https://www.sbir.gov/</u>. To view or print the information currently contained in the Company Registry Commercialization Report, navigate to My Dashboard > My Documents. To create or update the commercialization record, from the company dashboard, scroll to the "My Commercialization" section, and click 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.

Once the report is certified and submitted on SBIR.gov, click the "Company Commercialization Report" PDF under the My Documents section of the dashboard to download a PDF of the CCR. This PDF of the CCR must be uploaded to Volume 4: Company Commercialization Report in the Firm Information section of DSIP by the Firm Admin. All other firm users will have read-only access to the CCR from the proposal submission page, in order to confirm that the CCR has been uploaded by the Firm Admin to complete the Volume 4 requirement. The most recent version of the CCR that has been uploaded by the Firm Admin will be included in the proposal submission.

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).

Beginning with the DoD 21.1 SBIR BAA, all proposers are REQUIRED to submit the following documents to Volume 5:

- 1. Contractor Certification Regarding Provision of Prohibited Video Surveillance and Telecommunications Services and Equipment (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 Prohibited Video Surveillance and Telecommunications Services and 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 Federal Acquisition Regulation clauses 52.204-24, 52-204-25, and 52-204-26, executed by the proposer's authorized company representative. These Federal Acquisition Regulation clauses 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

If the proposer answers YES to any of the questions contained in the Firm Certifications section of the DSIP proposal submission page regarding foreign involvement (accessible only by the DSIP Firm Admin), 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.

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 the 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 http://www.dcaa.mil and click on "Guidance" and then click on "Audit Process Overview Information for Contractors," and also at http://www.dcaa.mil and click on "Checklists and Tools" and then click on "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:

Mr. Matthew B. Williams OUSD (R&E) Technology Portfolio Manager matthew.b.williams10.civ@mail.mil

Mr. Jason Talley OUSD (R&E) Outreach/Education/Transition Specialist jason.m.talley2.ctr@mail.mil

8.0 CONTRACTUAL REQUIREMENTS

8.1 Other 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.

- 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.
- 1. **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.
- 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. **Publication Approval**. Government review and approval will be required prior to any dissemination or publication, except within and between the Contractor and any subcontractors, of classified 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/pdf/CFR-2013-title48-vol3/pdf/CFR-2013-title48-vol3-sec252-225-7048.pdf.
- w. **Cybersecurity**. Any Small Business Concern receiving an SBIR award is required to provide adequate security on all covered contractor information systems. Specific security requirements are listed in DFARS 252.204.7012, and compliance is mandatory.
- x. 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 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 <u>provision</u> 252.225-7974 Class Deviation 2020-O0005 "Prohibition on Contracting with Persons that have Business Operations with the Maduro Regime.

8.3 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.

8.4 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.

8.5 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 <u>DFARS clause 252.227-7018 Class Deviation 2020-O0007</u> "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. The contract cannot be awarded until assertions have been approved.

8.6 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 <u>www.iedison.gov</u> for those agencies participating in iEdison.

8.7 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 http://www.dtic.mil/dtic/submit/guidance_on_submitting_docs_to_dtic.html. 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 2020-00007 (see Section 11.5, 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: <u>https://discover.dtic.mil/wp-</u> <u>content/uploads/2018/09/distribution_statements_and_reasonsSept2018.pdf</u>

- (3) Block 14 (Abstract) of the SF 298, "Report Documentation Page" must include as the first sentence, "<u>Report developed under SBIR</u> 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.

Derivery will normally be wrunn 50 days after completion of the r hase r technical errort.

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 2020-00007.
ATTACHMENT 1

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

CONTRACTOR CERTIFICATION REGARDING PROVISION OF PROHIBITED VIDEO SURVEILLANCE AND TELECOMMUNICATIONS SERVICES AND EQUIPMENT

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.

FAR CLAUSES INCORPORATED IN FULL TEXT:

52.204-24 Representation Regarding Certain Telecommunications and Video Surveillance Services or Equipment (AUG 2020)

The Offeror shall not complete the representation at paragraph (d)(1) of this provision if the Offeror has represented that it "does not provide covered 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" in the provision at 52.204-26, Covered Telecommunications Equipment or Services—Representation, or in paragraph (v) of the provision at 52.212-3, Offeror Representations and Certifications-Commercial Items.

(a) Definitions. As used in this provision-

Backhaul, covered telecommunications equipment or services, critical technology, interconnection arrangements, reasonable inquiry, roaming, and substantial or essential component have the meanings provided in the clause 52.204-25, Prohibition on Contracting for Certain Telecommunications and Video Surveillance Services or Equipment.

(b) *Prohibition*. (1) Section 889(a)(1)(A) of the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (Pub. L. 115-232) prohibits the head of an executive agency on or after August 13, 2019, from procuring or obtaining, or extending or renewing a contract to procure or obtain, 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. Nothing in the prohibition shall be construed to—

(i) Prohibit the head of an executive agency from procuring with an entity to provide a service that connects to the facilities of a third-party, such as backhaul, roaming, or interconnection arrangements; or

(ii) Cover telecommunications equipment that cannot route or redirect user data traffic or cannot permit visibility into any user data or packets that such equipment transmits or otherwise handles.

(2) Section 889(a)(1)(B) of the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (Pub. L. 115-232) prohibits the head of an executive agency on or after August 13, 2020, from entering into a contract 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. This prohibition applies to the use of covered telecommunications equipment or services, regardless of whether that use is in performance of work under a Federal contract. Nothing in the prohibition shall be construed to—

(i) Prohibit the head of an executive agency from procuring with an entity to provide a service that connects to the facilities of a third-party, such as backhaul, roaming, or interconnection arrangements; or

(ii) Cover telecommunications equipment that cannot route or redirect user data traffic or cannot permit visibility into any user data or packets that such equipment transmits or otherwise handles.

(c) *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 telecommunications equipment or services."

(d) Representations. The Offeror represents that-

(1) It [] will, [] will not provide covered telecommunications equipment or services to the Government in the performance of any contract, subcontract or other contractual instrument resulting from this solicitation. The Offeror shall provide the additional disclosure information

required at paragraph (e)(1) of this section if the Offeror responds "will" in paragraph (d)(1) of this section; and

(2) After conducting a reasonable inquiry, for purposes of this representation, the Offeror represents that—

It [] does, [] does not use covered telecommunications equipment or services, or use any equipment, system, or service that uses covered telecommunications equipment or services. The Offeror shall provide the additional disclosure information required at paragraph (e)(2) of this section if the Offeror responds "does" in paragraph (d)(2) of this section.

(e) *Disclosures*. (1) Disclosure for the representation in paragraph (d)(1) of this provision. If the Offeror has responded "will" in the representation in paragraph (d)(1) of this provision, the Offeror shall provide the following information as part of the offer:

(i) For covered equipment—

(A) The entity that produced the covered telecommunications equipment (include entity name, unique entity identifier, CAGE code, and whether the entity was the original equipment manufacturer (OEM) or a distributor, if known);

(B) A description of all covered telecommunications equipment offered (include brand; model number, such as OEM number, manufacturer part number, or wholesaler number; and item description, as applicable); and

(C) Explanation of the proposed use of covered telecommunications equipment and any factors relevant to determining if such use would be permissible under the prohibition in paragraph (b)(1) of this provision.

(ii) For covered services-

(A) If the service is related to item maintenance: A description of all covered telecommunications services offered (include on the item being maintained: Brand; model number, such as OEM number, manufacturer part number, or wholesaler number; and item description, as applicable); or

(B) If not associated with maintenance, the Product Service Code (PSC) of the service being provided; and explanation of the proposed use of covered telecommunications services and any factors relevant to determining if such use would be permissible under the prohibition in paragraph (b)(1) of this provision.

(2) Disclosure for the representation in paragraph (d)(2) of this provision. If the Offeror has responded "does" in the representation in paragraph (d)(2) of this provision, the Offeror shall provide the following information as part of the offer:

(i) For covered equipment—

(A) The entity that produced the covered telecommunications equipment (include entity name, unique entity identifier, CAGE code, and whether the entity was the OEM or a distributor, if known);

(B) A description of all covered telecommunications equipment offered (include brand; model number, such as OEM number, manufacturer part number, or wholesaler number; and item description, as applicable); and

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

(ii) For covered services-

(A) If the service is related to item maintenance: A description of all covered telecommunications services offered (include on the item being maintained: Brand; model number, such as OEM number, manufacturer part number, or wholesaler number; and item description, as applicable); or

(B) If not associated with maintenance, the PSC of the service being provided; and explanation of the proposed use of covered telecommunications services and any factors relevant to determining if such use would be permissible under the prohibition in paragraph (b)(2) of this provision.

(End of provision)

52.204-25 PROHIBITION ON CONTRACTING FOR CERTAIN TELECOMMUNICATIONS AND VIDEO SURVEILLANCE SERVICES OR EQUIPMENT (AUG 2020)

(a) Definitions. As used in this clause—

Backhaul means intermediate links between the core network, or backbone network, and the small subnetworks at the edge of the network (*e.g.*, connecting cell phones/towers to the core telephone network). Backhaul can be wireless (*e.g.*, microwave) or wired (*e.g.*, fiber optic, coaxial cable, Ethernet).

Covered foreign country means The People's Republic of China.

Covered 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) For the purpose of public safety, security of Government facilities, physical security surveillance of critical infrastructure, and other national security purposes, video surveillance and telecommunications equipment produced by Hytera Communications Corporation,

Hangzhou Hikvision Digital Technology Company, or Dahua Technology Company (or any subsidiary or affiliate of such entities);

(3) Telecommunications or video surveillance services provided by such entities or using such equipment; or

(4) Telecommunications or video surveillance equipment or services produced or provided by an entity that the Secretary of Defense, in consultation with the Director of National Intelligence or the Director of the Federal Bureau of Investigation, reasonably believes to be an entity owned or controlled by, or otherwise connected to, the government of a covered foreign country.

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).

Interconnection arrangements means arrangements governing the physical connection of two or more networks to allow the use of another's network to hand off traffic where it is ultimately delivered (*e.g.*, connection of a customer of telephone provider A to a customer of telephone company B) or sharing data and other information resources.

Reasonable inquiry means an inquiry designed to uncover any information in the entity's possession about the identity of the producer or provider of covered telecommunications equipment or services used by the entity that excludes the need to include an internal or third-party audit.

Roaming means cellular communications services (*e.g.*, voice, video, data) received from a visited network when unable to connect to the facilities of the home network either because signal coverage is too weak or because traffic is too high.

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

(b) *Prohibition.* (1) Section 889(a)(1)(A) of the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (Pub. L. 115-232) prohibits the head of an executive agency on or after August 13, 2019, from procuring or obtaining, or extending or renewing a contract to procure or obtain, 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. The Contractor is prohibited from providing to the Government any equipment, system, or service that uses covered telecommunications equipment or services as a substantial component of any system, or as critical technology as part of any system, unless an exception at paragraph (c) of this clause applies or the covered telecommunication equipment or services are covered by a waiver described in FAR 4.2104.

(2) Section 889(a)(1)(B) of the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (Pub. L. 115-232) prohibits the head of an executive agency on or after August 13, 2020, from entering into a contract, 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, unless an exception at paragraph (c) of this clause applies or the covered telecommunication equipment or services are covered by a waiver described in FAR 4.2104. This prohibition applies to the use of covered telecommunications equipment or services, regardless of whether that use is in performance of work under a Federal contract.

(c) Exceptions. This clause does not prohibit contractors from providing-

(1) A service that connects to the facilities of a third-party, such as backhaul, roaming, or interconnection arrangements; or

(2) Telecommunications equipment that cannot route or redirect user data traffic or permit visibility into any user data or packets that such equipment transmits or otherwise handles.

(d) *Reporting requirement*. (1) In the event the Contractor identifies covered 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, or the Contractor is notified of such by a subcontractor at any tier or by any other source, the

Contractor shall report the information in paragraph (d)(2) of this clause to the Contracting Officer, unless elsewhere in this contract are established procedures for reporting the information; in the case of the Department of Defense, the Contractor shall report to the website at *https://dibnet.dod.mil*. For indefinite delivery contracts, the Contracting Officer(s) for any affected order or, in the case of the Department of Defense, identify both the indefinite delivery contract and any affected orders in the report provided at *https://dibnet.dod.mil*.

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

(i) Within one business day from the date of such identification or notification: The contract number; the order number(s), if applicable; supplier name; supplier unique entity identifier (if known); supplier Commercial and Government Entity (CAGE) code (if known); 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 10 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 covered 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)

52.204-26 COVERED TELECOMMUNICATIONS EQUIPMENT OR SERVICES-REPRESENTATION (DEC 2019)

(a) *Definitions*. As used in this provision, "covered telecommunications equipment or services" has the meaning provided in the clause <u>52.204-25</u>, Prohibition on Contracting for Certain Telecommunications and Video Surveillance Services or Equipment.

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

(c) *Representation*. The Offeror represents that it \Box does, \Box does not provide covered 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. (End of provision)

Department of Defense (DoD) Small Business Innovation Research (SBIR) Program Small Business Technology Transfer (STTR) Program OMB No. 0704-0187 OMB approval expires August 31, 2021

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:	
	Name:	
Entity Controlled by a Foreign Government	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:

<u>Offeror's Point of Contact for Questions about Disclosure</u> (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)

DEPARTMENT OF THE NAVY (DON) 21.1 Small Business Innovation Research (SBIR) Proposal Submission Instructions

IMPORTANT

- The following instructions apply to SBIR topics only:
 N211-001 through N211-100
- The information provided in the DON Proposal Submission Instruction 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 NOTES.
- A Phase I proposal template specific to DON topics will be available to assist small businesses to generate a Phase I Technical Volume (Volume 2). The template will be located on 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.
- The Supporting Documents Volume (Volume 5) is available for the SBIR 21.1 BAA cycle. The Supporting Documents Volume is provided for small businesses to submit additional documentation to support the Technical Volume (Volume 2) and the Cost Volume (Volume 3). Volume 5 is available for use when submitting Phase I and Phase II proposals. DON will not be using any of the information in Volume 5 during the evaluation.

INTRODUCTION

The Director of the DON SBIR/STTR Programs is Mr. Robert Smith. For program and administrative questions, contact the SYSCOM Program Manager listed in <u>Table 1</u>; **do not** contact them for technical questions about a topic, contact the Topic Authors listed within each topic during the Pre-release period. During the Open period the DoD SBIR/STTR Topic Q&A platform (<u>https://www.dodsbirsttr.mil/submissions</u>) must be used for any technical inquiry. Review section 4.13 of the Department of Defense (DoD) SBIR/STTR Program Broad Agency Announcement (BAA) for further information related to Direct Contact with Topic Authors and the Topic Q&A platform. For general inquiries or problems with electronic submission, contact the DoD SBIR/STTR Help Desk at 1-703-214-1333 (Monday through Friday, 9:00 a.m. to 5:00 p.m. ET) or via email at <u>dodsbirsupport@reisystems.com</u>.

TABLE 1: DON SYSTEMS COMMAND (SYSCOM) SBIR PROGRAM MANAGERS

Topic Numbers	Point of Contact	<u>SYSCOM</u>	Email
N211-001 to N211-002	Mr. Jeffrey Kent	Marine Corps Systems Command (MCSC)	jeffrey.a.kent@usmc.mil
N211-003 to N211-028	Ms. Donna Attick	Naval Air Systems Command (NAVAIR)	navair.sbir@navy.mil
N211-029 to N211-078	Mr. Dean Putnam	Naval Sea Systems Command (NAVSEA)	dean.r.putnam@navy.mil
N211-079 to N211-080	Mr. Shadi Azoum	Naval Information Warfare Systems Command (NAVWAR)	shadi.azoum@navy.mil
N211-081 to N211-090	Ms. Lore-Anne Ponirakis	Office of Naval Research (ONR)	loreanne.ponirakis@navy.mil
N211-091 to N211-100	Mr. Michael Pyryt	Strategic Systems Programs (SSP)	michael.pyryt@ssp.navy.mil

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 <u>www.navysbir.com</u>. Additional information pertaining to the DON's mission can be obtained from the DON website at <u>www.navy.mil</u>.

PHASE I GUIDELINES

Follow the instructions in the DoD SBIR/STTR Program BAA at <u>https://www.dodsbirsttr.mil/submissions</u> for requirements and proposal submission guidelines. Please keep in mind that Phase I must address the feasibility of a solution to the topic. It is highly recommended that proposers follow the Phase I Proposal Template that is specific to DON topics as a guide for structuring proposals. The template will be located on <u>https://navysbir.com/links_forms.htm</u>. Inclusion of cost estimates for travel to the sponsoring SYSCOM's facility for one day of meetings is recommended for all proposals.

Proposals that are not successfully certified in the Defense SBIR/STTR Innovation Portal (DSIP) prior to BAA Close will NOT be considered submitted. Please refer to section 5.1 of the DoD SBIR/STTR Program BAA for further information.

PHASE I PROPOSAL SUBMISSION REQUIREMENTS

The following <u>MUST BE MET</u> or the proposal will be deemed noncompliant and shall be <u>REJECTED</u>.

• **Proposal Cover Sheet (Volume 1).** As specified in DoD SBIR/STTR Program BAA section 5.4(a).

- **Technical Proposal (Volume 2).** Technical Proposal (Volume 2) must meet the following requirements:
 - Content is responsive to evaluation criteria as specified in DoD SBIR/STTR Program BAA section 6.0
 - Not to exceed 10 pages, regardless of page content
 - Single column format, single-spaced typed lines
 - Standard 8 ¹/₂" 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.

*For headers, footers, listed references, and imbedded tables, figures, images, or graphics that include text, a font size smaller than 10-point is allowable; however, proposers are cautioned that the text may be unreadable by evaluators.

Volume 2 is the technical proposal. Additional documents may be submitted to support Volume 2 in accordance with the instructions for Supporting Documents Volume (Volume 5) as detailed below.

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 or any subsequent 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. Simply identifying fundamental research in the proposal does NOT constitute acceptance of the exclusion. All exclusions will be reviewed and noted in the award. NOTE: Fundamental research included in the technical proposal that the proposer is requesting be eliminated from the requirements for prior approval of public disclosure of information, must be uploaded in a separate document (under "Other") in the Supporting Documents Volume (Volume 5).

Phase I Options are typically exercised upon selection for Phase II. Option tasks should be those tasks that would enable rapid transition from the Phase I feasibility effort into the Phase II prototype effort.

- **Cost Volume (Volume 3).** The Phase I Base amount must not exceed \$140,000 and the 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.
- **Period of Performance.** The Phase I Base Period of Performance must be exactly six (6) months and the Phase I Option Period of Performance must be exactly six (6) months.

- Company Commercialization Report (Volume 4). DoD requires Volume 4 for submission to the 21.1 Phase I BAA. Please refer to instructions provided in section 5.4.e of the DoD SBIR/STTR Program BAA.
- **Supporting Documents (Volume 5)**. Volume 5 is available for use when submitting Phase I and Phase II proposals.

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 proposals must include as a part of their submission a written certification in response to the NDAA clauses (Federal Acquisition Regulation clauses 52.204-24, 52-204-25 and 52-204-26). 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 instructions provided in section 5.4.g of the DoD SBIR/STTR Program BAA.

A proposal that has an answer of "Yes" to any question regarding foreign investment disclosure in the Firm Certifications section of Volume 1 (Proposal Cover Sheet) must then include as part of their submission a Foreign Disclosure Addendum. The Foreign Disclosure Addendum can be found in Attachment 2 of the DoD SBIR/STTR Program BAA. The addendum, if required, must be completed by the authorized company representative and uploaded as a separate PDF file in Volume 5. Please refer to instructions provided in section 5.4.h of the DoD SBIR/STTR Program BAA.

Volume 5 is available for small businesses to submit additional documentation to support the Technical Proposal (Volume 2) and the Cost Volume (Volume 3). A template is available on https://navysbir.com/links_forms.htm. DON will not be using any of the information in Volume 5 during the evaluation.

- Letters of Support relevant to this project
- Additional Cost Information
- SBIR/STTR Funding Agreement Certification
- Data Rights
- 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
- Majority-Owned VCOC, HF, and PEF Certification, if applicable

NOTE: The inclusion of documents or information other than that listed above (e.g., resumes, test data, technical reports, publications) may result in the proposal being deemed "Non-compliant" and REJECTED.

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 to the 21.1 Phase I BAA. Please refer to instructions provided in section 5.4.i of the DoD SBIR/STTR Program BAA.

DON SBIR PHASE I PROPOSAL SUBMISSION CHECKLIST

- Subcontractor, Material, and Travel Cost Detail. In the Cost Volume (Volume 3), proposers must provide sufficient detail for subcontractor, material and travel costs. Enter this information in the "Explanatory Material" field in the online DoD Volume 3. 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. 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).
- **Performance Benchmarks.** Proposers must meet the two benchmark requirements for progress toward Commercialization as determined by the Small Business Administration (SBA) on June 1 each year. Please note that the DON applies performance benchmarks at time of proposal submission, not at time of contract award.
- **Discretionary Technical and Business Assistance (TABA).** If TABA is proposed, the information required to support TABA (as specified in the TABA section below) must be added in the "Explanatory Material" field of the online DoD Volume 3. If the supporting information exceeds the character limits of the Explanatory Material field of Volume 3, this information must be included in Volume 5 as "Additional Cost Information" as noted above. Failure to add the required information in the online DoD Volume 3 and, if necessary, Volume 5 will result in the denial of TABA. TABA may be proposed in the Base and/or Option periods, but the total value may not exceed \$6,500 in Phase I.

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 application by the SBIR/STTR awardee 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.

Approval of direct funding for TABA will be evaluated by the DON SBIR/STTR Program Office. A detailed request for TABA must include:

- 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 applicant
- Propose a TABA provider that is the SBIR applicant
- Propose a TABA provider that is an affiliate of the SBIR applicant
- Propose a TABA provider that is an investor of the SBIR applicant
- 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 must be included in the Cost Volume (Volume 3) as follows:

- Phase I: The value of the TABA request must be included on the TABA line in the online DoD Volume 3 and, if necessary, Volume 5 as described above. The detailed request for TABA (as specified above) must be included in the "Explanatory Material" field of the online DoD Volume 3 and be specifically identified as "Discretionary Technical and Business Assistance".
- Phase II: The value of the TABA request must be included on the TABA line in the DON Phase II Cost Volume (provided by the DON SYSCOM). The detailed request for TABA (as specified above) must be included as a note in the Phase II Cost Volume and be specifically identified as "Discretionary Technical and Business Assistance".

TABA may be proposed in the Base and/or Option periods. Proposed values for TABA must <u>NOT</u> 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

NOTE: Section 9(b)(5) of the SBIR and STTR Policy Directive requires that a firm receiving technical or business assistance from a vendor during a fiscal year submit a report with a description of the technical or business assistance received and the benefits and results of the technical or business assistance provided. More information on the reporting requirements of awardees that receive TABA funding through the DON can be found on <u>https://www.navysbir.com/links_forms.htm</u>. Awardees that receive TABA funding through the DON will upload the report to <u>https://www.navysbirprogram.com/navydeliverables/</u>.

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 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: <u>https://navystp.com</u>. 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.

EVALUATION AND SELECTION

The DON will evaluate and select Phase I and Phase II proposals using the evaluation criteria in Sections 6.0 and 7.0 of the DoD SBIR/STTR Program BAA respectively, with technical merit being most important, followed by qualifications of key personnel and commercialization potential of equal importance. As noted in the sections of the aforementioned Announcement on proposal submission requirements, proposals exceeding the total costs established for the Base and/or any Options as specified by the sponsoring DON

SYSCOM will be rejected without evaluation or consideration for award. Due to limited funding, the DON reserves the right to limit the number of awards under any topic.

Approximately one week after the Phase I BAA closing, e-mail notifications that proposals have been received and processed for evaluation will be sent. Consequently, the e-mail address on the proposal Cover Sheet must be correct.

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 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 1. If the protest is to be filed with the GAO, please refer to instructions provided in section 4.11 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 section 4.11 of the DoD SBIR/STTR Program BAA.

CONTRACT DELIVERABLES

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

AWARD AND FUNDING LIMITATIONS

<u>Awards.</u> 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 Section 4.12.b of the DoD SBIR/STTR Program BAA, 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 awards.

<u>Funding Limitations.</u> 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 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.

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. Please refer to instructions provided in section 7.2 of the DoD SBIR/STTR Program BAA.

ADDITIONAL NOTES

<u>Majority Ownership in Part.</u> 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.

For proposers that are a member of this ownership class the following <u>must</u> be satisfied for proposals to be accepted and evaluated:

- a. Prior to submitting a proposal concerns must register with the SBA Company Registry Database.
- b. The proposer within its submission must submit the Majority-Owned VCOC, HF, and PEF Certification. The SBIR VC Certification must be included in the Supporting Documents Volume SBIR (Volume 5). А copy of the VC Certification can be found on https://navysbir.com/links forms.htm.
- c. Should a proposer become a member of this ownership class after submitting its application 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, <u>https://beta.sam.gov</u>, 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.

<u>Human Subjects, Animal Testing, and Recombinant DNA</u>. 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: http://www.onr.navy.mil/About-ONR/compliance-protections/Research-Protections/Human-Subject-

<u>Research.aspx</u>. This webpage provides guidance and lists approvals that may be required before contract/work can begin.

<u>Government Furnished Equipment (GFE)</u>. 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 proposal.

<u>International Traffic in Arms Regulation (ITAR)</u>. 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).

<u>Support Contract Personnel for Administrative Functions.</u> 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.

PHASE II GUIDELINES

All Phase I awardees can submit an **Initial** Phase II proposal for evaluation and selection. 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 solicitations prior to FY13 will be conducted in accordance with the procedures specified in those solicitations (for all DON topics, this means by invitation only).

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, which includes assigning SBIR/STTR Data

Rights to any noncommercial technical data and/or noncommercial computer software delivered in Phase III that was developed under SBIR/STTR Phase I/II effort(s). Government prime contractors and/or 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.

NAVY 21.1 SBIR Topics

N211-001	Non-Lethal Payloads for Long-range Intermediate Force Capabilities on Small Tactical Vehicles and Unmanned Systems
N211-002	Just-In Time Medical Logistics Resupply System for Forward Medical
N211-003	Real-Time Detection, Location, and Isolation of High-Resistance, Wye Power System Ground Faults
N211-004	Naval Aircrew Specific Body Armor Release
N211-005	Packaged Mid-Infrared Non-Mechanical Beam Steerer
N211-006	Improving Performance of Solid Rocket Fuel through Advancements in Materials Science
N211-007	Hyperspectral Sensor Metamaterial Lens in Imaging Applications
N211-008	Tool to Predict Transient Spatial-Temporal Boundary Conditions for Processing Autoclave-cured Composite Parts
N211-009	Cyber Protection for Physical Avionics Data Inputs to Navy Platforms
N211-010	Cloud Based Air Traffic Control Training System
N211-011	Ping Strategies for an Intelligent Search using Multistatic Active Sonar
N211-012	Micro-Electromechanical Gyroscope for Improved Inertial Navigation Systems Performance
N211-013	Cooling Devices for Helmeted Maintainers, Flight Deck Crew, and Rotary-Wing Aircrew
N211-014	Predictive Model Based Control System for High Speed Dynamic Airframe Testing
N211-015	Long-Wave Infrared Transceivers for High Speed Free Space Optical Communications in Adverse Weather Conditions
N211-016	Lightweight Thermal Protection System for Hypersonic Aerial Vehicles
N211-017	Sonobuoy Improvements for Multistatic Active Sonar
N211-018	Non-Traditional Airborne Anti-Submarine Warfare (ASW) System
N211-019	Aging Prediction of Airworthiness of Aircraft Composite Components Accounting for Flight and Environmental Conditions
N211-020	Digital Firing Device
N211-021	High-Efficiency Midinfrared LEDs with High Brightness for High-Fidelity Infrared Scene Projection
N211-022	High Performance Continuous Wave Quantum Cascade Lasers Immune to Output Facet Optical Damage
N211-023	Collaborative Workspace for Next-Generation Navy Mission Planning System
N211-024	Munitions Lifting Assembly Sunshade Cover

N211-025	Manned-Unmanned Air Vehicle Team Tactical Cloud Analysis
N211-026	Boron-Based Energetics
N211-027	Ultra-Lightweight Protection Shielding Material Against Electromagnetic Interference/Electromagnetic Pulse for Avionics
N211-028	Conformal Antennas Miniaturized through Magneto-Dielectric Materials
N211-029	Recovery and Handling of Group 3 through Group 5 Unmanned Aerial Vehicles Aboard Navy's Expeditionary Sea Base
N211-030	Kilowatt (kW) Class Continuous Wave (CW) and Pulse Laser Hardened Optical Systems for Submarines
N211-031	Compact RAMAN System for Marine Wave Boundary Characterization
N211-032	Extra Large Unmanned Undersea Vehicle (XLUUV) Launch and Recovery, On-Board Handling, and Servicing System
N211-033	Wireless Sensing to Improve Submarine Machinery Health Monitoring
N211-034	Submarine Atmospheric Contaminant Scrubbing Technology
N211-035	Compact Battery Power Uncooled 5 kW-Class Laser System
N211-036	Innovative Simultaneous Localization and Mapping Techniques for Unmanned Underwater Vehicles
N211-037	Electronic Warfare Operator Workload Organization and Sharing
N211-038	Next Generation Laminated Bus Bar Technologies
N211-039	24/7 Reachback Artificial Intelligence Support Environment for Anti-submarine Warfare (ASW)
N211-040	Submarine Deep Escape
N211-041	Compact Cryocooler for Maritime Operations
N211-042	Sensitivity and Resolution Improvements for Small-Aperture Marine RADAR
N211-043	Intelligent Corrosion Simulation and Design Tool
N211-044	Inflatable Deployable Sail Systems for Future Submarines
N211-045	Extended Life and Low Maintenance Aircraft Tie Down Fitting
N211-046	Undersea Warfare Decision Support System Coalition Data Parser & Advanced Display
N211-047	Unmanned Underwater-Vehicle (UUV) Mission Sensitive Energy Usage Optimization Using Automated Intelligent Services
N211-048	Unified Operational Picture for Anti-Submarine Warfare
N211-049	High Power MegaWatt (MW) Class Grating for High Energy Laser (HEL) System
N211-050	Electronic Warfare System Alert Monitoring, Prioritization, and Display
N211-051	Non-acoustic, High Fidelity, Short Range Underwater Tracking System

N211-052	Navigational Positioning Source Using Very Low Frequency Signals
N211-053	Nickel-Zinc Submarine Main Storage Battery
N211-054	High Strength Composite System for Ships
N211-055	High Dynamic Range and Low Noise Figure (NA) Integrated Microwave Photonic Transceiver for 6G mmWave Radio
N211-056	Propulsor Geometric Certification System
N211-057	Flight Deck Tie Downs
N211-058	Automated Unmanned Systems (UxS) Boundary Protection Capability
N211-059	High Temperature, Low Dielectric Constant Ceramic Fibers for Missile Applications
N211-060	Human-Machine Interface for Directed Energy Weapons
N211-061	Fast and Efficient Read-Out for Staring Focal Plane Arrays
N211-062	Nondestructive Detection of Flaws through Thick Polymers using Electromagnetic Imaging Technologies
N211-063	Compact, Efficient, High Power Direct-to-Green Laser Source
N211-064	Low Cost Deepwater Delivery Systems
N211-065	Adaptive Narrowband Trainer
N211-066	Coupled Control of Expeditionary Remote Operating Vehicles (ROV) and Manipulator Payloads
N211-067	Atomic Inertial Sensor as an Alternate Position Source
N211-067 N211-068	Atomic Inertial Sensor as an Alternate Position Source S-Band Antenna System for Littoral Combat Ship Communications Relay
N211-067 N211-068 N211-069	Atomic Inertial Sensor as an Alternate Position Source S-Band Antenna System for Littoral Combat Ship Communications Relay Medium Voltage Direct Current (MVDC) Partial Discharge and Space Charge Test Apparatus for Cable and Insulated Bus Pipe (IBP)
N211-067 N211-068 N211-069 N211-070	Atomic Inertial Sensor as an Alternate Position Source S-Band Antenna System for Littoral Combat Ship Communications Relay Medium Voltage Direct Current (MVDC) Partial Discharge and Space Charge Test Apparatus for Cable and Insulated Bus Pipe (IBP) Lightweight Diver Handheld Underwater Hydraulic Friction Stud Welding System for 5000 Series Aluminum
N211-067 N211-068 N211-069 N211-070 N211-071	 Atomic Inertial Sensor as an Alternate Position Source S-Band Antenna System for Littoral Combat Ship Communications Relay Medium Voltage Direct Current (MVDC) Partial Discharge and Space Charge Test Apparatus for Cable and Insulated Bus Pipe (IBP) Lightweight Diver Handheld Underwater Hydraulic Friction Stud Welding System for 5000 Series Aluminum Nondestructive Evaluation (NDE) of Coated Multi-layered Fiber Reinforced Polymer (FRP) Components
N211-067 N211-068 N211-069 N211-070 N211-071 N211-072	Atomic Inertial Sensor as an Alternate Position Source S-Band Antenna System for Littoral Combat Ship Communications Relay Medium Voltage Direct Current (MVDC) Partial Discharge and Space Charge Test Apparatus for Cable and Insulated Bus Pipe (IBP) Lightweight Diver Handheld Underwater Hydraulic Friction Stud Welding System for 5000 Series Aluminum Nondestructive Evaluation (NDE) of Coated Multi-layered Fiber Reinforced Polymer (FRP) Components Automated Anchor Handling System
N211-067 N211-068 N211-069 N211-070 N211-071 N211-072 N211-073	Atomic Inertial Sensor as an Alternate Position SourceS-Band Antenna System for Littoral Combat Ship Communications RelayMedium Voltage Direct Current (MVDC) Partial Discharge and Space Charge Test Apparatus for Cable and Insulated Bus Pipe (IBP)Lightweight Diver Handheld Underwater Hydraulic Friction Stud Welding System for 5000 Series AluminumNondestructive Evaluation (NDE) of Coated Multi-layered Fiber Reinforced Polymer (FRP) ComponentsAutomated Anchor Handling SystemIntelligent Assistant for Anti-Submarine Warfare
N211-067 N211-068 N211-069 N211-070 N211-071 N211-072 N211-073 N211-074	Atomic Inertial Sensor as an Alternate Position Source S-Band Antenna System for Littoral Combat Ship Communications Relay Medium Voltage Direct Current (MVDC) Partial Discharge and Space Charge Test Apparatus for Cable and Insulated Bus Pipe (IBP) Lightweight Diver Handheld Underwater Hydraulic Friction Stud Welding System for 5000 Series Aluminum Nondestructive Evaluation (NDE) of Coated Multi-layered Fiber Reinforced Polymer (FRP) Components Automated Anchor Handling System Intelligent Assistant for Anti-Submarine Warfare Efficient Data Management to Improve Navy Maintenance and Ship Operational Readiness
N211-067 N211-068 N211-069 N211-070 N211-071 N211-072 N211-073 N211-074 N211-075	Atomic Inertial Sensor as an Alternate Position Source S-Band Antenna System for Littoral Combat Ship Communications Relay Medium Voltage Direct Current (MVDC) Partial Discharge and Space Charge Test Apparatus for Cable and Insulated Bus Pipe (IBP) Lightweight Diver Handheld Underwater Hydraulic Friction Stud Welding System for 5000 Series Aluminum Nondestructive Evaluation (NDE) of Coated Multi-layered Fiber Reinforced Polymer (FRP) Components Automated Anchor Handling System Intelligent Assistant for Anti-Submarine Warfare Efficient Data Management to Improve Navy Maintenance and Ship Operational Readiness Active Nano Antenna Emulator for Electromagnetic Simulation
N211-067 N211-068 N211-069 N211-070 N211-071 N211-072 N211-073 N211-074 N211-075 N211-076	Atomic Inertial Sensor as an Alternate Position Source S-Band Antenna System for Littoral Combat Ship Communications Relay Medium Voltage Direct Current (MVDC) Partial Discharge and Space Charge Test Apparatus for Cable and Insulated Bus Pipe (IBP) Lightweight Diver Handheld Underwater Hydraulic Friction Stud Welding System for 5000 Series Aluminum Nondestructive Evaluation (NDE) of Coated Multi-layered Fiber Reinforced Polymer (FRP) Components Automated Anchor Handling System Intelligent Assistant for Anti-Submarine Warfare Efficient Data Management to Improve Navy Maintenance and Ship Operational Readiness Active Nano Antenna Emulator for Electromagnetic Simulation Autonomous Draft Determination

N211-078	Operator Analytics and Training Integration through Artificial Intelligence and Machine Learning
N211-079	Enhanced Situational Awareness Through Smart Geospatial Comparative Analysis
N211-080	Wideband Interference Suppression for Dynamic-range OptiMization (WISDOM)
N211-081	Novel Flow Control Strategies for High-Speed Inlets and Isolators
N211-082	Accelerated Learning Model for Increased Strategic and Tactical Decision Making Using Multi-player Games
N211-083	Automated Formal Verification of Software Defined Network Implementations
N211-084	Low Cost, Single Use Precision Aiming Device for Explosive Ordnance Disposal Disrupters and Tools
N211-085	Developing Alloy Compositions Conducive to Additive Manufacturing
N211-086	N-Polar Gallium Nitride High Electron Mobility Transistor in Low-Cost Process Technology for mm-wave Transceiver Applications
N211-087	Solid State High Voltage Power Module Development and Packaging for High Power Microwave Drivers
N211-088	Live, Virtual, and Constructive Cyber Battle Damage Assessment for Training
N211-089	Airborne LIDAR Ocean Temperature Measurement
N211-090	Refrigerant Vapor Quality Sensor
N211-091	Real-time Simulation of Radio Frequency (RF) Signal Returns from Complex Targets and Backgrounds
N211-092	Onboard Flight Ablation Sensor
N211-093	Real Time Single-Shot AI Enhanced Coherent Wavefront Sensing for Intelligence, Surveillance, and Reconnaissance (ISR) and Directed Energy Applications
N211-094	Compact Phase Locked Laser System for Atom Interferometric Inertial Sensors
N211-095	Age Effect Evaluation: Test Methodology
N211-096	Producible Radiation-hardened Interconnects Technology
N211-097	Radar Seeker Model for Hypersonic Weapon Full Life Cycle Support
N211-098	Unconventional Navigation Approaches Using Signals of Opportunity
N211-099	Photon-Counting Image Sensors Using Complementary Metal-oxide Semiconductor (CMOS) Foundry Processes
N211-100	GPS Alternative for Reentry

N211-001 TITLE: Non-Lethal Payloads for Long-range Intermediate Force Capabilities on Small Tactical Vehicles and Unmanned Systems

RT&L FOCUS AREA(S): Autonomy; Directed energy

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 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: Develop a suite of compact multi-weapon system payloads that deliver scalable Intermediate Force Capability (IFC) effects combined with other military effects for: applicability and effectiveness in multiple domains; synergistic value of integrating the various IFC effects with other multi-use military capabilities in a common architecture, such as Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR); secure communications; and automated fire control systems, all integrated aboard small manned and unmanned systems (UxS) platforms. Platforms include small tactical vehicles/vessels and unmanned ground vehicles (UGVs) for both urban and austere terrains, unmanned aerial vehicles (UAVs) for both counter-air and ground support operations, unmanned surface vehicles (USVs) for both the littorals and open water operations, and unmanned underwater vehicles (UUVs).

DESCRIPTION: This SBIR topic seeks to develop a suite of more compact and lightweight long range non-lethal counter-personnel and counter-materiel payloads for integration on small tactical vehicles/platforms and UxS. These IFC payloads will support a variety of stabilization operations, gray zone warfare, and regular and irregular warfare missions across the full Range of Military Operations (ROMO) [Refs 1,2]. These non-lethal (NL)/IFC payloads with enhanced system performance seek to mitigate codified joint non-lethal weapon capability-gaps. There is Service transition interest in these NL/IFC payloads in both the Maritime (U.S. Navy and U.S. Coast Guard) and Ground (U.S. Army and USMC) domains as each Service currently desires IFCs via small/lightweight low-cost systems that can project/provide long-range IFCs. These desired effects across the full breadth of the ROMO must be accomplished with integration of these small NL/IFC payloads on tactical manned and unmanned platforms with significant reduced overall system size, weight, power consumption, thermal cooling (-55 degrees C to 125 degrees C) and lower system costs (SWAP/C2) [Ref 5]. Existing IFCs have known range and overall system size and weight limitations, i.e., the current COTS solutions only mitigate a very small portion of the codified Joint Requirements Oversight Council (JROC) approved counter-personnel and counter-materiel capability-gap. This topic supports future long range compact and lightweight IFC to provide long range hail and warn, non-lethal counter-personnel tasks: such as deny access, move, suppress, and disable individuals and non-lethal counter-materiel tasks: such as stop/disable vehicles, vessels and aircraft.

These new innovative compact/lightweight IFC payloads include existing, both commercial off the shelf (COTS) and developmental, NL weapon technologies/stimuli such as: (1) dazzling lasers, (2) 12 gauge/40mm non-lethal munitions (blunt impact, flashbang, riot control agents, human electro-muscular incapacitation, malodorant) with associated munition launching/targeting and fire control systems; (3) long range acoustic hailing devices, and (4) directed energy (DE) weapons such as counter-electronics

(e.g., high power microwave weapons) and Active Denial Technologies (ADT). These new innovative payloads shall also include new/novel non-lethal payloads with innovative human effects and new non-lethal stimuli such as optogenics modulation of high magnetic fields and other new non-lethal stimuli that provide long range IFCs such as: (1) long range hail and warn capabilities; (2) area denial – deny access capabilities; (3) human target suppression; (4) ability to move individuals and/or groups of individuals from open and confined spaces; and (5) ability to non-lethally incapacitate/disable threat human/material targets.

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 and/or subcontractor must be able to acquire and maintain a secret level facility and Personnel Security Clearances, in order to perform on Phase II of this project as set forth by DCSA and MCSC 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 wide variety of non-lethal stimuli for integration on a small tactical vehicle/platform and small UxSs, ensuring that each payload will have a minimal cost (of \$10's of thousands of dollars vice payloads that cost > \$1M) and weigh less than 50-100 lbs and with a compact form-fit of < 3 cu ft.

Demonstrate the feasibility/effectiveness of these novel Non-Lethal/IFC payloads with existing non-lethal weapon effectiveness models and against real counter-material targets such as against relevant threat vehicle and vessel engine targets. Collect weapon effectiveness data at range, e.g., Radio Frequency (RF) Target Susceptibility data corresponding to a Radio Frequency (RF) - High Power Microwave (HPM) payload's waveform against a broad relevant set of targets (e.g., threat vehicle and vessel engine) and human effects and weapon effectiveness data for non-lethal counter-personnel payloads. Demonstrate individual NL/IFC payload weapon effectiveness and performance data as well as this same type of data for a "combined effect" suite of NL/IFC Payloads. Demonstrate meeting JNLWD/JIFCO/Marine Corps needs and establish that the NL/IFC payloads weapon concept can be employed throughout the Joint Services. Establish weapon concept feasibility/effectiveness by rigorous NL/IFC individual and combined effects testing against both threat personnel and counter-materiel targets. Phase I will not require human subject or animal subject testing. Provide a Phase II development plan with performance goals and key technical milestones that addresses technical risk reduction and defines the development of a suite of compact/lightweight/low-cost Phase II non-lethal/IFC payloads integrated to small manned and unmanned systems.

PHASE II: Develop a suite of optimized (size/weight/cost) Non-Lethal/IFC payloads integrated to small manned systems and UxSs. Evaluate the prototype NL/IFC payloads via rigorous counter-personnel and counter-materiel target testing at both the contractor's facilities and at DoD laboratories such as the Naval Surface Warfare Center - Dahlgren Division (NSWC- Dahlgren) test ranges. The JNLWD-JIFCO maintains a set of counter-personnel human effects and weapon effectiveness models and a full set of counter-personnel and counter-material test targets at various DoD labs. Deliver the suite of NL/IFC payloads for manned and unmanned systems to Government lab facilities to be independently assessed and evaluated, with minimal cost to the performer, to determine the weapon's capability in meeting the performance goals defined in the Phase II development plan and the Marine Corps requirements for a suite of non-lethal/IFC payloads. Demonstrate system performance through the evaluation of the NL/IFC payload's ability to meet known non-lethal counter-personnel and counter-materiel capability-gaps. Confirm and verify modeling and analytical methods developed in Phase I to include measuring the required full range of parameters including numerous deployment cycles. Use evaluation results to refine

the prototype into an initial design that will meet the JIFCO/JNLWD/Marine Corps non-lethal/IFC payload requirements. Prepare a Phase III development plan to transition the technology to Joint Service 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 JIFCO/JNLWD/Marine Corps in transitioning the technology for Joint Service use. Develop this suite of next-generation NL/IFC payloads as integrated on GOTS manned and unmanned systems. Evaluate these weapons to determine their effectiveness in operationally relevant environments, e.g., Limited Military User Assessments (LMUAs) held by various Services. Support the JIFCO/JNLWD/Marine Corps for test and validation to certify and qualify the system for Joint Service use.

A suite of compact, lightweight, low-cost long range non-lethal intermediate force capability payloads have significant commercial applications beyond the DoD including other government agencies such as the Department of Justice (DoJ) and the Department of Homeland Security (DHS) to include Customs and Border Protection, which have actively been researching these type of non-lethal counter-personnel and counter-materiel effects. Local civilian law enforcement has these specific type of missions to support both counter-personnel and counter-materiel missions for law enforcement as well as to mitigate terrorist acts. Currently overall system size, weight, and cost have hindered the use of these systems by these agencies. This SBIR topic specifically addresses overall system size, weight, power consumption, thermal cooling, and overall system cost all while drastically improving NL/IFC weapon performance.

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KEYWORDS: Intermediate Force Capabilities; Non-Lethal Payloads; Non-Lethal Effects; Counter-Personnel Weapons; Counter-Materiel Weapons; Non-Lethal Payloads for Unmanned Systems

N211-002 TITLE: Just-In Time Medical Logistics Resupply System for Forward Medical

RT&L FOCUS AREA(S): Autonomy

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Reduce the workload on medical personnel through the development of a system that can provide automated real-time supply ordering, tracking, and monitoring capabilities to integrate into existing USMC medical logistics systems (e.g., Defense Medical Logistics Standard Support, DMLSS) and their operational parameters, DoD enterprise digital medical logistics systems, and medical common operating picture (MedCOP) management systems in order to allow demand-based just in time push/pull logistical resupply of medical consumables and supporting products.

DESCRIPTION: The USMC has a need for as-needed, just-in-time custom medical resupply. Current Authorized Medical Allowance List (AMAL) logistical resupply is handled through the push or pull of large resupply or consumable blocks consisting of 1-5 pallets of environmentally ruggedized cases (e.g., AMAL 636, Battalion Aid Supplies). These resupply blocks are a "one size fits all" approach based upon the projected needs for a fixed number of patients per a fixed time period and do not take into account the actual consumption rates of specific medical products. This approach drastically increases the logistical footprint and cannot flexibly adjust to specific needs as driven by operational use.

Advances in wireless information technology are bringing the Navy Medical Corpsmen new ways to monitor and track patients in the theater (e.g., the USAF Air Force Research Laboratory's (AFRL's) Battlefield Assisted Trauma Distributed Observation Kit or BATDOK, and Marine Corps Warfighting Laboratory's (MCWL's) prototype concept, Medical Common Operating Picture (MedCOP). Advances in automated and expeditionary Unmanned Systems (UxS) could be applied as new methods of "smallpayload on the spot" delivery of critical medical resupply items, such as blood products or medical consumables (e.g., drugs, bandages, IV lines) to Navy Corpsmen. These technologies, when combined with supply tracking technologies such as RFID, offer the potential for the real-time tracking of medical consumable use rates and for automated Push-Pull resupply requests for medical consumables. For example, the consumption of intravenous needle/tubing kits in response to battlefield casualties can be automated to keep track of the number of kits on hand at a field medical facility and automatically send a demand signal for additional kits once a critical threshold is reached. Furthermore, artificial intelligence (AI) and machine learning (ML) algorithms can hypothetically be developed that can predict future resupply needs based upon operational tempo and tracked casualty types. Such a predictive algorithm could automatically send demand signals in advance of casualty arrival at a field medical facility.

A Just-in-Time Medical Logistical Resupply System (JITMEDLOG) relieves the Navy Medical Corpsmen from the necessity to actively track consumable use rates by automatically tracking usage and automatically initiating critical resupply via unmanned vehicles (UxV) or other expeditionary means. It offers the ability for custom delivery of needed medical supplies while avoiding waste and oversupply. JITMEDLOG further allows for a smaller initial deployment footprint, reducing the upfront logistical burden and allowing for the deployment of more mobile and expeditionary medical teams, which will be critical under Distributed Maritime Operations (DMO).

The proposed system must address the following requirements, at a minimum:

• The USMC seeks the development of new algorithms and architecture integration to add Just-In-Time Medical Logistical tracking technology and predictive algorithms to the Project Phoenix architecture (e.g., BATDOK, MedCOP).

• The JITMEDLOG shall integrate with BATDOK and the prototype MedCOP architecture.

• The JITMEDLOG shall integrate with existing DoD medical logistics systems (e.g., DMLSS).

• The JITMEDLOG shall be compatible with UAS critical resupply systems. Any JITMEDLOG hardware supporting this architecture shall comply with MIL-STD-810x standards for use in all operational environments to which the USMC deploys.

• The JITMEDLOG shall be designed for use by any Navy Medical Corpsman, regardless of Navy Enlisted/Officer Code or specialty, and include new user training and operator and maintainer manuals.

• System transactions shall be timestamped.

- The system shall be accessible to all Expeditionary Medical and Tactical C2 nodes on the network.
- The system architecture shall provide location and inventory of Class VIII supplies.
- The system architecture shall provide the ability to send/receive forms.
- User interfaces shall provide the ability to copy and paste information within various user screens/forms.
- The system shall create a network sharable list of all consumables.
- The system shall create a network sharable list of blood supply.
- The system shall create a network sharable list of equipment.

• The system shall automatically pull information from designated sensors or databases relevant for the display.

• The system shall allow the user to enter information relevant to the display.

• The system shall minimize data sets when possible through packet size and compression to leverage narrow bandwidth.

• The system shall be capable of operation in an A2AD environment in mind.

PHASE I: Develop a concept for an architecture for a Just-in-Time Medical Logistical Resupply System (JITMEDLOG) that meets the requirements described above. Demonstrate the feasibility of the concepts in meeting Marine Corps needs. Establish that the concepts can be developed into a useful product (software and hardware) for the Marine Corps. Prove feasibility through material testing and analytical modeling, as appropriate. Provide a Phase II development plan with performance goals and key technical milestones, and addresses technical risk reduction.

PHASE II: Develop a scaled prototype. Evaluate the prototype to determine its capability in meeting the performance goals defined in the Phase II development plan and the Marine Corps requirements for the Just-in-Time Medical Logistical Resupply system. Demonstrate system performance through prototype evaluation and modeling or analytical methods over the required range of parameters, including numerous deployment cycles. Use evaluation results to refine the prototype into an design that meets 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 the Just-in-Time Medical Logistical Resupply system for evaluation to determine its effectiveness in an operationally relevant environment. Develop commercial operator and maintainer manuals and user new equipment training programs to support the system's operations and maintenance in the field environment. Support the Marine Corps for test and validation to certify and qualify the system for Marine Corps use.

JITMEDLOG technology has potential for use with commercial and non-governmental organization in remote areas such as interior Africa, remote parts of Alaska or Canada, the Amazon basin, or other places lacking in infrastructure. Such technology can be used for disaster relief or pandemic response and can support remote hospitals and other medical facilities, vaccination efforts, or even non-medical applications such as critical equipment or food/water deliveries.

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KEYWORDS: Medical; Logistics; Database; Artificial Intelligence; Machine Learning; Radio Frequency Identification; RFID; Just In Time; JIT

N211-003 TITLE: Real-Time Detection, Location, and Isolation of High-Resistance, Wye Power System Ground Faults

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Electronics; Human Systems; Information Systems

OBJECTIVE: Develop a solution, consisting of hardware and software, to detect and locate ground faults in a high-resistance, wye grounded, pulsed power system in real time.

DESCRIPTION: An existing system will benefit from increased ability to detect and locate ground faults. Although, solutions will ultimately integrate with equipment already available in said system's current health monitoring infrastructure, it is understood that new software and (in all likelihood) additional hardware will be needed to achieve the objective.

Ground faults occur due to insulation breakdown. A high-resistance, wye grounded, electrical power system is tolerant of one ground fault on any phase, but not multiple ground faults in different locations on the same phase. Since the existing system does not indicate when a first line-to-ground fault occurs, cables are regularly inspected using an insulation resistance tester. Although this process enables manual detection of ground faults, determining location for corrective action is more difficult. A less arduous, real time solution will assure that all ground faults are being detected and reported within milliseconds of occurring, which will increase overall safety of the system. The goal is to detect and locate the first ground fault virtually immediately, and correct it as soon as possible, so that there is never an instance in which two ground faults occur in different locations on the same phase.

Insulation breakdown in a particular location may result in a single line-to-ground fault. This line-toground fault causes very low fault currents, on the order of .01% of load current, and must be detected, located, and isolated before another ground fault occurs on the same phase. Shipboard ground faults can be located anywhere in runs of several hundred feet of hard-to-reach cable. Fault currents are in the milliamp (mA) range in a system that nominally carries several kiloamps (kAs). Thus, solutions must reliably and accurately detect and locate ground faults that generate signals orders of magnitude smaller than operational currents, which may be alternating or direct (AC/DC) depending on cable section. Operating voltage levels are also in the kV range.

Insulation breakdown in a second location may result in undesired large current flow between the two fault locations, resulting in catastrophic damage to the power system, its equipment, and possibly other high-power equipment.

The solution must be capable of detecting ground faults of 10,000 Ohms or less. False negatives should not occur below the 10,000-Ohm threshold, and false positives should be minimized as searching for nonexistent cable faults would prove burdensome and decrease confidence in the detection system. A false positive rate of 1% or below is considered appropriate at this time, but an official requirement has not yet been established. Measuring the exact resistance value (in Ohms) of the fault is not as vital as simply identifying that a ground fault is present, so accuracy, resolution, and sensitivity of the measurement are not defined at this time. Location should be determined with reasonable accuracy and resolution (e.g., ± 10 s of feet) to decrease mean time to repair (MTTR). Solutions that significantly narrow down location of faults are preferred, since they will decrease the time required to find and fix the damaged cable.

In summary, an innovative approach is needed to indicate the presence and location of an active ground fault in real time, so that it can be remedied before a second ground fault occurs. Additional capability may include prognostics that detect/predict the formation of ground faults before they occur.

PHASE I: Develop a concept for detecting and locating ground faults with minimal impact to existing power architecture. Validate the concept and demonstrate feasibility utilizing modeling and simulation and other software/hardware tools. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a prototype to validate/verify the technological approach. Demonstrate that a line-toground fault on a single phase, or formation of said fault, can be detected and located by the prototype system. The goal is to detect, locate, and correct the first fault before a second occurs in a different location on the same phase; therefore, a safe method for insertion of faults at known locations may be required for testing.

Determine if the solution will be effective at the voltage and current levels required. Fault detection and location results will be verified against requirements to confirm that the technology can reliably sense faults and estimate their position(s). Include preliminary calculation of false positive and false negative rates using the prototype system. Accuracy, resolution, sensitivity and other metrics will be assessed as deemed necessary.

Consider human factors, including how to best illustrate the presence and location of faults on a display so that maintainers understand where to go to resolve the issue. The graphical user interface should be easy to read, interact with, and understand. Validate that faults are indicated in an acceptable manner that may be integrated into existing systems.

PHASE III DUAL USE APPLICATIONS: Integrate solution at NAWCAD Lakehurst test site using a representative model that meets actual power requirements. Conduct extensive testing that includes all viable fault modes and locations, i.e., test ground faults in pertinent cable sections as detailed by SMEs (Subject Matter Experts). After detecting faults, use a secondary method (e.g., insulation resistance tester) to determine actual fault location and calculate percent error/accuracy of location measurement. If a fault is not present near the location specified within a certain distance threshold, it must be recorded as a false positive. Additionally, regular insulation resistance testing must continue to determine if any ground faults are going undetected. If so, these must be recorded as false negatives. Integrated Product Team (IPT) will determine accuracy and resolution requirements necessary for transition.

This SBIR topic may benefit private sector companies working with high-power electricity in the energy, industrial and transportation sectors. This may include power generation, transmission and distribution, including both AC and DC (e.g., photovoltaic) applications, large manufacturing/industrial plant operations, and high-power railroad applications. Any commercial application that utilizes high power and experiences relatively low-fault currents, in comparison to operational currents, may benefit.

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- "MIL-STD-810H, Department of Defense Test Method standard: Environmental Engineering Considerations and Laboratory Tests." Department of Defense. <u>http://everyspec.com/MIL-STD/MIL-STD-0800-0899/MIL-STD-810H_55998/</u>

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- "User Interface Design Basics." Office of the Assistant Secretary for Public Affairs. (n.d.). U.S. Department of Health and Human Services (HHS). Retrieved July 21, 2020, from <u>https://www.usability.gov/what-and-why/user-interface-design.html</u>

KEYWORDS: Ground-fault; high-power; pulsed-power; detection; sensors; diagnostics

N211-004 TITLE: Naval Aircrew Specific Body Armor Release

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Human Systems

OBJECTIVE: Optimally design and develop an innovative, affordable body armor release capability for Rotary Wing Naval Air Crew.

DESCRIPTION: Combat rotorcraft operators strongly desire the capability to jettison negatively buoyant hard plates from their body armor in water survival situations without jettisoning their entire survival vest, especially in the event flotation fails to inflate. Hard plates are worn inside the vest and under gear, and usually load from the bottom which is then secured with hook/loop tape. Typical quick-release designs are gravity-based and rely upon the survivor to find and pull a strap to open the bottom. These gravity-based designs have been found to require multiple pulls and re-gripping the pull strap at ever higher positions to open the bottom. The hard plate's downward drop is also resisted by the specific gravity of water, as well as frictional resistance from the tight, compressive fit of a heavy vest load. Pinand-cable quick-releases in typical "maritime" or "marine" vests are an improvement over pull-strap with hook-and-loop designs, but often require complicated rigging and careful donning, which are not often compatible with rapid launch operations. Automatic quick-release mechanisms may work but can pose other hazards; an automatically released plate in a submerged aircraft will contribute to the debris field through which survivors must swim (crews can number up to 40 individuals). An automatic system can also rob the surfacing survivor of his ballistic protection in what may well be a combat environment. Additionally, it is important that the hard plate release design avoid imposing additional dressed weight and bulk to the already burdened operator. In terms of dry weight, Crew Chiefs dressed in the summer combat configuration carry 52-60 additional pounds; most of it is carried on the front torso. The gear and armor load adds 3-6 inches to the front profile. Possible sources of confusion in an emergency are the round-beaded handle for flotation actuation, and the lozenge-beaded handle that releases the fall-arrest tether. These two releases are located near one another on the upper right and left chest. Although not required, it is highly recommended to work in coordination with the original equipment manufacturer (OEM) to ensure proper design and to facilitate transition of the final technology.

Aircrew need a hard plate release that, with commanded action and when retrofitted to existing vests that incorporate the ineffective gravity-based quick release, enable the below metrics.

a. releases a single hard plate with a single motion, only requiring one gloved left or right hand by a typical male or female, blind-folded operator;

b. releases respective sizes of Small Arms Protective Insert (SAPI)-cut, "shooter's cut", and "swimmer's cut" hard plate forms;

- c. does not appreciably increase the weight and bulk burden of the armored vest system;
- d. operates in windy or calm air and in turbulent or calm water conditions;
- e. operates at a submerged depth of less than or equal to 30 feet;
- f. operates in cold water (32 degrees F) through the range of freshwater and seawater salinities;
- g. operates in chlorinated swimming pool water;
- h. operates reliably in cold and hot ambient air;
- i. separates the plate from the vest within 2 seconds of actuation;

j. resists inadvertent actuation while: traversing ship ladders/hatches, operating within 120 knot rotor outwash, conducting pre-flight inspections and boarding aircraft, flying routine missions, flying combat missions, and egressing aircraft in routine or emergency situations;

k. does not create hazards (injury, foreign object debris, snag/trip, static discharge) in any mission or survival operations to include survivable vertical crash loads (those less than or equal to 5Gs);

l. does not interfere with vest or vest gear, inflatable flotation, seat harnesses, fall arrest tethers, helmets or head-mounted gear, communication cords and devices, clothing or other body-mounted gear;m. does not impede water survival or land survival procedures to include raft boarding and hoisting;n. does not contribute to wearer's burn injury hazard;

o. does not give away wearer's position in covert day or night operations;

p. is resistant to naval aviation environments (salt spray, humidity, drop impact, exposure to

petroleum/oil/lubricant contaminants; exposure to sun);

q. has an obvious visual indicator for correct rigging.

Note: NAVAIR will provide Phase I performers with the appropriate guidance required for human research protocols so that they have the information to use while preparing their Phase II Initial Proposal. Institutional Review Board (IRB) determination as well as processing, submission, and review of all paperwork required for human subject use can be a lengthy process. As such, no human research will be allowed until Phase II and work will not be authorized until approval has been obtained, typically as an option to be exercised during Phase II.

Note: Any textile components used to develop the resulting material must be entirely manufactured in the United States of constituents wholly grown and/or produced in the United States.

PHASE I: Develop a plate release and demonstrate feasibility for retrofit and operation in any military approved commercial vest that incorporates a typical gravity-based quick release design. Resulting concepts should include a background section with explanatory figures describing the basic principles of the proposed technology concept, and publications or other references that outline the application being considered. Provide a 3-tiered work breakdown structure with a Gantt chart of Phase I design activities, and include make/break criteria and events. Submit Technical Performance Measures (TPMs) that will be tracked throughout Phases I-III for Government review and approval and include at a minimum: dry weight, bulk/profile, time from actuation to plate separation (from vest structure) while submerged in swimming pool water, human-operated reliability, and maintainer mean time to rig, inspect, and certify mechanism "safe-for-flight". Provide experimental work that shows the technology concept will quickly release hard plates in air and in water by an operator with a single hand and a single action. The Phase I effort will include prototype plans to be developed under Phase II.

Note: Please refer to the statement included in the Description above regarding human research protocol for Phase II.

PHASE II: Develop and validate the plate release technology by incorporating it into a Governmentidentified vest system design. Provide a detailed, 3-tiered work breakdown structure with a Gantt chart of Phase III activities that include make/break criteria and events, perform required quality assurance testing utilizing approved quality assurance measures, and track performance against agreed upon TPMs throughout Phase II. During the Phase II Option, perform testing of the technology in the form of a system level demonstration while incorporated in multiple size small and size x-large armored vests in a swimming pool. Include, in this non-exclusive list of desired Phase II deliverables, raw data, photography and/or video recording, data recording sheets, documentation of test devices (manufacturer, model, serial, accuracy, calibration status, etc.), test reports, draft engineering drawings, an interface control document, and a performance specification.

Note: Please refer to the statement included in the Description above regarding human research protocol for Phase II.

PHASE III DUAL USE APPLICATIONS: Finalize the developed armor plate release technology and provide a technical data package to include a performance specification, interface control document, and

engineering drawings in accordance with military standards. Develop and assist with required qualification testing and training. Finalize all testing. Document the quality assurance test program in accordance with industry best practices. Transition the technology to the Fleet as a retrofit, and to new procurements as required.

This topic may benefit the private sector in recreational equipment for which quick divestment of structure-mounted or body-mounted gear carriers are desirable or required for safety. Examples may include boat deck go-bags, back-packs, tool vests for workers at height, and tool vests for oil rig workers.

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KEYWORDS: body armor; quick-release; hard plate; vest; drowning; water ditching
N211-005 TITLE: Packaged Mid-Infrared Non-Mechanical Beam Steerer

RT&L FOCUS AREA(S): General Warfighting Requirements

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

OBJECTIVE: Design and develop a packaged, high-throughput, non-mechanical beam steering device that is able to maintain stable operation with multiple-wavelength laser sources in the midwave infrared (MWIR) band with high beam quality, efficiency, and power on target.

DESCRIPTION: Non-mechanical beam steering (NMBS) has numerous advantages over conventional mechanical gimbals, including high point-to-point steering speeds, low size, weight, and power consumption, and low operating costs. To date, NMBS devices have primarily been developed and matured in the short-wave and near-infrared bands. Recent advances in refractive NMBS technology have resulted in MWIR-compatible liquid crystal-based refractive devices [Refs 1, 2], but they have primarily been demonstrated at the laboratory scale and require additional development for Department of Defense (DoD) applications. Of particular interest is development of robust packaging for refractive NMBS devices that combines the steering head, associated optical components, and thermal management in a compact package that is able to operate from room temperature to beyond 55 degrees C, using the latest MIL-STD 810 for thermal testing. Additional considerations include optical optimization of refractive NMBS devices to improve throughput performance and steering magnitude.

Driven by DoD application requirements, the Navy seeks development of technologies capable of continuously steering a beam across the field of regard (FOR) without blind spots. Steerers should satisfy specifications including, but not limited to:

- point-to-point steering speed: Threshold of 1 kHz (1 ms point-to-point transition time) across >75% of the FOR, Objective of 10 kHz (100 μs point-to-point transition time) for >75% of the FOR;
- angular steering range: Threshold of 15° horizontally by 2° vertically, Objective of 30° horizontally by 5° vertically;
- throughput: Threshold of 30%, Objective of 50%; and
- power-on-target: Threshold of >1 W, Objective of >10 W;
- beam quality: Threshold of M2 <5, Objective of M2<1.5;
- aperture: Threshold of 2 mm, Objective of 1 cm;
- total packaged beam steerer volume (including associated coupling optics and thermal management): Threshold of <50 cm3, Objective of <10cm3; and
- electrical power consumption of the steerer head and associated thermal management while under active illumination: Threshold <10 W, Objective <1 W.

While it is desired that the full angular steering range be accessible without any wavelength-based steering effects, solutions that incorporate wavelength-tuning methods may be considered. The steerer must be capable of transitioning between any arbitrary points within the FOR and holding position at any arbitrary point; the primary operation mode necessary to achieve threshold and objective specifications should not be a continuous raster scan. The designed device must be able to accommodate coupling and steering of multiple laser lines, individually, but in a single device, between 2-5µm with high efficiency.

The design should reasonably expect to achieve a manufacturing readiness level (MRL) of 5 within 3 years and MRL 7 within 5 years of beginning work on this NMBS device.

PHASE I: Design, develop, and demonstrate feasibility of refractive NMBS waveguides for improved optical performance, to include designs for improved steering while minimizing total optical path length. Designs for packaging of such a device should also be considered, taking into account thermal management and optical coupling of remoted lasers. An assessment of whether the proposed technology functions in reverse, as a scannable receiving optic, should be included. The Phase I effort will include prototype plans to be developed under Phase II. A schedule and explanation of the manufacturing readiness level shall be included in the Phase I final report.

PHASE II: Develop a packaged NMBS prototype device from the proposed design. Demonstrate that it is capable of maintaining stable operating temperature while meeting radiant power and M2 requirements. Include, in this demonstration, provisions to steer, either simultaneously or in rapid sequence, multiple wavelengths in the MWIR band. Ensure that volume and electrical power requirements apply to the prototype device.

PHASE III DUAL USE APPLICATIONS: Perform final testing the packaged NMBS device in a relevant environment, to include appropriate integration as applicable to the specific Navy platform. Transition and integrate to an airborne platform of interest chosen in consultation with PMA-272.

This technology is beneficial for medical diagnostics, chemical sensing, and other applications that utilize mid-infrared spectroscopy. Additionally, non-traditional beam steering may have lidar applications if the technology transitions the wavelength used in the lidar system.

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KEYWORDS: non-mechanical; directed energy; lidar; mid-infrared; quantum cascade laser; beam steering; NMBS

N211-006 TITLE: Improving Performance of Solid Rocket Fuel through Advancements in Materials Science

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Air Platforms; Materials / Processes; 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 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: Design and develop efficient near-throat controlled cooling technologies that would improve solid fuel performance by enhancing condensation of gaseous metal suboxides.

DESCRIPTION: Typically, solid rocket fuel is packed in a tubular motor case and consists of hydroxylterminated polybutadiene (HTPB) mixed with fuel additives in the form of metal powders, such as aluminum or boron. Upon deployment of a missile, the available fuel is ignited; and the combustion pressure that develops is funneled through the nozzle assembly. The throat, a critical component of the nozzle, is located near the exhaust end of the motor case. The nozzle diameter is intentionally reduced here in order to alter the flow and maximize performance.

The science of combustion of a solid fuel system is highly complex and it is believed that complete combustion of metal additives could dramatically increase performance [Ref 1]. A substantial part of combustion energy is released during condensation of the gaseous metal suboxides. A significant portion of this energy can be emitted as a flux of light. It could constitute more than 50% of the overall energy produced during the combustion of metals [Ref 4]. This energy should be dissipated from the condensation zone in order to enhance condensation. The thermal conductivity [Ref 5] and jetness of the nozzle are major parameters that control the rate of energy dissipation.

The condensation of metal suboxides occurs concurrently with the exhaust gas expansion in the nozzle. As such, the latter should be thoughtfully designed in order to:

(a) enable the most favorable conditions for condensation of gaseous metal suboxides into its condensed oxide form,

(b) accommodate the majority of condensation energy, and

(c) withstand a radiative heat flux of high intensity formed as a result of a localized light emission subsequent to condensation of gaseous metal suboxides.

This SBIR topic seeks to design and develop efficient near-throat controlled cooling technologies that enhances heat removal, and therefore enhances condensation of gaseous metal suboxides. The manufacturing materials of the nozzle assembly must be able to withstand temperatures of combustion gasses on the order of 3000 K, high-radiative heat fluxes (greater than 10 MW/m2 [Ref 8]) caused by intense emissions of light, erosion, stress, thermal shock [Refs 2, 3], and other factors involved in the operation of a solid fuel rocket engine. The legacy materials are mostly based on specialty carbons, such as a carbon-carbon composite, or isostatically molded graphite [Refs 6, 7]. The proposed solution must meet all of the properties of the standard carbon materials to include, but not be limited to, to withstand erosion, stress, and thermal shock. Additionally, the throat insert must have controlled material properties

such as thermal conductivity and jetness, so that it can remove heat from the condensing gas and from associated light emission at an ultrahigh rate, at least 10% more efficiently than the traditional materials.

PHASE I: Design and develop a numeric model for the purpose of tuning the throat nozzle assembly's material properties to induce a more efficient condensation near the throat. Initial prefeasibility studies with newly fabricated materials should be undertaken at the bench scale level. Deliver a prefeasibility report that outlines the results from the model and the delineation of nozzle assembly properties, which should at the very least, meet the performance characteristics of existing standard throat nozzle assembly materials at the end of Phase I. Outline a plan for improvement of material properties. Include prototype plans to be developed under Phase II.

PHASE II: Demonstrate that the new materials will be at least 10% more efficient at withdrawing heat from condensing gases and light emission sources. Qualitative modeling will be used to estimate exactly how the prototype parts would benefit the thrust. All other physical and chemical properties of throat assembly will be at the same performance level as standard throat assembly materials. Perform testing to validate the technology can withstand stress, shock, and erosion.

PHASE III DUAL USE APPLICATIONS: Finalize and mature the technology for transition and integration into surface-to-air and air-to-surface munitions, mobile targets, and space vehicle programs. Solid rocket fuel engines are heavily employed by various branches of the U.S. Navy, other branches of the DoD, and NASA to include commercial space exploration missions. Other applications include, but are not limited to, industrial uses for high-density electrically conductive graphite used in refractories, reactor components, and specialty liners for chemical vessels. Another application would be in industrial burners and in the design of exhaust of elevated temperature combustion engines, to include automotive applications.

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KEYWORDS: rocket nozzle insert; carbon-carbon composite; isostatically molded graphite; metal combustion; nozzle expansion; condensation efficiency

N211-007 TITLE: Hyperspectral Sensor Metamaterial Lens in Imaging Applications

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Battlespace Environments; Electronics; 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 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: Design, build, and demonstrate on-chip hyperspectral focal plane array, with integration of dynamically tunable metamaterial lens to perform and produce 2D spatial images with a single exposure at a few selected wavelength bands instead of 1D spatial and all spectral band images.

DESCRIPTION: Hyperspectral imagery (HSI) provides the means to detect targets smaller than the size of a pixel using spectral unmixing techniques. HSI contains hundreds of bands of spectral information per pixel. HSI is traditionally performed using a dispersive (prism or grating) reimaging system with a slit and focal plane array (FPA) at the conjugate image planes. Current HSI state-of-the-art detectors are based on various photon-to-electron conversion principles that, at best, have quantum efficiencies (QE) of 40 percent in the blue spectrum. Since the conversion process is substantially less than unity, additional laser power is required from the transmitter to make up for the loss of signal on the detector. If a photo detector type material with near unity QE could be used, the HSI system performance would dramatically increase with no additional laser power. The very high efficiency of metamaterial photodetectors will dramatically increase the electrical power available for electric small Unmanned Air Vehicle (UAV). Improvements in photo detection efficiencies are sought to advance the tactical capabilities of HSI systems used on UAVs.

Optical metamaterials with negative refractive index behavior have extraordinary promise in HSI applications. Unlike a conventional lens, a negative refractive index implies that when a material refracts an incoming light ray, the refracted ray will be deviated at a negative angle to the normal according to Snell's law. This seemingly trivial observation has profound consequences: focusing can be accomplished by a slab of material instead of a conventionally-shaped lens. More subtly, lenses made from negative index metamaterials (NIMs) can be much more compact than curved optical lenses such as cylindrical and aspheric lenses, since wave vector components along the optical axis can be used for imaging. In conventional optics, these components typically decay at distances very close to the lens surface (the near field), and account for a loss of imaging information, and ultimately, resolution. For a NIM, that decaying evanescent wave instead grows, allowing near-field resolution to extend into the far field. Furthermore, a negative index implies that the phase of a wave decreases, rather than advances, through the metamaterial NIM. A material with n = -1 can be considered to reverse the effect of propagation through an equivalent thickness of a vacuum. Consequently, NIMs have a potential advantage to form highly efficient low reflectance surfaces by exactly canceling the scattering properties of other materials. If the NIM is isotropic, then these effects occur regardless of the direction of the incident wave.

NIMs require negative values of both the electrical permittivity (e) and magnetic permeability (μ). Negative permittivity is common in metals at optical frequencies, but negative permeability does not occur naturally; therefore, the construction of metamaterials involves engineering an effective negative permeability using nonmagnetic materials. This can be done by including electromagnetically resonant

structures. Optical-frequency resonators are much smaller in scale (< 1 mm), have been recently made with advanced lithographic procedures, and have shown negative index behavior in the visible and near-infrared spectrum. Still, these NIMs are not isotropic as the features are planar, and the index varies with orientation. Additionally, most of them have large optical losses due to the materials that comprise them.

A quick examination of NIM literature reveals that in most cases where a metamaterial lens would be used to create images, the refractive index should be independent of direction of the incoming radiation. Yet, the properties of most NIMs reported in the literature are not randomly dispersed inclusions, are not dependent on random orientation of crystal grains, and are not inherently isotropic in three dimensions.

The primary challenge in NIMs is advancing the diffraction limit in Near Field capabilities to identify a threshold to separate targets from clutter in hyperspectral data idiosyncrasies. Hence, NIM designs need to provide larger phase shifts and reduce aberrations to enable tuning the focal length with adjustable sequential metamaterial lens structures, resulting in low far-field resolution of features beyond the diffraction limit in the visible spectrum. Highly viable/manufacturable single and sequential metamaterial lens designs addressing the 3-12 μ m spectral range with a focus on 3-5 and 8-12 microns are a possible solution.

NIM lens system parameters for trade analysis are:

- (a) Operational spectral range @ 3-12 microns;
- (b) Smallest Spectral sampling step @ 1 nm;
- (c) Spectral resolution @ full-width half maximum (FWHM) @ 7-10 nm;
- (d) Spectral Stability @ < 1 nm;
- (e) Wavelength switching speed @ < 2 ms;
- (f) Incidence angle to the Fabry-Perot Cavity $@<5^{\circ} (max < 7^{\circ});$
- (g) Average spectral transmission @>0.2;
- (h) Image size @ 480 x 750;
- (i) Dynamic range @ 10 bit;
- (j) F-number range of the optics @ 4.0 16.0;
- (k) Focal length @ 8–25 mm;
- (1) Field of View (FOV) @ $20^{\circ} \times 30^{\circ}$;
- (m) Object distance @ 0.05 m Infinity;
- (n) Operational quantum efficiency @ >100% in the 3-12 microns spectral band;
- (o) Noise factor @ < 1.1;
- (p) Bandwidth @ > 100 MHz;
- (q) Fast response speed@ (rise time tr < 68μ s);
- (r) Uniform optical quality in terms of refractive index and extinction co-efficient;
- (s) Root Mean Square (RMS) errors below 1×10-3 refractive index units (RIU)
- (t) Weight @ < 350 g;
- (u) Thickness @ 0.2 to 0.5 mm (ultrathin with < wavelength (lambda) divided by 8 surface flatness);
- (v) Active areas on the order of 1 to 2 inches in diameter; and
- (w) Focusing performance for oblique incidence with an incident angle up to 15 degrees.

PHASE I: Conduct research and experiments to determine potential NIMs for HSI NIM lens and select optimum technical approach using the system parameters for trade. Develop preliminary design and perform detailed analysis for on-chip hyperspectral focal plane arrays, with integration of dynamically tunable NIM lens to allow for spectral reconstruction with a single photodetector; and to be directly integrated with arbitrarily-sized read-out integrated circuits (ROICs) for real-time HSI in-pixel image processing. Preliminary design should also include an integrated/embedded metamaterial structure that can be easily subjected to change in temperature or to stress loads while interrogated by electromagnetic fields. Through experimentation, identify NIM technical risk elements in the HSI metamaterial lens and

provide viable risk mitigation strategies. The Phase I effort will include on-chip hyperspectral focal plane arrays, with integration of dynamically tunable NIM lens prototype plans to be developed under Phase II.

PHASE II: Refine the design based on outcomes of simulated data, boot strap error analysis, tests and customer feedback in Phase I. Develop, demonstrate, and validate an HSI metamaterial lens prototype in the lab, chamber, and/or field. Demonstrate and validate the prototype system with all of the parameters identified in Phase I. Prepare a report that summarizes the experimental evaluation and validation of the performance characteristics of the developed system.

PHASE III DUAL USE APPLICATIONS: Complete prototype hardware that will cover operational spectral range@ 300 – 1200 nm. Fully develop and transition the technology and methodology based on the research and development results developed during Phase II for DOD applications in the areas of UAVs detection and identification, and other anomaly surveillance and reconnaissance applications.

This SBIR topic has direct relevance to commercial private sector airborne remote sensing companies engaged in environmental monitoring, agriculture assessments and exploration of natural resources due to the system's compact form factor, flexible flight profiles and precision identification, and change/anomaly detection.

Lower cost hyperspectral sensors for agriculture, land use, search/rescue, and homeland security could employ this technology. The use of low-cost solution-based metamaterials and their ability to be directly integrated with arbitrarily-sized ROICs results in HSI cameras that can be produced at a small fraction of the cost of traditional camera systems.

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KEYWORDS: broadband metamaterial; flat lens; photo detector; optics-on-a-chip; ROIC; Hyperspectral Imaging; HIS; NIM; negative index metamaterial

N211-008 TITLE: Tool to Predict Transient Spatial-Temporal Boundary Conditions for Processing Autoclave-cured Composite Parts

RT&L FOCUS AREA(S): General Warfighting Requirements

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

OBJECTIVE: Design, develop, and validate an analytical tool to accurately predict the local transient thermal and mechanical boundary conditions during the processing of composite parts within an autoclave.

DESCRIPTION: Autoclaves are widely used to process and cure high quality parts for composite structural components used on aircraft. This high quality is possible due to the autoclave's high internal pressures and ability to apply high temperatures in excess of 350°F such that the intended resin systems can cure. When these assumed conditions are not met, defects such as porosity and poor fiber consolidation occur [Ref 5]. Autoclave systems are designed with these conditions in mind, but since part thickness, tool geometry, and part location can vary from run to run, the local conditions cannot be guaranteed. The conditions within are driven by the capabilities of the autoclave: air temperature, air flow and physical part geometry interaction with the tooling surface and vacuum bagging [Ref 6]. This environment is thus governed by a variety of physical interactions and requires a multiphysics modeling tool to accurately capture the boundary conditions experienced by the composite parts.

Modeling and simulation to predict composite part quality within an autoclave requires a coupling of the local boundary conditions with the mechanics and chemistry going on within the composite. The temperature of the part at the bag as well as the tooling surface is critical to couple with the cure kinetic models [Ref 4]. Boundary conditions are usually assumed in simple models where the air temperature throughout the autoclave is believed homogenous and the part is experiencing perfect hydrostatic pressure regardless of location or tool geometry. Without accurate boundary conditions, anticipating defects or reducing internal stresses and spring-back is very difficult to predict accurately [Ref 1]. Current modeling capabilities often utilize simplistic two-dimensional models or assumed boundary conditions [Ref 7]. The means to expand that to more complex three dimensions are commercially available but limited. Accurate modeling of the environment within the autoclave can be computationally expensive and require responsive software simulation integration to capture multi-physics interactions [Ref 2]. Hybrid models utilize a variety of physics including Computational Fluid Dynamics (CFD) and heat transfer which then feed into the boundary conditions for cure kinetic models. These models also require experimental validation from actual autoclave runs which can be difficult since each commercial autoclave system is unique [Ref 10]. This is where data fusion from in-situ monitoring can be used not only to validate but to tune a model for predicting boundary conditions. The goal of this SBIR topic is to provide a means to integrate both modeling capabilities as either a single tool or an add-on to existing software. This software tool will have validation from real-life autoclave runs and the means to be adapted to various autoclave systems per the user's need.

Many of the current methods for running parts in an autoclave come from simple models, best practices and extensive thermal surveys to confirm that the material has cured as intended. Autoclave runs completed in early acceptance testing feature parts that are outfitted with a multitude of sensors to measure temperatures throughout the part and tool. The temperature and pressure cycle is then adjusted until the desired cure profile is achieved throughout the part. Temperature ramp rates and early cycle dwell periods are critical to removing volatiles from the liquid resin and facilitating flow. Final cure temperatures and duration confirm that the resin has solidified and reached complete cure at every location in the composite part. Design engineers must intelligently place multiple tooling and parts within the autoclave such that the air flow is not blocked [Ref 3]. Any great change to this process must be

preceded with another thermal survey and part inspection teardown. Having a multiphysics software tool capable of modeling the system's boundaries would reduce the amount of expensive autoclave runs needed to start production. It can also provide production lead time flexibility since the operator can intelligently position multiple parts within the autoclave and still achieve the correct cure profile for each. When there are indications from Non Destructive Inspection (NDI), the software can then be run to assess problem areas within the cure as well as provide the operator feedback that the autoclave may be out of its designed thermal and pressure specification. The benefits of this software tool will allow engineers faster entry into production, gain flexibility in production stream through curing various part combinations and more rapidly assess problems that would later manifest themselves as part defects. Software simulations tools will reduce the number of test runs required for opening up a new composite part production run. They will also enable greater production scheduling freedom through process modeling of part layouts within autoclaves, which will make production more adaptive and save scheduling time and thus cost.

PHASE I: Propose a concept of a multiphysics tool that can address the local non-uniform transient thermal and mechanical boundary conditions accounting for conditions within an autoclave. Demonstrate the concept and quantify the effects of non-uniform environmental conditions via a numerical simulation of airflow temperature, pressure and heat transfer for a simple composite part during autoclave processing.

PHASE II: Enhance and develop the proposed concept prototype tool to address the manufacturing of composite parts containing inserts, complex curvatures, and thick laminates exceeding 1.5 inches in thickness. Validate the prototype tool by comparing simulation results to a live autoclave run containing a variety of composite parts and tooling with select geometries. Capture transient thermal and pressure distributions through in-situ monitoring to be then compared to simulation results. Demonstrate the ability to use this prototype tool coupled with a cure kinetics model for a chosen material system. Verify that this prototype tool can be used on a variety of autoclave systems and part/tool load-outs. Provide the developed prototype software tool for the Navy to use.

PHASE III DUAL USE APPLICATIONS: Transition this software tool to the program and production. Optimize this tool for difficult-to-process parts and layouts that have historically hindered production due to defects and warpage from incorrect autoclave heating.

The product outcome of this SBIR topic has extensive applications for companies producing autoclaved composite parts as well as other industrial processes that require the controlled enclosed heating and pressurization of a product. Software simulations tools will reduce the number of test runs required for opening up a new composite part production run. They will also enable greater production scheduling freedom through process modeling of part layouts within autoclaves. This will make production more adaptive and save scheduling time and thus cost. Secondary applications extend to any enclosed processing of a product using convective heating and external pressure. This includes, but is not limited to, heat treatment of metal, ceramic, and glass products as well as baked goods.

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KEYWORDS: Composites; autoclave; simulation; computational fluid dynamics; heat transfer; processing

N211-009 TITLE: Cyber Protection for Physical Avionics Data Inputs to Navy Platforms

RT&L FOCUS AREA(S): Cybersecurity; General Warfighting Requirements

TECHNOLOGY AREA(S): Air Platforms; Battlespace Environments; 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 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: Research and address the holistic cyber threat posed by the transfer of aeronautical data to Navy and United States Marine Corps (USMC) aircraft by taking physical avionics data inputs to the aircraft and developing solutions to harden those input channels, protecting the data from malicious tampering and errant corruption.

DESCRIPTION: Critical aeronautical data is transferred into avionics systems to provide pilot guidance or other information used to influence pilot decisions in the cockpit. This aeronautical data may include the navigation database, vertical obstruction database, flight plans, world magnetic model, maps, and imagery. To prevent malicious tampering of this data, cyber protection needs to be implemented on all physical avionics data inputs in these airborne systems. Currently, minimal cyber-safe mechanisms are offered and only provide protection against errant corruption. No complete cyber protection set exists for the physical avionics data inputs creating a multitude of threat surfaces to be addressed. The Navy must fully identify all threat surfaces and begin to prototype protections against those threats. The following are examples of physical data threat surfaces (but by no means intended to be a complete list):

Corrupt/Invalid Source –involves the data validity of the data sourced by the data provider (Government, industry, or open-sourced); could be a result of any other type of threat surface.

Errant Corruption –a non-intentional data corruption introduced by human or computer error; also the most easily identified by mechanisms such as Cyclical Redundancy Checks (CRCs).

Proposed approaches should include, but not be limited to, a white hat analysis of all physical avionics data inputs to all Navy and USMC aircraft. For each physical avionics data input this research should identify the data flow which includes data source, transitional systems (e.g., tablet, Navy/Marine Corps Internet (NMCI), Joint Mission Planning Software (JMPS), maintenance computer), and end use. For each data flow, perform a human factors assessment to determine if the pilot decision making based on operational conditions (e.g., instrument flight rules (IFR) vs visual flight rules (VFR), approach vs cross country) and alteration of data inputs can be altered. Potential mitigation strategies should be identified for each physical avionics data input. These mitigation strategies could be process, software, or hardware solutions depending on the scenario. An evaluation of current protections, postulate new or enhanced cyber protections, and perform experimentation to determine if protections are sufficient to mitigate risk should be performed. All postulated solutions should focus on performance of the solution to prevent unnecessary burden on the aircrew that could prevent them from attaining mission success.

Utilizing the white hat analysis, firms should develop prototype solutions for the two platforms with the largest threat surface in order to provide a formal design, implementation, and formal qualification testing

of protection strategies for the data chain from source to end use. Prototype solutions in this context could be hardware, software, and/or procedural guidance. To validate the initial threat surface analysis and protections implemented provide sufficient protections to avert any corrupt/invalid source, errant corruption, Denial of Service (DoS), or spoofing/hacking attack types, potential technologies will participate in a focused ethical hacking event (or Hack-a-thon). A successful demonstration of the prototype solutions would be the prevention of all attempts to infiltrate the system and successful identification and notification of operators of hazardously misleading information that would affect decisions within the cockpit.

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 and/or subcontractor 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: Determine feasibility of proposed approach by performing a white hat analysis of all physical avionics data inputs to all Navy aircraft. Provide a summary of the white hat analysis, a listing of all threat surfaces, the affected aircraft, mitigation strategies, and residual risk while also identifying gaps where analysis was non-deterministic. In the Phase I option, if exercised, develop a threat brief deployable to each platform and a Business Case Analysis (BCA). The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop and demonstrate prototyping solutions for the two platforms with the largest threat surface. Provide a formal design, implementation, and formal qualification testing of protection strategies for the data chain from source to end use. Prototype solutions in this context could be hardware, software, and/or procedural guidance.

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: Finalize prototype solutions and validate at a focused ethical hacking event (or Hack-A-Thon). Proofing of threat patches, if high priority topics are discovered, additional or iterative hacking events may occur to ensure completion of targeted topics (i.e., fly-fix). Transition and integrate the deployment of cyber protection strategies to naval platforms or Programs of Record.

The outcome of this topic will result in a packaged set of methodologies to protect data in transit from off-aircraft maintenance stations to on-aircraft usage to protect against both errant and malicious corruptions. Those methodologies could in turn be documented and shared with the private sector for use on Navy projects. Both the commercial sector (such as GE, Jacobs, Raytheon, Rockwell Collins, L3Harris) and other DoD services could benefit from a deployed base cyber protection suite of tools. Software, hardware, and procedural solutions would need to remain portable to multiple environments to support reuse of tools and methodologies.

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KEYWORDS: cyber; collision avoidance; obstacle; database; Hazardously Misleading Information; HMI; safety; cyber protection; corrupt/invalid source; errant corruption

N211-010 TITLE: Cloud Based Air Traffic Control Training System

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Battlespace Environments; Human Systems

OBJECTIVE: Develop an innovative and cost-effective Cloud Based Air Traffic Control Training System that can provide ready relevant training and encourage student participation through gamification of learning arcade style activities, with integrated student and class metrics that can increase training efficiency can address that need. This capability will provide a level of training fidelity that the community has not experienced while reducing training time and cost.

DESCRIPTION: Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources. Those resources include networks, servers, storage, applications, and services. These resources can be rapidly provisioned and released with minimal management effort or service provider interaction. Available on-demand, cloud environments are scalable and allow agencies to provision resources as required.

This SBIR topic seeks to investigate a Cloud Based Air Traffic Control Training System that leverages ready relevant learning and game theory. The system should allow remote access to a wide range of exercises and resources for students, instructors, and management. Consistent with the Cloud First policy, agencies will use cloud infrastructure when planning new mission and support applications. Additionally, agencies will consolidate existing applications to help reduce training time. In addition, one of the focus areas is improving training quality.

Ready Relevant Learning (RRL) is about driving fundamental changes into our approach to Sailor training. The goal of RRL is to provide the right training at the right time in the right way. To accomplish this, the Navy will modernize training to maximize impact and relevance, and accelerate processes for delivering new training to the Fleet. In order to improve Sailor performance and enhance mission readiness, the Navy's industrial-era, conveyer-belt training model will transform into a modern version. The modern version will contain content that meets Fleet-validated learning needs [Ref 7].

Gamification [Ref 5] is the process of defining the elements that make games fun and motivate players to continue playing while using those same elements in a non-game scenario to influence behavior [Ref 4]. For an educational scenario, some examples of gamification of desired student behavior include attending class, focusing on meaningful learning tasks, and taking initiative [Ref 6].

Some elements of games that may be used to motivate learners and facilitate learning include, but are not limited to:

- (a) progress mechanics (points/badges/leaderboards);
- (b) narrative and characters;
- (c) player control;
- (d) immediate feedback;
- (e) opportunities for collaborative problem solving;
- (f) scaffolded learning with increasing challenges;
- (g) opportunities for mastery, and leveling up; and
- (h) social connection.

The Cloud Based Air Traffic Control Training System should consist of networked Tower and Radar Trainer, and a Part-task computer-based trainer that has access to training modules on the cloud. More specifically, this effort seeks to investigate a Cloud Based Air Traffic Control Training System allowing

remote access to a wide range of exercises and resources for students, instructors, and management. The system should have the ability to remotely observe the simulator from anywhere in the world via the internet providing users the ability to simulate, simultaneously, operations of multiple Air Traffic Control (ATC) facilities such as multiple ATC approach control radars and multiple ATC towers operating in one given airspace. This ability should allow tower and radar controllers to simultaneously train using the same aircraft, handoffs, etc. to allow for a more realistic training scenario. Interactive development tools that allow for quick and easy creation of accurate scenarios can be immediately deployed to the cloud and used in full simulators and part-task trainers in all locations. Ready Relevant training via flexible part-task trainers that can be adapted to any curriculum aspect to provide targeted in-class training and off-class self-training reinforcement in all stages of student development for immediate implementation via the cloud trainer shall encourage student participation through gamification of learning arcade style activities with competitive scoreboards. If accessible via Department of the Navy (DON) networks, the Navy Marine Corps Intranet (NMCI), the Outside Continental United States (OCONUS) Navy Enterprise Network (ONE-Net), and the Marine Corps Enterprise Network (MCEN), comprehensive class, student, and exercise management tools, exercises and databases can be shared with all sites. The system should be able to quickly and easily identify problem topics for individuals and the whole class to effectively target instruction and deploy ATC training software across the enterprise.

PHASE I: Identify and demonstrate feasibility of a Cloud Based Air Traffic Control Training System that leverages RRL and game theory; and simulates, simultaneously, operations of multiple Air Traffic Control (ATC) facilities such as multiple ATC approach control radars and multiple ATC towers, operating in one given airspace. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop and demonstrate a functional Cloud Based Air Traffic Control Training System prototype with the ability to communicate via DON networks, the NMCI, the ONE-Net and the MCEN. The prototype of the software technology that considers and adheres to Risk Management Framework guidelines to support cyber-security compliance in a lab or live environment. Install, integrate, test, train, validate, and deliver the Cloud Based Air Traffic Control Training System prototype.

PHASE III DUAL USE APPLICATIONS: Obtain management framework certification for an authority to operate within operational/training systems. Finalize, refine, and integrate the Cloud Based Air Traffic Control Training System and instructional tools within the training system environment. Transition the technology to a Naval Air Station via a Program Office. Examples of commercial industries that could benefit from this cloud based training include commercial airlines and corporate training. This SBIR topic provides benefits to the private sector by opening up a Navy use case for cloud based training. Although cloud based training has been used outside of the DoD, leveraging cloud based training for the DoD will add additional challenges because of network limitations and cyber security requirements. This solution can be used in the defense industry as the foundation for all future cloud based trainers.

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KEYWORDS: Air Traffic Control; Cyber; Cloud-based Training; Training System; Ready Relevant Learning; RRL; Game Theory; gamification; air traffic control; ATC

N211-011 TITLE: Ping Strategies for an Intelligent Search using Multistatic Active Sonar

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Battlespace Environments

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: Develop ping strategies, in a simulation environment, that provide optimized performance for multistatic active sonar fields with a target that actively seeks to evade detection by the sonar field.

DESCRIPTION: One of the challenging components for developing new sonar systems and improvements to them is collecting data so that the system is mature with robust performance in a wide variety of acoustic environments. Execution of data gathering events requires large investments funding Navy personnel and assets. In order to reduce costs while developing a system, the Navy seeks to employ models and simulations to the maximum extent possible reducing the need for a large number of data gathering events.

This SBIR topic seeks to develop foremost ping strategies and signal and information processing techniques to optimize search performance that can be validated against a realistic target motion model in a simulation environment. Development of the target motion model is required and that model should include techniques for the target to avoid detection when located in a multistatic active coherent (MSAC) wide area search field. Real-world parameters such as the sound speed profile and bathymetry will be provided. A reactive target model that seeks to evade an active multistatic field and remain undetected will enable more meaningful simulation results of the ping strategies under evaluation and will better demonstrate the effectiveness of the proposed changes. Historical approaches to the detection problem [Ref 7] focus on reconciling the sonar equation. The Navy seeks to develop ping strategies that leverage signal and information processing or other techniques in addition to just reconciling the sonar equation that will improve the probability of detection and show an improvement against a reactive target model that is able to maneuver, change speed, and change depth. Because the target has mass (i.e., the size of a manned platform), instantaneous changes in speed or direction should not be considered in the target motion model.

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 known as Defense Security Service (DSS). The selected contractor and/or subcontractor 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.

PHASE I: Demonstrate the feasibility of ping strategies for a notional multistatic sonar system, which improves performance against an optimized reactive target model. Show that these new strategies improve performance versus a random ping schedule. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop and implement ping strategies for a simulated MSAC field with a reactive target including broadband and narrowband waveforms, multiple input multiple output (MIMO) pinging, and high-duty cycle (HDC) pinging. Demonstrate that new ping strategies can successfully detect a reactive target 25% more often than simple ping schedules.

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: Finalize and implement the capability as part of an operational sonar system. Transition of this capability should utilize the Advanced Product Builds (APB) process. The search techniques developed under this effort have application across the Navy for sonar, radar, electro-optic, and other sensor devices.

The searching or tracking of mobile targets where the sensors are stationary would benefit from this capability (i.e., tracking assets in an urban battlefield). A potential commercial application would be to the gaming industry especially if the object of the game was to avoid detection or capture.

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KEYWORDS: multistatics; intelligent search; evasive target; Multiple Input Multiple Output; MIMO; ping strategies; cost functions

N211-012 TITLE: Micro-Electromechanical Gyroscope for Improved Inertial Navigation Systems Performance

RT&L FOCUS AREA(S): General Warfighting Requirements

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

OBJECTIVE: Design and develop a miniature, low-cost, high-performance inertial navigation system based on novel micro-electromechanical system (MEMS) gyroscope technology for improved performance and Space, Weight, Power, and Cooling (SWaP-C).

DESCRIPTION: The Department of the Navy (DON) has emphasized the need for aerial platforms to have GPS-independent position, navigation, and timing capability. In order to satisfy the position and navigational capability goals, more advanced inertial navigation systems (INS) are needed. Inertial measurement units (IMUs) based on MEM technology could be the key to obtaining this sought after INS capability. MEMS gyroscopes are gaining increased usage in commercial and military applications because of their low size, weight, and power characteristics; MEMS-based IMUs that are shock/vibration resistant have the potential to provide accurate GPS-independent position and navigation data. Recent advances in the construction of MEMS devices have made it possible to manufacture small and light IMUs. Improvements in MEM gyroscope technology include characteristics such as bias drift prediction, micro-capacitance sensing, structure-borne noise and vibration analysis, quality factor optimization, bandwidth expansion, data compensation, quadrature error correction, and ease of fabrication. The availability of new MEMS, such as the Double U-beam vibration ring gyroscope (DUVRG), have the potential to improve unaided INS performance while retaining the ability to operate in the harsh environments common to Navy aviation platforms. A number of DUVRG structures can be combined into a small area, with opposing temperature and noise sensitivities to offset errors, and their outputs averaged for improved drift rates. The Navy seeks vibration and shock resistant tactical grade IMU for inertial navigation that are less than 3 in³, (volume), 100g (weight), and 2.3W (power) with position/angle/angle rate errors of 0.2m/0.1°/.005° per hour or less. This SBIR topic seeks vibration and shock [Ref 1] resistant tactical grade IMU for inertial navigation that are less than 3 in3, (volume), 100g (weight), and 2.3W (power) with position/angle/angle rate errors of 0.2m/0.1°/.005° per hour or less.

PHASE I: Demonstrate feasibility of the MEM gyroscope technology, including the use of DUVRGs in the design of a robust INS with state-of-the-art unaided drift characteristics. Determine how much improvement in position, pointing, roll and pitch accuracy can be obtained using advanced MEM gyroscope technology, and begin designing a DURVG-based (or other innovative MEM gyroscope) INS using modeling and/or analysis. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop, demonstrate, and validate a DUVRG-based or other innovative MEM gyroscopebased INS prototype. Perform bench level tests to verify the performance of prototype. Assess performance in a representative environment using MIL-STD-810 [Ref 1].

PHASE III DUAL USE APPLICATIONS: Complete development of a MEM gyroscope-based INS prototype and demonstrate performance in an actual, operational environment. Integrate and transition to Navy hosting platforms. This technology would benefit any organization (i.e., space launch vehicles, commercial driver less vehicles, Merchant Marine vessels, and civilian aircraft) seeking a means of long term navigation without GPS.

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KEYWORDS: Alternative GPS; micro-electromechanical system; MEMS; gyroscope; inertial navigation; inertial navigation system; INS; drift rates; Inertial measurement units

N211-013 TITLE: Cooling Devices for Helmeted Maintainers, Flight Deck Crew, and Rotary-Wing Aircrew

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Biomedical; Human Systems

OBJECTIVE: Design and develop a thermoregulatory control device to be worn in conjunction with maintainer, flight deck crew, and rotary-wing aircrew helmets to prevent overheating in hot climates and support continued mission operation without degradation in human performance for up to twelve hours.

DESCRIPTION: Helmet systems have been developed to improve hearing and head protection in extremely loud environments [Refs 1-2]. Most of these helmets are unvented and some have an edge roll seal around the face and neck to improve hearing protection. Consequently, these features also create the potential for increased risk of overheating while wearing the helmet, especially in hot environments, over a 12-hour work period [Refs 3-4].

The Department of the Navy (DoN) seeks thermoregulatory control devices to be worn in conjunction with maintainer, flight deck crew, and rotary-wing aircrew helmets. The proposed technology must prevent the potential overheating of maintainers, flight deck crew, and rotary-wing aircrew for up to 12 hours [Refs 5-7]. Cooling devices may be head, neck, or body mounted and worn in, or under, the current helmet system or clothing. The technology must not interfere with mission operation, nor should it cause a decline in human performance or hearing protection over a 12-hour period. Technologies must be portable, lightweight, and should integrate with current helmets or personal protective equipment without disruptions to the edge roll or shell of the helmet, which would degrade current levels of hearing protection. In addition, added weight on the head should not significantly change the center of mass so as to lead to discomfort or decreased performance, nor should the technology force the head into a forward pitch position. The desired system may include, but is not limited to, passive and active, evaporative, conductive, or convective cooling. The technology should have minimal components and no risk of accidental detachment during mission operations. The cooling must not introduce health or safety risks to the warfighter or the environment. Both a one-size-fits-all approach, as well as, specific solutions for each application will be considered.

Although not required, it is highly recommended to work in coordination with the original equipment manufacturer (OEM) to ensure proper design and to facilitate transition of the final technology [Refs 1-2].

NAVAIR will provide Phase I performers with the appropriate guidance required for human research protocols so that they have the information to use while preparing their Phase II Initial Proposal. Institutional Review Board (IRB) determination as well as processing, submission, and review of all paperwork required for human subject use can be a lengthy process. As such, no human research will be allowed until Phase II and work will not be authorized until approval has been obtained, typically as an option to be exercised during Phase II.

PHASE I: Develop approaches to an innovative cooling solution that does not compromise hearing or head protection. Demonstrate proof of concept through test fixture testing and modeling. The Phase I effort will include prototype plans to be developed under Phase II.

Note: Please refer to the statement included in the Description above regarding human research protocol for Phase II.

PHASE II: Develop and produce a prototype thermoregulatory device based on the design developed in Phase I. Perform subject testing to evaluate performance in work-representative scenarios. Develop life-cycle costs and supportability estimates.

Note: Please refer to the statement included in the Description above regarding human research protocol for Phase II.

PHASE III DUAL USE APPLICATIONS: Develop an optimized solution, finalize testing efforts, and assist in transitioning the technology to the fleet. Provide the Navy with all mechanical and electrical drawings associated with production representative solutions.

Developed technology could be used commercially in the utilities sector, sports industry, or any instance in which helmeted personnel require cooling solutions to maintain a sustained activity level.

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KEYWORDS: thermoregulatory; overheating; evaporative cooling; conductive cooling; convective cooling; cooling devices

N211-014 TITLE: Predictive Model Based Control System for High Speed Dynamic Airframe Testing

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Air Platforms

OBJECTIVE: Develop a scalable, real-time, predictive, and adaptive model-based test frame control system that increases load cycling frequency while maintaining load accuracy for high speed dynamic rotary wing airframe testing.

DESCRIPTION: Full-scale fatigue testing is required for all new aircraft designs. While all aircraft are subjected to this testing, rotary wing aircraft often prove to be much more difficult to evaluate because of the high cycle counts that helicopter airframes experience. Currently, the limitations of structural testing control systems require full-scale fatigue tests to be performed at frequencies much lower than those generally experienced on rotary wing aircraft. Full-scale fatigue testing on rotary wing aircraft is typically limited to a low cycle fatigue test, where Ground-Air-Ground cycles and simplified maneuver loads are applied to the airframe. Truncation and/or equivalent damage methods are used to reduce the cycle count in order to perform a test within a reasonable time period. However, there is evidence that shows that equivalent damage methods, which remove high frequency load components at high mean stress loads, can produce unconservative crack growth rates. The crack growth rates are slower than what would be accumulated on an in-service aircraft, which creates a risk of not being able to find premature cracking at a representative time, or even at all during the full-scale fatigue test. Since pure cycle count reduction cannot produce test results that are consistent with real fleet usage, increasing testing speed is required to be able to incorporate more loading cycles without significantly prolonging a test effort.

Current technology used in full-scale fatigue testing is limited to load cycle speeds of approximately 2 Hz, and most tests are practically slow enough to be considered quasi-static. At speeds this low, full-scale fatigue tests would take over 200 years to complete if all vibratory load content were to be included. The control system generally used for this testing is a reactive-style feedback loop that requires a load to be applied, usually by means of hydraulic servo-cylinders, and the system response to be read by sensors, such as strain gauges and load cells. Gains in the feedback loop are adjusted to provide satisfactory tracking between the target and measured loads or strains. While these reactive methods are adequate for quasi-static tests, they become insufficient as the frequency and speed of the test increases due to complexities caused by large airframe displacements, airframe inertial effects, actuator cross coupling, and phase lag caused by system response times. If these issues are unaddressed, the load cycling rate in a test will have to remain low in order for loads to be applied accurately. Accurate loads are required to attain representative test results to ultimately make a correct assessment of the actual life of the airframe, as well to catch and predict early cracking that might occur in the fleet.

This SBIR topic seeks a model-based, or "model-in-the-loop", control system for full-scale aircraft fatigue testing that can achieve higher cycling rates and faster test speeds compared to those achievable by current reactive control systems (0.5 Hz - 2 Hz). The control-system should be able to predict and generate the signals required for load application based on sensor data (including strain gauge bridges, load cells, displacement transducers) and a representative model of the system. This model could include the test article, fixtures, actuators, hydraulic valves and supply system, and sensors located on the test article or on the actuators. A peak loading frequency of at least 10 Hz is desired in order to match the primary loading frequencies on rotary-wing platforms. The control system should be capable of controlling high speed actuators that can achieve speeds in excess of 100 in/s in order to meet or exceed the frequency requirement while still being able to achieve displacements that may be several inches in magnitude. The controller should be able to simulate the test system in real time, use the model to predict

required actuation signals, adapt the model and parameters to account for nonlinearities and uncertainties, and be scalable to handle multiple degrees of freedom with coupled actuations with potential for 15 or more actuators.

Commercial and naval aircraft both face similar requirements for full scale fatigue testing. Improvements to testing speed while maintaining required loads and displacements would improve both cost and schedule for acquisitions and validation of new platforms. This technology could also improve dynamic testing in automotive applications, as well as for other ground-based military vehicles.

PHASE I: Determine feasibility of a real-time, predictive, and adaptive control system using a simplified test setup that leverages models of the test system in order to increase variable amplitude load accuracy at higher frequencies. Develop a plan for expanding the Phase I work into a prototype system that can be demonstrated on a simplified test article capable of increased test speeds and controlling multiple actuators.

PHASE II: Develop and demonstrate a prototype model-based control system based on the Phase I approach by integrating the controller into a test that applies representative loads onto simplified test article that is representative of an airframe structure in order to show increased control system performance (i.e., speed and accuracy) against a traditional control system. Demonstrate the ability to handle the coupling of multiple actuators as seen in a full scale fatigue test.

PHASE III DUAL USE APPLICATIONS: Develop and demonstrate a modular and scalable model-based control system on a full scale fatigue test specimen using multiple actuators and combined vibratory/maneuver loading. Verify that the system can apply vibratory loads accurately at load cycling rates of 10 Hz or higher.

Because commercial and naval aircraft both face similar requirements for full scale fatigue testing, improvements to testing speed while maintaining required loads and displacements would improve both cost and schedule for acquisitions and validation of new platforms. This technology could also improve dynamic testing in automotive applications and for other ground-based military vehicles.

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KEYWORDS: Control; Dynamic; Testing; Structure; Predictive; Adaptive

N211-015 TITLE: Long-Wave Infrared Transceivers for High Speed Free Space Optical Communications in Adverse Weather Conditions

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop long-wave infrared transceiver components with high-data rate and low-bit error rate for use in free-space optical communications in adverse weather conditions.

DESCRIPTION: Free-space optical (FSO) communication links provide high-data rate, low latency, secure wireless, mobile communication that are difficult to jam or intercept and do not require spectrum management. FSO communication is an especially compelling alternative to a radio-frequency (RF) link with external RF Interference (RFI) in a RF-denied environment. Most current proposed or deployed FSO systems are in the short wave Infrared (SWIR) regime at around 1.55 micrometers due to ubiquity of the laser and optical components customized for fiber optical communications. Exceptionally high data rates at this wavelength range are possible when atmospheric effects are not present [Ref 1], and laser-based FSO communication is the leading solution for interconnecting new constellations of low-earth-orbit satellites. Terrestrial FSO links have seen some success, but link budget in the SWIR regime is often limited by optical obscurants such as haze, fog, clouds, atmospheric absorption, and turbulence presence in the atmosphere. SWIR links with stabilized telescopes have been demonstrated to achieve gigabit per second (Gb/s) communication between naval vessels in ship-to-ship and ship-to-shore configurations at ranges of 12 and 45 kilometers (km) [Ref 2], despite the link limitation to 1 km when the visibility was impaired by heavy fog. For FSO laser communications systems operating in the SWIR bands, including 1300 nm and 1550 nm, the photonic wavelength is comparable to the size of aerosols that scatter and attenuate the laser beam propagation in the channel.

Recent analysis has shown that operation in a more optimal long wave infrared (LWIR) wavelength range accessible from monolithic sources only via Quantum Cascade Lasers (QCLs) enables dramatically lower attenuation from a variety of atmospheric effects [Ref 3]. The attenuation due to the presence of optical obscurants, such as fog, haze, and maritime aerosols for 10-micrometer (μ m) wavelength transmission, is strikingly over 300 times lower than that at 1550 nm. Furthermore, LWIR FSO communication link at 10 μ m wavelength have much reduced Rayleigh scattering compared to the 1.55 μ m counterpart. At the same time, the fast carrier dynamics of QCLs make high-speed direct modulation possible [Ref 4], thereby also reducing transmitter complexity.

The main goal of this SBIR topic is to develop the LWIR transceiver, including the laser for the transmitter and detector for the receiver to leverage the unique LWIR atmospheric transmission window that is more transparent than other wavelengths in adverse weather conditions. The adverse weather condition is defined as the atmospheric conditions where a 1.55 μ m FSO link would suffer > 25dB attenuation due to multiple scattering caused by various hydrometeor types such as haze, clouds, fogs, and aerosols such as dusts, smoke, and pollens [Ref 1]. Current Fabry-Perot (FP) QCLs emitting in the 10-micron regime provide less than 1W single-facet continuous wave (CW) power with less than 5% efficiency [Ref 5]. Large QCLs have modulation bandwidths that are limited by the large device capacitance. Commercial distributed feedback (DFB) QCLs in this wavelength range emit less than 100 milliwatts, potentially limiting the FSO link budget. Innovative QCL designs are needed to increase the QCL room temperature CW output power while maintaining beam quality (M^2 < 1.5) and high reliability for the LWIR FSO system.

The Threshold and Objective parameters of QCL, detectors, and the transceivers are as follows:

• QCL CW max power: Threshold of 250 mW, Objective of 1000 mW

- QCL wavelength: Threshold of 8.5-12 micron, Objective of 9.5-11.5 micron
- QCL linewidth: Threshold of 10 nm, Objective of < 2 nm
- Detector detectivity: Threshold of D* 2.25E9 cm* SQRT(Hz)/W, Objective of 5E9 cm* SQRT(Hz)/W
- Detector quantum efficiency: Threshold of 10%, Objective of 50%
- Data rate (worse case conditions): Threshold of 1 Gb/s, Objective of 10 Gb/s
- Data rate (clear conditions): Threshold of 10 Gb/s, Objective of 40 Gb/s
- Average transmitter power: Threshold of 125 mW, Objective of 500 mW
- Receiver sensitivity at 1E-12 bit error rate (BER): Threshold of -18 dBm, Objective of -25 dBm
- Receiver saturation: Threshold of 1 mW, Objective of 10 mW

Cost-effective FSO links must function with devices' temperatures near ambient (25 degrees C) to minimize cooling system cost, size, and power. At these temperatures, thermally induced dark current unacceptably limits detectivity of conventional LWIR photodetectors needed for the receiver side of the FSO link. Reducing detector volume reduces the dark current, but also the area and responsivity. Recent research has shown that metal and dielectric resonators can enhance the collection area and responsivity, enabling high detectivity in the LWIR near room temperature [Ref 6]. High detectivity has been demonstrated in devices based on both inter-band and inter-subband absorption, but innovative designs are certainly required to achieve both high speed and high receiver sensitivity simultaneously.

FSO links based on LWIR QCLs and detectors operating at wavelengths optimized for highest system level performance will enable secure, mobile, naval communications in RF congested and denied environments. With the successful development of these critical LWIR components, a cost-effective and low space, weight, and power (SWaP) digital communication link that supports encryption with effective range over 100 km will be the objective of future development.

PHASE I: Design, develop, and demonstrate LWIR lasers and detectors needed for 10 Gb/s transmission for the adverse weather conditions [Ref 1]. The design should include plans for growth, fabrication, packaging processes, and a monolithic QCL transmitter emitting in the 10-micron wavelength region capable of 1W single facet CW operation and direct modulation bandwidth > 5 GHz. Detectors should have commensurate performance to enable the 10 Gb/s link. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop, demonstrate, and validate a prototype FSO link operating in the 10-micron region with at least 10 Gb/s data rate and BER of 1E-12 with 1 W average, single-spatial-mode transmitter launch power for the adverse weather conditions. Perform testing to explore the limits of operational speed and distance. Provide a production cost model.

PHASE III DUAL USE APPLICATIONS: Finalize development of the prototype based on Phase II results for transition and integration into a Navy operational test asset. Conduct risk management and mitigation.

Telecommunications and local, urban communications (communication nodes – line of sight) would benefit from this technology due to its high bandwidth capability even in adverse weather conditions.

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KEYWORDS: long wave infrared; LWIR; photonics; lasers; photodetector; Free-space Optical; FSO Communications; adverse weather

N211-016 TITLE: Lightweight Thermal Protection System for Hypersonic Aerial Vehicles

RT&L FOCUS AREA(S): General Warfighting Requirements

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 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: Develop a lightweight, high-performance, thermal protection system for hypersonic aerial vehicles operating in hypersonic flight environments.

DESCRIPTION: Hypersonic aerial vehicles have more aerodynamic shapes with sharp leading edges to improve performance. When a vehicle is travelling through the atmosphere at hypersonic speeds of Mach 5 or higher, it encounters intense friction with the surrounding air. The nose cone and the leading edges of the flight vehicle will experience extremely high temperatures up to 3000 to 5000 degrees Fahrenheit (F). The extreme temperature of the leading edge caused by the kinetic heating is inversely proportional to the square root of its radius of curvature [Ref 1]. Therefore, the more aerodynamic the shape of the vehicle, the higher the temperatures of the leading edges.

Ultra-high temperature ceramics (UHTCs) materials, such as Hafnium carbide and Tantalum carbide [Ref 2], have extremely high melting points and high resistance to oxygen-induced ablation. Additionally, active research has been performed to develop these types of ceramics materials with mechanically and thermally robust structural and coating materials for hypersonic vehicles. Besides the thermal challenges of hypersonic vehicle exteriors, the extreme heat from the high-temperature external surfaces transported to the interior of the vehicle can impact performance and reliability of the internal systems, avionics and payloads.

This SBIR topic seeks to address the vehicle's interior high-temperature challenges by developing and creating a lightweight, high-performance, materials and cooling system to insulate the exterior high temperature from the interior of the hypersonic vehicle. Any innovative passive or active thermal protection solution will be considered as long as it will maintain the internal ambient temperature of a hypersonic aerial vehicle at no more than 110 °F and the total weight is no more than 15% of the hypersonic aerial vehicle when empty [Ref 3]. The final hypersonic aerial vehicle shape and form will be determined at the beginning of the Phase I.

PHASE I: Design, develop, and demonstrate feasibility of the proposed lightweight thermal protection system for the hypersonic aerial vehicles. Conduct analytical and experimental models of the design. Determine any technical risks of the design and provide risk mitigation strategy. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Fully develop and optimize the approach developed in Phase I. Validate the lightweight thermal protection system's performance via testing in a relevant representative hypersonic environment. Demonstrate that the lightweight thermal protection system can meet the performance requirements stated

in the Description in a high-fidelity simulated aerothermodynamics heating for hypersonic flight environments [Ref 4].

PHASE III DUAL USE APPLICATIONS: Finalize development, based on Phase II results, for transition and integration of the product into a hypersonic vehicle candidate airframe. Conduct flight test units for fielding on Navy experimental flight tests.

This system could be applied to any commercial air vehicle, which must fly at high supersonic-tohypersonic speeds (space access and recoverable vehicles). In addition, any low cost, high-temperature materials capable of surviving in a high-supersonic-flight environment would have diverse application in other industries that have components exposed to high temperatures, such as automotive engines, industrial processes, aircraft engines, airliner fuselages, industrial furnaces and confined electronics. Finally, the product could also be used as a cryogenic insulation for liquid natural gas fuel storage tanks or other kinds of cryogenic liquids.

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KEYWORDS: hypersonics; thermal protection materials; thermal protection systems; hot structures; high temperature materials; air vehicles; aerial vehicles

N211-017 TITLE: Sonobuoy Improvements for Multistatic Active Sonar

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Battlespace Environments

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: Develop improvements for active sonar search detection, classification, and localization performance by using or adding non-acoustic sensors to sonobuoys.

DESCRIPTION: Air ASW multistatic active sonar detection, classification, and localization (DCL) performance relies on advanced processing algorithms to exploit transmitted and received sonobuoy signals. The uncertainty surrounding these signals place fundamental limits on system performance and mission success.

The Navy seeks to upgrade or add non-acoustic sensing hardware to sonobuoys which will measurably improve DCL or tracking performance for active sonar (threshold 10% improvement over a sonobuoy without the capability, objective 25% improvement), particularly for scenarios where GPS is not available. An ideal solution will be low cost (adding less than \$50.00 to the cost of a production sonobuoy), fit within the existing sonobuoy size (i.e., cylinder of diameter 4 7/8 inches, length 36 inches), weight (i.e., not cause a sonobuoy to exceed a maximum of 39 lbs) and power (SWaP) constraints (ideally a sensor requiring less than 12 volts and 25 milliamps), and be capable of improving several performance metrics.

Proposed solutions should identify the sonobuoy(s) to be upgraded, the performance metrics expected to benefit from the proposed sensor hardware improvements, and quantify the expected improvement through simulation and/or experiments. Sonobuoy improvements may consider adding transducers and/or replacing existing ones. Examples of such include, but are not limited to, buoy localization performance could potentially be improved by adding/replacing sensors to increase accuracy of time-of-flight and/or bearing measurements. Temperature and/or salinity sensors could be added to provide a partial sound speed profile for individual buoys. Sensors such as inertial measurement units (IMU), gyroscopes, and accelerometers could be used for motion compensation.

Work produced in Phase II may be classified. Note: If the work is classified then, 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 and/or subcontractor 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.

PHASE I: Demonstrate feasibility of the proposed concept through analysis, simulation, and real-world measurements where possible. Analysis should include estimating the bounds of performance for the proposed method, and potential impacts to the existing sonar system operation. Conduct trade-offs of SWaP versus performance improvements for different sensing strategies. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Refine the concept and develop prototype sonobuoys with improved sensing. Evaluate the improvements using at sea experiments. Develop processing software for using the new sensors either aboard an aircraft or embedded in the sonobuoy.

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: Finalize and implement the capability into a sonobuoy that can be deployed in an open ocean environment during a data gathering event conducted by the Navy. Analyze the data collected in this real-world environment event and verify that the realized gains in performance matched the expected gains.

The technology developed under this effort has application across the Navy for sonar, radar, electro-optic, magnetic anomaly detection and other sensor devices. Any commercial application that uses sensors whose positions need to be known with more precision would benefit from this effort. A possible commercial application could include improved sensor positions during medical imaging procedures.

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KEYWORDS: sensor position; position uncertainty; sonobuoy positions; sensor movement compensation; Detection, Classification, Localization; DCL; sonar sensors; sonobuoy

N211-018 TITLE: Non-Traditional Airborne Anti-Submarine Warfare (ASW) System

RT&L FOCUS AREA(S): General Warfighting Requirements

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 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: Design and develop a non-traditional airborne Anti-Submarine Warfare (ASW) system capable of detecting modern quiet submarine targets from high altitude aircraft.

DESCRIPTION: Detection of operational modern-day submarines is becoming increasingly complex due to advances in submarine technologies. Acoustic signature detection is the traditional method in use today. For fixed-wing aircraft, those systems employ expendable sensors - sonobuoys - to enable detection of the submarine's acoustic signals. The Navy would like to explore alternate, non-traditional concepts that overcome the detection limitation, in order to expand the tools available to operating forces and develop potentially more robust systems.

The principal fixed-wing ASW aircraft in operation today is the P-8 Poseidon. Any new approaches to airborne ASW will eventually require compatibility with that airframe. Also, the acoustic sensors used today are expendable devices. Testing will include hardware in-the-loop or laboratory modeling. Finally, any new approaches should not be considered a replacement for existing systems but as a supplement to expand airborne surveillance capabilities to detect those submarines, surfaced or submerged, with enhanced covert technology.

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 and/or subcontractor 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.

PHASE I: Develop and demonstrate feasibility of a non-traditional concept for an airborne ASW system that detects targets through exploitation of novel target/environment interactions. Consider the operating platform's capabilities and limitations for guidance for the overall and ultimate system proposed. Provide sufficient detail to identify the concept (e.g., history, components, effects, hardware). The Phase I effort will also include prototype plans to be developed under Phase II.

PHASE II: Identify critical technology areas requiring validating experimental data. Working with the Navy, define testable hypotheses and identify test equipment and geometries necessary to collect the

critical data, which could also involve analysis of any existing data, building software/hardware fabrication, and potential laboratory experimental measurements. Demonstrate the prototype system and perform analysis as applicable.

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

PHASE III DUAL USE APPLICATIONS: Complete final testing and perform necessary integration and transition for use in ASW and countermine warfare, counter surveillance, and monitoring operations with appropriate current platforms and agencies, and future combat systems under development. Commercially this product could be used to enable remote environmental monitoring such as in oil, gas and mineral industries, and in geophysical survey, facilities, and vital infrastructure assets.

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KEYWORDS: Non-Acoustic; Detection; ASW; Imagery; Magnetics; Algorithm; Radar; Anti-submarine Warfare
N211-019 TITLE: Aging Prediction of Airworthiness of Aircraft Composite Components Accounting for Flight and Environmental Conditions

RT&L FOCUS AREA(S): General Warfighting Requirements

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

OBJECTIVE: Develop a data-driven computational framework to enable prediction of material aging for designing a new/replacement composite component or its repair, assessing airworthiness of such a component during its lifetime and for assessing life extension.

DESCRIPTION: A building block approach is typically used in the design of composite material systems and their qualification and certification (Q&C). Knowledge gained by employing analytical models, along with tests at the coupon level, is employed in developing the next level design of structural elements. Similarly, the knowledge gained at the structural elements through computational models and testing enable the development of subcomponents and components [Ref 1].

Composite structures are typically designed to operate at much lower stress levels than their maximum strength and most of the loads are below fatigue threshold. However, history has shown widespread damage to occur towards the end of the designed life. This could very well be due to degradations in the metallic structures with which the composite parts interface in an aging aircraft. It could also be due to the accumulations of in-service overloads, such as flying over the rated G limits or impact loads caused by severe landings, both resulting in flaws that grow with further usage. These reveal the uncertainties and shortcomings of the current design and Q&C's approach in meeting the damage tolerance design requirements, as included in the Joint Services Specification Guide, JSSG2006 [Ref 2].

A novel, computationally efficient framework is sought to accurately assess the structural integrity of individual airframe subjected to realistic flight usage and operating environments [Refs 3, 4, 5]. It should be capable of integrating various aircraft data ranging from flight state parameter history, available Structural Health Monitoring (SHM) sensors (e.g., strain gages, acoustic and/or fiber optic sensors) to airframe configuration, and maintenance and repairs [Refs 5, 6].

The framework should account for, but not be limited to,:

- (a) realistic flight history data of flight conditions;
- (b) the gaps in the data;
- (c) mission specific loading and environmental variability; and,
- (d) identifying potential multiphysics trade-offs to enable accelerated testing.

Some of the composite material systems of Navy's interest are glass fiber reinforced plastic and graphite-epoxy resin systems such as IM7/ 8552, AS4/3501-6, AS4/ IM977-3, and IM7/977-3.

PHASE I: Explore the feasibility of developing a framework for data-driven multiphysics algorithms for predicting the damage tolerance requirements of JSSG2006 for composites, as described above. Include the methodology for testing in-service loading and environmental conditions [Refs 9,10] for validation of the algorithms. Further, include the mechanism for filling gaps in the data for prediction of the airworthiness of composite components. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop the framework and demonstrate it for the platform chosen by the Navy by utilizing realistic flight history data for predicting damage tolerance of the component with specific issues

identified by the Navy. Validate the multiphysics-based algorithms using appropriate tests simulating the in-service loading environment and for different blocks in the building block approach.

PHASE III DUAL USE APPLICATIONS: Apply the framework to the Navy selected platforms by integrating it with the data available from Structural Health Monitoring sensors, if any, and databases providing aircraft history of maintenance, repairs, and structural upgrades. Commercial passenger and cargo airlines could potentially benefit from this technology.

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KEYWORDS: Composites Design; Aging Aircraft; Structural Health Monitoring; SHM; Fatigue; Repair Design; Qualification and Certification

N211-020 TITLE: Digital Firing Device

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Air Platforms; Electronics; Weapons

OBJECTIVE: Design, develop, and demonstrate an innovative digital firing device that will be used as a form, fit, and function interchangeable replacement for the airborne rocket launcher.

DESCRIPTION: The Navy is currently using an intervalometer, which fits inside launchers such as the LAU-68 or LAU-131. The device allows pilots to fire individual rocket tubes in sequential order or ripple-fire an entire launcher within seconds. With limited space, the current design seeks enhancement of power, while accounting for the controlling voltage losses due to ambient circuit resistance to ensure sufficient firing current. The only time power is applied to the circuit is when the pilot pulls the trigger. The desired design needs to use innovative circuit designs to overcome the lack of power needed to maintain the current firing state of the intervalometer when the trigger is released. The lack of power can be overcome by storing information during the power cycle or by other means such as, but not limited to, energy harvesting to provide supplemental power.

The Navy would like to steer away from the current analog device and move to something digital. The Navy is looking for a form, fit, and function innovative replacement that can be used interchangeably with the existing intervalometer and launchers, except that the functionality is expected to be achieved via a digital circuit board design (vice the current analog design). The device should be roughly the size of a small (roughly 8"L x 2"W x 2"H) handheld flashlight. The current device uses a rotating dial, but another means of allowing user input (LOAD/ARM, rocket selection) may be used such as, but not limited to, rotary encoders.

General operation of the intervalometer should provide rocket firing current outputs including, but not limited to,:

a) input power of 20.0 to 31.5 volts direct current (Vdc), otherwise, in accordance with the dc normal operation characteristics of MIL-STD-704 [Ref 1], is supplied through a 5.0 ohm ± 10 percent resistor; b) control and apply rocket firing current to output pins sequentially;

c) each rocket firing output pins should be tested using a 4 ohm ± 10 percent resistor;

d) rocket firing current pulse measured at each pin should be not less than 1.5 amperes (amps), with the load specified for not less than 10 milliseconds (ms).

e) interruptions of this power, as a result of any type of contact bounce or switch chatter of 4.0 ± 0.4 ms duration, should not interfere with the performance of the intervalometer;

f) the single and ripple modes are controlled by an electrical switch located on the launcher structure; and g) interface with the single/ripple switch and identify firing mode prior to operation.

The operation of the digital firing device should be defined in two modes: single mode operation and ripple mode operation. In single mode operation, the intervalometer should apply rocket firing current to only one output pin in sequence with each application of power, and be capable of not less than 12 firings per second. In ripple mode operation the intervalometer ripple rate should be self-generating in such a manner as to apply rocket firing current to output pins in sequential order. The overall firing time in the ripple mode should fire rockets with a minimum delay of 5 ms and a maximum delay of 30 ms with at least a 10 ms dwell time and an output between firing pulses of a minimum 35 ms and a maximum of 45 ms.

Setting the intervalometer to the LOAD position should internally ground all output circuits and prevent the intervalometer from being electrically sequenced upon the application of power. The internal grounding should be accomplished by means of the ground circuit. Upon completion of the last rocket firing, the intervalometer output should sequence to the LOAD position and not sequence any further (i.e., should not return to first rocket) upon the application of power. The arm circuit should provide the ground circuit to all outputs, but should also allow for electrical sequencing upon the application of power. The intervalometer should be manually switched from the LOAD position to the ARM position to provide positive arming of the intervalometer.

The intervalometer should provide a grounding circuit through the intervalometer to ensure safety during loading and preparation. The ground circuit should ground all output pins when the intervalometer is in the LOAD or ARM position. As the intervalometer is electrically advancing through its sequence, the ground circuit should ground each output pin except those being fired. The ground circuit should ground the output pin with a resistance of not greater than 0.1 ohm. If the intervalometer is manually advanced through firing positions to the LOAD or ARM position, all output pins should remain grounded.

The intervalometer should have a settable firing sequence to maintain launcher center of gravity during firing. In the event of a short circuit to ground or an open circuit on the output pins during rocket firing current application, the intervalometer should be fault tolerant and be capable of continuing operation without damage.

PHASE I: Design, develop, and determine feasibility of a proof of concept for the digital firing device. Ensure to account for tube slipping, handling, and manufacturing plans. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a prototype digital firing device, and demonstrate its application in a test rocket launcher (provided as Government furnished equipment (GFE)). If available, demonstrate the capability on existing platform and/or platform representative examples.

PHASE III DUAL USE APPLICATIONS: Perform final development and testing to include conformance testing to applicable MIL-STDs [Refs 1, 2]. Support final system application testing onboard aircraft with full system test, in coordination with NAVAIR Test and Evaluation.

The intervalometer has a potential commercial use in the fireworks industry to sequence the launching of multiple fireworks with a determined time interval. In addition to this commercial use, these intervalometer can be sold to foreign militaries.

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KEYWORDS: launcher; intervalometer; firing current; timing delay; relay; rockets

N211-021 TITLE: High-Efficiency Midinfrared LEDs with High Brightness for High-Fidelity Infrared Scene Projection

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop midinfrared light emitting diodes (LEDs) with optical cavities electromagnetically engineered at a subwavelength scale to enhance wall-plug efficiency and brightness of devices beyond the current state-of-the-art technology and to demonstrate multipixel mid-infrared LED arrays.

DESCRIPTION: Efficient light-emitting diodes (LEDs) operating in the midinfrared spectral range, that includes both mid-wave infrared (MWIR) (3-5 micron) and long-wave infrared (LWIR) (8-12 micron) wavelength regions, are highly desired for the use in systems for infrared scene projection (IRSP), chemical sensing, and spectroscopy. Hardware-in-the-loop (HITL) testing of infrared (IR) guided weapons necessitates infrared imagery to provide target signatures with high fidelity in a simulated environment with sufficient brightness. The capability to engage IR weapon and aircraft sensors and seekers with high-brightness, high-definition imagery of targets and backgrounds in HITL simulation is essential in the test and evaluation of the systems, such as threat detection and missile warning systems. Current IR scene projectors based on resistive emitter array technology have performance shortcomings such as low output radiance, slow frame rates, and small frame size. Compared to thermal sources, midinfrared LEDs can offer substantially higher radiance, modulation speeds, and significantly larger frame size over existing technologies. However, current devices are still highly inefficient. External wall-plug efficiency of state-of-the-art MWIR LEDs is currently below 0.5% at room temperature [Refs 1, 2] and that of LWIR LEDs is at least one order of magnitude lower [Ref 3].

Low wall-plug efficiency leads to low brightness of MWIR and LWIR LED systems. Low efficiency and brightness of midinfrared LEDs primarily result from a combination of low internal quantum efficiency (IQE) of light generation and low light extraction efficiency. IQE is limited by rapid non-radiative carrier recombination, which is dominated by strong Auger recombination at high pump currents [Ref 4]. As a result, IQE is estimated to be approximately 10% in the state-of-the-art MWIR LEDs operating around 3 microns [Ref 2] and drops quickly at longer wavelengths. For LWIR LEDs, IQE is well below 1% [Ref 4]. Furthermore, mid-infrared LEDs suffer from low extraction efficiency at 2% resulting from a narrow total internal reflection cone in LED materials [Ref 1, 2]. Parasitic voltage drops in the semiconductor heterostructure also have a negative effect on the midinfrared LED efficiency, although this factor has relatively minor effect compared to the two factors mentioned above [Refs 2, 3].

Electromagnetic engineering of LED optical cavities at a subwavelength scale can dramatically enhance light emission in the near- and far-infrared bands [Refs 5, 6, 7]. Subwavelength LED cavities can produce strong Purcell enhancement of spontaneous emission rates, which leads to drastic improvements in IQE, and enables optimal radiative emission rates of the photons in the cavity mode to free space, which improves output efficiency [Refs 5, 6, 7].

This SBIR topic seeks to investigate if similar approaches may dramatically enhance midinfrared LED efficiency and to demonstrate high-performance midinfrared LED arrays based on this technology. Proposed approaches should design, fabricate, and characterize midinfrared LEDs with optical cavities electromagnetically engineered at a subwavelength scale to enhance wall-plug efficiency and brightness of devices beyond the current state of the art. The threshold and final objective wall-plug efficiencies of this MWIR LED arrays are 10% and 15%, respectively. Multipixel LED arrays based on this technology for high-fidelity, HITL testing should be demonstrated.

PHASE I: Design, develop, and demonstrate the feasibility of brightness and wall-plug efficiency enhancement of midinfrared LEDs using subwavelength optical cavity structuring to enhance spontaneous light emission rates into the LED material and out-coupling rates of light from the LED material to free space. The Phase I effort will include prototype plans to be developed in Phase II.

PHASE II: Fabricate and characterize a single element midinfrared LED prototype, with wall-plug efficiency at room temperature. Based on the new LED geometry, demonstrate feasibility of fabricating multipixel LED arrays. Fabricate and completely characterize the prototype with a 64x64 pixel addressable LED array. Prepare a report that summarizes the experimental evaluation and validation of performance characteristics of the developed system.

PHASE III DUAL USE APPLICATIONS: Fully develop and transition a 512x512 pixel addressable LED array-based dynamic IR scene projector per specifications based on the research and development of results developed during Phase II for DoD applications.

This type of high brightness, high-fidelity infrared scene projectors can be used as HITL testing of thermal imaging cameras used by firefighters. In direct projection, images are projected directly into the camera; in indirect projection, images are projected onto a diffuse screen, which is then viewed by the camera. These high performance LED-based scene projectors can also be used in virtual reality for testing of IR search, track and rescue operations systems, and calibration for any spectrally sensitive IR remote sensing instrument.

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KEYWORDS: Electromagnetic Engineering; high-efficiency; midinfrared; light emitting diode; LED; high brightness; infrared scene projection; mid-wave infrared; MWIR

N211-022 TITLE: High Performance Continuous Wave Quantum Cascade Lasers Immune to Output Facet Optical Damage

RT&L FOCUS AREA(S): Directed energy; Quantum Science

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 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: Develop high-performance large output aperture mid-wave infrared (MWIR) Quantum Cascade Lasers (QCLs) with a large laser catastrophic optical damage threshold, thereby eliminating QCL failures due to the optical facet damage.

DESCRIPTION: Reliable Quantum Cascade Lasers (QCLs) capable of delivering 10 Watts continuous wave (CW) optical power [Ref 1] with high efficiency are of great interest to the Navy for various naval applications. Current generation devices with continuous wave (CW) output power over 3 Watts generally have a poor long-term reliability. Post-mortem analysis of failed high-power QCLs typically shows catastrophic output facet damage. The damage is strongly correlated with the peak optical intensity at the output facet. A game-changing solution is needed to enable the high-performance QCLs to have long-term reliability and meet/exceed the MILSPEC requirements [Ref 2].

An effective, innovative approach to solving the laser optical damage problem is to reduce optical power density at the output laser facet. For a fixed output power level, this can be attained by judiciously increasing the output aperture size without affecting the diffraction-limited beam quality. This can be achieved by employing a second-order distributed feedback (DFB) configuration where optical output is collected from either the surface or the substrate side of the device, as opposed to the edge of the laser. In this case the output aperture is three orders of magnitude larger than that for edge-emitting QCLs, thereby improving the catastrophic optical damage threshold by more than 1,000 fold. An additional advantage of second order DFB QCLs is that they can be pre-screened on the wafer-level, leading to labor and material saving cost benefits associated with cleaving and testing substandard edge-emitting QCL devices. Also, packaging of surface-emitting devices on submounts is less demanding due to their increased alignment tolerance. Therefore, QCLs with large output aperture and reduced optical power density can provide a significant reduction in price per watt for high power CW QCLs.

Although second order DFB QCLs were demonstrated over a decade ago, their performance significantly lags that for Fabry-Perot devices [Refs 3, 4]. In most explored DFB configurations, the grating interacts with the guided mode along the entire laser cavity. This unavoidably leads to additional optical losses, increasing laser threshold and reducing slope efficiency. This is especially detrimental to CW QCL operation.

This SBIR topic seeks the development of a novel QCL configuration that effectively leverages improvements in CW power and efficiency achieved for state-of-the-art Fabry-Perot QCLs, while at the same time offering the unparalleled reliability advantage due to a significant increase in output aperture size. The final device configuration should be compatible with a large-throughput, low-cost production,

and therefore should not involve epi-growth interruptions. The specifications of the CW QCLs should have a large output aperture size no smaller than 1 millimeter(mm) x 10 micrometers (μ m), CW efficiency higher than 20% and output power level higher than 20 Watts delivered in a nearly diffraction-limited beam with M2 < 1.5.

PHASE I: Design, document, and demonstrate feasibility of high performance CW QCLs with a large output aperture size (no smaller than 1mm x 10 μ m). Demonstrate, using numerical modeling, that projected CW efficiency exceeds 20% and output power level exceeds 20W delivered in a nearly diffraction limited beam with M2 < 1.5. Ensure that the approach shows that projected fabrication cost for new devices does not exceed that for state-of-the-art commercial buried heterojunction QCLs. In the Phase I Option, if exercised, carry out proof-of-concept experiments. The approach should show that projected fabrication cost for new devices, does not exceed that for state-of-the-art commercial buried heterojunction QCLs. The Phase I effort will include prototype plans to be developed in Phase II.

PHASE II: Construct, develop, and demonstrate the prototype devices based on the design from Phase I. Test and continually improve QCL performance while demonstrating CW efficiency and power to meet topic requirements. Demonstrate that the QCL devices can operate at full power for over 10,000 hours.

PHASE III DUAL USE APPLICATIONS: Fully develop, fabricate, test, and transition the technology based on the design and demonstration results developed during Phase II for DoD applications in the areas of Directed Infrared Countermeasures (DIRCM), advanced chemicals sensors, and Laser Detection and Ranging (LIDAR). The commercial sector can benefit from this crucial, game-changing-technology development in the areas of detection of toxic gas environmental monitoring, noninvasive health monitoring and sensing, and industrial manufacturing processing.

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KEYWORDS: Quantum Cascade lasers; QCL; optical facet; reliability; optical damage; Fabry-Perot; continuous wave

N211-023 TITLE: Collaborative Workspace for Next-Generation Navy Mission Planning System

RT&L FOCUS AREA(S): General Warfighting Requirements; Machine Learning/AI

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 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: Develop a collaborative workspace to integrate the disparate locations where mission planning occurs, and to facilitate the mission planning process within the ready room while maintaining operational security.

DESCRIPTION: In order to greatly improve capability in mission planning, the Next-Generation Navy Mission Planning System (NGNMPS) is tasked to facilitate collaborative mission planning across ready rooms and planning cells both in close proximity and, when applicable, across ready rooms and planning cells that are distant from one another. Unfortunately, the current mission planning process utilizes a single laptop computer that will not suffice for the collaborative mission planning vision. With new technological tools such as tablets, smart boards, and digital touch screen tables, it is necessary to leverage these capabilities to improve the mission planning process. Technical approaches should identify potential solutions to achieve the integration and transfer of unclassified and classified (i.e., Secret) mission planning data. This effort will require a highly innovative approach to develop a solution that is sufficiently secure to meet National Security Agency (NSA) requirements for highly classified communications. Various levels of Emissions Control (EMCON) should be considered in the solution. Evaluations will be based on the ability for a solution to provide connectivity across various hardware (e.g., laptops, tablets, smart boards) from disparate shipboard locations (or even land-to-ship communications, if possible) while maintaining NSA requirements for secure communications in support of air operations mission planning.

Current mission planning processes include calculating or planning data in one location, and then transmitting the information, whether by phone or by hand, to the mission planning lead where it is handentered into the current mission planning system. This relay of information can occur over and over again, leading to human errors in communication and increased opportunities for typographical error. The first goal of this project is to integrate the disparate locations where mission planning occurs. This solution will require an innovative solution to move data from the location where it is entered and transmit the data to all mission planning components while maintaining operational security.

A secondary goal of this project is to facilitate the mission planning process within the ready room. The current use of obsolete technology for mission planning, mission briefing, and mission rehearsal are time-intensive, redundant, and prone to human error. Utilizing current state-of-the-art technologies for mission planning will greatly improve the mission planning process. Some of the tools used require time-intensive processes like formatting slides, editing screenshots, and other redundant actions that could be eliminated with improved mission planning and briefing hardware. This second goal should leverage current state-of-the-art technologies including, but not limited to, tablets, smart boards, augmented or virtual reality (AR/VR) devices, and digital touch screen tables. Connectivity between these devices

should consider security and space available on shipboard operations. Finally, working closely with the Strike Planning and Execution Systems Program Management Office (PMA-281), Naval Information Warfare Center – Pacific (NIWCPAC), and the NGNMPS development team, the performers on this project should understand and implement the software and user-experience considerations provided by NGNMPS program management.

To achieve these goals, performers should consider innovative solutions including data fusion or other data consolidation techniques to reduce large amounts of spreadsheet data into smaller, more easily understood formats for briefing. Cognitive psychology, human perception, user interface, and human information processing should be considered when proposing a solution to this topic.

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 known as Defense Security Service (DSS). Since this project will ultimately integrated into the Consolidated Afloat Networks and Enterprise Services (CANES), the selected contractor and/or subcontractor 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.

PHASE I: Assess briefing spaces, shipboard and otherwise, to identify the current state of the mission planning environment and mission planning processes. Consider communication with mission planners to determine which technological tools would be most utilized in a mission planning environment should also be considered. During Phase I Option, if exercised, perform user interviews that the Government will facilitate and support. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a hardware solution prototype to resolve security considerations and further develop the data reduction solution. Conduct continuous user evaluations facilitated and supported by the Government. Compile user feedback. Further refine the solution regularly. Perform software integration (React | Redux) and testing with NGNMPS. Continuous user evaluations and feedback will be conducted throughout Phase II. Government will facilitate and support user evaluations for performers. Final delivery should include a collaborative workspace that can provide efficient data management (i.e., multiple locations of data entry transmit to one central mission planning hub) and visualization for mission planning using the NGNMPS. Participate in the Scaled Agile Framework (SAFe) process for NGNMPS throughout this phase.

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 software tool into NGNMPS. Conduct security validation and final user evaluations.

The ability to efficiently plan a mission is applicable to other efforts such as fighting wildfires or medical system coordination during a global pandemic. Multiple firefighting agencies must coordinate personnel, assets, and map data during crisis situations. For medical system coordination, similar information must be coordinated within and across hospitals, insurance agencies, and Government. Data visualization that facilitates quick information processing from users will facilitate decision making and quick deployment

of solutions. This rapid information presentation and processing capability can improve decision making timeliness across sectors such as sports, medicine, and emergency response.

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KEYWORDS: Mission planning; data management; cybersecurity; automation; networking; Consolidated Afloat Networks and Enterprise Services; CANES

N211-024 TITLE: Munitions Lifting Assembly Sunshade Cover

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Materials / Processes; Weapons

OBJECTIVE: Develop a strong, lightweight, lowest price, technically acceptable sunshade capable of blocking 70% of solar radiation and attain Naval Ordnance Safety and Security Activity (NOSSA) authorization for use with the A/E32K-11 Munitions Lifting Assembly (MLA).

DESCRIPTION: The United States Marine Corps (USMC) requires the assembly of munitions in forward operational areas. The following descriptions are detailed in two parts: description of the fielded MLA system followed by the required performance of the Sunshade Cover. The solution desired through this effort is for the Sunshade Cover, but details of the MLA are necessary for developing the solution.

In an effort to satisfy the USMC requirements, the Naval Air Systems Command (NAVAIR) procured the A/E32K-11 MLA; a replacement to the legacy A/E32K-3 Munitions Assembly Conveyor, and similar to the A/E32K-9 Munitions Assembly Conveyor II used by the United States Air Force [Ref 1]. The MLA provides a mobile capability for rapid assembly/disassembly of conventional munitions and a means to load/unload them from/onto munitions trailers. The system can be assembled/disassembled in a day, can be packed into three storage containers, and is C-130 transportable, making it capable of expeditionary missions. The system consists of roller conveyors, two A-frame gantries (each with a pneumatic hoist), four rail conveyors with associated munitions cradles, an Interface Control Board (ICB), and a lighting system. The rail conveyors each measure 10 ft (3 m) in length and are assembled end to end to create a 40 ft (12 m) munition assembly line. The two gantries are positioned at either end of the rail conveyor assembly for lifting bulk munitions from incoming pallets and removing assembled munitions from the rail conveyor to a munitions transport vehicle/trailer. The MLA also incorporates a grounding system comprised of a ground rod conforming to (CID) A-A-55804, Type III, Class B; and ground straps connecting the conveyors, gantries, ICB, etc. [Ref 3].

The MLA requires a durable Sunshade Cover approved for use on the system by NOSSA – the technical authority pertaining to ordnance safety and the NAVSEA OP 5 Ammunition and Explosives Safety Ashore [Ref 5]. Design requirements include, but are not limited to, use of a static dissipative (surface resistivity between $10^5 \Omega/sq$ and $<10^9 \Omega/sq$) or conductive (surface resistivity $<10^5 \Omega/sq$) material capable of discharging to ground. The static dissipative properties of the material used should not be met by use of topically applied treatment; that is, sprayed on the material. The material's static dissipative properties must remain stable with long-term UV exposure and under varying humidity conditions. If the Sunshade Cover consists of multiple layers, the layers must be electrically integrated such that the surface resistivity measured with one probe on the outside of the material, and the second on the inside of the material, will yield the same results as if both were on the outside of the material. The Sunshade Cover design must not allow point-discharging and/or must bleed off any accumulated charges in a manner that will reduce the buildup of sufficient charge for electrostatic spark discharge (ESD).

The MLA Sunshade Cover must span the width of the two gantries, about 33 ft (10 m), and provide adequate protection from the sun to operators working in the rail conveyor area. The Sunshade Cover must not hinder the MLA system's stability or operational capability, including the operator's ability to assemble munitions without Sunshade Cover interference. The Sunshade Cover can, but is not required to, be attached to the MLA and must be capable of easy deployment/storage while the MLA structure remains standing about 16 ft in height (5 m). The Sunshade Cover should block at least 70% of solar radiation and be able to withstand the following environmental conditions:

(a) low Temperature Operating Life (LTOL) with temperatures of -25 $^{\circ}$ F (-32 $^{\circ}$ C);

(b) low temperature storage with temperatures of -65 $^{\circ}F$ (-54 $^{\circ}C$);

(c) high Temperature Operating Life (HTOP) with temperatures of 140 °F (60 °C) with a solar load;

(d) high temperature storage with temperatures of 180 °F (82 °C);

(e) 3% to 95% Relative Humidity (RH) (Ref 2);

(f) rain, and/or blowing rain, falling at a rate of 2 in./h (5 cm/h) in winds of 40 mph (64 km/h);

(g) blowing dust in concentrations of 0.3 g/ft³ +/- 0.2 g/ft³ in winds of 35 mph (56 km/h); blowing sand in concentrations of 0.0623 g/ft³ +/- 0.015 g/ft³ in winds of 35 mph (56 km/h);

(h) ice, freezing rain, and/or water delivery with a rate of 25 mm/h with a droplet size of 1.0 mm–1.5 mm; and

(i) salt fog for at least 96 hours [Ref 4].

The components comprising the MLA sunshade system should have a minimal footprint when not in use to enable storage in the MLA systems existing storage containers or a small standalone storage container. Material should be shown to resist fungus growth or deterioration. The Sunshade Cover must be field repairable to the greatest extent possible. Periodic maintenance and testing requirements must be minimal to none.

PHASE I: Develop a design for a sunshade cover. Demonstrate the feasibility of the proposed concept in meeting the requirements through analysis and lab demonstrations. Provide one or multiple conceptual designs of an A/E32K-11 MLA Sunshade Cover. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Design and develop a prototype sunshade cover for the A/E32K-11 MLA. Demonstrate use and wear over time to determine any degradation. Provide an estimate of per-unit cost with backup cost data, including parts/manufacturing. Provide a top-level failure analysis and service life estimate. Demonstrate the static dissipative or conductive nature of material using best industry practices. Facilitate and receive NOSSA approval for use of prototype with A/E32K-11 MLA system. Demonstrate that the use of the prototype does not negatively impact use of the A/E32K-11 MLA system. Provide a top-level assessment of whether the cover would pass requirements detailed in Reference 3, and when tested in accordance with the following information: (a) HTOL in 505.7 solar radiation with (procedure) I (cycling and heating effects) of 140 °F (60 °C) ambient air, (b) high temperature storage in 501.7 solar radiation with (procedure) I (storage) of 180 °F (82 °C) maximum; (c) LTOL in 502.7 solar radiation with (procedure) II (operational) in -25 °F (-32 °C) minimum; (d) low temperature (storage) in 502.7 solar radiation with (procedure) I (storage) in -65 °F (-54 °C) minimum; (e) rain in 506.6 solar radiation with (procedure) I (rain and blowing rain); (f) icing/freezing rain in 521.4 solar radiation with (procedure) I glazed ice of 13 mm thick; (g) humidity in 507.6 solar radiation; (h) sand and dust in 510.7 solar radiation with (procedure) I (blowing dust) and (procedure) II (blowing sand) in Air Velocity of 35 mph (56 km/h); and (i) salt fog for 96 Hours [Ref 4].

PHASE III DUAL USE APPLICATIONS: Transition the MLA sunshade for use on the A/E32K-11 MLA. Support United States Government testing and fielding of developed solution. The technology could be used for improved solar protection and material coverage in dusty/explosive environments (e.g., mining, refineries, oil rigs).

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- 5. NAVSEA OP 5 VOLUME 3. AMMUNITION AND EXPLOSIVES SAFETY ASHORE FOR CONTINGENCIES, COMBAT OPERATIONS, MILITARY OPERATIONS OTHER THAN WAR, AND ASSOCIATED TRAINING.

Additional information: Request can be made to Naval Surface Warfare Center Indian Head Explosive Ordnance Disposal Technology Division Detachment Picatinny, G13 Naval PHST Division Bldg. 458, Whittemore Ave. Picatinny Arsenal, NJ 07806-5000: POC: Martin F. Orozco, ihdiv.estm@navy.mil, 973-724-5925 OR Explosives Safety Technical Manuals (ESTM) data is also available on the secure Naval Ordnance Safety and Security Activity (NOSSA) website at:

https://nossa.dc3n.navy.mil/nrws3/Home.aspx. You must register for access to the website in order to view the electronic library.

KEYWORDS: Support Equipment; Ordnance; System Safety; Armament; Electrostatic Dissipation; Materials

N211-025 TITLE: Manned-Unmanned Air Vehicle Team Tactical Cloud Analysis

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Battlespace Environments; Information Systems

OBJECTIVE: Develop an innovative analysis process to assess/grade various communications technology improvements against operational mission effect chains and outcomes.

DESCRIPTION: The communications complexities in today's battlespace continue to increase at an exponential rate. The Joint force is anticipating and entering an era where our tactical and operational communications dominance is in question and considers the peer/near-peer environment where the potential enemy can interrupt and impede our military operations. Looking to 2030, analysts and military professionals can no longer assume an unfettered technological advantage in the battlefield or established Joint Operational Area (JOA). Given these assumptions, the services have embarked on a variety of advance solutions needed to achieve success in the communications battlefield today's, near-term, and future operating environments. The central theme to future improvements is a force that leverages several key concepts such as agile communications, single source networking, app services, and ultimately, a seamless Joint All Domain Command and Control Combat Cloud.

Crucial in meeting the Joint forces demands of the future is gaining an understanding of the trade space; specifically, looking at the various products and concepts over the intervening years that are intended to help inform and guide service programmatic decision makers to the 2030 timeframe. Numerous developmental efforts such as agile communications, software defined radios, mobile Ad hoc networking, and emerging free space optical communications (FSOC) represent new innovation and in some cases center on refinements of existing capability.

Given the wide array of new innovation, an assessment process is needed in which to ascertain the trade space to overall risk, and with the ability to attain needed capabilities in which to engage and win in all warfighting domains. Typical individual communications research products tend to focus on a given set of metrics such as latency, jitter, link closures, bandwidth usage, and other detailed performance metrics. While detailed measure of performance (MOP) research and analysis is important, there is a significant gap presented to the decision maker, this gap centers on the ability to understand exactly what the trade space is with regard to attaining a desired operational mission F2T2EA (Find, Fix, Track, Target, Engage and Assess) effect, or the ability of a system, or system-of-systems, to successfully execute mission effects chains. The operational mission analysis effects chain analysis would serve to further the overall development of emerging capabilities such as:

(a) Manned-Unmanned Directional Mesh Enhanced Tactical Airborne Networks. This capability would support missions such as battlespace awareness, target development, intelligence preparation of battlefield, assault support approach and retirement lanes, landing zone evaluation, flank and rear area security, and Tactical Recovery of Aircraft and Personnel (TRAP). The application of the operational mission effects analysis would provide the ability to assess the effects of the Directional Mesh Enhanced Tactical Airborne Networks in quantifiable metrics which would include overall mission accomplishment assessments, risks and the ability to compress engagement–recovery timelines; and
(b) Analysis of communications and networking solutions in support of Agile Communications

architectures focusing on the secure cloud computing environment and impacts to warfare execution based on transactional information flow to and from permissive, contested, and anti-access and area denial (A2/AD) environments.

It is not enough to simply store raw data within the Tactical Combat Cloud-based infrastructure, such as the Hadoop Distributed File System (HDFS) or Apache Accumulo, because this does not provide a

common data model that can be shared across a Multi-Domain Secure Lake architecture that meets the Data Sharing Authoritative Guidance for Enterprise Knowledge Base.

An alternative is a data management strategy and a work flow that recognizes the strengths of the focal plane gate arrays (FPGA)s at the edge with the task of providing specific data to the Tactical Combat Cloud. In turn, the Tactical Combat Cloud recognizes the role of the FPGA and graphics processor unit (GPU) at the edge in a Parent Child relationship. As a child of the cloud, a sensor will respond to tasking low level tasking in support of the overall data objective. The sensor will collect both the locally required (tactical) data as well as the data needed to complete the overall picture of the Tactical Combat Cloud object. The aggregate of sensors via a data normalization strategy will provide the machine to machine analytic to provide the human with a machine enabled decision.

The intent of conducting operation analysis is to provide quantitative data to the various proposed communications and networking solutions as presented. The results are focused on the operational effectiveness and benefit to the warfighter, to include tactical, operational and strategic level of warfare planning and execution. The analysis will aid in identifying:

(a) the relevance and outcomes of proposed capabilities needed to enable modernization in the near-term and future timeframes when differing information sources, in both content and format are in use and differing information consumers across contexts to which information ought to be transmitted;

(b) an operational assessment of communications and networking system shortfalls (gaps) such as missing, unreliable, and stale data; and multiple diverse input data/video streams use;

(c) impacts of current, near-term, and future capabilities versus advancing threat capabilities;(d) a rapid and repeatable process that measures the operational impact of various proposed communications and networking solutions in geospatial and temporal relationships that are not permanent;

(e) a probabilistic interpretation of the unlimited range of actual specific outputs of sensors and analytics to produce meaningful information management decisions and judgements; and

- (f) quality of Service (QoS)
- Frequency of information updates: the rate at which updated values are sent or received.
- Priority of data delivery: the priority used by the underlying transport to deliver the data.
- Reliability of data delivery: whether missed deliveries will be retried.

• Parameters for filtering by data receivers: to determine which data values are accepted and which are rejected.

• Duration of data validity: the specification of an expiration time for data to avoid delivering "stale" data.

• Depth of the 'history' included in updates: how many prior updates will be available at any time, e.g., 'only the most recent update,' 'the last n updates,' or 'all prior updates'.

Assumptions:

(a) an IP-routable network is assumed to exist, and be self-managing and self-healing;

(b) when and where one exists, the local Tactical Operations Center/Forward Operating Base (TOC/FOB) is assumed to be linked to the Global Information Grid/Joint Information Environment (GIG/JIE) with reliable, high-bandwidth connections. Further, it is assumed to have sufficient compute capacity to operate as a local Cloud, offering services to the tactical edge networks (TENs) linked to it; (c) operational units are hosting the tactical network within which that warfighter operates. It is further assumed that this tactical network may have attached sensors producing data that would typically be forwarded to the TOC/FOB for data enrichment. If, however, the tactical unit is temporarily disconnected from the TOC/FOB, then it is assumed that there is a local tactical processing gateway (TGW) serving the tactical unit that will offer backup services (appropriate for the compute platform available on the gateway), minimally, performing sensor data enrichment (such as tagging it with the current "team" and "mission") in support of VoI analysis (see below). Note, however, that the proposed architecture allows for a fully distributed gateway meaning that any participating node within the TEN could potentially

"become" the TGW if required due to failure or destruction (albeit with potentially more constrained performance); and

(d) processing power at the tactical node level (individual warfighter) will be extremely limited, due to Size, Weight, and Power (SWaP) rations. Management of the tactical data flow will be managed by one or more TGW nodes at the unit level that can support the additional processing load, such as a vehicle, which connects the TEN to the TOC/FOB network.

PHASE I: Develop an initial concept design to assess/grade various communications technology improvements against operational mission effect chains and outcomes to include requirements analysis and scenario development. Demonstrate that the proposed concept(s) is/are able to provide data distribution and information sharing within a battlespace, where each authorized user, platform, or node transparently contributes and received essential information and is able to utilize it across the full range of military operations among ad hoc and mesh networks. If the Phase I Option is exercised and if appropriate, include data ingress/egress and transformation/subscription services to validate processes, verify processes functionality, and assess processes readiness to conduct trade space analysis versus mission outcomes. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop a prototype based on the Phase I design; and demonstrate in a realistic data-todecision mesh network tactical cloud environment. Propose, test and validate mitigations for any technical issues that are discovered during the testing and assessment. In the first Phase II Option, if exercised, augment in response to events/attacks with a proof-of-concept featuring automation of processes. In the second Phase II option, if exercised, fabricate the prototype using these automated processes and an aggregate of data consistent with these use cases, reflecting system operation over a sufficient period of time on which proposed learning processes can operate. The prototype system should be capable of running level 1 (data resolution) and level 2 (interference) fusion algorithms across geographically separate cloud nodes, each holding different data sources, some streaming; and be able to maintain data models and inferences about behavior while allowing machine learning from a distributed cloud architecture.

PHASE III DUAL USE APPLICATIONS: Assess the prototype performance as part of a technology readiness level 6 or higher demonstration to support transition. Prototype should be capable of producing an application or set of applications that are capable of being generalized to N number of cloud nodes with relevance to Navy and Marine Corps use cases. The Phase III product(s) should be capable of running on program of record cloud systems such as DCGS-N using existing services to run against operational data. Realize the objective should be a concentration of operational relevance and transition. Propose commercial variants of the aerial layer network cloud philosophy.

The use of cloud architectures is becoming prevalent in both the DoD and private sector. Law enforcement and news services are private sectors that have a need to move beyond capabilities that enable data discovery in distributed clouds to systems that can implement complex data fusion algorithms. Data stored in clouds are already being used by these sectors to assess trends and discover events and activities of interest.

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KEYWORDS: Cloud; networks; security; Size Weight and Power; SWaP; analysis; Find, Fix, Track, Target, Engage and Assess; F2T2EA; Multi-Domain Secure Lake

N211-026 TITLE: Boron-Based Energetics

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Air Platforms; Materials / Processes; 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 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: Determine a form of boron or a boron-based chemical pathway that leads to implementation of boron in energetic compounds, especially fuels (solid and liquid).

DESCRIPTION: Boron combustion tends to form species that are energetic dead-ends (the principal offender in this tendency is H-O-B-O). The use of a small amount of fluorine will tend to interrupt this result by breaking down the ceramic micro-encapsulation that molten boron exhibits. Current work to use boron in solid motors employs this technique, but the results depend on the application and test configuration. One potential reason for this is that this technique uses metallic (bulk) boron as a fuel, with the thermodynamic necessity of melting and evaporating the fuel prior to combustion.

Previous energetics work with boron indicated a necessity to incorporate the boron into potentially unstable compounds, the process of which increased the cost of the feedstock, and raised the likelihood of creating hazardous scenarios in the employment of the compound. Recent developments in the formation of boron allotropes have the potential to both lower feedstock cost and eliminate the need to use hazardous boron-bearing compounds.

A possible alternate combustion pathway begins with another form of boron, either as a compound that yields boron during combustion of another fuel, or an allotrope of boron that features an oxidizing element already attached to it in the desired ratio. Ideally, the attachment of oxidizing species to a boron allotrope would also yield the desired properties that would allow the compound to be successfully employed in a solid motor grain or in a petrochemical liquid suspension or solution.

This topic seeks to survey boron compounds and combustion pathways that enable complete boron combustion (to B2O3 or other oxidized species) in both solid fuel and liquid fuel uses. Solutions can be considered in both solid and liquid forms. Compound characterization will be completed using:

- a. Liquid chromatograph-mass spectrometer (LCMS) to identify chemical species;
- b. Gas chromatograph-mass spectrometer (GCMS) to identify chemical species;
- c. Calorimetry to gauge the energetic potential;
- d. Nuclear magnetic resonance (NMR) to characterize atomic arrangement of fuel species;
- e. Fourier Transform Infrared (FTIR to characterize the evolved combustion species;
- f. Laser ablation of a solid casting to characterize the evolved combustion species;
- g. Combustors set to detect increased in thrust over neat-fuel combustion.

Tailoring the properties of the proposed materials will be undertaken after the determination of the material properties is made and an understanding of the needed property amendments can be described. When a suitable compound is achieved, the material will be tested in both solid and liquid forms. Laser

ablation of a solid casting to characterize the evolved combustion species (captured as gases that are analyzed via GCMS) as well as calorimetry will provide the necessary data to evaluate the proposed use in a solid motor grain. Liquid combustion will be similarly sampled, using a calorimeter, a small-scale afterburner, and in a research-scale RDE. The combustors will provide the combustion gases to be analyzed by GCMS. Additionally, the combustors will be set to detect increases in thrust over neat-fuel combustion.

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 Security Agency (DCSA), formerly the Defense Security Service (DSS). The selected contractor and/or subcontractor 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.

PHASE I: Survey boron compounds and combustion pathways that enable complete boron combustion (to B2O3 or other oxidized species) in both solid fuel and liquid fuel uses. Select the most promising compounds and pathways for further development in Phase II. Determine the technical feasibility of boron or a boron-based chemical pathway that leads to implementation of boron in energetic materials in a solid matrix (such as HTPB, or PBAN) for use in solid rocket motors, and in a hydrocarbon fuel (such as JP-10). Consideration of the materials for use in an afterburner or rotating detonation engine while also ensuring material characterization by Fourier-transform infrared (FTIR) and nuclear magnetic resonance (NMR) to ensure full understanding of the material composition. Additional material characterization should include calorimetry to discover the energetic potential of the material, liquid chromatograph mass spectrometer (LMCS) to characterize the compound properties in a liquid or suspended state, and gas chromatograph mass spectrometer (GCMS) to characterizations should result in understanding the boron-compound's composition, structure, bond energies, energy-release potential, reaction pathways, combustion precursors, and combustion products.

If exercised, the Phase I Option will include tailoring the properties of the proposed materials so that they can be eventually tested in both solid and liquid forms. As new materials, there are no relevant MILSPECs pertaining to their performance testing; however, the materials will fall under the energetic materials testing SOP requirements at NAWCWD China Lake.

PHASE II: Based on Phase I work, continue to develop and validate selected material by modeling of the combustion of the materials to provide predictive results for small-scale testing to be scaled up for larger combustors/larger solid motor grains, while identifying and testing cost-reduction techniques for feedstock and compound production. Successful test results in full scale representative hardware will be documented, as appropriate, and will lead to Phase III.

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: A flying demonstrator will summarize progress to date and will collect data that will be of interest to mission requirements generators and technology stakeholders. An inexpensive flight platform will be selected for testing, a flight test will be executed, and the resulting data will be documented. Insertion of the technology into a Program of Record will be sought within PEO

U&W. Production of the materials and techniques to obtain them will be pushed to full-scale, to allow economic production of the needed precursors, and finished fuels.

This technology has the potential to create commercial opportunity in supersonic and hypersonic transport, as well as for the space-launch industry.

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KEYWORDS: boron; energetic; rocket fuel; turbine engine; afterburner; material characterization

N211-027 TITLE: Ultra-Lightweight Protection Shielding Material Against Electromagnetic Interference/Electromagnetic Pulse for Avionics

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Air Platforms

OBJECTIVE: Develop an ultra-lightweight carbon-based nanostructure composite shielding material capable of replacing metal shielding for naval electronic and avionics equipment for counter electromagnetic interference/electromagnetic pulse (EMI/EMP) defense.

DESCRIPTION: Recently, various functional nanocomposites are emerging as a new class of EMI/EMP shielding materials with light weight and high functionality. For instance, polymer matrices embedded with carbon-based conductive materials have been demonstrated to attain excellent shielding performance.

It is the objective of this program to develop an ultra-lightweight EMI/EMP shielding material, based on the most state-of-the-art graphene composite, that will form a protective shield for naval avionics and other electronic systems against EMI/EMP threats. The graphene composite should be integrated with lightweight polymer to form conformal shield material that can conform to any shapes and sizes of packaging. The conformal composite should have shielding effectiveness of more than 70 dB across the wide frequency range from 500 MHz to 100 GHz for the completely shielded sensitive electronics/avionics. The electrical conductivity of the graphene composite should be higher than 3000S/cm. The weight of the graphene-based shielding composite should weigh no more than 10% of an aluminum shield with equivalent EM shielding performance.

PHASE I: Develop a shielding material composite and fabrication method that meets shielding protection requirements. Use the proposed fabrication method to fabricate a sample of no smaller than 6 x 6 inches in size with appropriate thickness that will meet the shielding protection requirements. Demonstrate the feasibility of the material design via experimentally characterizing the electromagnetic performance of the sample relative to the metal analog in terms of shielding effectiveness over the frequency range from 500 MHz to 100 GHz, in accordance with the MIL-STD requirements [Refs 5, 6, 7, 8]. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop, demonstrate and validate a three-dimensional (3-D) enclosure prototype for EMI/EMP shielding protection for naval avionics and electronics. The enclosure prototype dimension should be12x24x6 inches. Perform reliability testing of the prototype enclosure in accordance with MIL-STD 810 [Ref 8] and report the test results. Deliver one prototype for independent testing.

PHASE III DUAL USE APPLICATIONS: Finalize and elevate the EMI/EMP shielding material system. Perform system prototype demonstration in a field environment. Transition the shielding materials to various naval applications such as manned and unmanned air vehicles, radio communication systems, air defense systems, and all avionics and electronics that are vulnerable to EMI/EMP disruptions.

Commercial avionics and electronics can benefit from improved ultra-lightweight shielding of EMI/EMP. Broad and beneficial shielding applications of this type of innovative shielding materials such as any wearable and mobile electronic devices, portable computers, cellular phones, smart watches, and portable/wearable medical devices are envisioned.

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KEYWORDS: Electromagnetic interference; EMI; electromagnetic pulse; EMP; shielding; lightweight composite; graphene; nanocomposite

N211-028 TITLE: Conformal Antennas Miniaturized through Magneto-Dielectric Materials

RT&L FOCUS AREA(S): General Warfighting Requirements

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

OBJECTIVE: Demonstrate printed-microstrip antenna size reduction through substrate permeability for improved size, weight, and power (SWaP), bandwidth performance, phased array architecture, improved low observability and probability of detection characteristics.

DESCRIPTION: The limits of microstrip antenna miniaturization are reached as permittivity values approach low double digits; at which point the antenna becomes too inefficient a radiator for practical use in an airborne communication system. Appreciable reductions in microstrip antenna size can be gained through an increase in the permeability of the printed antenna's substrate [Refs 1, 3, 5, 6]. When compared to traditional permittivity (only) increases, a combination of standard permittivity increases with novel permeability increases could result in comparable size reduction and better Radio Frequency (RF) performance [Refs 1, 3, 6]. The permittivity of printed antenna substrates is often increased to decrease antenna size, sacrificing antenna efficiency resulting in poorer RF performance and heat generation [Refs 2, 4, 6]. Permeability can also be increased to reduce size while counterbalancing the effect of permittivity increases on the antenna's characteristic impedance, resulting in a better performing, more efficient, miniaturized antenna that operates over a wider bandwidth [Refs 1, 3, 6]. Smaller conformal printed antennas can be integrated while minimizing impact to the aerodynamic characteristics of the hosting aircraft. Smaller antennas that have undergone a 50% reduction in size due to magnetic properties are sought. In addition, miniaturized conformal antennas can be integrated while minimizing negative impacts to the Radar Cross Section of an aircraft, when compared to common antennas. Aircraft with smaller conformal antennas operating from the Aircraft Carrier (Nuclear Propulsion) (CVN) could potentially have better Low Observable/Low Probability of Detection (LO/LPD) profiles than their standard counterparts, decreasing the likelihood of CVN detection.

PHASE I: Develop an initial conceptual design for a conformal microstrip patch antenna that has been reduced in size by 50% solely as a result of the substrate material's electromagnetic permeability characteristics while minimizing loss so that loss is comparable with practical printed antennas miniaturized through other means. Perform modeling and simulation in order to provide a conceptual design trade study for the antenna and its substrate. The Phase I Option period, if exercised, must include developing an initial antenna design that includes a plan for substrate fabrication, antenna feed design, and anticipated prototype antenna fabrication cost. Any microstrip antenna shape can be considered, as well as any permittivity characteristic for the substrate as long as a 50% reduction in size due to magnetic properties can be demonstrated. The design must also demonstrate improved antenna efficiency and frequency bandwidth for the prototype antenna over traditional antennas of equivalent size that have been miniaturized solely through increased permittivity. The Phase I effort must design, develop, and deliver a model of the antenna radiation pattern, impedance, efficiency, and explanation of antenna miniaturization attributes. The Phase I effort must include prototype plans to be developed under Phase II.

PHASE II: Develop a prototype based on the Phase I design. Test antenna prototype to validate maturity and expected/modeled performance. Characterize initial prototype's performance, identify any deviations from modeled performance and cause(s) for deviation, and produce improved design to address deviations and deficiencies. The Phase II Option period, if exercised, must produce an improved prototype; it must characterize improved prototype's performance; and identify any deviations from expected performance and cause(s) for deviation.

PHASE III DUAL USE APPLICATIONS: Complete development of the miniaturized antenna, demonstrate performance in an operationally relevant environment. Miniaturized conformal antennas would find use on any commercial aircraft or space vehicle desiring to save weight while achieving the same or better communication system performance experienced with legacy antenna options.

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KEYWORDS: antenna; conformal; magneto-dielectric; miniaturized; permeability; permittivity

N211-029 TITLE: Recovery and Handling of Group 3 through Group 5 Unmanned Aerial Vehicles Aboard Navy's Expeditionary Sea Base

RT&L FOCUS AREA(S): Autonomy

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Recovery and Handling of Group 3 through Group 5 fixed wing UAVs from ships other than an aircraft carrier to significantly increase lethality, project force, and increase the coverage of Intelligence, Surveillance and Reconnaissance (ISR) assets.

DESCRIPTION: The USAF's XQ-58A Valkyrie drone aircraft is the primary fixed wing Unmanned Aircraft System (UAS) planned for integration into Navy ships smaller than aircraft carriers. This SBIR topic complements a previous NAVAIR topic N202-109 entitled "Launch System for Group 3-5 Unmanned Aerial Vehicles for Land-and Sea-Based Operations." In order to reduce costs, the XQ-58A was not designed to be outfitted with landing gear. The Air Force instead uses rocket assist to launch the drone and deploys an on board parachute for recovery. The Navy under this topic is seeking an innovative approach that does not mandate the use of a parachute in order to recover the XQ-58A. Additionally, this topic needs to address the recovery of group 3 through 5 UAVSs that are outfitted with their own landing gear and equipped with a tail hook.

Operation of Group 3 through Group 5 (Group 3-5) fixed wing Unmanned Aerial Vehicles (UAVs) from ships other than aircraft carriers with a UAV Capture and Handling System must be capable of decelerating a fixed wing jet-powered UAV, with a wingspan of 30 feet and weight up to 6000 pounds, down from speeds up to 160 Knots Indicated Air Speed (KIAS). The placement of system components must reside, to the maximum extent possible, within the hull of the Expeditionary Sea Base (ESB) class of ships. Coordination with both Naval Sea Systems Command (NAVSEA) and Naval Air Systems Command (NAVAIR) will be critical to understanding the available space(s) aboard ship for system placement to minimize mission impact of other functions of the ship, as well as any weight and power restrictions.

The Recovery and Handling System must be designed to not interfere with normal topside flight deck operations of the ESB and accommodate Group 3-5 UAVs with or without landing gear including the Air Force XQ-58A Valkyrie. It must also be reconfigurable such that it can be transported to conduct both ground-based operations and shipboard operations aboard an ESB. Should features of the system exceed available onboard space, a stowable sponson assembly can be envisioned to extend from either side of the ESB, serving as the UAV "runway" and interfacing directly with the capture and handling technology. The sponson may extend as far as 79 feet from the ESB and is limited to a length of 300 feet. Any design solution relying on a sponson must address impact on the ship's performance, both pier-side and at sea, and may not interfere with basic ship or flight deck operations. Ship attitude during UAV recovery should be at a fixed bearing to optimize wind conditions and ship speed up to 15 knots as required.

The UAV Recovery and Handling System must be simple enough in design to allow for sustained operations at high sortie generation rates with a goal of a UAV capture every two minutes. The system must demonstrate high reliability with minimal maintenance down time for 24 hour/7 day surge periods. It is desired that routine maintenance should be accomplished in stride with operations. Details of the Recovery and Handling System need to include all the necessary subsystems and interface components required for installation aboard the ESB. The system must also adhere to all applicable environmental standards of the latest version of MIL-STD-810 such as shock, vibration, electromagnetic interference/emission, etc.

PHASE I: Develop a concept design to meet the objectives in the Description. Through modeling and simulation, demonstrate the feasibility of the concept in meeting Navy needs and establish that the concept can be developed into a useful product for the Navy. 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. Demonstrate a 1/8 scale prototype of the Launch System using a 100-pound UAV provided by the Government, conduct a ground demonstration of the prototype Recovery and Handling System. If the land-based testing is determined to be successful, a full-scale design suitable for at-sea testing will be developed during the options of the Phase II effort. This prototype development will involve multiple ship check visits to an ESB Class ship on either the east or west coast of the United States. One full-scale prototype will be constructed for both the land-based and at-sea testing. After successful full-scale land based testing, at-sea testing will follow in further development.

PHASE III DUAL USE APPLICATIONS: The technology being developed in this proposed NAVSEA SBIR topic as well as NAVAIR SBIR N202-109 are being planned for installation aboard a ESB to enable operation of fixed wing UAVs with or without landing gear ranging in size from Group 3 through 5. In addition to being able to operate these fixed wing UAVs from ships the Marine Corps have expressed interest in having this same technology packaged in kit form, so it could be transported via ground vehicles in the field to remote areas including islands and readily assembled by troops operating in the field to enhance air domination as the USMC seek to engage our enemies in their own backyard. This type of technology could be useful for commercial UAV delivery systems in cities.

The growing industry of aerial consumer package delivery could be profoundly impacted by advances in UAV capabilities.

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KEYWORDS: Unmanned Aerial Vehicle (UAV); Unmanned Aircraft Systems (UAS); Expeditionary Sea Base (ESB); XQ-58A Valkyrie; Sponson; Group 3 through Group 5 UAV.

N211-030 TITLE: Kilowatt (kW) Class Continuous Wave (CW) and Pulse Laser Hardened Optical Systems for Submarines

RT&L FOCUS AREA(S): Directed energy

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 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: Develop a Kilowatt (kW) class Continuous Wave (CW) and Pulse laser hardened optical system for submarines.

DESCRIPTION: Submarines may be subject to high power laser beams, which may damage optics and sensors in beam directors and periscopes. The Navy is seeking a technology that would allow laser hardening of vulnerable optical components in beam directors, periscopes, or other optical system without compromising their functional capabilities such as imaging, and directing a high-energy laser beam with no losses or wave front distortion. The radiation hardening system will integrate into submarine optical systems to include at minimum beam directors, periscopes, and imaging systems. Commercial optics employ thin films whose primary purpose is not the scope of this SBIR topic.

The Navy is seeking a design to be developed employing technology based on 4th generation transparent materials. In general, the current thin film based technology, thin enough not to generate substantial heating within the film when exposed to the high-power laser beams, while still having high optically nonlinear response to the influence of high power CW (continuous wave) or pulsed laser beams of relevant wavelengths will be considered. Due to 100's kW class CW laser power at 1 or 1.5 μ m laser wavelength and picosecond laser pulse of greater than 10 mJ per pulse, the material response shall not be accompanied with increased absorption as for example two-photon absorption per pulsed beams. The blocking of the high-power beams shall rather be a result of beam deflection away from the vulnerable optics into, for example, a radiation dump. Such photo-triggered diffraction gratings should diffract over 99% of radiation and have an aperture up to 12" in size. The proposed materials damage threshold shall be greater than 100's MW for CW and greater than gigawatts for pulse lasers at 1 and 1.5 μ m wavelength. Prototypes will be tested at a Navy lab in order to test, evaluate, and validate the specifications identified above.

Passive approaches will be considered, provided they are capable of rejecting high-power beams with an efficiency of rejecting greater than 80% of the optical power with only 20 degrees C of additional increase in the substrate temperature. Thin film photonic bandgaps, passive or photo-responsive seem particularly promising for this purpose.

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 and/or subcontractor 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: Provide a concept to solve the Navy's problem based on the requirements in the Description, and demonstrate the feasibility of that concept. Develop a concept for laser hardening and perform a trade study for submarine applications. Demonstrate feasibility through modeling 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 a prototype system for HEL kW class direct high energy laser testing and evaluation based on the results of Phase I and the Phase II Statement of Work (SOW). Develop the required technology into a prototype device and demonstrate that it meets the requirements in the Description. Test and refine the prototype into a technology that the Navy can use. Deliver the prototype laser hardened optical system, around 12 inch in diameter for kW class test and evaluation by U.S. NAVY.

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 transitioning the technology for Navy use. Identify the final prototype product for transition into NAVSEA undersea platform and plan for the transition to Phase III, to include validation, testing, and HEL testing for Navy use. This technology has potential commercial transition to other applications such as industrial material processing window (welding, cutting, soldering, marking, cleaning, etc.) and fundamental research window.

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KEYWORDS: Pulse laser; laser hardened optical system; photo-responsive; laser damage threshold; picosecond pulse (ps); nonlinear optics.

N211-031 TITLE: Compact RAMAN System for Marine Wave Boundary Characterization

RT&L FOCUS AREA(S): Directed energy

TECHNOLOGY AREA(S): Battlespace Environments

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: Develop an advanced detection and targeting control for High Energy Laser (HEL) operating in the complex marine environments where the proposed RAMAN metrological sensor will also improve the submarine imaging and Radio Frequency (RF) detection.

DESCRIPTION: The Navy seeks technologies that are oriented toward a deeper experimental and theoretical understanding of maritime turbulence and laser light propagation in the marine boundary. Ocean evaporation is occurring within a very thin molecular layer at the surface. However, there are indications that turbulent structures in the ocean and atmospheric mixing layers play a critical role in determining the water vapor flux. The current measurement techniques, such as Laser Doppler Velocimetry (LDV), are limited to resolutions of 1 micro meter or greater and fall short of the required sub micrometer level resolution. A new type of spectral imaging modality and instrumentation is required that will increase our understanding of ocean evaporation and lead to better tools for measuring and modeling the near-marine boundary layer for optical and radio frequency Naval applications. This generalized understanding will significantly enhance beam optic directors, adaptive optics, and other turbulence mitigating techniques to enhance the reach and effectiveness of communication as well as defensive and offensive laser light engagement in the marine boundary layer.

The overall objectives of this STTR topic are to: 1) develop a system capable of measuring atmospheric turbulence near the ocean surface (0 to 60 feet); 2) develop models that can predict turbulent effects given a set of atmospheric and marine surface conditions, such as surface temperature, humidity, pressure, wind speed, wave, fog, etc., that can affect marine wave boundary layer atmosphere; and 3) develop a metrological instrument based on RAMAN light detection and ranging (LIDAR). A RAMAN metrology system should be capable of accepting RAMAN signals from lasers operating in three octaves from the Near-Infrared (NIR) (~1 um), Visible (~500nm), to the Deep Ultraviolet (DUV) (~250nm). The multiband RAMAN metrology system's simultaneous backscattering analysis of three wavelength intensity measurement ratio would be able to validate atmospheric Rayleigh and Mie scattering models. The system would be used to adapt existing atmospheric models or creating new physics-based models of the marine boundary layer. The RAMAN spectrometer must be able to collect data at a repetition rate of at least 1 kHz in all three wavelength ranges. The metrology system technology should be compatible with a marine operating environment in accordance with MIL-STD-810H and capable of integration into a submarine sail or mast. This form factor capable of fitting within a 12 inch cubed volume would facilitate widespread deployment as a metrological tool for marine wave boundary atmospheric characterization. The RAMAN metrology system (multiband source, detector and software for analysis) is also the part of High Energy Laser (HEL) closed loop circuit to control the HEL beam on target. The proposed 3-band picosecond RAMAN laser shall be able to integrate into HEL systems for target ranging and detection. In this configuration, the system has the potential to enhance substantially Navy capabilities for deployed

high power lasers operating in the marine environment. In this effort the proposer should use Open Model Based Engineering (MBEE) for the development of software, hardware and documents.

Testing and evaluation will occur at a Navy laboratory and will measure the effectiveness of the RAMAN metrology system to accept three synchronized laser pulses in the ultra violet (UV), visible (VIS), and infrared (IR) spectral bands. The laser pulse will have a temporal pulse width between 5 ps and 1 ns and a pulse repetition rate between 1 kHz and 5 kHz, and a stable, narrow laser bandwidth of a few wavenumbers or less sufficient to distinguish RAMAN lines. The RAMAN metrology system (multiband source and detector) should have a resolution of a few wavenumbers in each spectral region. The company shall acquire mJ per pico second multiband source for the compact RAMAN System development. The Government may also furnish a 3-band mJ per band pico source as a second source to the company for integration and comparison studies into compact RAMAN System. Both software and hardware of the integrated RAMAN system (source and detector) are to be delivered to Navy.

PHASE I: Develop a concept for a RAMAN metrology system based on Model Based Engineering (MBE) as outlined in the Description. Demonstrate the feasibility of that concept through architecture modeling, simulation, and theoretical calculation. Ensure that the RAMAN metrology system is capable of producing the required spectral resolution in each of the wavelength bands at the predicted repetition rate. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a RAMAN metrology prototype solution based on MBE.

PHASE II: Develop and deliver a prototype of a 3-band RAMAN metrology system based on the concept developed in Phase I and the Phase II Statement of Work (SOW). Integrate the RAMAN metrology system with the 3-band laser source, detector and software for analysis. Work with the Navy for the evaluation of performance and further characterization for the purpose of RAMAN back scattering to characterize atmospheric temperature, pressure, and humidity. Support the Navy for validation and additional testing to be qualified and certified for Navy use.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy submarine platforms as a metrological tool for marine wave boundary data collection. This technology can improve a commercial ship's localized weather prediction and update the weather software for safe operation. Additionally, improved LIDAR detection for range at day, night, and all-weather conditions is beneficial for both commercial and DoD applications. The RAMAN metrology system could also find applications in trace gas and pollution monitoring.

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KEYWORDS: RAMAN LIDAR; Laser Beam Propagation; Maritime Environment; Turbulent Boundary Layer; 3-band RAMAN Laser System; Laser Doppler Velocimetry (LDV).

N211-032 TITLE: Extra Large Unmanned Undersea Vehicle (XLUUV) Launch and Recovery, On-Board Handling, and Servicing System

RT&L FOCUS AREA(S): Autonomy

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop a modular Launch and Recovery system for On-Board Handling and Servicing of Extra Large Unmanned Undersea Vehicle (XLUUV) that can be used on amphibious platforms.

DESCRIPTION: Current Unmanned Surface Vehicle (USV), Unmanned Undersea Vehicle (UUV) recovery systems are designed for the LCS Classes or Shore based operations, and not easily transferrable to other Ship Classes. The Extra Large Unmanned Undersea Vehicle (XLUUV) with a length of 85 feet, weight of 180,000 pounds and height and width of 8.5 feet would provide a physical challenge to deploy from any Navy ship. These systems are specially designed to capture an Unmanned Vehicle (up to the Large Diameter size) and bring it onboard an LCS using the Twin Boom Extensible Crane (TBEC) on the Independence Class or Launch Recovery Handling System (LRHS) on the Freedom Class. The TBEC and LRHS are specialized systems with unique design features that are not found on other platforms throughout the fleet. Since the original design for the launch & recovery systems were tailored to the LCS variants, they do not integrate easily on other Ship Classes where conventional launch and recovery procedures are used. Current launch and recovery requirements drive the Navy to develop unique solutions that are not cross compatible with other USVs, UUVs, and XLUUVs. The technology to be developed in this effort will provide NAVSEA with a common launch and recovery capability deployed on LCS, L-class, and Shore-based platforms to launch and recover vehicles in the NAVSEA UxV portfolio. The developed launch and recovery system must not require structural modifications to the ship, must operate in Sea State 3 and the design should not impede stern gate actuation, ballasting, or other critical ship operations. A preferred system would be modular, adaptable and scalable to support smaller future unmanned systems.

The LPD 17 Class ships mission is to transport troops and equipment for amphibious operations and land them in the assault area by means of embarked Landing Craft Air Cushion (LCAC), conventional landing craft, or Amphibious Assault Vehicles (AAV). Each LPD 17 Class ship encompasses more than 22,000 square feet of vehicle storage space and 28,000 cubic feet of cargo storage. Vehicle storage space is provided through a well deck design. The LPD 17 Class well deck is 188 feet long and approximately 50 feet wide at mid well, increasing to 59 feet at the sill, or stern of the ship. Clearance above the well deck is 31 feet. The ship is able to ballast down to flood the well deck with 9 feet of seawater at the sill and 4.5 feet at the forward portion of the well during wet well operations and landing craft maneuvers.

PHASE I: Develop a concept for a modular Launch and Recovery system for On-Board Handling and Servicing of the current Navy XLUUV that can be used on an LPD 17 class of ship. The Navy will provide dimension and movement specifications for both the unmanned system, and the ship locations in which the modular Launch and Recovery system for On-Board Handling and Servicing would reside. Companies will demonstrate feasibility of their designs through modelling and draft concepts of 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: Based on the results of Phase I efforts and the Phase II Statement of Work (SOW), develop and deliver a prototype modular Launch and Recovery system for On-Board Handling and Servicing of the Navy XLUUV on the LPD 17 class of ship. This prototype development will involve multiple ship check visits to a LPD 17 Class ship on either the east or west coast of the United States. The prototype will first be evaluated on land at both the company's facility and the location where the XLUUV is stored

to determine the system's capability in meeting the performance goals defined in Phase II SOW. If the land-based testing is determined to be successful, at-sea testing will be accomplished at the end of the Phase II effort with the XLUUV and the company's prototype modular Launch and Recovery system for On-Board Handling and Servicing. The at-sea testing will involve the company's system demonstrating movement of the XLUUV from a stowage location on the vehicle deck to the well deck, and then launching and recovering the XLUUV. One overall prototype can be used for both the land-based and at-sea testing. Validation and qualification of the final company product will be achieved during Phase II. The company will prepare a Phase III development plan to transition the technology to Navy use.

PHASE III DUAL USE APPLICATIONS: Upon successful completion of Phase II, the company will be expected to support the Navy in transitioning the technology to Navy use. The company will refine the design of the final modular launch and recovery system that can be used for the XLUUV, but also adapted to other Navy unmanned systems. The company will support the Navy for test and validation in accordance with Navy regulations and requirements. Following testing and validation the end design is expected to first be deployed on the LPD 17 Class, and capable of being utilized across all Navy amphibious platforms with well decks. This technology will help the Navy meet critical needs of increased warfighting capability for L-Class ships and expand the Amphibious Warfare Mission Area(s).

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KEYWORDS: Unmanned Maritime Vehicle Systems; Launch and Recovery; Unmanned Undersea Vehicle (UUV); Extra Large Unmanned Undersea Vehicle (XLUUV); Modular Unmanned System; Unmanned Vehicle Stowage.

N211-033 TITLE: Wireless Sensing to Improve Submarine Machinery Health Monitoring

RT&L FOCUS AREA(S): Networked C3

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop a solution that can wirelessly monitor and transmit shipboard machinery data to provide an easy means of collecting data on an operational platform to enhance machinery health monitoring.

DESCRIPTION: The U.S. Navy does not currently employ autonomous continuous based machinery monitoring and predictive maintenance systems aboard fleet platforms – current methods although broadly effective may be infrequent, labor intensive, prone to measurement error and may delay actionable information to decision makers. Current methodologies in the submarine fleet, for example, employ periodic, hand-held, wired machinery vibration measurements to provide predictions of machinery failure.

The Navy is thus seeking a broad range of emerging technologies that take advantage of commercial advances in sensor development, Internet of Things (IoT), and data analytics as applied to machinery data to develop digital twins that allow for Condition Based Maintenance (CBM) of assets. Monitoring the current and expected future states of these systems will allow the Navy to more effectively maintain their platforms through an increased awareness of system health. Furthermore, maintenance planning is better served by an increased awareness of remaining useful life of components. By analyzing the optimal mix of resilient design and onboard/forward deployed spares, this solution supports On Time Delivery by maintaining the right parts where they are most needed to support the mission, ultimately reducing life cycle costs of the program sustainment activities.

Of specific interest, the Navy is interested in the use of wireless sensing technologies that can simultaneously collect and transit machinery vibration (0 - 6000 Hz) and power data (current and voltage TBD) that are in conformance with naval platform operational restrictions. Although this technology has been demonstrated in academia, there is no commercial application of such technology aboard current Navy platforms.

Use of wireless sensing technologies will provide an easier means of collecting and storing data from a broader range of sensors when compared to similar wired solutions. The small business should develop a combination of software (sensor proprietary if necessary; COTS telemetry infrastructure) and hardware that would allow for collection of data from shipboard machinery and wirelessly transmit this data to an onboard storage or display device.

The solution should allow for a minimum of two simultaneous sensing modalities – mechanical vibration and machinery power attributes – to support monitoring of machinery health. Additional sensing modalities could include temperature, pressure, or acoustics depending on the type of machinery monitored. The developed sensor should be able to obtain power at its installed location source and should not require cabling to a remote power source. Solutions that do not require human intervention, i.e., replacement of batteries, are preferred but not required. The solution could, but is not required to, be applicable to either manned or unmanned platform. However, the solution will be required to communicate data securely from the sensor to the storage medium on board the submarine.

While the solution provided by the company will be used to support the development of digital twins for Condition-Based Maintenance (CBM), CBM solutions are not required to be provided as a deliverable. Rather the vendor should focus on developing a modular infrastructure that allows for secure

communication between the sensor and storage location. These communication protocols will be platform dependent but include considerations such as physical access controls, power management and environmental controls and strategic/local command security protocol procedures. Size, weight and power should be constrained to not interfere with machinery operation and to operate autonomously in excess of two weeks without maintenance (e.g., battery replacement).

The Phase II effort is anticipated to include testing by the small business in an operationally relevant environment with final testing by the Navy (Naval Surface Warfare Center, Carderock Division) in a laboratory or at-sea environment as appropriate. The product will be validated, tested, qualified, and certified for Navy use across a wide range of conditions (e.g., machine operating parameters, ship depth, sea water temperature, etc.) as applicable for the relevant class of problem.

Depending on the scope of the proposal, the Phase II effort may require secure access, and NAVSEA will process the DD254 to support the contractor for personnel and facility certification for secure access. The Phase I effort will not require access to classified information. If need be, data of the same level of complexity as secured data will be provided to support Phase I or Phase II work.

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 and/or subcontractor 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 to solve the Navy's problem and then demonstrate the feasibility of that concept. The expected product will be a combination of hardware and software. Feasibility should be demonstrated by a laboratory bench test or a limited scale field experiment. As an example, a vendor might propose a demonstration of one modality of data being collected on a representative asset in the lab and transmitted securely to a storage device and/or display. The vendor is expected to propose concept feasibility testing as part of their proposals. 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 system for testing and evaluation based on the results of Phase I work and the Phase II Statement of Work (SOW). The prototype system will vary based on the awardee's proposed approach, but it may include hardware and software. The test and evaluation hardware may be a commercial system (e.g., a commercially available vent fan), a Navy-provided system (e.g., a main seawater pump), or a combination of commercial and Navy-provided systems (e.g., an integrated life support system). The prototype will be evaluated in a Navy lab or at-sea environment. The Navy may opt to choose a surrogate platform for at-sea testing based on availability of assets. Additional laboratory testing, modeling, or analytical methods may also be appropriate depending on the company's proposed approach. In general, two prototype articles should be provided to the Government for testing, at least three months prior to the end of Phase II. A Phase III development plan will be required at the end of Phase II.

It is probable that the work under this effort and any follow-on efforts could be classified (see Description section for details).
PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. The final product will be software integrated with Navy-provided hardware, or software integrated with company-provided hardware. The Navy expects the vendor to support transition to Phase III through system integration, testing support, software and hardware documentation, and limited hardware production if applicable. Possible platforms where the technology will be used include current and future submarine platforms. The technology must meet critical Navy requirements in terms of secure communications between the source and the storage medium onboard the platform. These may be related to WLAN security (encryption, authentication), Electromagnetic Interference (EM), radiological and hazardous material constraints, limits on total radiated power and other relevant requirements in effect at such time. In Phase III, the product will be validated, tested, qualified, and certified for Navy use in at-sea trials across a wide range of conditions as applicable for the relevant class of problem. Additional software testing will likely also be required to ensure that all applicable conditions can be tested even if they do not occur during at-sea test periods.

These solutions have potential for use on other undersea platforms such as Unmanned Undersea Vehicles (UUVs) as well as a wide range of surface platforms.

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- 8. N211-033 Reference Document 728A-728T-spec-98056B_1
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KEYWORDS: Data Analytics; Condition Based Maintenance; Digital Twin; Wireless Sensing; Predictive Analytics; Rotating equipment

N211-034 TITLE: Submarine Atmospheric Contaminant Scrubbing Technology

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: To provide passive atmospheric contaminant scrubbing technologies to reduce and/or eliminate gas contaminants from 1 to 6 atmospheres absolute (ata).

DESCRIPTION: When a DISabled SUBmarine (DISSUB) event occurs, several dangerous and potentially lethal atmospheric contaminants can be introduced from fire, battery malfunctions, and other potential sources. These contaminants, if not appropriately managed or removed, can limit the time DISSUB survivors can await rescue. At this time, the submarine force has limited means of removing dangerous atmospheric contaminants, beyond Carbon Dioxide (CO2), from the DISSUB atmosphere when the internal compartment is either pressurized or there is insufficient available power to utilize other scrubbing technologies. Currently there is no known commercially available technology to passively scrub these contaminants.

The concept of operations (CONOPS) for a DISSUB rescue begin with a senior onboard survivor measuring and monitoring specific atmospheric containments via the USN DISSUB Guard Books. These guard books provide the procedures necessary to support DISSUB survivors in awaiting rescue by rescue forces for a minimum of seven days after the DISSUB event. Additionally, the Guard Books enable the survivors to determine when the atmosphere has been contaminated to a point that it is no longer safe to wait for rescue and therefore escape is required. While awaiting rescue is the preferred method for survivors, the inability to lower or eliminate specific hazardous contaminants may require survivors to attempt escape. Oxygen (O2) is added to and CO2 is removed from the internal compartment atmosphere passively via Chlorite candles and Lithium Hydroxide (LiOH) scrubber curtains, respectively. However, there are an additional seven constituents that have been identified by medical personnel as being dangerous to DISSUB survivors when subjected to prolonged exposure to elevated levels. These constituents are defined as the Submarine Escape Action Limit (SEAL) gases and are Carbon Monoxide (CO), Hydrogen Cyanide (HCN), Ammonia (NH3), Chlorine (Cl2), Hydrogen Chloride (HCl), Sulfur Dioxide (SO2) and Nitrogen Dioxide (NO2).

The program office desires the development of a technology that can provide the ability to passively lower and/or eliminate the 7 SEAL gases identified from a DISSUB internal compartment. In the event of a DISSUB, it is anticipated that the submarine will not have sufficient available power to support an active system. Additionally, the use of a passive system will reduce the production of Carbon Dioxide that would result from survivors using a manually operated system. Due to onboard constraints, the solution(s) should minimize the footprint of the equipment and maintenance requirements. Additionally, to reduce survivor physical stressors and CO2 generation, the solutions(s) should minimize human system operations while also remaining cognizant of the limited power that may be available. Note that standalone battery power for the equipment is acceptable, but the use of Lithium Ion (LIO) batteries is not. Due to internal compartment space constraints, the proposed solution should minimize, as much as practical, the footprint of any required installed equipment as well as maintenance and lifecycle cost requirements.

In terms of technology development efforts, the threshold is the ability to reduce contaminant levels below SEAL 2 levels as quickly as possible and maintain the contaminant levels below SEAL 2 levels for a minimum of seven days. The SEAL 2 levels are CO 150ppm, HCN 15 ppm, NH3 125 ppm, Cl2 2.5ppm, HCl 35 ppm, SO2 30 ppm, and NO2 10 ppm. The objective is the ability to reduce and maintain contaminant levels at or below SEAL 1 levels for a minimum of seven days (CO 125ppm; HCN 10 ppm; NH3 75 ppm; Cl2 1 ppm; HCl 20 ppm; SO2 20 ppm; CO2 5 ppm). Testing will be conducted via bench-

test in a simulated environment comparable to the anticipated operational environment at NSWC Philadelphia.

In addition to being a safety and duty of care issue, continued advancement and modernization of the USN Submarine Escape and Rescue Program is considered an Assistant Secretary of the Navy core field in support of the larger Undersea Warfare, and directly aligns to both the National Defense Strategy and the Submarine Commander's Intent by defending the homeland; enabling interagency counterparts to advance U.S. influence and national security interests; ensuring USN submarine warfighting readiness and survivability; and strengthening alliances and attracting new partners. The latter was highlighted in the geopolitical outcome following the USN Submarine Escape and Rescue response to the ARA SAN JUAN incident in November 2017.

PHASE I: Develop a conceptual solution that defines the methods and identify the major components required to meet the requirements in the description. Feasibility will be determined by identifying the catalyst required and scientific calculations and modeling to support required contaminant reduction catalyst technologies. The Phase I Option, if exercised, will include refinement of the proposed solution to support Phase II prototype development and the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Based on the results of the Phase I and the Phase II Statement of Work (SOW), refine, as necessary, the design to build and deliver one prototype for test. Testing will be conducted via bench-test in a simulated environment comparable to the anticipated operational environment at NSWC Philadelphia.

PHASE III DUAL USE APPLICATIONS: Beyond the ability to provide atmospheric containment removal technology to support the Submarine Escape and Rescue program, this technology could also provide benefits to all confined space emergency applications. In additional to the USN and Department of Defense (DoD), PMS391 collaboration initiatives and established Memorandum of Agreements with non-DoD federal and state emergency management organizations – to include the Federal Emergency Management Agency (FEMA), Department of Labor Mine Safety and Health Administration (DoL-MSHA), National Institute of Occupational Safety and Health (NIOSH), and National Aviation and Space Administration(NASA) – can be leveraged to address similar technology needs and requirements. Upon successful prototype testing, the technology is anticipated to be transitioned via backfit installation onboard in-service submarines and implemented as part of new construction for the USS COLUMBIA class and the future SSN(X) class of submarines.

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KEYWORDS: Atmosphere in submarines; Atmospheric Contaminant; Emergency Services onboard submarines; Submarine Rescue; Contaminant Removal; Submarine Escape Action Limit (SEAL) gases.

N211-035 TITLE: Compact Battery Power Uncooled 5 kW-Class Laser System

RT&L FOCUS AREA(S): Directed energy

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 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: Develop a compact battery power, efficient uncooled kW class laser system capable of producing > 5 kW output at high atmosphere transparency wavelength.

DESCRIPTION: Compact battery power uncooled kilo-watt (kW) class high energy laser (HEL) prototype systems have been deployed in a variety of platforms as laser weapons to destroy targets and threats. However, high cooling capacity chillers have to be used to dissipate the heat generated by the laser medium and pump sources of these kW-class HEL systems. The size, weight, and power (SWaP) of a HEL system is thus deteriorated by the demand of the cooling chillers on the available SWaP, which also constrains the deployment of such kW-class HEL systems in small, airborne, or unmanned weapon platforms. The DoD has a great demand for compact and robust uncooled kW-class laser system for a variety of applications. Industry will benefit as well from the reduced SWaP requirement of the technology in applications where lasers are used to cut, weld, or ablate material. This project aims to develop kW-class HEL laser sources with improved SWaP and other specifications using innovative laser technology. The Navy is looking for a kW-level laser prototype device with following specifications to be developed; Wavelength: High atmosphere transparency; Average Power Output Threshold: 3 kW (Objective: 5 kW); HEL spectrum wavelength shall be around 1 um, laser beam quality (M2) Threshold: < 1.5); Weight Threshold: 40 lbs (Objective 20 lb); Volume Threshold: 10 inch3 (Objective < 5 inch3); Air cooled compact HEL prototyped system. At present uncooled compact battery power kW class HEL system is not commercially available.

The initial prototype compact 5 kw uncooled battery power HEL system shall be evaluated at a Navy facility to understand the HEL performance and beam quality. During this test and evaluation period Navy will also evaluate the duration of the operation and the system wavelength shifts as system temperature increase. Cycle should be 5 minutes operation at full power and 5 minutes cool down. Maximum surrounding temperature equivalent to eastern summer time (80 to 85 degrees F).

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 be implemented and approved by the Defense Counterintelligence Security Agency (DCSA). The selected contractor and/or subcontractor 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 the design of the architecture for a compact ~5 kW-class HEL prototype system that does not require an active cooling system (air cooled). Additionally, the vendor will demonstrate the feasibility of the concept and power scalability of an air cooled HEL prototype system and provide the prototype design of a 5-kW prototype HEL system to NAVY. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype system in Phase II.

PHASE II: Develop and deliver a prototype air cooled approximately 5kw HEL with good beam quality (M2< 2) system for testing and evaluation based on the results of Phase I at NAVY lab. The initial prototype compact 5 kw uncooled battery power HEL system shall be evaluated at Navy facility to understand the HEL performance and beam quality. During this test and evaluation period Navy will also evaluate the duration of the operation and the system wavelength shifts as system temperature increase. Optimize the design and scaling the Phase I laser concept to prototype a compact uncooled battery power laser system capable of producing > 5 kW output power at high atmosphere transparency wavelength that meets the requirements in the Description.

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. This support is expected to be in the form of fully developing and transitioning the kW-class laser system for DoD HEL weapon systems. This technology has potential commercial transition to other applications such as industrial material processing (welding, cutting, soldering, marking, cleaning, etc.) and fundamental research.

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KEYWORDS: High energy laser; Kilo-watt (kW) -class laser; laser weapon system; size, weight, and power (SWaP); uncooled laser; Beam quality (M2).

N211-036 TITLE: Innovative Simultaneous Localization and Mapping Techniques for Unmanned Underwater Vehicles

RT&L FOCUS AREA(S): 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 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 development of robust Simultaneous Localization and Mapping (SLAM) techniques for assisting the navigation of Unmanned Underwater Vehicles operating in GPS-denied environments.

DESCRIPTION: Despite the considerable effort directed towards UUV navigation, a self-contained solution remains a key challenge. Due to the cumulative error that an inertial navigation system (INS) experiences with time, UUVs typically require regular surfacing to obtain GPS fixes, or the presence of acoustic localization beacons, in order to correct position drift. Such options can be undesirable/unavailable in certain applications (e.g., deep-water and/or Intelligence, Surveillance, and Reconnaissance (ISR) missions). Underwater Terrain Aided Navigation (TAN) methods have also demonstrated the ability to provide accurate navigation resets, though they are limited by the requirement for accurate high-resolution reference bathymetry maps, which are not available for much of the Earth's sea floor. In response to the presently limited navigation capability, this topic will focus on the development of robust SLAM algorithms to assist UUV navigation in GPS-denied environments.

The Navy is rapidly developing and fielding a family of Unmanned Undersea Vehicles (UUV) specifically designed for operations within GPS-denied environments. Advances in underwater sensing technology and computing power have yielded new possibilities in the underwater domain. For instance, advanced sensor processing and new underwater navigation techniques have become available, including SLAM. SLAM broadly refers to the problem of jointly creating (and updating) a map of an unknown environment and estimating the system's position and pose within it. The topic has attracted a flurry of research in the robotics community over the past three decades, including indoor, land-based, aerial and even underwater vehicles. It has been a critical tool in the development of commercial robot vacuum systems, allowing them to operate in any home without prior knowledge of the layout. Other examples include the field of self-driving cars, where SLAM serves as a supplement to GPS navigation, allowing the system to build obstacle maps of the surrounding environment, and continue driving in unmapped areas or when GPS becomes unavailable.

Although SLAM has been proven effective for mobile robots operating in structured environments, the application of these techniques in the highly unstructured underwater domain presents unique challenges. As a result, there is still considerable room for growth in the use of SLAM techniques for UUVs. Some examples of SLAM-based approaches for UUVs include applications for achieving improved velocity-over-ground estimates, and algorithms for improving the accuracy of bathymetric maps generated from a UUV survey. For many UUV SLAM applications, the ultimate goal is to take advantage of the process to reduce position error growth, not necessarily to generate a map of the environment. Likewise, for this topic the UUV will not need to rely on mapping its entire operational environment in order to conduct the

mission. As advances in energy technology continue to increase the endurance and operating range of UUVs, missions will cover wider areas, longer distances, and longer times. It can be assumed that the target UUV system for this effort will feature a navigation-grade INS as the baseline navigation system. PMS 406, Unmanned Maritime Systems program office, seeks the development of robust SLAM algorithms that will increase the mission capabilities of such UUVs by providing additional methods for aiding vehicle navigation. The goal is to increase overall navigational accuracy during a GPS-denied mission beyond what can be achieved with just the standard Doppler Velocity Logger (DVL) aiding to the INS, and provide a means of resetting what otherwise would be unbounded position error growth.

While initial validation of the algorithms can leverage off-line post-processing of vehicle and sensor data, the ultimate system design needs to provide output in-situ that can aid the UUV during the mission. Additionally, the solution should address the limitation of operating in areas without prior knowledge of the bathymetry or specific bottom features. Prior reference information, where available (i.e., any knowledge about natural or man-made features) can be used to enhance performance, however the system must also be capable of operating without any such assistance.

The algorithms developed should be utilized in a wide range of different environments and mission scenarios. This includes both rugged and smooth terrain, as well as cluttered and un-cluttered environments. A list of some potential Navy mission concepts and scenarios will be provided during Phase II. The system should be designed to serve as an aiding source for a UUV navigation framework based on a navigation grade INS. The solution should not be an integral piece of the UUV navigation system to the point that it needs to be operating continuously in order for the vehicle itself to navigate. Instead, the system solution encompassing the SLAM algorithms is expected to provide outputs that can be used as aiding sources into an INS framework.

The proposer will identify the available environmental information, features the algorithms aim to extract and the necessary sensors and sensor processing needed to utilize this information. The company will address how the algorithms are applicable to different UUV mission scenarios across a range of potential operational environments. The company will identify the vehicle behaviors and maneuvering necessary to utilize the algorithms and how these behaviors fit into the context of the overall vehicle mission. The concept will cover how the algorithms address areas where no prior information is available and the handling of both cluttered and un-cluttered environments. The company will identify the output data products of the algorithms and how this data aids the performance of the UUV navigation framework.

It is envisioned that the solution be tailored to aiding a UUV navigation framework based on a commercial off-the-shelf (COTS) Inertial Navigation System. Additionally, the solution may provide a means of saving new maps generated on-board or updating existing maps stored on the system for future use. The proposer will provide a detailed plan for validating the algorithms in a computer simulation environment. This test plan should include the types of vehicle and sensor data, both historical and simulated, that would be required to carry out relevant simulation test cases, and how such data will be acquired and/or generated. Phase II shall also include the development of a plan for at-sea tests of the computer program on government-owned UUVs and a list of validation metrics for such tests.

To ensure interoperability with PMS 406 portfolio, the solution must comply with the 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 UxS vehicles. The UMAA common standard for Interface Control Documents (ICDs) mitigates the risk of vendor lock from proprietary autonomy solutions; effects cross-domain interoperability of UxS vehicles; and allows for open architecture (OA) modularity of autonomy solutions, control systems, C2, and payloads. The Navy will provide the open standards for UMAA upon award of Phase I.

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 and/or subcontractor 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: Phase I will consist of a concept and feasibility determination on the implementation of SLAM-based techniques for aiding a UUV navigation system during long-duration submerged missions. Feasibility determination will describe a path for development of SLAM algorithms that leverage existing navigation-grade INS solutions and current UUV payload sensor technology to assist in managing position error drift in accordance with the requirements within the Description section of this document.

The Phase I Option, if exercised, will include a detailed outline for a prototype system design for implementation in Phase II and a detailed plan for validating the algorithms in a computer simulation environment. This plan should include the types of vehicle and sensor data, both historical and simulated, that would be required to carry out relevant simulation test cases, and how such data will be acquired and/or generated. Additionally, the company will develop a comprehensive summary of how the proposed solution can address the challenge of improving state-of-the-art UUV navigation systems for long-range missions.

PHASE II: The Phase II effort will focus on implementing the SLAM algorithms proposed and outlined in Phase I by developing and delivering a prototype system. The simulation test plan outlined in Phase I should be used for initial validation and testing of this prototype system during development. Relevant vehicle navigation and sensor data feeds, generated through playback of historical datasets and/or simulation, will be used to create suitable test cases to demonstrate the feasibility of the proposed approach.

A successful Phase II project will demonstrate that the algorithms and prototype system can perform as expected using data representative of a variety of environments and deliver a detailed plan for the integration of the proposed algorithms into a software application compatible with government-owned UUV software architectures. This includes specifying a software interface compliant with the Unmanned Maritime Autonomy Architecture (UMAA). It is envisioned that the solution be tailored to aiding a UUV navigation framework based on a COTS Inertial Navigation System. Additionally, the solution may provide a means of saving new maps generated on-board or updating existing maps stored on the system for future use. Phase II shall also include the development of a plan for at-sea tests of the computer program on government-owned UUVs and a list of validation metrics for such tests.

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 integrating the technology for Navy use. The proposed prototype will be integrated into the software architecture of Navy UUV systems. This includes both research-oriented UUV systems performing Science and Technology missions, as well as acquisition program UUVs conducting Navy missions at sea.

The proposed solution has applicability in a wide variety of commercial as well as defense applications. Organizations that require the use of UUVs for tasks such as inspecting and repairing submerged infrastructure, searching for airplane black-boxes, conducting port and harbor security and collecting environmental data or mapping the sea floor, can leverage this technology to increase navigational and mission reliability. There are significant advantages in transitioning this technology to other DoD agencies, government, and private sector entities to enhance UUV mission capability.

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KEYWORDS: Unmanned Undersea Vehicles; UMAA; Navigation in GPS-denied environments; Undersea Mapping; SLAM; INS.

N211-037 TITLE: Electronic Warfare Operator Workload Organization and Sharing

RT&L FOCUS AREA(S): Machine Learning/AI

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 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: Develop a methodology for effective and efficient electronic warfare workload organization and sharing that increases the performance of the Electronic Warfare Operator and Supervisor.

DESCRIPTION: The Surface Fleet is deploying a comprehensive suite of integrated and closely coordinated electronic warfare (EW) systems and countermeasures. Employing the latest radio frequency (RF) and digital technology, these systems have vastly improved sensitivity and increased capacity to detect, resolve, classify, and identify signals of interest as well as surveille the RF spectrum over a wide area. This increase in capacity is concurrent with the general increase in RF transmitters in the maritime environment. The RF spectrum, even in open ocean, is now far more crowded than just a few years ago. Every small craft (fishing boats, small merchantmen, patrol craft, etc.) can now afford to install commercial radar and communications equipment. The problem in navigational choke points, such as highly trafficked straits and the approaches to major ports, is severe and often complicated by the proximity of shore-based transmitters. In addition, future naval engagements will be marked by an unprecedented array of threat transmitters that use the electromagnetic spectrum.

Increased levels of EW system performance combined with the proliferation of RF transmitters (threat, friendly, and civilian) presents a significant increased burden on the EW operator (EWOP). The EWOP now has access to more electronic support (ES) information of a greater depth than ever before. Operator overload and fatigue are serious problems. While some of this data can be processed automatically by machine learning or adaptive algorithms, the Navy cannot remove the human decision-maker entirely from the loop and the EWOP remains a critical element in surface combat. Fortunately, the EWOP teams with an EW supervisor (EWSUP) to share the workload and coordinate more broadly with the combat information center. Applied effectively, the EWOP-EWSUP team is an effective element for eliminating errors, maximizing situational awareness, minimizing response times, and ensuring proper execution of EW doctrine during complex engagements. During normal operations, this teaming reduces fatigue. However, this reduction is predicated on effective organization, prioritization, and sharing of the EW battlespace information and responsibilities. This problem is similar to an air traffic control center's organization and performance. However, air traffic control is based on a structured hierarchy of tasking, fairly predictable patterns (by intention), relatively constant workload, and cooperative "targets". This is not the case during EW engagements and no comparable commercial application can be easily adapted for the EWOP-EWSUP team structure.

The Navy seeks an innovative method (realized in prototype algorithms and demonstrated on surrogate hardware and displays) to efficiently organize, prioritize, and share information and tasking between the SLQ-32 electronic warfare system EWOP and EWSUP to assure situational awareness, coordinate EW

assets, and efficiently execute engagements. The solution must prioritize tasking by taking into account that the EWSUP is the senior watchstander, typically responsible for mission planning, response coordination (including countermeasures management), sensor networking and cueing, EW doctrine, and overall coordination with the combat information center. The EWSUP may also be called upon to assist in the evaluation of problematic emitters and environmental conditions. However, the solution must also be dynamic and recognize and adapt to fluctuating shifts in workload resulting from the natural progression of complex engagements. The solution must also be flexible to the addition of future EW capabilities and assets. Finally, while it is not intended that the solution include embedded training, it should accommodate embedded training by including the ability to display Surface EW Team Training (SEWTT) controls from either the EWOP or EWSUP console so that the EW Training Supervisor or instructor can monitor and manipulate (i.e., start, stop, pause, reset, add elements, etc.) embedded training scenarios while in progress.

It should be noted that acceptable solutions should demonstrate a science-based knowledge of human perception, human cognition, team dynamics, and decision-making. "Hard wired" solutions that organize and manage the EWOP-EWSUP interaction based on fixed assignments and pre-prioritizations of functions are unacceptable. The goal of this effort is to complement and facilitate the relationship between the EWOP-EWSUP team in a manner that elevates their performance to a level that they could not otherwise achieve on their own. Testing will consist of controlled and monitored execution of the prototype solution with human operators utilizing surrogate display hardware. Final validation of the prototype will be demonstration of the workload sharing prototype on the surrogate display hardware, as witnessed by Government subject matter experts and program managers.

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 and/or subcontractor 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: Propose a concept for an EW workload organization and sharing application that meets the objectives stated in the Description. Feasibility shall be demonstrated by a combination of analysis, modelling, simulation, and evaluation of initial workload sharing use cases. The feasibility analysis shall include predictions of operator performance in use of the application. The Phase I Option, if exercised, will include the initial design specification, decision trees, and capabilities description necessary to build a prototype solution in Phase II.

PHASE II: Develop, deliver, and demonstrate a prototype of the concept for an EW workload organization and sharing application meeting the requirements contained in the Description. A software prototype shall be demonstrated on surrogate display hardware (supplied by the performer) and delivered to the Government along with full software interface descriptions and any ancillary software needed to demonstrate the application. It should be noted that this effort may require the development and delivery of synthesized EW scenarios and emitter data to be used in demonstration of the prototype solution. Government subject matter experts and program managers will witness demonstration of the prototype technology on the surrogate display system.

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 for Government use. Since the Phase II effort result is a prototype that is not necessarily demonstrated on a tactical system, assist in integrating the EW workload organization and sharing application into the EW display tactical code. Assist in certification of the resulting tactical code. Assist the Government in testing and validating the performance of the resulting application as integrated into the EWOP and EWSUP consoles.

The workload organization and sharing software can also be customized for additional applications such as other military systems (e.g., radar systems) and for commercial applications such as air traffic control systems, power grid control stations, train and mass transit dispatch systems, and complex security systems.

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KEYWORDS: Electronic Warfare; Workload Sharing; Decision-Making; Team Dynamics; Human Cognition; Embedded Training

N211-038 TITLE: Next Generation Laminated Bus Bar Technologies

RT&L FOCUS AREA(S): Directed energy

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Increase the reliability and confidence of laminated bus bars through the development of new insulation materials and Non-Destructive Testing (NDT) methods.

DESCRIPTION: DDG 1000 Class utilizes an Integrated Power System (IPS) to generate and distribute power to the propulsion system, ship service distribution system, and combat systems. Multi-layer, multi-conductor, laminated bus bars are used within the IPS system to distribute local high voltage (4160 VAC RMS) power distribution within switchboards, propulsion motors/drives, and other high voltage equipment. We currently use multi-layer, multi-conductor, laminated bus bars in the system.

While laminated bus bars are used throughout the power industry, recent bus bar failures have highlighted the need for new technologies that will increase the reliability of bus bars in a non-sterile, shipboard environment. ASTM B187 provides guidance for copper commercial bus bars. Development areas of interest are insulation materials, conductor-connection interfaces, and associated NDT procedures.

Bus bars must be capable of handling various voltages, frequencies and currents dependent upon their application including maximum layer-to-layer potentials of 10.5 kV peak to ground, +/- 6500 VDC, 60A and pulse width modulation (PWM)-switched output waveforms of 3300 VAC 0-18Hz 450A. Nominal PWM switching frequency between the range of 1kHz and 20kHz.

Installed bus bars must be capable of passing qualification testing for a shipboard environment including to MIL-S-901 Grade A, Type A, Class 1 Shock, MIL-STD-167-1 Vibration, and MIL-STD-810 for Temperature and Humidity. Bus bars shall be mechanically compliant / flexible to provide excellent resistance to stresses from the above shock and vibration standards as well as installation handling. Bus bars shall meet the requirements of MIL-DTL-23928.

Quality & Assurance (Q&A) processes and NDT technologies should be developed. This path will allow for the identification of insulation flaws prior to installation and the ability to verify bus bar condition through service life of current bus bars. High fidelity Q&A processes reducing the number of defective units being delivered to the fleet would increase confidence of delivered bus bars. Currently, partial discharge testing based on IEC 60270 is used to determine insulation material condition. New scanning technologies or test methods are needed to verify insulation condition which would increase confidence in in-service and spare bus bars.

PHASE I: Develop a concept for alternative insulation materials, connector interfaces, and NDT method in accordance with specifications and requirements outlined in the topic description section. Demonstrate the feasibility of the developed technology to meet the Navy's needs through material testing. The Phase I Option, if exercised, will outline the requirements and specifications to build prototypes in Phase II.

PHASE II: Based on the results of Phase I efforts and the Phase II Statement of Work (SOW), develop the prototype bus bar to meet the Navy's needs and verify in accordance with MIL-DTL-23928. Mature NDT technology and demonstrate the capability to detect bus bar insulation flaws. Demonstration/verification testing will occur at a company-provided facility. Refine the fabrication process and test procedure with a focus on creating consistent product to aid transition in Phase III. 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 bus bar technology to DDG 1000 class destroyers and future Navy high voltage systems. The final product will be capable of meeting 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.

The use of high voltage distribution systems and electric propulsion is becoming more frequent in the offshore and shipping industries. Reliable bus bars and the ability to verify manufacturing quality will be required to support this expansion. The technology developed to support the Navy is directly applicable to these industries and the shore-side power industry.

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KEYWORDS: Laminated Bus Bar; High Voltage Insulation; High Voltage Connectors; Shipboard Power Distribution; Partial Discharge Testing; Non Destructive Testing.

N211-039 TITLE: 24/7 Reachback Artificial Intelligence Support Environment for Antisubmarine Warfare (ASW)

RT&L FOCUS AREA(S): General Warfighting Requirements

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 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: Develop a 24/7 reachback artificial intelligence (AI) support environment to modernize anti-submarine warfare (ASW) in-service and logistics troubleshooting both to support the large variety of fielded baselines and configurations; enable machine learning to inform best fixes; and drive future design improvements to tactical sonar suites.

DESCRIPTION: A 24/7 Reachback AI Support Environment can modernize the in-service and logistics support (ILS) infrastructure so that sailors and ILS personnel have rapid alignment regarding the particular baseline and configuration in question. Commercial AI support tools are increasingly used in industry but these tools are specific to the industry in which it is created. The tools are needed for ASW support. The modernized environment would be based on an ontology that allows for data mining and machine learning regarding issues with greatest Fleet impact, both from a standpoint of understanding the breadth and scope of impact as well as elevating the most appropriate fixes.

As the 24/7 Reachback AI Support Environment accrues information, evidence collected could drive design improvements.

The technology sought will increase mission capability by accelerating resolution of system casualties identified by sailors across the many different fielded variants. The technology will also create a Navy-wide database on which artificial intelligence and machine learning can operate to identify root causes to inform future acquisition decisions related to improving system availability.

Navy surface combatants engage in anti-submarine warfare (ASW) using variants of the AN/SQQ-89, a complex system of systems composed of processing software, processing hardware, and sensitive sensor arrays. When operating properly, the ASW sensor suite gives a Fleet combatant a powerful capability to detect, classify, localize, and attack submerged threats.

The in-service and logistics infrastructure for the AN/SQQ-89 has evolved over decades, building on the Cold War sonar capability fielded in the 1950s as the AN/SQQ-26 sonar. In the two decades since the end of the Cold War, a majority of fielded AN/SQQ-89 systems were legacy systems, with problems that had remained relatively stable.

Initial introduction of the A(V)15 modernization to the AN/SQQ-89 in 2009 brought modernized capabilities that the Fleet welcomed, including introduction of the Multi-Function Towed Array (MFTA). The A(V)15 leverages commercial off-the-shelf (COTS) processing hardware. Though relatively

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inexpensive and very powerful from a processing standpoint, COTS infrastructure drives a relatively rapid pace of technology updates.

The rapid pace of updates required by COTS infrastructure has enabled introduction of numerous improvements. However, the proliferation of distinct variants has made the ILS challenge increasingly complex. Support personnel using infrastructure designed to support legacy baselines have identified potential for significant improvement in in-service and logistics support (ILS) outcomes should a modernized reachback capability be developed.

When problems arise, sailors seek reachback support from ILS personnel who work 24/7 to provide timely guidance to resolve Fleet casualty reports (casreps). When new parts are required, the ILS team speeds them on their way. It is crucial that communication between the Fleet and the ILS team is robust, ensuring that the ILS specialist is 1) troubleshooting based on the proper baseline and configuration and all pertinent data; and 2) ensuring that any replacement parts are appropriate to the baseline and configuration. As diagnosis of many system casualties involve interaction with displays, it is important that the ILS specialist have ready access to the particular displays associated with the system the Fleet sailors are attempting to fix.

The technology will be tested using the IWS 5.0 Advanced Capability Build (ACB) step testing process. The seminal transition event will be validation by the Government that the technology performs as required. Testing will include user exploration of the tool, examination of the fault isolation capabilities and associated accuracy, and comparison of the tool menus to the tactical system menus to ensure consistency.

Finally, the information accrued by the modernized reachback capability should be organized into an ontological framework that facilitates machine learning and artificial intelligence to enable analysis of casualties across the Fleet, their root causes, and prioritization of investments to make the overall system more robust. A particular challenge, required to be provided by the new tool, is providing timely and appropriate ILS for the MFTA. As a towed sensor, the MFTA operates hundreds of feet below the ocean surface, necessarily deployed and retrieved through the punishing conditions in the wake of the combatant. The OK-410 handling system associated with the MFTA, while robust, has numerous moving parts. The MFTA operates in the ocean depths where submerged threats often seek to hide, and is therefore particularly valued by the Fleet. Initial transition of the 24/7 Reachback AI Support Environment will likely focus on systems related to MFTA and other towed 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 Security Agency (DCSA). The selected contractor and/or subcontractor 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 24/7 Reachback AI Support Environment that meets the requirements in the Description section. The concept will show feasibility through analytical modeling; developing and documenting infrastructure concepts; proposed ontological framework; and architectures that support both sailors, ILS specialists, and analysts. The Phase I Option, if exercised, will include the initial system specifications and a capabilities description to build a prototype in Phase II.

PHASE II: Develop and deliver a prototype 24/7 Reachback AI Support Environment with embedded machine learning meeting the requirements for ASW as stated in the Description. Demonstrate the prototype performance across a subset of the total SQQ-89 ILS historical findings and demonstrate the prototype is fit for use by Fleet operators, ILS specialists, and acquisition analysts as discussed in the Description. If needed, coordination with the Government will occur to conduct testing at a Government or company-provided facility to validate the prototype capability. Data sets extracted from Cruiser/Destroyer casualty reports will be used to validate the prototype's capabilities. The Government will provide the data. Demonstration of the prototype performance will take place at a Government- or company-provided facility.

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 ASW. Demonstrate and report on performance during laboratory testing. Integrate the prototype into the IWS 5.0 surface ship ASW combat system ILS infrastructure, which will drive updates to sensor systems, handling equipment, and the Advanced Capability Build (ACB) program used to update the AN/SQQ-89 Program of Record.

This technology can be used to support a broad range of commercial and military industries where support originally designed for complex legacy systems needs to be modernized to include a proliferation of unique models.

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KEYWORDS: In-service and Logistics Support; Artificial Intelligence; Anti-Submarine Warfare; ASW; Machine Learning; Casualty Reports; Towed Systems

N211-040 TITLE: Submarine Deep Escape

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Biomedical

OBJECTIVE: Develop an innovative solution that will improve the ability to successfully accomplish single-man escape to 600 feet of seawater (fsw) of survivors from a disabled submarine and potentially increase the ability to provide safe deep escape beyond 600 fsw.

DESCRIPTION: All United States Navy (USN) submarines are provided with the equipment certified to support single-man escape of Disabled Submarine (DISSUB) survivors down to a depth of 600 fsw. This equipment is comprised of a flood valve, auto-vent valve, single-man escape suit, and an escape suit hood inflation system, among other components.

The escape trunks onboard are capable of supporting escape of two survivors (also referred to as 'escapers') per escape cycle. Two escapers, outfitted with escape suits, enter the escape trunk from the internal submarine compartment. After entering, the lower hatch of the escape trunk is closed and the escapers, using hood inflation valving connected to a 700-pound ship's service air source, inflate the escape suits. The escape suits fully inflated provide up to 70 pounds of buoyancy to each escaper. This buoyancy is to allow for the rapid ascension of the escape suits are fully inflated, the escape trunk flood valve is opened to fill the trunk with external seawater up to the trunk auto-vent valve. The auto-vent valve is calibrated to ensure that the flooding of the trunk stops at a pre-determined level and when the auto-vent valve fully lifts, the rapid pressurization cycle of the remaining air bubble begins. At 600 fsw, the pressurization cycle is designed to be no greater than 20 seconds before the escape trunk pressure is equalized with the external sea pressure. Once equalized, the upper hatch opens and the escapers automatically exit the upper hatch and ascend to the surface. The design of the escape suits allows the escaper to breathe normally during ascent.

Human subject testing has been successfully accomplished to prove the capability of escape down to 600 fsw. However, that testing highlighted that it is physically challenging and as the depth of the escape is increased, the risks associated with decompression obligations and mortality increase exponentially. In addition to the body's ability to withstand the designed rapid pressurization, the ability to withstand the heat loads generated by the pressurization cycle is also of a concern. Although the mortality risk increases significantly as depths exceed 600 fsw, it is anticipated that successful escape may be achievable, based upon experimental trials and the theorized mechanical robustness of the submarine escape system and escape suits. At this time, escape protocols only allow for escape from depths greater than 600 fsw in situations when impending death is inevitable if survivors do not initiate immediate escape. Due to advances in technology and biomedical research, it may be possible to decrease the associated risk with escape from deeper depths.

The rescue of survivors from a DISSUB is the preferred method for the Navy. However, internal conditions of the DISSUB may require some, if not all, of the survivors to initiate escape in lieu of waiting for rescue forces to arrive. The time necessary to mobilize rescue forces may be in excess of the available time for survivors to remain onboard the DISSUB. Due to the risks associated with deep escape, the program office is in need of technology that will decrease the risks associated with escape to 600 fsw and potentially increase the ability to provide safe escape deeper than 600 fsw with an objective to allow

for reasonable safe escape to 1000 fsw. This may involve addressing the physiological stressors associated with deep escape, the mechanical components used to accomplish escape, or a combination of both.

In addition to being a safety and duty of care issue, continued advancement and modernization of the USN Submarine Escape and Rescue Program is considered an Assistant Secretary of the Navy core field in support of the larger Undersea Warfare and directly aligns to both the National Defense Strategy and the Submarine Commander's Intent by defending the homeland, enabling interagency counterparts to advance U.S. influence and national security interests, ensuring USN submarine warfighting readiness and survivability and strengthening alliances and attracting new partners. The latter was highlighted in the geopolitical outcome following the USN Submarine Escape and Rescue response to the ARA SAN JUAN incident in November 2017.

PHASE I: Develop a design concept, with notional feasibility determined via computer based modeling and simulation, that will support a conceptual solution that improves the ability to escape to 600 fsw and potentially increases the ability to provide safe deep escape beyond 600 fsw. Considerations of the potential design concept should include internal compartment space constraints and minimal increase to stowage requirements, maintenance requirements, and lifecycle costs. 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 the Phase I and the Phase II Statement of Work (SOW), develop a breadboard design based upon the conceptual solution, including the major components identified, to provide a representative simulation of the proposed solution. Following breadboard testing, refine, as necessary, the design to build and deliver one reduced scale prototype for testing. Due to risks associated with human subject testing, all testing accomplished will be via modeling and simulation in a computer-aided or laboratory environment. The ability to use human subjects in a lab-created or real-world environment would require approval beyond the scope of the SBIR program.

PHASE III DUAL USE APPLICATIONS: The dual use application of proposed technology is dependent upon the technology identified. However, the ability to decrease the risks associated with escape from a USN Submarine has follow-on benefits to partner ally submarine forces and other organizations who support confined space personal recovery, both within and external to the USN and DoD. Conduct further testing and certification in accordance with requirements set forth by the USN Undersea Medical community. It is anticipated that this certification will require human subject testing to be performed at the Pressurized Escape Submarine Tower (PSET) and/or Navy Experimental Dive Unit (NEDU).

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- "Submarine Rescue Diving and Recompression System Operational Requirements Document." Chief of Naval Operations, Serial Number 489-87-98, 3 Jun 1998. https://www.navysbir.com/n21_1/N211-040-REFERENCE-2-Operational-Requirements-Document.pdf

KEYWORDS: Submarine Rescue; escape from 600 fsw; submarine escape suits; rapid pressurization; decompression; submarine escape trunk

N211-041 TITLE: Compact Cryocooler for Maritime Operations

RT&L FOCUS AREA(S): Directed energy

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 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: Develop a scalable, compact, high-efficiency, low-cost, cryocooler capable of operations in maritime environments.

DESCRIPTION: Superconductivity is a unique state of matter, where at cryogenic temperatures a material has near zero resistance allowing a large current to pass through a relatively small wire. The ability to pass large currents through the wire enable it to be used for magnetic applications. Two temperature ranges of superconducting materials exist as low temperature superconductors (LTS) and high temperature superconductors (HTS). HTS materials begin to transition from a resistive to zero resistance superconducting state around 100 K, while LTS transition begins at much colder temperatures typically below 15 K. The exact transition temperature is material specific; however, regardless of material, superconductive systems require cryogenic environments. The elevated operating temperature of HTS makes the cryogenic cooling systems orders of magnitude more efficient than LTS.

The Navy plans to use HTS in several application including degaussing operations of large surface combatant ships. These systems require large cryocoolers and are less sensitive to the impacts of cryocooler size, weight, and efficiency than tactical applications. As the Navy explores future smaller-scale applications, there are commensurate requirements for novel compact cooling solutions. One such area is the Navy's development of superconducting magnets on the order of 6" to 24" diameter that will require cooling to cryogenic temperatures between 20-50 K with 40-80 W of available cryogenic cooling power. These magnets can serve a multitude of different applications and may be subject to varied operational environments.

Currently, commercial cryocooler technologies exist that can provide cooling on the order of 20 W at 60 K within a total system volume of 320 in3 and mass of 6.4 kg. Configuration of these coolers allows the entire cryocooler package to fit in a 5" diameter envelope. In addition to being small profile, these coolers boast a mean time to failure (MTTF) of 120,000 hrs, giving them excellent long-term reliability. Prior Navy developments targeted large-scale applications of superconductivity requiring cryocooling solutions from 300 to 700 W at 50 K, with targeted efficiencies of 30% of Carnot. Currently there is an order of magnitude gap in cooling capacity between COTS technology and the Navy-developed technology that attains high levels of efficiency.

The Navy is seeking technical solutions that can provide scalability to bridge the gap between the existing cryocooler technologies and the anticipated requirements to field future systems. The Navy anticipates several environmental constraints that will be imposed on the cryocooling technology including various mounting angles, changes in gravitational orientation due to platform roll and pitch, large shock forces, and operation in a high magnetic field environment, on the order of 2 T. Consequentially, any fully

realized product needs to pass military shock requirements as listed in MIL-S-901D Grade A and military vibration standards established in MIL-STD-167-1A. Any product also needs to function independently of gravitational orientation (full 360 degrees, six degrees of freedom) and in the presence of magnetic fields approaching 2T. A viable solution must also be capable of operation with a range of cooling water temperatures from 4°C to 40°C. The solution should be less than 350 in3 total volume while fitting within a 6 in diameter container, weigh less than 6 kg and possesses the ability to operate where input power availability maybe greatly diminished. Therefore, designed efficiency targets should be greater than 25% of Carnot. The technical solution should include flexibility to be designed around input power that may include DC (12V, 24V, 48V), or AC (single-phase 120 V, or three-phase 440 V). The technical solution should target approximately 100 W (± 20 W) of cooling at 50 K validated by experimental testing, which will include the injection of heat and temperature recording of the cryogenic space.

PHASE I: Develop a concept and complete a feasibility analysis of the cryocooler concept to meet desired performance specifications detailed in the Description. Design and manufacturing concepts should be assessed through modeling, analysis, and benchtop testing. Size, weight, nominal performance at design as well as capacity map from no-load to 300 K, and input power shall be documented. Perform a cost estimate for both prototype development and full-scale production. The Phase I Option, if exercised, includes a detailed design and specifications to build a prototype during a Phase II effort.

PHASE II: Develop, design, and fabricate a functional prototype of a compact cryocooler based on the results of the Phase I and Phase II Statement of Work (SOW) and complete characterization testing of key performance parameters at the proposer's facility or other suitable test center identified by the proposer. The designed capacity map developed in Phase I shall be updated and experimentally validated through testing of the initial prototype. Deliver the prototype to the Navy for further testing, along with maintenance and integration relevant designs and drawings. Test results, lessons learn, and design update recommendations derived from lessons learned during prototype testing shall be integrated into an additional prototype unit.

PHASE III DUAL USE APPLICATIONS: Aid in the transitioning of the technology for Navy use, as well as engage in market research, analysis, and scouting of potential industry partners to stand up production level manufacturing capabilities and facilities. The final product will be tested and verified for Navy use through the completion of qualification according to the relevant military specification and standard documents. This technology has value in any compact cryogenic application, including; to portable magnetic resonance imaging (MRI) systems, superconducting magnetic energy storage (SMES), and a wide variety of other applications, both commercial and military.

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KEYWORDS: Compact Cryocooler; High Temperature Superconductor; HTS; Superconductivity; Cryogenics; Magnetics; Cryo-refrigeration; low temperature superconductors; LTS

N211-042 TITLE: Sensitivity and Resolution Improvements for Small-Aperture Marine RADAR

RT&L FOCUS AREA(S): Directed energy

TECHNOLOGY AREA(S): Sensors

OBJECTIVE: Achieve higher detection sensitivity and angular resolution in small-aperture marine RADAR applications.

DESCRIPTION: Modern submarine navigation systems leverage commercial off-the-shelf (COTS) magnetron RADAR technology to detect moving vessels and distant shorelines. In this architecture, long-range detection sensitivity is limited by the effective radiated power (ERP) of commercially available RADAR products, many of which have been discontinued or experienced power reduction in recent years due to the emergence of low-cost broadband and pulse compression devices. Furthermore, submarine surface navigation RADAR systems must operate within a pressure proof volume (i.e., "pod") that remains permanently mounted on a penetrating mast. There are acquisition and shipbuilding advantages to using smaller pod volumes, and therefore smaller antennas, but this comes at the expense of angular resolution, which degrades with shorter diameters. The use of large and powerful open array marine RADARs is not practical in these applications, yet International Electromagnetic Commission (IEC) standards still require strict RADAR performance against small, distant and closely spaced contacts. This puts IEC compliance out of reach for these small-aperture RADAR systems.

The Navy seeks innovative concepts that increase detection sensitivity and angular resolution of small aperture RADARs without breaking the pod-based sensor model. Reliable detection and resolution of navigation buoys (5 m2), small vessels (2.5 m2) and channel markers (1 m2) is required at IEC compliant ranges. The challenge is to overcome physical sensor limitations by using new architectures, innovative apertures, or digital processing to improve detection and resolution performance on these required targets. Doppler beam sharpening (DBS) algorithms can improve bearing resolution and are now available digitally in commercial marine RADAR products. Further resolution improvement is attainable using knowledge-aided DBS techniques. Sensitivity improvements are achievable using minor modifications to COTS devices. For example, the incorporation of low-noise amplifiers, coherent processing threads, or multi-static/netted sensor architectures all offer sensitivity advantages. The use of frequency and phase-modulated waveforms is shown to provide predictable improvements in processing gain and range resolution. The technology introduced by this topic will help retain navigation RADAR performance for the warfighter without forfeiting the cost and shipbuilding advantage of small and COTS-based designs. This technology is also applicable to the commercial RADAR industry as a means of reducing sensor size and improving the standard for safe navigation.

In the submarine application, the available volume for a rotating antenna is less than 20" in diameter and 8" in height. Analog-to-digital conversion must be performed within the sensor pod using a commercial RADAR processor assembly or similar small form factor device that would fit in a 20" diameter by 3" high volume. Digital RADAR video and data processing outputs will be distributed from the pod to inboard processors, so low network speeds (10 GbE or less) are preferred to enable integration with legacy platforms. Solutions that rely on commercially available components are preferred because of cost and availability, but not required. Digital processing capabilities must be implemented on Government-furnished servers or field-programmable gate arrays (FPGA) using open interface standards to allow periodic and modular software/firmware upgrades.

PHASE I: Conduct innovative research, design, and modelling to demonstrate the proof of concept. Evaluate the feasibility of using the concept to improve sensitivity and resolution of small-aperture X-band RADAR. The concept shall include simulated performance analysis, performance estimates for

achievable angle resolution, and range of first detection of required targets identified in the Description Section. Develop system architecture diagrams to identify technical challenges, risks, and any cost/performance trades associated with the technology. The Phase I Option, if exercised, will include development of the capability description, design specifications, and performance requirements for a Phase II prototype.

PHASE II: Mature the concept by building and testing a functional prototype based on the Phase I design and the Phase II Statement of Work (SOW). Conduct demonstrations and collect measurements in simulated and over-water environments to validate the prototype. Ideally, Phase II testing will consist of field measurements that demonstrate the ability to meet Phase I performance predictions and applicable IEC 62388 performance metrics in a relevant over-water environment. Controlled laboratory experiments may also be used to verify and validate performance estimates where field measurements are not practical. Develop a transition plan for technical insertion on Navy platforms, and report on the overall commerciality and suitability of the prototype for tactical fielding. Transition the final solution to appropriate platforms and end users.

PHASE III DUAL USE APPLICATIONS: Assist the Navy to transition the concept from prototype development to full production. The final design will be produced with tactical form, fit and function. Factory acceptance testing is expected to formally verify system performance and survivability against MIL-STD-167-1A, MIL-STD-461F, MIL-STD-464C, and MIL-STD-810G environmental standards.

The targeted platforms for Phase III transition are VIRGINIA and COLUMBIA class submarines, and so a temporary alterations (TEMPALT) fielding may also be used to reduce production technical risks. While the primary motivation for this technology is to improve performance of military marine RADARs, commercial applications also exist in any industry where a sensor aperture is limited by physical constraints, for example, small aperture RADARs are used in modern automobiles to automatically detect and resolve moving objects, predict collisions, and assist in driver decision making. Similarly, the use of commercial unmanned aerial vehicles (UAVs), or drones, has gained interest in many service industries. The technology described in this topic can be used to improve the performance of electromagnetic sensors in these non-military applications.

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KEYWORDS: Marine RADAR; Beam sharpening; Frequency Modulate Continuous Wave; FMCW; Collison Avoidance; Coherent integration; Field-programmable gate arrays; FPGA

N211-043 TITLE: Intelligent Corrosion Simulation and Design Tool

RT&L FOCUS AREA(S): Machine Learning/AI

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop an Intelligent Corrosion Simulation and Design Tool that will read Computer Aided Design (CAD) drawings, select the corrosion modes that the materials are likely to encounter, and assign the service environment to the selected computational engine.

DESCRIPTION: Currently available commercial options for computational corrosion modeling are based on modeling approaches that require detailed materials science knowledge for the end users, apply narrowly focused subset of relevant corrosion modes for materials of interest, and are not context sensitive to select which modes of corrosion are most likely for materials of interest.

The cost of corrosion to the Naval fleet exceeds \$9.5B/year, with 40% of that cost avoidable with improved corrosion design. The current state of the art for computational corrosion simulations requires the end user to have advanced knowledge of materials science, service environment chemistry and corrosion countermeasure options. Designing warship subsystems for corrosion cost avoidance requires detailed knowledge of construction material performance to each mode of corrosion damage, service environments in which the materials are intended to be used, available corrosion countermeasure technologies, and ownership costs associated with these decisions.

The Navy seeks development of an intelligent modeling environment, which is agnostic to the source of materials properties data allowing user-definable corrosion materials properties, user-definable corrosion modes/mechanisms, user-definable behavioral relationships between properties & environmental stressors; and provides an integrating platform to connect these corrosion modes/mechanisms to specific materials & geometries read from Computer Aided Design (CAD) data inputs. This would create a corrosion information ecosystem allowing corrosion behavior modes/mechanism relationships to be developed under a technical community crowd-sourcing paradigm, and aid in the development of an integrated Naval corrosion simulation paradigm. The Navy intends to leverage the skills and expertise of a broad base of materials science specialists from academia, industry, and DoD subject matter experts in creating a diverse toolbox of available corrosion simulation engines.

The objective of this SBIR topic is to create an intelligent corrosion tool that can store (and retrieve) a complex dataset along with key materials information and use cases that would trigger selection of specific corrosion simulation engine. The tool would also create an interface to assemble the information from a designer's CAD drawing/modeling environment in order to implement the proper corrosion simulation engine. Specifically, the tool must adequately incorporate modules that accommodate: (1) the materials of interest, derived from CAD packages, (2) the service environment corrosion severity, (3) mechanisms of material corrosion and driving physical parameters for such, and (4) handoff parameters for incorporating these mechanisms into external modeling codes.

Implementing advanced analytics into warship design requires simplifying access to the simulation engines that can perform these analyses. This intelligent tool will have the capacity to read a designer's drawing and extract the key information parameters that may be required to hand over to a corrosion simulation engine. The tool will have capabilities to down select which CAD dimensions, materials, coatings, corrosion countermeasures, etc. are required to evaluate the design against a specific mode of corrosion attack. The tool will also house a cursory analysis module that allows a design engineer to evaluate which modes of corrosion attack are most likely in the specified design, prior to conducting rigorous simulations to determine their severities.

This effort will leverage the Navy-owned materials database as well as materials data or behavioral characteristics to the corrosion database from academia, industries and DoD partners through an interface provided by the developer. The intelligent tool will have clear guidelines on how the data or algorithm must be implemented to be of value to the Navy and provide a means to assess cost avoidance through improved design changes.

Requirements:

1) Develop a concept for an Intelligent Corrosion Tool that will develop and demonstrate a computational database architecture that can store and retrieve user-specified material properties and behavior equations for specific materials corrosion modes; and is searchable in context of the material, corrosion mode, corrosivity of the environment, and other user-definable contextual parameters.

Demonstrate the ability to gather key geometry and materials information from a component drawing file, reading Standard Triangle Language (STL)-based drawings designed in commercial CAD software.
 Allow designation of a "Service Zone" or "Service Environment" based on selecting service parameters from a diagram of a ship/submarine diagram where the component is intended to operate or corrosion severity zone selection. Extract and assemble key information required to exercise corrosion simulation models.

4) Demonstrate the ability to read multiple CAD drawings, identify materials and potential corrosion modes, automatically prepare model preprocessing files, and interface files for commercial modeling tools including geometry and modeling parameters.

5) Demonstrate the ability to capture cost avoidance data from corrosion countermeasures simulation results.

6) Incorporate logic to evaluate drawings/designs against the US Navy's Corrosion Control and Design Criteria Manual – a wide ranging design document that outlines best practices for robust designs and corrosion cost avoidance.

As part of Phase III, the products will be included in the anticipated Future Naval Capability (FNC) program as a key component that can be utilized by ship designers to enable corrosion-informed materials selection and design.

PHASE I: Develop a concept for a tool that will satisfy requirements 1, 2, and 3 in the Description.

Perform testing and certification using materials properties and drawings supplied by the Navy. Demonstration must include exercising the Intelligent Corrosion Tool against a prototypical working CAD model of a section of the ship's hull and cathodic protection system to capture corrosion interactions between wetted materials. The Intelligent Corrosion Tool will then return this information to the user in a distilled format. Phase I Option, if exercised, would include the initial layout and capabilities description to build the unit in Phase II.

PHASE II: Based on the results of the Phase I and Phase II Statement of Work (SOW), develop the Intelligent Corrosion Tool that incorporates requirements 4, 5, and 6 in the Description.

Testing and verification for the tool will include analysis of prototypical CAD drawings and comparison against the user-provided materials properties/corrosion modes database. Successful outcomes will involve selecting multiple potential corrosion modes for the materials and geometries included in the CAD drawings, and down select the most likely corrosion mechanism occurrences in the presented scenarios based on the CAD drawings and user-supplied materials database. The tool will then compile the necessary information in order to hand off corrosion mode simulations to commercial/Navy specific analytical packages that are consumers of pre-packaged information provided by the Intelligent Corrosion Tool.

PHASE III DUAL USE APPLICATIONS: Dual Use Applications for the Intelligent Corrosion Tool will naturally evolve from a demonstrated ability to incorporate corrosion cost avoidance into design practices. Engineering design processes for naval warships are similar to engineering design processes for non-military vessels, and many partners that design/build components for the Naval fleet also design/build components for non-military customers, such as automotive, aerospace, oil & gas, and piping industries.

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KEYWORDS: Corrosion Model; Corrosion Simulation; Open Framework Architecture; Corrosion Database; Computer Aided Design; CAD Drawing; Corrosion Informed Materials Selection and Design

N211-044 TITLE: Inflatable Deployable Sail Systems for Future Submarines

RT&L FOCUS AREA(S): General Warfighting Requirements

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 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: Develop technology that will advance traditional submarine design toward accommodating an Inflatable Deployable Sail System (IDSS) for future submarines.

DESCRIPTION: A submarine designed without a sail would have inherent advantages in submerged operations over a design with a sail in the areas of speed, maneuverability, and acoustic stealth. However, until a solution can be found to safely navigate a submarine without the height of eye and visibility afforded by a sail, no such design can be entertained. Advances in inflatable structures can provide the freeboard needed for surface transit with a temporary and reusable structure. Maturation of this technology will open up the SSN(X) design space to entertain submarines that can operate submerged without the impediments of a sail.

The submarine sail is an integrated structural platform that hosts various Undersea Warfare (USW) systems and equipment including periscopes; communication antenna masts; acoustic, electromagnetic and radar sensor systems; exhaust ports; and crew access/escape trunks. The sail connects the bridge to a secondary (non-pressure) hull that, in turn, connects to the pressure (primary) hull. Crew hatches are positioned at each boundary interface along the sail access/escape trunk. The sail vertically offsets the bridge from the primary hull to provide a specified freeboard. Each submarine class in today's USN Fleet incorporates a fixed rigid sail structure. These traditional sail structures provide a manned bridge that enables the crew to command, communicate and control operations remotely from the internal control room while affording necessary height of eye and on-ship visibility to facilitate surface transits. The sail structure also provides freeboard necessary to enable vertical and underway replenishment (VERTREP and UNREP, respectively) operations without flooding the primary hull.

Sail geometries are optimized for their hydrodynamic performance to minimize flow-induced noise, vibrations and wake effects by using faired leading and trailing edges and, for specific class variants, optional cusp fairings. Unlike the Seawolf, Virginia, and improved Los Angeles class submarines, variants such as the Ohio, original Los Angeles, and Columbia classes incorporate articulating dive planes external to the sail.

The structural loadings, deployment/retrieval operations and stability mechanisms required present significant design and material challenges for an inflatable and deployable sail. NAVSEA's design objectives for future submarines are to explore and innovate sail concepts, including development toward achieving an Inflatable and on-demand Deployable Sail System (IDSS) that is capable of controlled deployment from and stowage inside the secondary hull. The IDSS shall primarily be used for manned bridge operations with a crew access/escape trunk only and will not house the aforementioned USW systems and related equipment.

There are many dimensional and configuration constraints exist for IDSS: The sail dimensions for deployable assembly should have a minimum 16-ft freeboard (other dimensions as necessary for manned bridge capabilities that match current submarine sails); Crew bridge capacity should be at a minimum of 2 crew shoulder-to-shoulder forward of bridge hatch with minimum of 2 crew shoulder-to-shoulder rear of bridge hatch; Bridge and pressure hull hatches should be 30-inch inner diameter; Bridge should have power, lighting and communications (from pressure hull to bridge) and conduits, flip-up windshield, storage lockers, etc.; Crew access/escape trunk (connects pressure hull hatch to bridge hatch), include ladder system; Wave slap should have uniform pressure loading; Bridge weight should be 4,000-lbs maximum; Sail external vertical loads must include weight of ice, etc.; Ice and foreign object impact protection; Ballistic protection (small arms fire); Positive locking stowage configuration.

The minimum operational constraints for IDSS are: Inflatable actuation (potable water, seawater, air/water combination); Operational cycles of 10,000, Deploy/stow at 0.0 knots from periscope depth with cross flow of 5.0 knots; Maintain shape at periscope depth in cross flow velocity of 5 knots; Deploy/stow at surface at vessel speed of 5.0 knots; Deploy/stow during range of sea states (operational to SS6, survivable to SS8); Provide pressure relief for internal pressure exceeding 2.5x ambient pressure within 5.0 seconds; Safety factors for inflatable components: 4.0; Deployment time of 1.0 minute; Stowage time of 1.0 minute; Deflection limits at full deployment shall be 5.0-inches yaw, pitch, roll with respect from bridge to secondary hull (existing fixed sails are stress-limited); and Temperature range of -60°F to 150°F.

The current state of inflatable soft structures technologies can provide unique solutions to the many challenges limiting today's USW operations, capabilities and system designs. Inflatable soft structures have been successfully developed for DoD, NASA, and industry and are generally categorized in the following sectors: Inflatable control surfaces, deployable energy absorbers, and temporary on-demand structures.

Successful design and performance of soft inflatable structures is attributed to technological advancements derived from: High Performance Fibers (HPF) including, but not limited to, Vectran®, DSP® (dimensionally stable polyester), PEN (polyethylene napthalate), Spectra® (ultra-high molecular weight polyethylene), Kevlar®; Novel fabric architectures and 3-dimensional woven preforms capable of unique mechanical behaviors; Continuous weaving processes for elimination of seams in inflatable structures; Robust Physics-Based Modeling (PBM) methods with Fluid-Structure Interaction (FSI) capabilities including FEA and CFD; and material test methods for characterization of multi-axial and pressure-dependent mechanical behaviors for inputs to numerical models.

Collectively, these advancements have established a sound technology base; one that can be leveraged for innovative solutions to soft structure designs requiring significant load-carrying capacities, shock mitigation, dynamic energy absorption, rapid deployment, large deployed-to-stowed volume ratios, and fail-safe modes of operations.

The Inflatable Deployable Sail Structure (IDSS) shall consist of a generally soft or soft/rigid hybrid inflatable structure with a rigid or hybrid rigid/inflatable bridge. The IDSS will connect to the submarine's seawater pump interface (SPI) and air flask interface (AFI). The tube seawater pump and air flask shall be used to control inflation and deflation of the IDSS with seawater and air as the possible inflation media.

The soft structures considered for use in developing the IDSS may include, but are not limited to, control volumes constructed of inflated membranes, 3-D woven preforms, flexible bladders, coated fabrics, and hybrid (soft/rigid) material systems, and hard goods-to-soft goods connections. Hybrid inflatables may

include inflatable elements with semi- or fully-rigid reinforcements serving as deployment shaping controls, and abrasion resistant contact surfaces. The pressurization media for all inflatable components will be limited to seawater and air.

Structural testing of the IDSS concept shall be required to validate the operational performance and resistance to wave slap loading using a full-scale IDSS prototype and in accordance with stated objectives using air, water, or both as the inflation media. The tests shall demonstrate: Test-1: deployment from the stowed to the fully deployed (operational) configuration. Test-2: resistance to wave slap and impact loadings along the port and starboard athwart ship directions and the fore and aft longitudinal directions when fully deployed. Test-3: retrieval from the fully deployed configuration to the stowed configuration.

The company shall identify recognized issues and propose resolutions affecting operational performance and reliability, crew and system safety, environmental exposure effects (temperature, cyclic fatigue, UV, abrasion, puncture, impact, biofouling, chemical/biological, etc.) and maintenance concerns including crew accessibility and repair methods. Failure modes effects analyses (FMEA) shall be performed for the primary structural and inflatable components.

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 and/or subcontractor 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: Create a virtual design concept for an IDSS including a Concept Feasibility Analysis (CFA). The CFA shall assess the IDSS concept using Finite Element Analysis (FEA) to characterize the structural response and stability for hydrostatic, hydrodynamic, wave slap, ice and foreign object impact loading events. Additionally, Computational Fluid Dynamics (CFD) modeling shall analyze the hydrodynamic and flow noise/vibrations responses. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build and test a prototype solution in Phase II.

PHASE II: Optimize the IDSS design based on the results of the Phase I and Phase II Statement of Work (SOW) including material selections for the soft structural components, pneumatic/hydraulic layout design and manifolding, inflation/deflation sequencing, porting to the submarine's seawater interface pump and air supply flask, hard-to-soft-goods connections, power, data and lighting connections to the pressure hull, environmental factors. Identify and document all operational, safety, environmental and maintenance issues as recognized during development of the proposed IDSS design. Perform risk identifications, risk assessments, and risk mitigation plans from the concept development stage.

Build a full-scale structural prototype of the proposed IDSS and test to validate the above requirements. Correlate the results of models developed to those obtained from the prototype tests, including deflections, reaction forces and the pressure-time histories for each inflated component and loading direction.

Deliver the prototype IDSS to the NAVSEA designated Warfare Center(s) for testing in accordance with the stated operational requirements.

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: The technologies are applicable to future underwater weapons, Unmanned Underwater Vehicles (UUVs), Unmanned Surface Vehicles (USVs), and commercial/industrial dual use. All technologies including designs, material data, manufacturing methods, prototype test results, etc. developed under this topic shall be transferred to the Navy for transition to future submarines, UUVs, USVs and underwater weapons. Potential commercial applications include adaptable and deployable structures for the construction industry, Lighter-Than-Air (LTA) ships, space vehicle structures (including deployable control surfaces) and habitats, civil infrastructure protective systems (land, air and port barriers; levee sealing and erosion repair), chemical/biological containment systems for internal use aboard aircraft and mass transit ground vehicles, blast/shock mitigation and impact energy absorption devices), and maritime safety systems (rescue and buoyant recovery platforms).

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KEYWORDS: Submarines; Submarine Sail Structures; Soft Structures; Inflatable Structures; Fabric Structures; Technical Textiles; Inflatable Deployable Sail Structure; Deployable Submarine Bridge; IDSS

N211-045 TITLE: Extended Life and Low Maintenance Aircraft Tie Down Fitting

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop an extended life, low maintenance, affordable aircraft deck tie down fitting for aircraft carrier applications.

DESCRIPTION: Aircraft securing fittings (commonly refer to as "deck tie-down fittings") as part of flight deck provides an attachment point for onboard aircrafts (i.e., fighter jets, auxiliary planes, helicopters) to prevent movement of aircraft, equipment, or materials due to ship movement and wind. It is essential that the aircraft and equipment be secured in a manner to prevent motion in all directions aboard the ship. Depending on the sea state and weather condition, on average 4 to 12 deck tie-down securing points are used for securing an aircraft. A typical configuration of a deck tie down fitting assembly consists of a crossbar welded onto a fitting cup, which is typically manufactured from heat treatable low alloy steel, and welded onto the flight deck. In aircraft carrier applications, a five-crossbar type tie down fitting is welded directly onto a deck, which is the application of focus under this SBIR topic.

For corrosion protection from marine environment, a coating of military specification grade polyamide epoxy primer is applied on both the crossbar and fitting/deck, post installation; however, due to a constricted access point for paint application and exposure to heavy abrasion during service, the coating is prone to damage. As a result, the corrosion and abrasion of the steel flight deck tie down assembly, especially on the crossbar, has been a persistent issue, leading to severe degradation on ship readiness and increased maintenance burden. A more durable flight deck tie-down fitting needs to be developed for the aircraft carrier application. Durability of the new flight deck tie down fitting must be able to withstand the corrosive marine environment, abrasion and impact from the securing hook and support a significant reduction in maintenance requirements than the current version of the deck tie down fittings to reduce the maintenance burden. The new flight deck tie down fitting must be affordable to support a reduction in total ownership cost during its life cycle. The affordability needs to be addressed both on the material and labor cost front, for the overall economic feasibility.

There are several types of Navy-approved aircraft secure tie down fittings conforming to NAVSEA Drawing 803-1916300 (Hull Standard Drawing Aircraft Securing and Engine Run–Up Fittings). On aircraft carriers, five crossbar fitting Type VIII is installed for providing an additional pull strength for securing aircrafts and equipment aboard the carrier. Type VIII tie down fittings are welded onto the deck, instead of welding onto a fitting cup as previously mentioned. Dimensions and requirements data for deck tie down fittings are covered under the referenced NAVSEA drawing. This NAVSEA drawing is not available on internet on public domain; however, a commercial version of this specific tie down fitting is available through a commercial vendor and their relevant design information [Ref 1]. It is noted that the referenced NAVSEA drawing (803-1916300) supersedes any existing discrepancy on dimensions and design requirements between the two drawings. Replacement of a failed or degraded secure fitting is a significant driver for cost and maintenance burden due to the high number of flight deck tie down fittings installed and the required replacement rate of several hundred tie down fittings for supporting mission operation and readiness.

The Navy is seeking a more durable (e.g., fabricated from a material that is more resistant to corrosion and abrasion than current steel when exposed to seawater and marine environment) deck tie down fitting that would support a form, fit, function replacement of the legacy steel tie down fittings (five crossbar Type VIII version only) on aircraft carriers. This also includes replacement of the two deck lugs installed

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between the two crossbars for each tie down fitting installed on landing areas of the flight deck with the same corrosion resistance and durable lugs.

The Navy requires tie down fittings that have similar strength as the current fittings (4130 grade steel), are also resistant to corrosion, and wear for a minimum service life of 25 years or more with desirable target of 50 years for supporting entire life cycle of an aircraft carrier. While in service, 100% of the tie down fittings are inspected with a go/no-go gauge per Navy maintenance inspection procedure. The go/no-go gauge is intended to inspect for a reduction in thickness of the crossbar below the required minimum level due to degradation from corrosion and wear/tear while in service.

Dimensions: For this SBIR topic, the only applicable flight deck tie down fitting is five crossbar Type VIII, which is the most common type installed on aircraft carriers. The commercial equivalent of Type VIII and the relevant design parameter is available for access and view online through the commercial vendor's website. Due to limitation of flight deck configuration, increase or scaling up of the tie down fitting design cannot be supported and will not be considered as a potential solution.

Load: Refer to the flight deck tie down fitting pull test requirements in System Requirements section above.

Shock: N/A as flight deck tie down fitting is considered as a part of the overall ship structure and not subjected to a separate shock requirement.

Vibration: N/A as flight deck tie down fitting is considered as a part of the overall ship structure and not subjected to a separate vibration requirement.

Welding: Cross member material must be compatible to be welded/joined to high strength steel and minimal heat control processing to support in service replacement. In order to meet the minimum heat control-processing requirement, material selection consideration must include a base material/filler metal not subject to heat-affected zone hardenability and hydrogen cracking. Final weld to meet nondestructive testing, such as visual and dye penetrant inspection to acceptance standards, and load testing are requirements for a successful tie down fitting. Minimum requirements for the fabrication and welding design for ship structures are covered in MIL-STD-1689 and provides general welding and inspection requirements for the tie down fittings.

PHASE I: Develop a concept for a corrosion resistant and durable aircraft deck tie down fittings for aircraft carrier application. Describe how the technology will be implemented, provides cost ranges for the systems, and provides notional shipboard implementation. Conduct both literature review and testing of material properties to meet various Navy requirements. (Note: Navy can provide guidance document to selected performers.) Establish feasibility by material testing and/or through analytical modeling. Phase I Option, if exercised, should include the initial specifications and capabilities for the technology to be developed in Phase II.

PHASE II: Produce 15 prototype aircraft securing fittings for delivery and evaluation to determine its capability in meeting the performance goals defined in the Phase II SOW and the Navy requirements specified under NAVSEA Drawing 803-1916300 (Hull Standard Drawing Aircraft Securing and Engine Run–Up Fittings). Ensure that the prototype material can be welded to high strength steel with qualified welding procedures in accordance with the appropriate Navy specific requirements for welding on high strength material. Demonstrate performance through prototype evaluation and testing over the required range of parameters (i.e., accelerated corrosion, wear, weld-ability, and mechanical properties) including numerous deployment cycles to verify test results. For mechanical properties, ensure that the fitting satisfies the pull strength requirement specified in the NAVSEA Drawing 803-1916300 applicable to

Type VIII tie down. Using the evaluation results, refine the prototype into an initial design that will meet Navy requirements. Prepare a Phase III development plan to transition the technology for Navy use.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Navy use. Support the Navy for test and validation to certify and qualify the system for Navy use. The technology must be transitioned to the aircraft carrier platform.

This technology may also reduce maintenance and operations costs for commercial ships and aviation. Government and commercial space programs may also benefit from adopting the technology.

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KEYWORDS: Aircraft Secure Fittings; Aircraft Deck Tie Down Fittings; Flight Deck Tie Downs; Tie Downs; Corrosion Resistant Tie Downs; Five Crossbar Type VIII Tie Down Fitting

N211-046 TITLE: Undersea Warfare Decision Support System Coalition Data Parser & Advanced Display

RT&L FOCUS AREA(S): Autonomy

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 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: Develop an automated coalition data parsing and 4D display application that enables coalition interoperability for Theater Undersea Warfare (TUSW).

DESCRIPTION: The Undersea Warfare Decision Support System (USW-DSS) is an Anti-Submarine Warfare (ASW) command and control (C2) system installed aboard United States Navy (USN) carrier strike group (CSG) platforms (CVN, CGs/DDGs); Surveillance Towed Array Systems (SURTASS) ships; embarked Destroyer Squadron Staffs and select shore nodes to include the Naval Oceanographic Processing Facilities (NOPF); and Commander Task Force (CTF)/Theater USW Operations Centers (TUSWOC) that enable the networking of ASW forces to collaboratively plan and execute ASW missions. USW-DSS uses both live data and constructed or simulated data to create a live, virtual, and constructive (LVC) modeling and simulation (M&S) capability for Theater ASW planning and analysis of mission execution.

USW-DSS contains applications for environmental analysis, collaborative search planning, force management, sharing of a common tactical picture with networked tactical decision aids, sensor tracks and sensor metrics, automated and manual cross-platform track fusion, search execution measures of effectiveness, graphics storage, recall, and ASW briefing support. The applications also improve effectiveness by decreasing the time required to search an area to a desired probability of detection.

Currently, a universal data adapter for deployed systems is not commercially available; However, there is a similar solution in the training and M&S communities. It is IEEE Distributed Interactive Simulation (DIS). DIS is commonly used as a standard for conducting real-time platform level war-gaming. In order to participate in LVC event, a data adapter is usually developed to bridge the communication between platforms.

The Navy seeks a solution for an automated coalition data parser and 4D display application that may be shared with foreign partners. The data to be exchanged include environmental information (such as local sound speed profiles, ambient noise measurements), data that informs search planning and force management (such as ship speed and maneuvering characteristics, fuel availability and consumption, ASW sensor health and system capabilities), data to generate common tactical pictures, output from tactical decision aids, tracked contacts, search execution measures of effectiveness, and graphics required to generate ASW briefing materials. Additional data and format of existing systems will be provided during Phase II.
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 and/or subcontractor 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 coalition data parser and 4D display application. Demonstrate the concept can feasibly meet the requirements in the Description through modeling 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 of the coalition data parser and 4D display application. Provide to USW-DSS subject matter experts for testing and verification at a government-provided facility. Demonstrate the prototype performance through the required range of parameters given in the Description.

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 an integrated element of USW-DSS through system integration and qualification testing. The coalition data parsing and display adaptation capability will be delivered to support a single transition event. Integrate the prototype into a future build of USW-DSS.

The coalition data parsing and display application can be adapted to other technical fields requiring complex systems to straddle disparate systems with similar data, including systems for engineering and medical uses. The ability to readily adapt to similar but disparate systems with displays that optimize utility by users of all the disparate systems would also be useful in the education and business community.

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KEYWORDS: Theater Undersea Warfare; Undersea Warfare Decision Support System; Distributed Interactive Simulation; Live, Virtual, and Constructive; LVC; M&S; Modeling & Simulation

N211-047 TITLE: Unmanned Underwater-Vehicle (UUV) Mission Sensitive Energy Usage Optimization Using Automated Intelligent Services

RT&L FOCUS AREA(S): Autonomy

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop decision-making algorithms and planning software that can recommend UUV mission plans satisfying operator-defined mission goals and priorities by proposing joint UUV-path plans and sensor-usage schedules that optimize the UUV's energy-usage efficiency over an entire mission.

DESCRIPTION: Unmanned Underwater Vehicles (UUVs) are energy-constrained platforms that execute complex missions in dynamic, and often unpredictable, environments. The advent of advanced sensing payloads and the Navy's interest to extend the operational lifetime of UUVs demand advanced, dynamic, UUV mission-planning tools that go beyond path-planning optimization and "static" mission objectives alone. In particular, there is a need to optimize UUV mission plans based on prioritized objectives with respect to path plans, sensor usage, and energy consumption while ensuring that prioritized mission objectives continue to be satisfied. Most UUV mission planning tools available today rely on models that quantify sensor coverage and energy consumption to define a 'static' mission plan prior to starting the mission. These plans often predefine the power budget for the UUV and its payloads, and guarantee an ample energy reserve for UUV emergency procedures. Missions are, however, dynamic in nature and the corresponding mission plans should be revaluated and optimized on-board the UUV during mission execution.

The Navy is looking for mission-effectiveness optimization algorithms that leverage classical control, optimization techniques, and modern artificial intelligence and machine learning methods to develop software tools able to dynamically recommend UUV routes and sensor-usage schedules. The proposed energy usage schedule must account for the UUV's energy usage over the entire mission and dynamically adjust the schedule according to the mission requirements. The proposed algorithms must also define clear mission-objective satisfaction metrics for assessing mission effectiveness as a function of the mission priorities, the sensor-payload activation schedule, and the overall energy consumption of the UUV. The software implementation of these algorithms should provide the initial mission plan (i.e., route, and sensor operating modes and activation schedules); support on-board monitoring of the UUV's energy usage across the navigation and sensor payloads; evaluate the path and schedule effectiveness with respect to mission objectives of the sensor payload activations along the planned UUV route in real-time on-board the UUV; and dynamically recommend changes to the current mission plan to maximize mission effectiveness. It is critical that any decision-making approach executed on-board the UUV in response to the dynamics of the mission and the environment to redefine the mission plan can be executed efficiently and within predefined computational and power-usage constraints demarcated by the UUV's internal configuration.

To ensure interoperability with the PMS 406 portfolio, the software solution must comply with the 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 vendor lock from proprietary autonomy solutions; effects cross-domain interoperability of UxS vehicles; and allows for open architecture (OA) modularity of autonomy solutions, control systems, C2, and payloads. The Navy will provide the open standards for UMAA upon award of Phase I.

Work produced in Phase II may require access to classified information and become classified. Note that 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 be implemented and approved by the Defense Counterintelligence Security Agency (DCSA). The selected contractor and/or subcontractor 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 contractor will be required to safeguard classified material IAW DoD 5220.22-M during the advance phases of this contract.

PHASE I: Develop a software-system concept with dynamically reconfigurable routing and sensor-usage schedule algorithms to maximize UUV mission effectiveness by making efficient use of the available energy. Quantify expected energy-usage efficiency improvements and their impact on UUV mission execution, e.g., duration and increased sensor duty cycles, and vehicle configuration, e.g., reduced battery size. Conduct simulations using realistic scenarios and surrogate UUV autonomous control systems to demonstrate and quantify mission effectiveness improvements to demonstrate feasibility of the concept. The software products completed during this phase should be sufficient to demonstrate the implementation feasibility of algorithms, with corresponding software modules interfaced with surrogate UUV autonomous control systems that optimize planning, execution, and energy usage on UUVs to achieve maximum mission effectiveness. The Phase I Option, if exercised, would include the initial layout and capabilities description to build the unit in Phase II. Notional computational and power-usage constraints for select classes of UUVs will be identified in this Phase by the performer in collaboration with PMS 406.

PHASE II: Prior to starting prototype development, performers must identify and discuss with PMS406 the following items: (i) target UUV, access requirements and availability; (ii) UUV autonomy framework and required documentation; (iii) computational and power-usage constraints applied to the targeted UUV (leveraging Phase I analysis); and, (iv) approach for accessing the UUV and all related information needed. Develop a full-scale system prototype that can generate initial mission plans that maximize mission effectiveness and dynamically quantify their effectiveness in realistic mine countermeasure (MCM) scenarios (both real world and simulated). Conduct test and evaluation of the system prototype to quantify UUV-mission-effectiveness improvements. Demonstrate the feasibility of integrating the prototype system with one or more UUV autonomy systems using either a real UUV or a high-fidelity software-in-the-loop (SITL) simulation. Conduct extensive test and evaluation to quantify the UUV mission effectiveness from dynamic mission optimization in realistic MCM mission scenarios with successful demonstration showing that the software can be used on-board a UUV to maximize mission effectiveness without significantly overburdening the computational resources available within the UUV.

It is possible that portions of the work under this effort could be classified under Phase II or Phase III (see Description Section).

PHASE III DUAL USE APPLICATIONS: To ensure interoperability with the PMS 406 portfolio, refine the system solution to comply with the UMAA. Ensure that the system provides a UMAA-compliant software service that provides joint path-planning and energy-usage optimization services by dynamically defining UUV routes and payload activation schedules; and that the resulting service interfaces with UUV autonomous control systems and supports the development of mission plans that maximize mission effectiveness. The target transition platform for the software solution developed as part of this SBIR topic is the Razorback UUV. Inspection, maintenance and repair (IMR) missions for undersea infrastructure,

and ocean-bottom mapping and exploration are dual-use applications where the UUV technology developed as part of this SBIR topic will have commercial impact.

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KEYWORDS: Algorithms and Software for UUVs; A&S; Mission Planning and Execution for UUVs; Dynamic Mission Planning; Energy Usage Optimization for UUVs; Unmanned Underwater Vehicle; UUV; MCM Operations

N211-048 TITLE: Unified Operational Picture for Anti-Submarine Warfare

RT&L FOCUS AREA(S): Machine Learning/AI

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 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: Develop a fused picture from acoustic and non-acoustic sensors that transforms masses of data into concise, useful information for operators, watch team, and decision makers.

DESCRIPTION: Undersea warfare (USW) presents a uniquely complex environment to the human operator involving phenomena not present in environments commercial products focus on. Current systems rely heavily on manual association of contact information across sensors. This can be challenging in cluttered environments. Sensor improvements (resulting in more arrays, more gain, more beams, etc.) compound the problem, which can in turn lead to a degradation in situational awareness, incorrect contact picture, and possibly loss of tactical control.

The variable nature of the ocean floor, changing currents, unpredictable water temperature and density layers, marine life, and a huge spectrum of vessel traffic create a highly complex tactical picture in which an adversary can hide. Multiple specialized and highly sensitive sensors have been deployed over the years to contend with these conditions and fully penetrate the undersea battlespace. However, under stressing conditions and, taken collectively, the array of sensors employed by the undersea warfighter yields a copious flow of data and information that must be rapidly analyzed and interpreted. A multisensor fusion technology is needed to generate a unified and consistent tactical picture. The solution must be capable of analyzing, assimilating, and fusing data in an approach that considers both coherent and incoherent processing across multiple sensors with utilization of kinematic and spectral information in order to generate a single, unified, decision-quality, tactical picture.

While the technology sought under this topic will need to comply with cybersecurity protocols, cybersecurity, per se, is not necessarily required as an embedded aspect of the solution provided. While ideally fusion would involve multiple sensors having simultaneous contact, there will be times when only one sensor has contact. The fusion desired is an overarching awareness of contacts as they are perceived by different sensors and modes, both when there is temporal overlap and when there is not temporal overlap.

During Phase II, the technology will be evaluated by Navy subject matter experts and Fleet operators in a prototype sonar system using at-sea test data for validation. It may also be evaluated in an unmanned operation if appropriate for the solution.

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 and/or subcontractor 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 the unified tactical picture that meets the requirements in the Description section. Feasibility will be demonstrated through analytical modeling, and developing and documenting the innovative algorithms, concepts, and architectures, and quantifying achievable performance gains. The Phase I Option, if exercised, will include the initial system specifications and a capabilities description to build a prototype in Phase II.

PHASE II: Develop and deliver the concept for the unified tactical picture into a prototype. The prototype will be evaluated by Navy subject matter experts and Fleet operators in a prototype sonar system using atsea test data to validate that it is fit for use. Conduct additional laboratory testing, modeling, or analytical methods as appropriate depending on the company's proposed approach.

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 unified tactical picture prototype developed in Phase II. Assist in transition and integration of the prototype to a future Advanced Capabilities Build (ACB) update to the AN/SQQ-89A(V)15 Combat System. Potentially integrate the technology into other sonar systems and military sensor systems.

Additionally, the technology could be of interest to intelligence, military, law enforcement, or market tracking for situations where a unified view needs to be assembled from a diverse set of sensor measurements or real-time situational awareness must be assembled in dynamic or volatile situations.

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KEYWORDS: Multi-sensor; Fusion of tactical sensors; Tactical Picture; coherent processing; incoherent processing; kinematic information.

N211-049 TITLE: High Power MegaWatt (MW) Class Grating for High Energy Laser (HEL) System

RT&L FOCUS AREA(S): Directed energy

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 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: Develop a new high peak power broad bandwidth efficient diffraction grating for MegaWatt (MW) class continuous wavelength (CW) and ultrashort pulse laser (USP) technology.

DESCRIPTION: High efficiency Volume Bragg Gratings (VBGs) in photo-thermo-refractive (PTR) glass provide unmatched optical filtering capabilities with optical densities as high as 50 dB and linewidths as narrow as 1 cm-1. In this area, the Navy has reviewed recent advances in VBG technologies that enabled key improvements of high efficiency grating properties and led to development of unique VBG-based optical filters for RAMAN spectroscopy and other applications. Currently commercial VBG operates with laser beams that have only narrow band (< 1 nm) linewidth for spectral beam combination At present narrow linewidth (< 1 nm) KW class CW laser are very expensive.. Broad linewidths around 5 nm are more stable and cost-effective. Spectral beam combination (SBC) using current VBG is limited to its operating at spectral range. The proposed broadband VBG can combine multi wavelengths within 200nm bandwidth and has the potential to increase power > MW in a very cost-effective approach to fabricate high-energy laser (HEL) for navy battle space supremacy. The proposed broadband grating (> 200 nm) shall be able to increase laser power greater than MW class using spectral beam combination and shall also have high damage threshold to compress the high peak power (> GW) femtosecond laser.

VBGs in photo-thermo-reflective (PTR) glass has been used for various applications, such as longitudinal and transverse mode selection in diode, solid-state laser resonators, stretchers and compressors for picosecond and femtosecond lasers, and mirrors for high brightness dense spectral beam combining angular beam deflectors/magnifiers. Theoretical and experimental studies of VBGs, their properties and the possibility to make much thicker VBGs in PTR glass compared to polymer-based materials or thin oxide and semiconductor films allow for fabrication of optical filters with linewidths orders of magnitude narrower than those by other techniques.

Volume Bragg Gratings (VBGs) have become an essential component of high-power laser technologies by allowing SBC, stretching and compression of ultrashort laser pulses, frequency stabilization, etc. An innovative compact efficient VBG technology has potential applications due to its high efficiency and high-power laser-radiation damage threshold. However, their high efficiency is limited to a narrow spectral bandwidth, and is typically accompanied by a narrow angular bandwidth.

The Navy seeks an innovative compact, efficient high-power Volume Bragg Grating (VBG) that could exhibit near 99% optical efficiency in broad bands of spectrum (> 200 nm) at 1 to 2 μ m optical wavelength. Of particular interest are infrared operation wavelength with a broad spectral range of angles, which can be inexpensively manufactured (i.e., using affordable standard optical material processing

equipment's and affordability that does not required any special manufacturing process and equipment) in sizes exceeding 200mm. The technology has to offer the versatility of controlling the spectral bandwidth of diffraction for adaptation to specific application needs. Emerging grating technologies such as diffractive wave plates and metamaterials appear promising for the technology objectives. The Navy seeks the inclusion of recent advances in VBG technologies or any new innovation that shall meet the proposed volume of around 4 inch3, and ease of manufacturing that enable fabrication of very high efficiency (> 90%) reflecting gratings with broad linewidth >200nm at 1 to 2μ m wavelength.

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 be implemented and approved by the Defense Counterintelligence Security Agency (DCSA). The selected contractor and/or subcontractor 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 innovative, spectral and angular broadband, high diffraction efficiency grating technology that will support ultrafast lasers for pico second/femto second pulse compressor for > 10 mJ pulses at kHz repetition rate or spectral beam combining MW class high energy laser (HEL). Demonstrate the feasibility of the technology for scaling to large area. Through modeling and simulation, demonstrate the feasibility for combining spectrally broadband laser beams > 200 nm. The Phase I Option, if exercised, will include a proposed design that will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop the required technology and incorporate it into a prototype device for high power CW laser Spectral beam combining (SBC) and for ultrafast lasers CPA beam compression technology. Demonstrate that the technology meets the requirements as described. Perform SBC and high power testing for beam combination, and peak power pulse compression to generate GW class of pulse femtosecond laser. Follow on testing will refine the prototype into technology for operational use. Deliver the prototype diffraction grating for the purpose of femtosecond pulse compression or SBC of MW class laser system. Deliver the prototype VBG for -MW class CW HEL SBC and femtosecond laser > 10 mJ per pulse beam compression and evaluation of its power and EO efficiency in a HEL prototype system that can meet Navy performance goals (> 200 nm spectral bandwidth) by the US Navy.

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 to transition the Phase II prototype of the high power compact efficient broad linewidth VBG to Navy use for the purpose of HEL technology integration at 1 to 2 um MW class laser. Assist in the integration of the laser system into a submarine or other Navy platform to advance the future Navy warfighting capability. Transition this technology into commercial markets, such as automobile and aircraft industries that employ very high power lasers for cutting, drilling, and welding applications.

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KEYWORDS: Spectral beam combination; SBC); picosecond pulse; ps; femto second laser; Volume Bragg Gratings; VBG;

N211-050 TITLE: Electronic Warfare System Alert Monitoring, Prioritization, and Display

RT&L FOCUS AREA(S): Machine Learning/AI

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 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: Develop algorithms and visual display elements to ingest, analyze, prioritize, display, and monitor electronic warfare system alerts that optimize human operator performance and combat efficiency.

DESCRIPTION: The Navy's surface electronic warfare (EW) systems are receiving a series of complete technology upgrades under a phased development and acquisition approach that delivers new capabilities (system hardware) to the Fleet in "block" updates. This includes the introduction of new electronic support (ES), electronic attack (EA), countermeasures (CM), and electro-optic and infrared (EO/IR) systems. Taken collectively, these updates result in a completely new, fully modernized, and greatly expanded Surface Fleet EW capability. However, the increased levels of performance and enhanced mission capabilities being deployed by these hardware improvements are accompanied by an increased burden on the EW operator. The EW operator now has access to more ES information of a greater depth than ever before. As sensor data from radar, EO sensors, and even other ships are fused with the expanded ES data available, the burden on the operator increases exponentially. Operator overload and fatigue are serious problems. While some of this data can be processed automatically by using machine learning or adaptive algorithms, the Navy cannot remove the operator entirely from the loop and the EW operator and display will remain a critical element in surface combat.

Of particular importance, the EW operator receives a continuous stream of alerts detailing target contacts, system performance, and mission status. Add to these external cues, commands, and situational updates and the volume of alerts can rapidly become unmanageable, especially during highly dynamic operations in dense signal environments. These alerts are important to maintaining successful operations; however, not every alert is of equal importance. Operation during stressing engagements demands that the operator recognize and parse the most important information in real time and in parallel with a large amount of other information presented on the display. While this problem is currently revealing itself in EW operations, the same situation will no doubt present itself in other display consoles as other legacy weapon systems are upgraded and new weapon systems (such as directed energy weapons) are introduced to the Fleet. There are no current commercial applications that can meet this need.

The Navy requires an alert messaging management and display technology that ingests, analyzes, prioritizes, organizes, monitors, displays, and tracks alert information presented on the EW operator display. The solution should incorporate a coherent methodology, realized in an architecture of algorithms, and demonstrated on representative displays. Tactical software is not expected from this effort. The solution must be modular and extensible to allow deployment to other display consoles (for example, future directed energy weapons displays) and the solution must be compatible with other elements of the display – for example, processing and display of the alerts must not alter, overwrite, or

obscure other elements presented on the display nor should it inhibit other display functions. Since actual tactical displays will not be available, the prototype solution should be demonstrated, tested, and validated on representative display mock-ups.

This effort expects the application of the current state of the art in human cognitive science. The solution should be dynamic to adjust to changing situations that demand re-prioritization of alerts. However, clarity of the display is paramount and the operator cannot be expected to search for constantly changing information. The solution should also include an analysis function that prioritizes and organizes alerts in light of current mission requirements and the evolving battlespace. Finally, the solution should monitor, track, and capture the operator response, elevating alerts and enhancing visual cues in order to make sure the most important alerts are addressed and not overlooked. Compatibility with embedded training events during which scripted alerts are injected into the system is required.

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 and/or subcontractor 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: Propose a concept for an EW alert analysis, prioritization, and monitoring application that meets the objectives stated in the Description. Feasibility shall be demonstrated by a combination of analysis, modelling, and simulation. The feasibility analysis shall include predictions of operator performance in use of the application. The Phase I Option, if exercised, will include the initial design specification and capabilities description necessary to build a prototype solution in Phase II.

PHASE II: Develop and demonstrate a prototype of the concept for an EW alert analysis, prioritization, and monitoring application meeting the requirements contained in the Description. Deliver the software prototype to the Government along with full software interface descriptions and any ancillary software needed to demonstrate the application.

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 for Navy use. Since the Phase II effort result is a prototype that is not necessarily demonstrated on a tactical system, assist in integrating the alert analysis, monitoring, and display software into the EW display tactical code. Assist in certification of the resulting tactical code. Assist the Government in testing and validating the performance of the resulting application, as integrated into the EW console. The alert display software can also be customized for additional applications such as other military systems (including radar and weapons displays) and for commercial systems such as air traffic control systems.

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KEYWORDS: Electronic Warfare; Human-Machine Interface; Alert Monitoring; Cognitive Science for EW; Embedded Training; Algorithms for EW displays

N211-051 TITLE: Non-acoustic, High Fidelity, Short Range Underwater Tracking System

RT&L FOCUS AREA(S): 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 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: Develop a non-acoustic underwater Mine Countermeasures (MCM) tracking system with accuracies suitable for signature measurements within 1-2 yards.

DESCRIPTION: This SBIR topic seeks technology to reduce the susceptibilities of Explosive Ordnance Disposal (EOD) MCM equipment in a broad range of contested operational environments, specifically high-risk mine areas while improving EOD ability to enable fleet access and maneuver in challenged sea space. The technology will build a more lethal force and improve fleet readiness. Current available systems use various forms of acoustic tracking beacons which interfere with the acoustic data collection, require very accurate placement of additional hydrophones and do not have the centimeter or inch level of accuracy needed for the small items (UUVs, ROV Divers) used by Expeditionary Mine Countermeasures (EXMCM).

Navy Expeditionary forces responding to underwater threat objects require an ability to safely deploy and operate Maritime Expeditionary Mine Countermeasures Unmanned Undersea Vehicle (MEMUUV) systems and Maritime Expeditionary System of Systems Response (MESR) Remotely Operated Vehicles (ROVs) in a broad range of environments. Navy Expeditionary forces thus require stringent signature measurement and control, which can only be achieved with highly accurate tracking. Once high accuracy tracking is implemented, electromagnetic and acoustic signature reduction techniques can be applied at exactly known sources on the EXMCM EOD equipment.

After measuring first generation USN UUV and ROV signatures using arrays of acoustic sensors at multiple field tests, it became clear that the existing acoustic tracking techniques did not have the tracking range-position spatial resolution required to provide the level of signature fidelity necessary to adequately characterize for minefield suitability purposed, EOD systems for the purposes in which they are employed.

Existing systems normally involve the attachment of a known high-frequency, high-power, and narrow bandwidth acoustic transponder on the vessel under test, such that through the detections on multiple sensors located on the range, a determination of range can be accomplished. For fairly large USN vessels that create more noise than smaller units, increased stand-off ranges are possible, and errors or variations in range accuracy are much more tolerable.

A tracking system would help improve the ability to ensure minefield suitability of EXMCM EOD equipment (e.g., UUVs, ROVs, diver-held sensors as well as other equipment operating in mine danger areas [e.g., EOD boats]) and supports USN UUV systems as defined in the Secretary of the Navy Report to Congress on Autonomous Undersea Vehicle Requirements for 2025.

UUV tracking experience for measurements of <10 yards sensor to source highlighted that acoustic tracking technology achieved marginal accuracy, if at all, and required dynamic positional accuracy for close-in high-fidelity tracking. The goal of this SBIR topic is to design a system to provide accurate, real-time tracking capability in both sea water and fresh water locations. The tracking accuracy threshold is plus or minus 7 inches with an objective of plus or minus 3 inches at a 6-foot Closest Point of Approach (CPA) over a dynamic range of plus or minus 60 feet from CPA. This capability would allow signature reduction prioritization in the developmental stages of EOD equipment production as well as lowering the risk of expensive equipment loss when employed in combat. Naval Surface Warfare Center Carderock Division (NSWCCD) will test the prototype tracking at an appropriate site to verify 3" accuracy at 6 feet both static (in a tank [e.g., TRANSDEC]) and dynamically in a tank [e.g., CD tow tank]).

The Phase I effort will not require access to classified information.

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). The selected contractor and/or subcontractor 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: Design a concept for a tracking system that can provide accuracies on the order of inches while tracking an underwater object in real time as detailed in the Description. Demonstrate the feasibility by modeling and simulation as well as technical and engineering design review. 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 tracking system and validate it with accuracies suitable for signature measurements within 1-2 yds. NSWCCD will test the prototype in an appropriate tank and document the tracking algorithm and fidelity (improved range accuracy of 3 inches at 6 feet). Demonstrate the system with a full underwater acoustic measurement array. Plan and conduct a requirements analysis session with the Navy technical team to further refine source mounting, feasibility (e.g., determine if anything that's attached to the unit for tracking affects the performance of the unit, if any additional sensor needed for the system should be added to systems being measured) and UUV interface requirements for a prototype tracking system. Refine the demonstration prototype of an improved tracking system with a designated small or medium-sized Government Furnished Equipment and Information (GFE/GFI) UUV and/or ROV asset.

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: Work with the Navy personnel and contractor Field Service Representatives (FSRs) to transition the technology to Navy use and gain additional detail on the designated EOD systems that ultimately would be used for integrating the improved tracking system. Support the Navy testing and evaluation team with introduction of the tracking system as a potential ranging capability for UW EOD systems.

A potential platform for this tracking system is the Underwater Signature Measurement System (USMS), a prototype multi-influence point ranging sensor system developed jointly by the NSWCCD and industry partners, consisting of advanced magnetic, electric, pressure, and acoustic sensors that have been selected and integrated into two qualification units consisting of a cylinder (USMS#1) and a hemisphere (USMS#2). USMS#2 is the proposed unit to be upgraded and made suitable for EOD UUV/ROV vehicle tracking and underwater EM communication.

Additionally, several commercial companies produce UUVs and ROVs for U.S. and allied military applications including mine countermeasures, port protection, underwater unexploded ordnance remediation, and naval oceanographic mapping missions. These missions may benefit from the improvements in off hull tracking.

The tracking system could also be adapted to small and medium-sized UUVs used for underwater tracking and surveillance tasks by the gas and oil industry, fisheries, scientific research communities, commercial diving and salvage industries; and have a wide applicability in high accuracy tracking applications, even outside of signature applications.

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KEYWORDS: Unmanned Undersea Vehicle; UUV; Remotely Operated Vehicles; ROV; Mine Countermeasures; MCM; Expeditionary Mine Countermeasures; ExMCM; Original Equipment Manufacturer; OEM; Magnetic and Acoustic Influence Signature of UUVs

N211-052 TITLE: Navigational Positioning Source Using Very Low Frequency Signals

RT&L FOCUS AREA(S): General Warfighting Requirements

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 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: Develop receivers and algorithms that employ Very Low Frequency (VLF) radio signals from existing United States Government (USG) ground stations to determine position and velocity information at sea on a United States Navy (USN) ship or submarine.

DESCRIPTION: The success of U.S. Navy missions depends on personnel and platforms having access to accurate and reliable position, velocity, attitude, and time information. Maritime platforms specifically need this information continuously to support safety of ship, weapons deployment and network communications, and geo-registration. The DoD developed a Global Positioning System (GPS) to provide accurate, worldwide, all-weather, continuous position and time information to warfighters. As a result, GPS is the primary positioning and time source for maritime surface platforms. However, GPS is susceptible to interference and may not be continuously available in a time of conflict. Consequently, backups to GPS are needed for positioning and timing information to meet mission support.

Many military platforms also deploy inertial navigation systems along with GPS. Inertial navigation systems (INSs) are continuous, all-weather sources of position, velocity, and attitude information. INSs are not susceptible to interference in the same manner as GPS. Also, many maritime platform missions can be met with a military grade INS. INSs drift over time and require periodic fixes to reset their position. Typically, an INS will be corrected by fixes to GPS or some other fix source, such as a visual source, a radar contact or some other navigational feature. In the event of a prolonged period of GPS not being available and no other usual sources being available, additional sources of position fixing are needed.

Using VLF signals to aid navigation has its origins from the middle of the 20th century with the OMEGA hyperbolic navigation system being the most widely used system by the U.S. (Russia had a comparable system known as ALPHA.) OMEGA had 8 ground-based transmitters strategically located around the world and provided 24-hour global coverage, operating in the 10-14 kHz range. In these hyperbolic navigation systems, transmitters were synchronized by using one of the transmitters as the trigger for the other to broadcast after a fixed known delay. A receiver measured the signals from the transmitters and a comparison was made between the known delay and the measured delay, and the location of the receiver was determined to lie on a curve that was a function of this delay. Using two or more pairs of transmitters allowed for an accurate horizontal position measurement.

The OMEGA navigation system had accuracy in the 1-4 nautical mile (nmi) range, which was dependent on a number of factors. Synchronizing of the two transmitters over transmitter distances of thousands of miles was challenging in the mid-20th century. This error source would later be overcome using atomic clocks at all transmitter sites; however, aligning clocks at multiple sites was still problematic.

Additionally, the paths of VLF signals from transmitters to receivers are severely distorted by the ionospheric changes along the very long transmission paths. The OMEGA navigation system ceased transmissions in 1997 with the advent of alternative systems that had greater accuracy, such as GPS.

However, near the end of OMEGA operations, many of the technical challenges limiting VLF navigation's accuracy performance were solved, including improved ionospheric modeling and better signal processing.

Recently there has been renewed interest in positioning using VLF signals. A terrestrial-based position and timing source is desired as a backup to GPS, and an OMEGA-like VLF system can provide global coverage with just a few transmitters. VLF signals are very difficult to interfere with because of the high power with which they are transmitted. DARPA's Spatial, Temporal, and Orientation Information in Contested Environments (STOIC) program sought to achieve GPS-level or better performance in part using VLF signals. The STOIC program demonstrated much improved positioning over OMEGA by creating a stable VLF signal, developing high fidelity physics models of the ionosphere along the signal path and improved signal processing at the receiver.

The Navy seeks innovative technology that can mature the VLF navigation technology to support navigation resilience on U.S. Navy shipboard platforms. The focus of this SBIR topic is expected to center on improved receivers for processing the VLF signals, and algorithms to extract the signals that can be used to develop accurate position and velocity to estimate INS errors without a backchannel communications need for ionospheric corrections. Position fix accuracy should be within 0.5 nmi (dRMS) or better, with fixes available at least 12 hours per day. Short-term velocity output performance should be within 0.1 knots or less (rms, each horizontal axis) over 1 hour. An additional research focus will be on modeling the error characteristics of the VLF-derived position and velocity reference, as this model will need to be incorporated into real-time Kalman filter algorithms of an inertial navigation system. VLF antenna will be a contractor selection, but must not exceed 22" x 22" x 22" in volume. Electronics must fit within a standard 19" electronics rack and not to exceed four electronic rack units (RU). However, receiver and algorithms should be adaptable to both purpose-built and existing VLF shipboard antenna systems.

The technology sought will develop the algorithms and receiver technology that will deliver reliable, consistent, and predictable position and velocity information providing known error characteristics.

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 and/or subcontractor 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 VLF system navigation algorithms and receivers. Demonstrate feasibility for obtaining accurate position and velocity from maritime platforms using existing Navy or purpose-built antennas. Demonstration will show that the concept meets the requirements as described in the Description and includes analysis, modeling, 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 of an improved VLF system navigation algorithm(s) and receiver(s). The prototype will show that it achieves the parameters described in the Description. 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 position and velocity accuracy using VLF signals.

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. Develop a mature prototype capable of testing on a maritime platform. Mature any key algorithms, software or hardware. Field test the system on a maritime platform to demonstrate performance of the mature system. Compare the system's demonstrated performance with GPS to determine the usefulness and the applicability of this technology in GPS-challenged environments.

Potential commercial applications include navigation and positioning in mining, aviation, surveying, agriculture, marine, and recreation. Department of Navy could use the technology for multiple missions including surface, submarine, and air navigation.

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KEYWORDS: Very Low Frequency; Navigation; OMEGA; STOIC; Atmospheric Signal Propagation; RF Receivers and Antenna

N211-053 TITLE: Nickel-Zinc Submarine Main Storage Battery

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Develop a Nickel-Zinc (NiZn) battery system that does not rely on Lithium Ion (Li-ion) technology and would replace lead-acid battery system with a more efficient, environmentally safe, maintenance free, and long life battery in the form of a large-format (1,000Ah+) NiZn battery with cycle life and capacity maximized within the design.

DESCRIPTION: The U.S. Navy Submarine Fleet main storage battery currently employs Valve-Regulated Lead-Acid (VRLA) technology to meet platform energy and power requirements. However, with the increasing reliance of electronics on large platforms, future mission needs will require additional battery capacity beyond what current lead-acid battery technology is able to provide. The submarine battery compartment cannot be expanded, so VRLA technologies have seemingly reached operational limits. Therefore, there is a mounting need to transition from the current VRLA battery to an alternative battery technology with a higher energy density and improved reliability. Accordingly, NiZn battery technology has the potential to bridge the energy density gap until Li-ion battery technology can be made reliably safe for submarine applications. Further, submarines continue to see electrical load growth requiring more main storage battery capacity in the same volume. The development of a large-format NiZn battery will offer the needed battery capacity increase on submarines while offering a safer alternative to Li-ion batteries, which, though energy dense, come with a high risk of failure. A Li-ion failure onboard a submarine has the potential to be a catastrophic event. The Navy could potentially delay, or eliminate altogether, a Li-ion transition requirement allowing for lower risk design cycle.

NiZn is an emerging battery technology optimized for high capacity and long life while also delivering high power in an environmental friendly and safe chemistry. NiZn batteries have a projected increase of about 50% the capacity of lead-acid batteries, with a 25% weight reduction given the same footprint. Currently, prototype and commercial NiZn batteries are of small-format design. Large-format, scaled-up versions of the NiZn designs are not commercially available. Submarine main storage battery replacement will require scale-up of small-format NiZn technology to submarine-specific sized large-format 1,000Ah+ NiZn batteries with cycle life and capacity maximized within the design. The NiZn battery concept must achieve 75% of capacity through 200+ Navy Equivalent Charge/Discharge cycles. Feasibility of concept will be determined through various characterization and operational testing at NSWC Crane. The developed and delivered prototype large-format batteries will be provided to NSWC Crane at the end of Phase II for testing and evaluation. NSWC Crane has the expertise to test and aid development of largeformat NiZn batteries using lessons learned from VRLA efforts. The focus of testing at Crane will be to validate the performance of the large-format batteries through characterization and Operational Cycle Life (OCL) testing. OCL will be performed to evaluate the ongoing performance and expected cycle life of the design by pushing the prototypes through various charge and discharge rates over a period of 200+ Navy Equivalent Cycles (NECs). The prototypes will be tested to obtain performance data and demonstrate viability of NiZn as a replacement for Submarine VRLA main storage battery.

PHASE I: Develop a minimum 1,000 amp-hour NiZn battery concept that can achieve 75% of capacity through 200+ Navy Equivalent Charge/Discharge cycles. Develop a design and fabrication approach to scale small-format NiZn to large-format and determine technical feasibility. The initial design concept should include expected cycle life, performance, and manufacturability of large-format NiZn cells and batteries. Feasibility of concept will be determined through various characterization and operational testing at NSWC Crane. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype in Phase II.

PHASE II: Develop and deliver a prototype large-format NiZn cells and batteries based on Phase I work and Phase II Statement of Work (SOW) for demonstration, testing and validation which will include characterization testing to understand the range of capacities through various discharge rates as well as operational testing to validate long-term performance. Prototype will be provided to NSWC Crane at the end of Phase II for testing and evaluation.

PHASE III DUAL USE APPLICATIONS: Utilize the Phase II prototype testing and analysis results to assist the Navy in transitioning to Navy use. Update design and system development. Integrate Battery Management System (BMS) requirements (furnished by the Navy based on results of testing and evaluation) into final NiZn large-format cells and batteries.. Implement full-scale design manufacturing and transition the end product to the Navy for submarine main storage battery validation, testing, qualification, and certification at NSWC Crane with PMS 392 support.

This technology has potential commercial transition to other applications such as aircraft, alternative energy, and data center energy storage. Large-scale NiZn batteries can easily be integrated in current lead-acid applications such as engine start, trucking, and large-scale data centers.

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KEYWORDS: Submarine Main Storage Battery; Nickel-Zinc Battery; Nickel-Zinc Replace Lead-Acid; Nickel-Zinc Alternative Energy; Rechargeable Nickel-Zinc Batteries; Safer Alternative to Lithium-ion.

N211-054 TITLE: High Strength Composite System for Ships

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop a high strength composite material that meets U.S. Navy standards for Flame, Smoke and Toxicity Requirements.

DESCRIPTION: Ship building programs throughout the U.S. Navy have begun to increase the use of composite structures throughout the ship, i.e., Landing Craft, Air Cushion (LCAC) and Ship-to-Shore Connector (SSC) ramps, LPD 17 mast, and DDG 1000 deckhouse. These composite structures offer lighter weight and better corrosion resistance than a similar metallic part. The composite systems include resin, filler fabric and the methodologies involved in building finished products in various forms with differing functions.

To date, identification of composite material solutions have required either relaxation of Flame/Smoke/Toxicity (FST) requirements (outlined in NAVSEA MIL-STD-3020, ASTM E84 and ASTM E662), compromise in material strength (durability) or increase in weight. Fatigue life calculations are based on 270 x 106 cycles, using allowable material properties. The Navy is seeking a new composite material system that provides a more agile forward force maneuverability and posture resilience and all the benefits of using composites while still meeting structural requirements for strength and durability and maintaining Naval fire resistance performance requirements.

PHASE I: Develop a concept for a composite system, which will meet FST requirements while allowing for the needed strength and durability characteristics. Demonstrate the feasibility of the concept in meeting Navy needs and establish that the concept can be developed into a useful product for the Navy. Feasibility will be established by coupon development, laboratory testing and demonstration of the materials. 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 test the new system prototype composite system. Test in accordance with NAVSEA MIL-STD-3020MIL-STD-3020, ASTM E84 and ASTM E662 as well as plastic, elastic and failure pull testing to demonstrate strength characteristics. Product performance will be demonstrated through prototype evaluation, modeling, analytical methods, and demonstration over the required range of parameters including numerous cycles. A Phase III development plan and cost analysis will be prepared to outline transition of the technology to Navy use. Provide detailed drawings, code and specifications in Navydefined format. In addition, provide support to shepherd the new composite system through the Navy technical approval process.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the new composite system for Navy use on shipbuilding programs beginning with LCAC and SSC Air Cushioned Vehicles. Once a new composite system is validated it is expected to have impact across the full range of composite usage in the Navy. Commercial applications include all aspects of composites including aerospace, hovercrafts, airplanes, helicopters, ferries, the oil and mineral industry, automotive, cold climate research, and exploration.

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KEYWORDS: Ship-to-Shore Connector; Air Cushion Vehicle; Composites; Flame Smoke and Toxicity; Hovercraft; Composite Material System

N211-055 TITLE: High Dynamic Range and Low Noise Figure (NA) Integrated Microwave Photonic Transceiver for 6G mmWave Radio

RT&L FOCUS AREA(S): Directed energy

TECHNOLOGY AREA(S): Battlespace Environments

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: Develop a compact high dynamic range and low noise figure integrated optical amplifier microwave photonic transceiver module for DoD 6G mmWave radio.

DESCRIPTION: The Navy seeks technologies that are oriented toward a deeper understanding of the upcoming 5G and future 6G communication systems which impose stringent requirements and challenges for hardware systems. The commercial state of the art consists of the 5G systems that are under development and will be deployed soon. These 5G systems utilize the lower millimeter-wave frequency low band (e.g., <6 GHz), while the high band (6-24 GHz) region has not yet being considered due to the lower transmission ranges and higher equipment density in a given area for the same coverage. 6G will operate above 24GHz and will have the similar challenges as 5G but on a higher scale. At present significant efforts have been devoted to developing low to mid band millimeter-wave circuit systems. The challenge is to develop a low-cost photonic integration of high speed active optical modulator, high speed photodetectors, and mmWave electronics. The benefit of this approach is to improve performance of the Navy's optical wireless communication throughput, security, and reliability.

To meet the Navy challenges, this topic shall be able to address Spectrum Supremacy as stealth communication for battle space supremacy; the Navy Focus Area for Expand the Advantage through increased capability; and a number of objectives within increased capability to have Navy battlespace supremacy and water-space management.

To overcome the transmission range of the standard microwave 5G network, the Navy is interested in an innovative hybrid approach of integrated optical and mm wave transmission. The new System architecture will support future 6G hybrid network systems, that will have significant bandwidth and datarate improvements (x100-time improvement) over current 5G technology. This demand necessitates significant developments and investigations of different techniques that will enable the required data-rate and bandwidth capacities. Correspondingly, an innovative integrated microwave photonic 6G mm Wave radio transceiver features great advantages to address these issues when compared to traditional microwave/millimeter-wave approaches. Optical fiber enables large operating frequency and bandwidth for 6G networks (operating frequency from 100 GHz to 1000 GHz). However, the field of 6G is still a nascent area. To have 6G hybrid high data rate optical network, the integrated microwave photonic transceiver must overcome the crucial technical challenges in the receiver (RX) modulator's efficiency by achieving an ultra-low Vpi < 1 volt (where Vpi is the voltage drop needed to cause a 180 degree phase change) and the Transmitter (TX) photodetector's poor optical-to-mmWave power conversion efficiency. The company and the research institution should use the Open model base engineering environment, open source software such as C++, for the product development and documentation. The goal of this program

is to develop hybrid microwave photonic transceiver modules that can operate from 60GHz (5G) up to 200GHz (for future 6G). The transceiver should demonstrate greater than 10 percent fractional bandwidth. For 5G operation, the transceiver should enable a base station to demonstrate >10Gbps up/down link throughputs. For future 6G operation, the transceiver should enable >1Tbps throughputs.

PHASE I: Develop a concept for mmWave wide dynamic range and low noise figure integrated amplified Photonic system based on model-based engineering (MBE) as outlined in the Description. Demonstrate the feasibility of developing a compact size, weight, area, power, and efficiency (SWaPe) mmWave 6G radio transceiver that enables ultra-high efficiency conversion between mmWave and optical signals using integration microwave photonic implementation as discussed in the Description through simulation and identify the primary technical risks of the concept. The Phase I Option, if exercised, will include the initial design specifications and capabilities description for the ground fault detection and localization system; and develop a test plan and test procedures for the prototype to be developed in Phase II.

PHASE II: Based on the results of Phase I efforts and the Phase II Statement of Work (SOW), develop, demonstrate, and deliver a prototype low SWaPe mmWave 6G radio transceiver using integrated microwave photonics. The working prototype must address technical risks, validate the draft specifications, and demonstrate the functionality of the overall design. Develop, demonstrate, and deliver a prototype low SWaPe mmWave 6G radio transceiver using integrated microwave photonics at 60GHz or higher. The transceiver should demonstrate greater than 10 percent fractional bandwidth. The working prototype must address technical risks in developing integrated high speed linear optical modulators and high speed photodetectors, and their integration with millimeter electronics and swap antenna. The working prototype must demonstrate 6G base-station operation with >10Gbps up/down link throughputs. The Phase II work should also demonstrate a clear path for achieving future 6G operation at 200GHz band.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning of the technology to Navy 6G platform mmWave communication link into subsurface and surface platform. Document the design and capabilities of the modulator prototype developed under Phase II. Work with the Government to develop specifications. Provide support by finalizing and validating the compact low Vpi wide dynamic range, low noise figure, optical modulator based on needs of the Navy Electronic Warfare analog fiber optic links. Integrate and test the modulator with high dynamic range fiber optic links. Private Sector Commercial Potential: The development of compact, low Vpi wide dynamic range modulator has commercial potential for telecom applications such as cable TV, radio over fiber, etc.

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KEYWORDS: Compact size, weight, area, power and efficiency; SWaPe; microwave photonic; mmWave; Dynamic range; Vpi; 6G communications systems

N211-056 TITLE: Propulsor Geometric Certification System

RT&L FOCUS AREA(S): General Warfighting Requirements

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 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: Develop and integrate a digital solution for naval propulsor repair and new manufacture geometric certification for greater war readiness, performance, and affordability.

DESCRIPTION: The certification of the geometric properties of propulsors are a key factor in meeting many Key Performance Parameters and Key System Attributes for United States Navy (USN) ships. Proper execution of propulsor geometric inspection and certification supports ship powering, signature, and vibration performance requirements. Current practice for USN propulsor certification requires the application of highly maintained sets of physical gages in a controlled and detailed process. The cost and time involved in this process can lead to delays in delivery to ship and degraded ship propulsor performance. The Navy seeks a fast and practical way to inspect and certify new and repaired propulsor assets to create a more resilient and agile logistics path and support on time delivery of ships and submarines.

USN propulsors are large, finely machined assets that have unique and complex manufacturing tolerances, both of which present challenges to geometry certification and challenge the current state of the art in digital surface scanning and assessment. Certification of propulsors requires both very tight local surface profile tolerance over a wide area, as well as local and global derived geometric characteristic tolerances unique to propulsors. Current commercially available components lack the required speed and accuracy of data collection, the analytical capability to assess against relevant propulsor tolerances, and the capability to easily direct repair; and they are not integrated systems. Development is required to allow for a 23' diameter x 5' deep volume to be captured on a newly machined metallic surface at sufficient accuracy to verify tolerances of 0.005". Specialized software development is required to process the captured data in a manner consistent with USN propulsor tolerances. Innovation can also be applied to the interpretation of the data analysis and its application in identifying corrective actions and conveying them to the machinist.

This SBIR topic seeks to develop an integrated survey, analysis, and reporting system for use in new manufacture and repair of USN propellers. The survey system shall be able to measure a representative NiAlBr propeller of 23' diameter to a precision of at least 0.00025" in less than 6 hours. The analysis software shall quality control the surveyed data, and analyze it in a fashion consistent with USN guidance on propeller dimensional inspection in near-real time with minimal user involvement.

The system will be assessed against a standard inspection of a test monobloc propeller or controllable pitch propeller (CPP) blade and a process review of the analysis method. The system shall document the blade condition and aid the inspector/machinist in identifying dimensional exceedances and coordinating corrective actions.

PHASE I: Propose a concept for an integrated system solution for geometric inspection, evaluation, and result output of monobloc propellers and controllable pitch propeller (CPP) blades. Demonstrate the capability to optically evaluate a representative article to the required accuracy. Provide a concept for blade dimensional analysis and demonstrate ability to produce and develop similar software. Provide and demonstrate a concept for utilizing the analysis data to assist in the remediation of the blade to determine feasibility. The Phase I Option, if exercised, will include initial design specifications and description of capabilities to build a prototype in Phase II.

PHASE II: Build and demonstrate a prototype system of the solution on a USN asset provided by the Government team, i.e., a USN propeller and a controllable pitch propeller (CPP) blade will be arranged in a repair facility along with required reference information. Demonstrate that the prototype can perform all aspects of the inspection process on the provided propeller and CPP blade, including setup, data acquisition, data analysis, and reporting. Assess prototype performance against a standard inspection of the test articles, as well as on the design specifications and capabilities outlined in the Description.

PHASE III DUAL USE APPLICATIONS: Assist the Navy in transitioning the technology by providing systems (4-20) for procurement by 2SCog Propulsion Program, USN Regional Maintenance Centers or other NAVSEA facilities, and/or industry vendor partners as well as training in their use. The resulting systems should include surveying devices and associated items required for operation, analysis software, and any software or items required for output/utilization of analysis data.

These systems will be used to support all Navy surface ship assets, particularly DDG, LPD, CVN, and LCS classes. These systems will allow rapid evaluation of units in the field and in facilities, providing better and faster assessment of required repairs and performance impacts. This would allow for a reduction in repair lead times of roughly 60-360 days, creating a shorter, more flexible logistics chain to support fleet needs. This would also reduce non-recurring engineering (NRE) and capital costs on designing and manufacturing the blade gages required for traditional inspection, 0.5-2M over the next five years, as well as virtually eliminating the \$50-200K expense of each inspection leading to more affordability in ship procurement and availabilities. Not including new delivered ships or emergent repairs, the 2SCog program plans to procure at least 46 new or refurbished propellers and blade sets over the next 5 years. This system could also likely be extended to virtually any foil-like high performance part, such as turbines or aviation for both DoD and commercial applications.

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for example). While this is an example of standard surface definition formatting, proposers are free to outline modifications to this format as required by their system. <u>https://urlprotection-sjl.global.sonicwall.com/click?PV=1&MSGID=202101112029300094983&URLID=11&ESV=10.0.6.3447&IV=32811331931958146CC374749BBBCFA8&TT=1610396972206&ESN=iUeqoQ4QKRrxm%2BBRI%2FME4Zs%2BU1TzkE5C3BGLpgLkOQA%3D&KV=1536961729279&ENCODED_URL=https%3A%2F%2Fnavysbir.com%2Fn21_1%2Fp5525.zip&HK=C5224C27B3A72E7E2E3DF1BACC1357E3D964692EF98619F686F6D6525550812D</u>

KEYWORDS: Propeller Inspection; Airfoil Metrology; Propeller Gages; Geometry Certification; Laser Scanning; Optical 3D Scanning

N211-057 TITLE: Flight Deck Tie Downs

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop an advanced non-corroding material to use in replacement DDG-51 FLT III Helicopter Flight Deck Tie Downs.

DESCRIPTION: The U.S. Navy's DDG-51 Class Destroyer helicopter flight deck utilizes tie downs to anchor and secure the helicopters on the flight deck. While the tie downs should ideally last for the 40-year service life of the vessel, in practice they fail due to corrosion and often need replacement. The corrosion of a flight deck tie down is a grave hazard, as its failure at an inopportune time could cause extensive damage to valuable equipment and endanger the lives of the sailors aboard. Anti-corrosion coatings and coverings have not been effective at eliminating the problem. The Navy requires the development of an innovative, noncorroding material to replace the existing flight deck tie down.

The development of a noncorroding material to meet the Navy need will require significant innovation to overcome several technical challenges, it must withstand saltwater immersion, exposure to industrial chemicals and jet fuel, and exposure to ultraviolet radiation; and be fire resistant and resistant to galvanic corrosion. Attaching tie downs of a new material class to the deck may require innovative welding techniques or advanced mechanical fastening methodologies. Whatever method is developed, it must be able to meet the same requirements as the current Navy tie down. Required maintenance must be able to be performed by Navy personnel. The joining method must also be watertight to the deck and prevent corrosion below the tie down.

Research into noncorroding materials has identified materials that could potentially be developed to meet the Navy's need. Some of the more promising possibilities include Advanced Thermoplastic Composites, High Strength Metallic Glass, and Novel Metallic Alloys. However, no material within these categories has been adequately demonstrated to be a replacement for the strength and durability provided by steel. Thermoplastic Composites and Metallic Glass would most likely require mechanical joining. Novel Metallic Alloys might be easier to weld to the deck, but care must be taken to prevent galvanic corrosion in the steel. All these materials would need to pass extensive testing to demonstrate that they can replace the existing flight deck tie downs and withstand the repeated heavy loads required to anchor the ships assigned aircraft as defined in NAVSEA Drawing 803-1916300 Rev P (2013), "Hull Standard Drawing Aircraft Securing and Engine Run–Up Fittings", July 2013. Innovation will be required to reduce acquisition costs and produce a viable product for the Navy.

PHASE I: Develop a concept for an innovative noncorroding material for Flight Deck Tie Downs that meets the requirements described above. Demonstrate the feasibility of the concept in meeting Navy needs and establish that the concept can be developed into a useful product for the Navy. Feasibility will be established by test of a material sample that will be analyzed in such a way that its failure mechanism will be representative of the larger product supported by finite element analysis. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build and demonstrate a prototype in Phase II.

PHASE II: Based on the results of Phase I and the Phase II Statement of Work (SOW), develop and deliver at least one prototype tie down for evaluation to determine capability in meeting the performance goals defined in the Phase II SOW. Product performance will be demonstrated through prototype evaluation, modeling, analytical methods, and demonstration over the required range of parameters including numerous cycles. Perform an extended test in a maritime environment to refine the prototype(s)

into a design that will meet Navy requirements. Prepare a manufacturing and development plan to transition the noncorroding tie down to Navy use. Support the Navy in transition planning and initiation of the Flight Deck Tie Down to Navy use. Develop installation and maintenance manuals for the tie down to support transition to the fleet.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the tie down technology to DDG-51. Potential private sector uses for advanced noncorroding materials include both the automotive and aerospace industries. Other commercial applications include architecture and maritime use.

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KEYWORDS: Noncorrosive Material; Corrosion Resistance; Flight Deck Tie Downs; Metallic Glass; Advanced Thermoplastic Composite; Novel Noncorroding Metallic Alloy.

N211-058 TITLE: Automated Unmanned Systems (UxS) Boundary Protection Capability

RT&L FOCUS AREA(S): Cybersecurity

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop solutions that maximize use of automated network configuration management, machine learning (ML), advanced data analytics, Security Incident and Event Monitoring (SIEM), and decision analysis to execute unmanned systems UxS missions in a cyber-contested environment.

DESCRIPTION: The Navy seeks development of software, or a combination of software and hardware, to provide advanced cybersecurity capabilities in accordance with Navy Cybersecurity Technical Authority Standards Naval Systems Command Enclave Process v1.0 (dated 19 Sep 2017) and Defense-in-Depth Functional Implementation Architecture (DFIA) Standard (STD-DFIA-004R0), and the National Institute Standards for Technology Special Publication 800-53 rev 4 to UxS vehicles (e.g., Medium Displacement Unmanned Surface Vehicle [MDUSV], Medium Unmanned Surface Vehicle [MUSV], Large Unmanned Surface Vehicle [LUSV]), as well as support the needs of ships and vessels with reduced crew complements (e.g., FFG(X), Littoral Combat Ship [LCS], Military Sealift Command [MSC] ships). The solution provides an effective platform boundary that enables UxS vehicles to operate in a cyber-contested environment. The contested environment includes denial of services (DOS), man-in-the-middle [MITM], and unauthorized data exfiltration from both internal and external actors. The hardware and software may include technologies such as intrusion protection systems (IPSs), intrusion detection systems (IDSs), and SIEM.

To ensure interoperability with PMS 406 portfolio, the solution must comply with the Unmanned Maritime Autonomy Architecture (UMAA), which 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 UxS vehicles. The UMAA common standard for Interface Control Documents (ICDs) mitigates the risk of vendor lock from proprietary autonomy solutions; effects cross-domain interoperability of UxS vehicles; and allows for open architecture (OA) modularity of autonomy solutions, control systems, C2, and payloads. The Navy will provide the open standards for UMAA upon award of Phase I.

The Navy is seeking a broad range of emerging technologies that take advantage of commercial advances in network monitoring and management, SIEM data analytics, and ML to detect cybersecurity anomalies and automatically reconfigure network control points to isolate cyber events and preserve mission critical functions. No current commercial technologies exist that have the military applications that the Navy seeks, without significant tailoring to meet mission specific requirements.

Commercial solutions for network management, SIEM analysis, and system configuration often presume highly skilled humans in the loop or on the loop to evaluate the overall health of a network and execute (or at minimum, approve) changes to network configurations prior to execution. The Navy is interested in solutions that execute these functions without human intervention or supervision to perform tactical UxS missions.

In execution, these solutions would monitor traffic flow across multiple network enclaves within a UxS vehicle, make automated decisions regarding how to reconfigure the network to isolate anomalous behavior, and provide supervisory control of network traffic to enable/prioritize flow of mission-critical data flow while protecting the vehicle from horizontal escalation of anomalous traffic patterns.

The small business solution could take advantage of ML to integrate with commercially available SIEM and network configuration technologies. The solution should demonstrate the ability to identify anomalies and automate the process for identifying the appropriate responses needed to isolate the anomalies and implementing the appropriate network changes. Solutions must be effective without human intervention, given a number of pre-approved 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 Security Agency (DCSA). The selected contractor and/or subcontractor 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: Provide a concept to solve the Navy's problem and demonstrate the feasibility of that concept. Assess the feasibility by including at least one cyber table top (CTT). Identify the product(s) that comprise the overall solution, which may be either software or a combination of hardware and software based on Commercial off the Shelf (COTS) technology solutions and in accordance with the UMAA standards for physical and logical interfaces for ports, protocols, and services. Demonstrate feasibility using techniques such as modeling and simulation or demonstration testing in a commercial laboratory. As an example, propose a demonstration of a ML algorithm that analyzes SIEM data and issues a control to a network management device that changes the configuration of a network host. The Phase I demonstration could include human-in-the-loop supervisory control, provided the company explains how follow-on phases would fully automate the control function. Companies are expected to propose a specific plan for testing concept feasibility as part of their proposals.

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 prototype systems for testing and evaluation based on the statement of work (SOW) and Phase I results. The solution must demonstrate full automation (i.e., no human intervention required) of the process to detect an anomaly, determine the appropriate response, and execute the network configuration changes necessary to isolate the anomaly while still enabling mission-critical traffic flow.

The prototype system will vary based on the company's proposed approach, but it may include hardware and software. The hardware may be a commercial system, a Navy-provided system, or a combination of commercial and Navy-provided systems. The prototype will be evaluated in a Navy lab or at-sea environment. If the prototype is evaluated at sea, it may be evaluated on a manned or unmanned platform as appropriate for the solution. The Navy may opt to choose a surrogate platform for at sea testing based on availability of assets. Additional laboratory testing, modeling, or analytical methods may also be appropriate depending on the company's proposed approach. The test location will be at the USS Secure.

The system will be evaluated on its ability to with stand cyber-attacks (e.g. DOS, MITM) and the exfiltration of information from both internal and external threat actors. The testing and evaluation process will be accomplished through penetration testing. The personnel overseeing the tests will include representation from PMS 406. In general, two prototype articles should be provided to the government for testing, at least three months prior to the end of Phase II. A Phase III development plan will be required at the end of Phase II.

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 (i.e., software integrated with Navy-provided hardware, or software integrated with company-provided hardware) to Navy use through system integration, testing support, software and hardware documentation, and limited hardware production if applicable.

Possible platforms where the technology will be used include the Medium Unmanned Surface Vehicle (MUSV), the Large Unmanned Surface Vessel (LUSV), and the Mine Countermeasures Unmanned Surface Vehicle (MCM USV).

In Phase III, the product will be validated, tested, qualified, and certified for Navy use in at-sea trials across a wide range of conditions as applicable for the relevant class of problem. Additional software testing will likely also be required to ensure that all applicable conditions can be tested even if they do not occur during at-sea test periods.

These solutions have potential for dual use in unmanned or minimally manned commercial ships or unmanned vehicles that would benefit from the automation of rapid response techniques to isolate.

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KEYWORDS: Cybersecurity; Boundary Protection Capability; Unmanned Systems; Perimeter defense; Automated network security management; Machine Learning; ML; UxS

N211-059 TITLE: High Temperature, Low Dielectric Constant Ceramic Fibers for Missile Applications

RT&L FOCUS AREA(S): General Warfighting Requirements

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 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: Develop advanced high temperature ceramic fibers exhibiting high strength, low dielectric constant, low loss tangent, high thermal stability, and high oxidation resistance for missile and projectile system applications.

DESCRIPTION: Missile components such as radomes and control surfaces are subjected to tremendous thermal stress during missile flight. Current missiles use high temperature metals for control surfaces and ceramics (such as silicon nitride or silica) for radomes. Future advanced missiles will require components with greater thermal shock resistance with properties such as those exhibited by ceramic matrix composites (CMCs). However, the only fibers available for incorporation into CMCs are fused silica ("quartz" fibers), Nextel aluminosilicate fibers from 3M, and Nicalon fibers. These fibers suffer from a limitation on service temperature, generally about 1000-1200°C for the oxide fibers, and 1400°C for silicon carbide fibers. In the past, there has been insufficient market potential to support commercial development of fibers for higher temperature service.

Higher temperature fibers are desired, with the capability of surviving 1500°C or higher. For radome applications, fibers with low dielectric constant and low loss tangent are needed. The desired values for dielectric properties, mechanical properties, and thermal properties depend on specifics of the radar system and overall weapon design, and can vary. There is no absolute limit for either, but the concepts are discussed in the reference by Walton [Ref 5]. Examples of possible compositions for high temperature, low-dielectric constant fibers include boron nitride (BN) and silicon nitride (Si3N4). Both types of fibers were produced experimentally in the 1975-1995 timeframe but are not available commercially. Availability of high temperature fibers possessing the desired combination of properties (such as high elastic modulus, low dielectric constant and loss tangent, and high strength to elevated temperatures) will enable the development of ceramic matrix composites with vastly improved high temperature properties compared to current CMCs.

Missile components needing these material technology improvements include radomes and control surfaces, since they tend to experience the worst of thermal heat stresses during high-speed flight. As such, the material solutions will need to have electrical properties conducive to radome functionality (e.g., low dielectric constant, low loss tangent) in addition to high thermal stability and high oxidation resistance necessary for both radomes and control surfaces.

Possible applications for the desired technology include tactical missiles, long range guided projectiles, and hypersonic vehicles.

PHASE I: Develop a concept for high temperature ceramic fiber materials that meets the parameters and applications in the Ddescription. Establish concept feasibility of 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 demonstrate functionality under the required service conditions including thermal and mechanical stresses. Use evaluation and testing to include high temperature mechanical tests, thermal shock tests, electrical tests, non-destructive testing, and microstructural examinations to show the prototype will meet Navy performance requirements. Develop and propose a Phase III Development Plan to transition the technology to Navy.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use in the STANDARD Missile program or other missile and/or projectile programs that could benefit from the material advancement. Support the manufacturing of the components employing the technology developed under this topic and assist in extensive qualification testing defined by the Navy program.

Potential commercial uses for high-speed radome and control surface performance improvements exist in the commercial spacecraft and aircraft industries and satellite communications.

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KEYWORDS: Missiles; Guided Projectiles; Radomes; Thermal Shock; Missile Erosion; Hypersonics.

N211-060 TITLE: Human-Machine Interface for Directed Energy Weapons

RT&L FOCUS AREA(S): Directed energy

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 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: Develop and demonstrate an advanced display technology that maximizes operator performance for high energy laser weapons.

DESCRIPTION: The Navy has a long history of experience with radar, electronic warfare, and gun and missile weapon systems. Operator controls for these systems have historically been developed slowly over time in conjunction with advances in the system technology and in response to operational experience, simply adding new features to the existing displays. For example, current radar operator displays and controls evolved from the analog scopes and dials used to measure and adjust analog radar functions. As new radar features were added, displays and controls were added and the operators were trained to absorb, process, and respond to the additional information. The advent of digital and flat panel technologies caused an exponential growth in the amount of information about target detections and extracted target parameters that could be displayed, but the system designer still had a solid foundation of prior art to guide the evolution of the operator interface. This is equally true in commercial applications, for example, air traffic control radars and displays.

In contrast, directed energy (DE) weapons are being developed in technological leaps such that the human-machine interface (HMI) can no longer afford this type of deliberate evolution. From the outset, the DE operator will be inundated with tactical information, much of it requiring quick decisions and responses. The potential for operator overload is significant, and the display must be developed in a manner that supports how the operator uses the available information to provide the most efficient and effective display of data, thus reducing the potential for human error in lethal and non-lethal engagements. The commercial world provides few, if any analogies and provides no ready solution that meets the particular combination of demands placed on the naval warfighter during combat – especially in the use of a weapon system that has no non-military counterpart and no historical precedent. Furthermore, evolving threats and the insertion of new capabilities and tactics to meet those threats means that the DE console, and its interaction with the human operator, will not remain static over time. The HMI must accommodate the addition of new capabilities as well as updates to both software and tactics, and provide the flexibility for operators to hone their skills while exploring new operational concepts without the need for extensive re-training. The DE console must therefore incorporate technology that reflects the current state of the art in human cognitive science.

In particular, high energy laser (HEL) weapon, are unique in their capability and complexity. HEL systems incorporate elements of both sensors and weapons; are instantaneous; and have essentially unlimited range. Target cueing, de-confliction, atmospheric conditions, sensor coordination, resource
management, battle damage assessment, and multiple other operational considerations place unprecedented demands on system operators and on the displays and controls at their command. An integrated HEL operator display is needed that maximizes operator performance while mitigating operator fatigue and the potential for error.

From a hardware aspect, the HEL operator HMI is anticipated to utilize and be based on the existing shipboard combat system display console. This console features three large flat panel LCD color displays with touch screen capabilities available on at least one of the panels. The intent of this effort is not to design a new and dedicated set of console hardware – this would be contrary to the Navy's goal of commonality and affordability. Neither is the goal of this effort to develop finished tactical code for deployment (validation and certification of tactical code is prohibitively expensive). Rather, the goal of this effort is to design an HMI display that is based on how the user gathers and employs information that complements the particular strengths of human perception and the decision-making processes. It should be noted that "display" in this context is not just a collection of graphical interfaces and data read-outs. The display technology required is a coherent theme of graphical elements, symbology, visual cues, realtime video, and textual data captured in an HMI style guide and demonstrated (with representative software) on surrogate displays. This includes the methodology that organizes and presents these elements in conjunction with operator actions and queries. The technology should optimize the human operator's effectiveness and efficiency by making the interaction between the HEL weapon system as seamless and natural as possible, and enabling the operator to effectively process and employ the myriad of information available in the most effective means to achieve mission success. Therefore, acceptable solutions must be firmly grounded in the science of human cognition. Testing will consist of controlled and monitored execution of the HMI technology with human operators utilizing the surrogate display hardware. Final validation of the prototype will be demonstration of the HMI prototype on the surrogate display hardware, as witnessed by Government subject matter experts and program managers.

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 and/or subcontractor 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 HEL weapon operator HMI as defined in the Description section. Demonstrate the feasibility of the approach based on the principles of modern human cognitive science and some combination of analysis, modeling, simulation, and evaluation of initial candidate display architectures and themes. Show that the proposed approach can be fully realized and demonstrated on surrogate hardware in Phase II. The Phase I Option, if exercised, will include the initial design specifications and format for the display style guide as well as a capabilities description of the prototype solution that will be delivered in Phase II.

PHASE II: Develop a prototype of the concept of the HEL weapon operator HMI technology that meets the requirements defined in the Description section. Demonstrate the prototype on surrogate computer hardware and displays (may require the synthesis of surrogate display inputs for example, video imagery). Further demonstrate the prototype through the development of non-tactical code that emulates the tactical displays. Update, finalize, and deliver the design specification that was initiated in Phase I along with the fully demonstrated style guide. Government subject matter experts and program managers will witness demonstration of the prototype technology on the surrogate display system.

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. This may include evaluation of the final HMI implementation in tactical code on the tactical displays to validate compliance with the design specification and style guide; and may also include expansion of the style guide as additional data elements are incorporated in the HEL operator display in the future and as the display hardware receives normal updates.

Potential additional uses of the fundamental display technology developed under this effort include applications to highly complex and networked systems such as air traffic control, train dispatching, control centers for the electrical power grid, and wide-area security systems.

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KEYWORDS: High Energy Laser Weapons; HEL; Directed Energy; DE; Human-Machine Interface; HMI; Tactical Displays; Human Cognition; Operator Performance for HEL

N211-061 TITLE: Fast and Efficient Read-Out for Staring Focal Plane Arrays

RT&L FOCUS AREA(S): Microelectronics

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 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: Develop an advanced read-out technology that improves the detection of small targets with large, staring, infrared focal plane arrays.

DESCRIPTION: Focal plane arrays (FPAs) are used in narrow field of view (NFOV) sensors (i.e., cameras) to obtain high resolution images and in wide field of view (WFOV) sensors to surveil large areas of interest. In military applications, NFOV sensors typically benefit from powerful optics with high magnification and stabilized gimbal mounts that hold the camera on target and maintain a moving track. In this application, relatively small format FPAs can be used to image individual targets. In contrast, sensors used for persistent surveillance typically stare in a fixed direction to ensure that all possible targets within the field of view are detected. For staring sensors, the only way to increase resolution is to increase the size of the FPA since the magnification of the optics alone can't be increased without changing the angle of view. For WFOV staring sensors therefore, extremely large FPAs must be used to provide the maximum resolution possible. Not only does this drive up cost (FPA cost typically scales with size), it also introduces other design problems in the imaging system. In particular, large FPAs (with pixel counts in the millions) generate a huge amount of data. Not only is processing this data a challenge, but simply moving the image data off of the FPA to the image processor becomes problematic. This is especially so if the system operates at a high frame rate.

In staring sensors, a great deal of the image space does not appreciably change from frame to frame. Empty sky remains empty sky and even clouds, calm water, shoreline, and land features are static when compared to the fast changing features of the image. In typical image file formats, these constant pixels can be compressed, greatly reducing the file size. However, this isn't done until after the image data is read out from the FPA. Capture and read-out of the FPA image data is done by a dedicated circuit, the read-out integrated circuit (ROIC). The ROIC is tightly coupled to the FPA and it is the ROIC that detects and integrates the signal generated by each pixel in the FPA. Therefore, the ROIC largely determines the signal to noise (S/N) ratio, the optical dynamic range, and the frame rate of the sensor. Image data captured and output by the ROIC can be improved by post processing but the ROIC characteristics place a fundamental upper limit on the detection performance of the sensor system. A fixed dynamic range, uniform across the image plane, inhibits simultaneous detection of both extremely dim and intensely bright objects.

Commercially available sensors are subject to this constraint, which is why digital photographs often have areas that are "blown out" and other areas are so dark as to record no detail. This is accommodated for by adjusting exposure to exclude dim subject matter by biasing the sensor to preferentially capture the brightest part of the image. High dynamic range image capture compensates for this by taking multiple images. However, compensation is accomplished in post-processing and no acceptable real-time solution

is commercially available. Furthermore, a fixed frame rate, also uniform across the image and limited by the ability of the system to ingest the huge volume of data generated, inhibits the ability to detect and track small, fast moving, or rapidly fluctuating objects. In all such cases, it is "small" targets that are the most difficult to detect. Practical considerations limit the read-out of very large format FPAs to low frame rates. Coupled with the limitations of well capacity, this mean that only a small percentage of the light in a given frame can be captured and imaged by a large format FPA. This results in a reduction in signal-to-noise that effectively "hides" low signature targets.

Optically small targets are not necessarily small in physical dimensions. A large target at great range appears small to the sensor. Such targets may also be unresolvable due to the FPA size and limitations in the imaging optics. In the limit, a detectable target may occupy as little as one pixel. Typically, these targets are also dim as compared to the surrounding image. However, extremely bright small targets cannot be ignored. Motion or fluctuation in intensity of the target further complicates detection. Therefore, multiple, simultaneous, unresolved targets of a few pixels or less, exhibiting large brightness ranges and moving or fluctuating in intensity, present a particular challenge to staring WFOV sensor systems – largely due to limitations in the ROIC. Yet it's these targets that are most critical for the system to detect, track, and identify.

A better solution would be to dynamically adjust the read-out of the image to optimize detection performance of the FPA over small, select, "windows" of interest – for example, over a 16 by 16-pixel area. Since targets may be fast moving and/or rapidly fluctuating in intensity, the selected window should track with the target and automatically adjust its size and integration time as the localized intensity, contrast, and target motion and fluctuation demand. Since the application envisions very large format staring FPAs that may contain multiple simultaneous targets of interest in the field of view, multiple independent windows (up to 40) are needed.

The Navy needs an innovative FPA read-out technology that automatically identifies and selects regions of interest in the overall image and then interrogates the pixels within that region to define and then dynamically adjust the capture of pixel data within that region for optimum detection. Furthermore, the identified regions of interest should be capable of moving with the target and adjusting in size to maintain the necessary target detection and tracking, thereby minimizing the amount of additional data output from the ROIC. The goal is to increase WFOV sensing in the mid-wave infrared (MWIR) band without significantly increasing sensor cost. Therefore, the solution should not demand the concurrent invention of a new FPA but should be compatible with at least one of the existing families of MWIR FPA technologies (minimum 1 Megapixel format and maximum 12 micron pitch). Validation of the prototype will be accomplished by testing the combined FPA and readout circuit against moving targets (either targets of opportunity or synthesized targets on an outdoor range). Successful demonstration will include detection and tracking of targets as small as one pixel where the target is so dim as to be at least 3 dB below the FPA's normal dynamic range.

PHASE I: Develop a concept for an innovative FPA read-out technology that improves the detection of multiple small and hard=to-resolve targets as described in the Description section. Define the architecture of the read-out technology and identify and select a compatible FPA technology in the MWIR band (minimum 1 Megapixel format and maximum 12 micron pitch). Demonstrate the feasibility of the proposed approach including the ability to scale to large format (tens of Megapixel) FPAs and predict the ability of the concept to achieve the simultaneous detection of targets that exceed the read-out circuit's inherent dynamic range and are undetectable at the read-out circuit's native frame rate. Demonstrate feasibility by some combination of analysis, modelling, and simulation. Analyze and predict the impact of the technology on the volume of image data produced by the read-out circuit. The Phase I Option, if exercised, will include a device specification, initial process description, and test plan in preparation for device prototype development and demonstration in Phase II.

PHASE II: Develop, demonstrate, and deliver a prototype FPA read-out technology as detailed in the Description section. Demonstrate that the technology meets the requirements in the Description section. Demonstrate the technology by selection of and integration with a suitable MWIR FPA (minimum 1 Megapixel format and maximum 12 micron pitch). Additionally, demonstrate the combined FPA and read-out circuit by imaging scenes of suitable complexity that contain combinations of small, dim, bright, moving, and fluctuating (in intensity) targets. After performance testing, deliver two prototype sensors (read-out circuit, FPA, and supporting circuitry) as well as any custom software, specialized test equipment, calibration equipment, fixtures, and targets developed under this effort to the Naval Research Laboratory.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Government use. Assist in scaling and applying the design for specific sensor systems. Mature, ruggedize, and validate the prototype designs for application to Navy imaging systems and assist in the transition of the technology to those systems. The technology resulting from this effort will have application in the field of scientific imaging as well as in commercial products for security systems, law enforcement, and search and rescue operations.

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KEYWORDS: Read-Out Integrated Circuit; Focal Plane Array; FPA; Staring Sensors; Wide Field of View Sensors; WFOV; Mid-Wave Infrared; Optical Dynamic Range

N211-062 TITLE: Nondestructive Detection of Flaws through Thick Polymers using Electromagnetic Imaging Technologies

RT&L FOCUS AREA(S): General Warfighting Requirements

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 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: Develop a wireless nondestructive testing (NDT) capability to inspect hull metal surfaces and assess hull-to-polymer bond health under thick polymer layers without polymer removal.

DESCRIPTION: There is currently no method for nondestructive testing (NDT) of metal health through thick polymers. Current methods for inspections through thick polymers involve destructive removal of sections of the thick polymer. Removal and replacement of these polymer sections involve costly (in labor, time, and materials) operations that generate hazardous waste. An electromagnetic imaging NDT method for inspections through thick polymers is needed to reduce lifecycle costs, improve accuracy of initial maintenance work scoping, and increase operational readiness by reducing emergent maintenance issues in-field that were not discovered during scheduled maintenance. Any solution designed herein must wirelessly transmit data from the electromagnetic imaging sensor unit to a remote device for user-analysis. The electromagnetic imaging sensor unit must weigh 15 pounds or less (including power supply).

The developed NDT system must conform with all Federal Communications Commission (FCC) regulations and deliver a signal-to-noise dynamic range that corresponds to a linear interpolation as a function of frequency between 80dB at 15 GHz and 100 dB at 25 GHz (the frequency range of interest) via either a single frequency, narrowband, broadband, or multi-band solution. The NDT system must detect and classify debonds of any separation distance, corrosion, water intrusion, and surface metal loss (due to damage) of 0.41" diameter or greater on a metal substrate through a thick polymer coating with a refractive index of 1.0.

NDT of a metal substrate through a thick polymer coating while maintaining sub-wavelength resolution has been a long-standing challenge for electromagnetic imaging technologies, such as Terahertz imaging or millimeter-wave imaging, operating at far-field distances from the signal source. At 15 GHz with n =1.0, the diffraction limit (wavelength size) is 0.79", and at 25 GHz with n = 1.0, the diffraction limit is 0.47". Thus, for the designated frequency band of interest, the given 0.4125" at n = 1.0 feature detection requirement requires sub-wavelength resolution, far-field interrogation of the target. Far-field detection of features smaller than 0.4125" at n = 1.0 is also of interest if possible. Sub-wavelength resolution is possible with geometric super-resolution techniques, such as Multi-spectral Signal Characterization (MUSIC). Far-field super-resolution techniques exist, yet no ruggedized end-user solutions with suitable detector/classifier algorithms are available in the current market. The development of a commercially viable prototype is needed for Navy applications.

Current and near-future Navy preservation applications require fine-resolution detection and classification of metal substrate flaws through thick polymer preservation coatings to perform needed inspections for specific flaws of interest at reduced maintenance cost to the Navy due to repair labor and material from destructive inspection practices. As materials become thicker, they become more attenuating for electromagnetic waves. The materials of interest also become more attenuating with increasing frequency. Thus, to perform needed NDT imaging through the materials of interest, an electromagnetic imaging source is needed that operates along a linear trendline between 15 GHz at 80dB of dynamic range and 25 GHz at 100dB of dynamic range (i.e., 20 GHz at 90dB of dynamic range fits along that linear trendline). Solutions that use performance extrapolations outside of the 15-25 GHz range (along the same dynamic range trendline) are also of interest as long as they meet the required 0.41" minimum flaw detection size, are able to detect "kissing" debonds (defined as when two bonded surfaces break their bond but are still touching), and are in accordance with all FCC regulations.

Any prototype solution developed will also include commercial off-the-shelf (COTS) software tools that provide automated detection and classification of any flaws in the collected data as well as software tools to enable the Navy to incorporate Navy-developed automated detection and classification algorithms. These flaws include debonds ("kissing" and larger debonds), substrate metal corrosion, and water abscessed at the preservation-to-metal interface. The prototype solution should scan for flaws and give processed results as expeditiously as possible. The preferred solution provides results as close to real time as possible, is portable (1-person carry) with supporting equipment, and provides a graphical user interface that is easy to use and understand by a technician with sufficient training. Such training will be developed as part of this topic. The software may be developed in any modern programming language (i.e. Python, R, Rust, Julia, or an appropriate Javascript derivative) and should provide tools for the user to develop and include their own detection/classification algorithms to process the data in real time.

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 and/or subcontractor 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 develop a concept for a far-field electromagnetic imaging system with the capacity to meet the operational, frequency, dynamic range, minimum detectible flaw size, and automated detector/classifier requirements specified in the Description. Perform modeling and simulation to provide the initial assessment of concept performance and feasibility. Phase I Option, if exercised, would include the initial layout and capabilities description to build the unit in Phase II.

PHASE II: Develop and deliver a prototype based on the Phase I work and the Phase II Statement of Work (SOW) for demonstration and validation through a field test on a specified, Navy-developed test panel that is equivalent to testing on an in-service Navy asset under field conditions, showing that the prototype meets the performance requirements in the Description. Refine the prototype as required based on the results of the demonstration and validation process. Deliver the final prototype at the end of the Phase II, ready for field use by the Government. Deliver comprehensive instructions and documentation for prototype setup, operation, maintenance, and software SDK development to enable a user to make full use of the prototype.

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

PHASE III DUAL USE APPLICATIONS: Assist the Navy in integrating the Phase II prototype into a field-use technology for Navy technicians. Provide a formal training curriculum (Level 1, Level 2, and Level 3) for Navy NDT inspectors to become certified in using this prototype for formal Navy NDT inspections. Update the training based on end-user feedback to the first version of the curriculum. Support Navy personnel to ensure all required software is approved for end-user use as well as testing, validating, certifying, and qualifying the prototype for Navy use.

Dual Use applications include other challenging electromagnetic imaging applications, such as assessing rebar health through concrete in structures, through-wall imaging, and contactless suspected bomb inspection.

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KEYWORDS: Terahertz imaging; electromagnetic imaging; millimeter-wave imaging; mm-wave; nondestructive testing; NDT; nondestructive evaluation; NDE; Multi-spectral Signal Characterization; MUSIC; synthetic aperture radar imaging; geometric super-resolution; SAR

N211-063 TITLE: Compact, Efficient, High Power Direct-to-Green Laser Source

RT&L FOCUS AREA(S): Directed energy

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop a highly efficient, direct-to-green laser source for detection of mine and mine-like objects in the Surfzone (SZ) and Very Shallow Water (VSW) regions, Increase the laser efficiency by more than 100% as compared to methods used today.

DESCRIPTION: Current laser sources are very inefficient due to the requirement to obtain the "Green" light from splitting an "Infrared" light source. The generation of green laser light via frequency doubling has typical conversion efficiencies that are ~50% for the process. In addition, the heat dissipation usually requires a method for dissipating the excess energy from the conversion process, upwards of 90%. Research into a relatively new technique of nano-particle doping of fiber lasers shows improved efficiency and power output over current fiber lasers and should be considered when proposing a solution.

In Stride Detect to Engage UAVs requires highly efficient laser sources to meet challenging size, weight, and Power (SWaP) requirements. A direct-to-green source would enable higher power at the same or less SWaP, enabling improved Area Search Rates and Time on Station. For the purposes of estimating SWaP requirements in proposals, the targeted air vehicle is similar to a Bell 407. The laser source will be enclosed in a to-be-designed externally mounted pod with an external diameter of 21 inches and external length of 110 inches. The SWaP will be shared with other sensors. The SWaP potentially available for the laser is 0.75 cubic feet, 60 pounds, and 700 Watts at 28 Volts Direct Current. However, it should be noted that one of the goals of the SBIR is to minimize SWaP. Desired output energy is approximately 500 millijoules at 532 nanometers. Trades will be considered between output energy and SWaP.

The laser shall take into consideration American National Standard Institute (ANSI) Z136.1, Safe Use of Lasers, and Code of Federal Regulations Title 21, Part 1040, Performance Standards for Light-Emitting Products. Other laser requirements, such as pulse width and repetition rate, are based on the chosen receiver. At this time, the Government does not have a receiver in mind but the laser should function with either a 2D Gated or a 3D receiver.

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 and/or subcontractor 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 determine the feasibility of the concept to design a "direct-to-green" laser with improved efficiency over current "green" lasers. Demonstrate the feasibility of methods to manufacture "direct-to-green" lasers, which are manufacturable and able to be amplified in a highly efficient manner. Initial prototype validation of concept will be encouraged. 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), the company shall develop and deliver a minimum Technology Readiness Level 5 prototype "direct-to-green" laser source suitable for follow-on Government testing (to include flight testing) and validation. The Government may test the laser in accordance with MIL-STD-810 test methods for low pressure (altitude), high temperature, low temperature, acceleration, and vibration for an airborne rotary wing environment. Additional tests may use MIL-STD-461 and MIL-STD-464 to verify electromagnetic compatibility.

Perform laboratory testing and fully characterize the system prototype. Parameters to characterize include bandwidth, pulse width, repetition rate, beam quality, output pulse energy, and output pulse intensity divergence and uniformity.

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: The final product should be a ruggedized prototype direct-togreen sensor and software package that can interface with the Coastal Battlefield Reconnaissance and Analysis (COBRA) Sensor. Assist the Government to obtain flight certification on a NAVAIR UAV.

Other applications of blue-green lasers include oceanographic bathymetry, underwater sensing, LiDAR, and communications.

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KEYWORDS: Direct to Green; Airborne Mine Detection; Detection of Ocean Mines; Compact Multi-Spectral Laser; Tactical Unmanned Air Vehicle Sensor; TUAV; Drifting Mines

N211-064 TITLE: Low Cost Deepwater Delivery Systems

RT&L FOCUS AREA(S): General Warfighting Requirements

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 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: Develop an innovative, low-cost method for delivering sensor payloads to specific locations or along specific trajectories for oceanographic, environmental, and biologic data collection in various depths of water.

DESCRIPTION: Oceanographic, biologic, and environmental data collection is needed to better understand the world's oceans and to support naval operations. A large portion of ocean data is collected using underwater sensors. Networks of underwater sensors are enhancing data collection and enabling an Internet of Things (IoT) approach to marine monitoring. Although marine sensors vary widely in design and application, there is a need for low cost deployment approaches for marine sensors.

Numerous methods exist for the deployment of underwater sensors. Some sensors are placed using cranes and winches from surface ships. Precise placement of the sensors at deeper depths requires sophisticated station keeping and tracking capabilities, and typically results in moderate to high deployment costs. Surface ship deployment of deep sensors using cranes and winches have costs that scale with platform size and mission duration. Costs can range from \$0.5M to \$10M depending on the sensor payload size and mission details. Remotely operated vehicles (ROVs) or deep submergence vehicles (DSVs) are also used to assist in sensor placement. These approaches typically require support from specialized surface ships and thus result in moderate to high deployment costs. Costs for ROV- and DSV-supported placement of deep water sensors typically range from \$2-3M to \$10-20M. Some sensors are deployed as a payload on an underwater vehicle. Example of vehicles used include underwater gliders, buoys, and unmanned underwater vehicles (UUVs). Underwater gliders are typically a low-cost combined sensorvehicle approach using relatively simple vehicles and components and one- to two-person deployment operations that can be carried out from most any surface vessel. Sensor deployment as part of an underwater glider can result in costs as low as \$100K. However, most underwater gliders have limited payload capacity. UUVs vary greatly in size and also in payload capacity. UUVs have excellent payload delivery potential. However, most UUVs, especially those that can operate at deeper depths, have moderate to high purchase and operation costs. Deep-water sensor deployment via UUV typically incurs costs of \$500K to \$3M, depending on mission details. Floats offer a balance of low cost and moderate payload capacity, with costs ranging from \$100K to \$300K for some common systems. However, most float systems lack sufficient maneuverability to act as deeper depth sensor deployment systems.

At present, most existing methods for deployment of underwater sensors suffer from either high costs, low payload capacity, minimal maneuverability, or restrictions to shallow depths. Low-cost deep capable alternatives are needed.

The intent of this SBIR topic is to solicit novel ideas for low cost payload deployment in various depths of water. A system cost less than \$200K and deployment costs less than \$300K per deep water mission would greatly enable and extend deep water sensor-based activities in oceanographic, biologic, and environmental data collection. All concepts that can provide a low-cost means of deploying common sensor packages are of value and shall be considered. The following metrics are provided as general guidance, but solution concepts can deviate from these metrics as long as the solution provides an advancement in deployment operations or reduction in cost of established or future underwater sensors systems.

Potential payloads vary greatly in size, shape and weight. A target payload size is provided for purposes of design studies. Concepts that meet or exceed the target payload size will have strong potential for selection and transition. The target payload size is a dry weight of up to 100 lbs (45 kg), a net buoyancy ranging from 0 to 50 lbs (23 kg) negatively buoyant, and a total volume of up to 1000 cubic inches (16400 cubic cm). Although many sensor payloads are currently of cylindrical form factors, solution concepts should have moderate flexibility to accommodate both variations in payload shape and net buoyancy over the ranges provided.

The delivery solution shall be easily transported and stowed, ideally with minimal storage footprint and special equipment required. An on-deck footprint of roughly 3ft (1m) by 6ft (2m) would greatly expand surface ship deployment options and thus provide deployment cost reduction potential. Deployment of the delivery solution and payload will ideally require minimal support equipment. It is anticipated that two-person portable and deployable solutions will likely provide the greatest cost savings and have the greatest potential for transition to military and commercial use. Recovery of the delivery solution shall also be considered in comparing solution concepts. The recovery approach should minimize personnel and resources required. It is conceivable that some delivery solutions may be of sufficiently low cost and have a negligible environmental impact such that recovery of the delivery system is not required. Such solutions will have a favorable impact on logistics and will be rated accordingly.

The required placement performance of the delivery solution varies with different sensor payloads, but a placement uncertainty of 33ft (10m) is considered to have good transition potential. Placement at a fixed bottom location is considered a primary evaluation criterion. However, the ability to traverse a specified trajectory is also considered a valuable capability and will be considered when evaluating solution concepts.

It is desirable for the delivery solution to be able to operate in various depths of water. Depth capability will be a key factor for transition. Concepts should maximize depth capability. Concepts that can operate to full ocean depth will be applicable to the largest range of sensor deployment operations and will thus maximize transition potential.

Under many conditions, it can be advantageous to deliver a sensor payload to locations away from the deploying vessel in order to maximize sensor coverage while minimizing distance traveled by the deploying vessel. A delivery approach that can achieve accurate placement of a sensor over an operationally relevant horizontal distance from the deploying vessel has greater transition potential than a solution that can only deliver a payload to a location directly below the deploying vessel. Simple delivery concepts can be conceived which could provide horizontal standoff (range) from the deploying vessel. Concepts that can provide operationally relevant range (1km or greater) will have strong transition potential.

Cost is expected to be the most critical factor affecting transition. As discussed above, significantly reducing the operational costs of current delivery approaches will result in meaningful reductions in the

cost of underwater sensor delivery, and therefore any innovation with cost reduction potential is valuable. Solutions that can achieve low system costs, while providing the performance attributes above, will have significant transition potential. Cost savings potential are on the order of \$0.5 to \$3M+ per payload deployment and placement.

Phase II will feature prototype development and testing. The Navy will assist in developing a test plan that demonstrates and establishes the full range of performance characteristics of the solution. Potential test sites include the Atlantic Undersea Test and Evaluation Center (AUTEC), Pacific Missile Range Facility (PMRF), or an open ocean test site. Testing depths, environmental conditions, and test payloads shall be selected to fully exercise solutions in order to maximize demonstration value and enhance transition potential.

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 and/or subcontractor 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 a low cost deep-water delivery system that consists of the design, identified critical components, estimates of solution materials and manufacturing costs, and Rough Order of Magnitude (ROM) costs for transport, stowage, and deployment. Combinations of analysis, modeling and simulation may be required to establish solution feasibility. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a full-scale prototype system in Phase II.

PHASE II: Develop and deliver a prototype system and validate it with respect to the topic's objective. The prototype system shall consist of a vehicle functional and system diagram, a complete technical design package, vehicle integration plan, vehicle assembly plan, and vehicle test and evaluation plan that shows how to validate the prototype system performance. Evaluate the prototype based on payload capacity, delivery accuracy to a fixed bottom location for select depths and ranges, delivery accuracy along a desired trajectory for select depths, total system cost, and overall projected costs of transport, launch, and recovery. Aspects of Phase II testing will be dependent on the scope of solutions provided in Phase I.

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 the form of follow-on prototypes, using any lessons learned from the Phase II to improve the solution. Tailor the solution for deployment from specific vessels as required. Additionally, there is extensive commercialization potential for low cost deep-water delivery systems to support deep sea oil and mineral extraction as well as enable the sensors needed to regulate such industries. As such, Phase III will enhance the technologies to maximize alignment for delivery of sensors to support oceanographic, environmental, and biologic data collection, as well as resource management.

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KEYWORDS: Sensor payload delivery; Underwater Vehicle; Deep Ocean Delivery; Low Cost Navigation, Low Cost Underwater Systems; Low Cost Autonomy; Low Cost Deployment

N211-065 TITLE: Adaptive Narrowband Trainer

RT&L FOCUS AREA(S): General Warfighting Requirements

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 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: Develop an adaptive narrowband trainer that leverages artificial intelligence (AI), machine learning (ML), and real-world elemental playback data to detect, analyze, and classify real-world Passive Narrowband (PNB) signatures of submarine contacts.

DESCRIPTION: As adversary submarine forces field platforms that are increasingly capable and stealthy, the ability to detect these ships becomes ever more challenging. The ability to pace the threat with newer sensors and processing systems is part of the solution, but sonar sensor operators require better tools to effectively exploit the new sensor and system capabilities, specifically regarding narrowband detection and analysis. Relatively few training products address narrowband detection and analysis. Those narrowband training products that exist fail to leverage adaptive training, and Artificial Intelligence and Machine Learning (AI/ML). Existing interfaces to the latest tactical systems are limited, and existing narrowband trainers are not equipped for updates to represent emerging narrowband phenomena.

Sailor evaluation of PNB signals is particularly critical in successful Anti-Submarine Warfare (ASW) prosecutions. Depending on the sensor suite available, passive narrowband signals to be analyzed can be hidden across hundreds of beams of bearing and hundreds of frequency bins per line of bearing. Identifying specific signals associated with undersea threats in a timely manner is both a difficult skill to acquire and a skill that is highly perishable when use or effective training is not constant.

The Navy seeks an innovative narrowband trainer that adapts to emerging threats and maximizes accelerated learning. Essential elements of the trainer include a training or gaming platform that is both engaging and instructive. The trainer would ideally be accessed through the Moodle Learning Management System (LMS) resident on the respective shipboard tactical system, and capture operator performance data by leveraging experience API (xAPI) and the learning record store (LRS) resident on the tactical system. The trainer may also be accessed by ashore trainers such as the Submarine Multimission Team Trainer (SMMTT), the Multifunctional Instructional Trainer (MIT), the Applied Classroom (ACR) or the Virtual Operational Team Trainer (VOTT).

The trainer should be designed to include updateable real world elemental acoustic data provided by the Navy as a stimulus for the tactical displays the operator observes. The trainer should employ adaptive training techniques that will progress the student depending upon his/her level of knowledge and level of performance. In cases where the student is more proficient, that student should progress faster through the scenario and not be required to complete tasks associated with lower levels of knowledge or proficiency. The trainer should employ AI/ML to increase the challenge to the student according to the student's capabilities and to facilitate a rapid learning curve. The trainer should provide feedback to the student, both in the form of dynamic hinting during the scenario and a post exercise evaluation or after action

report that is referenced to an approved performance standard for better objectivity. The trainer should represent all display surfaces for data analysis and be able to represent the state of automation present in the build of sonar analysis software the sailor is tasked to use.

Additionally, the new training capability should leverage best practices in adaptive training. According to Metzler-Baddeley [Ref 2], "adaptive training used study time more efficiently than the chosen control conditions that is participants did not waste time studying items they already knew and were able to concentrate on items that required more training." In turn, the trainer would maximize the operator's time and increase training efficiency. According to Forsyth et. al [Ref 3], "adaptive learning recognizes the pace of student learning varies and provides instructors with the tools needed to relieve the time pressure of increased enrollment to reach students where they are in the learning process to enhance both student and teacher effectiveness." Applying new adaptive learning approaches would benefit not only sonar operators at sea, but would also provide the schoolhouses with an additional resource for classrooms ashore. In addition, Sailor 2025's Ready Relevant Learning initiative focuses on developing a "learning continuum where training is delivered by modern methods to enable faster learning and better knowledge retention at multiple points throughout a career." Adaptive training would provide an excellent modern solution to this problem.

This SBIR topic addresses CNO's desire to achieve "high velocity learning at every level" and supports Sailor 2025. This topic would seek to apply the best concepts, techniques and technologies to accelerate learning for individuals, teams, and organizations.

Additionally, this topic addresses current training requirements identified in the most recent Submarine Tactical Requirements Group Advanced Development Prioritized Focus Area letter specifically requesting "embedded training systems should be adaptive to the skill level of the trainee and …real world elemental data should be capable of playback…allows for continuous learning on and off watch".

Finally, this topic addresses current training requirements identified in the most recent AN/SQQ89 Advanced Capability Build Prioritized Focus Areas letter, to wit: "System training for operators should be readily available and delivered using modern training techniques and adaptive system training..."

Sailor evaluation of passive narrowband signals is particularly critical in successful ASW prosecutions.

Initial testing of this trainer can be accomplished at the company site given the prerequisite to provide a representative simulation of narrowband acoustic information that would be resident on a tactical system, tactical trainer or virtualized training simulator. Final testing and certification would be accomplished at the prime system integrator site or a site that contains a representative tactical system simulator with an installed Moodle Learning Management System. Initial testing would be conducted by the developer with Government-designated representatives. Final testing and certification would be conducted by Government-designated representatives in concert with Naval surface and submarine force active duty sonar operators.

Metrics used to assess the learning training capability will refer to learning gain, successful assessment of the adaptive training algorithm, and an acceptable usability score using the System Usability Scale (SUS). The Kirkpatrick Four-Level Training Evaluation Model will be used to objectively measure the effectiveness of training. The learning narrowband trainer must be able to integrate into the Moodle LMS as well as the learning record store (LRS) present in the learning architecture embedded in the tactical system of submarines and surface ships.

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 and/or subcontractor 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 adaptive narrowband trainer utilizing AI/ML to teach and reinforce passive narrowband signature recognition. Demonstrate the concept feasibly meets all the parameters detailed in the Description through modeling and analysis. Also, demonstrate the concept can operate in the Moodle LMS, experience API (xAPI), and the LRS discussed in the Description. 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 adaptive narrowband trainer for testing by ASW personnel in the Fleet. Demonstrate prototype performance through the required range of parameters in the Description. The Government or the company will provide facilities for testing and validating the prototype.

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 adaptive narrowband trainer prototype. Assist in transition and integration of the prototype to a future Advanced Processing Build (APB) Combat System with the potential integration including the Advanced Capabilities Build (ACB).

The narrowband training capability can be adapted to other technical fields that involve operator assessment of faint signals, found in electronic communications, medical diagnostic tools, and other engineering disciplines that deal with oscillating signals. Adaptive learning and AI/ML are innovative approaches that would be useful to the wider education and business communities as a whole.

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KEYWORDS: Narrowband Training Products; Adaptive Training Techniques; Ready, Relevant Learning; Artificial Intelligence; Machine Learning; Kirkpatrick Model.

N211-066 TITLE: Coupled Control of Expeditionary Remote Operating Vehicles (ROV) and Manipulator Payloads

RT&L FOCUS AREA(S): Autonomy

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop a coupled control system for optimal manipulator operation onboard an expeditionary class underwater Remotely Operated Vehicle (ROV) for greater performance.

DESCRIPTION: The United States Navy's Maritime Expeditionary Standoff Response program seeks to improve the capabilities of expeditionary Remotely Operated Vehicles (ROVs), which currently have limited manipulation capabilities. One of the improvements that is being implemented is the integration of multi-degree of freedom manipulator and end effector payloads that will enable these ROVs to perform increasingly complex tasks in the marine environment. ROVs currently in use operate with vehicle control systems that are independent from their payloads. During most operations using this paradigm, the ROV is able to adequately maintain its pose while the manipulator conducts its intervention tasks, operating with its own fully independent control system. For many tasks, an operator at a topside control station must intervene to alter the ROV orientation, communicating with a second operator of the manipulator/end-effector payload(s) who uses a second control station for operation of the manipulator. Work conducted under this topic will develop a fully integrated and coupled single control system for the combined ROV-manipulator system enabling the ROVs thrusters to provide additional degrees of freedom to the manipulator end effector. This approach will enable more fully optimized manipulation and reduce operator workload while performing complex manipulation tasks, and it will reduce the size and complexity of the ROV-manipulator system's control station as the ROV and manipulator will no longer require separate control interfaces.

A coupled control system will improve ROV and manipulator/end-effector payload system effectiveness and efficiency in performing complex underwater tasks, while concurrently reducing the size and complexity of legacy topside control stations, the requisite skill level and the quantity of system operators required for task accomplishment. Introduction of improved automation and coupled control of ROVs and payload control will reduce operator burden, training, and life cycle control costs for sustaining operational readiness of Maritime Expeditionary Standoff Response (MESR) systems.

To facilitate currently fielded systems as well as future developments, platform agnostic control systems architectures will be strongly preferred. Initial ROV platforms for demonstration and feasibility study should include either the VideoRay Defender or SRS Fusion vehicles that are currently in use with Expeditionary EOD units.

Initial feasibility studies and demonstrations may take advantage of open source simulation environments such as Open Source Robotic Foundation's Gazebo [Ref 3] or other suitable models that have sufficient fidelity to test and evaluate proposed solutions.

After a candidate coupled control system prototype is developed, it will be used to conduct a series of tasks that would currently be conducted with independent control systems. The differences between the current method and the prototype coupled control system will be quantified and recorded. Particular areas of interest to be explored during this experiment will be total system energy consumption, operator experience, manipulator function, and any other notable changes in capabilities and limitations of the system. This experiment will be conducted in an operationally relevant environment. Access to an operationally relevant environment for the experiment can be provided by the Navy, or the experiment may be conducted at a suitable location chosen by the selected company.

The control system developed under this program must employ a cybersecurity-compatible open architecture design to facilitate modular application to ROV platforms and manipulator payloads other than those for which it is specifically developed during this effort.

The Phase I effort will not require access to classified information.

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). The selected contractor and/or subcontractor 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 proposed control system concept and perform a feasibility study of that proposed concept Feasibility will be assessed based on analytical results of the study.

Open source robotics simulation environments are acceptable for evaluating feasibility as are proprietary, custom, or in-house simulations, provided their underlying assumptions and constraints are sufficiently documented. For simulation-based experiments, the ROV and the manipulator system that is modeled should be representative of current Expeditionary ROVs and commercially available manipulator systems to the maximum extent possible. In areas where the model diverges from current systems, the necessary modifications to more closely align with fielded systems should be documented. At minimum, simulated models should demonstrate the fundamental concepts of the coupled control system well enough to evaluate their potential application to Navy ROVs outfitted with multiple-degree of freedom manipulator/end-effector 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), the company will develop a prototype of the coupled control system to be integrated onto an ROV-manipulator system that is representative of expeditionary class ROVs the Navy utilizes. Evaluate improvements against current systems through the conduct of a series of manipulation tasks in an operationally relevant ocean environment using both the coupled control system and the independent ROV and manipulator control systems. Quantify energy consumption requirements and characterize capabilities and limitations of path planning, operator experience, and overall manipulation functionalities of the proposed coupled control system in an operationally relevant environment. The Navy will provide access to operationally relevant environments for testing and demonstration if requested. Alternatively, selected companies may conduct tests and demonstrations in environments of their choice provided those environments maintain sufficient fidelity to fully evaluate candidate solutions.

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. Ensure that the final product to be transitioned to the Navy will be a coupled control system for a Navy expeditionary class ROV with integrated manipulators; and will be designed and fabricated with a cybersecurity compatible open systems architecture that will enable modular application to systems other than

the prototype hardware/software on which it was originally developed, tuned, and demonstrated. Validate the system by carrying out a series of manipulation tasks relevant to Navy operations.

Coupled control for ROV/manipulator systems must demonstrate the potential to reduce operator workload and complexity of topside workstations, improve system energy efficiency, and improve the range of manipulation tasks that can be accomplished. Remote underwater manipulation is widely applicable beyond solely Navy applications, particularly in oil and gas, scientific, and academic communities.

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KEYWORDS: Remotely Operated Vehicle; ROV; Manipulation; Expeditionary; Coupled Control; Autonomous Manipulation; Unmanned Systems

N211-067 TITLE: Atomic Inertial Sensor as an Alternate Position Source

RT&L FOCUS AREA(S): Quantum Science

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 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: Develop atomic inertial sensors that advance the state of the art in inertial navigation.

DESCRIPTION: The success of U.S. Navy missions depends on personnel and platforms having access to accurate and reliable position, velocity, attitude, and time information. Maritime platforms specifically need this information continuously to support safety of ship, weapons deployment, and network communications and geo-registration. The DoD developed Global Positioning System (GPS) to provide accurate, worldwide, all-weather, continuous position and time information to warfighters. As a result, GPS is the primary positioning and time source for maritime surface platforms. However, GPS is susceptible to interference and may not be continuously available. Consequently, in the absence of GPS, other technology is sought to provide positioning and timing information to meet mission support.

Many military platforms also usually deploy inertial navigation systems along with GPS. Inertial navigation systems are continuous, all-weather sources of position, velocity, and attitude information. Inertial navigation systems are not susceptible to interference in the same manner as is GPS. In addition, many maritime platform missions can be met with a military grade inertial navigation system. Inertial systems drift over and require periodic fixes to reset their position. Typically, an inertial navigation system will be corrected by fixes to GPS or some other fix source, such as a visual source, a radar contact, or some other navigational feature. In the event of a prolonged period of GPS not being available and no other usual sources being available, additional sources of position fixing are needed.

Inertial measurement sensors based on atomic interferometry solve the problem of sensor drift by providing measurements of acceleration and rotation with very low bias instability and random walk. This high performance is essential for GPS-denied inertial navigation, because position errors grow quadratically in time, proportional to random walk in the inertial sensors. Atomic interferometry uses wave-particle duality to measure accelerations and rotations as interference effects. These methods are precise because atoms have an exact internal electronic structure, which can be manipulated by electromagnetic radiation. The typical atomic interferometer is conceptually similar to a Mach-Zehnder interferometer, but with laser pulse induced Rabi oscillations enacting the behavior of beam splitters and mirrors. In laboratory settings, atomic interferometers have demonstrated super strategic-grade performance with long-term stabilities in the nano-g accelerometers and nano-radian/sec gyroscopes.

Atomic interferometers have previously been deployed on ships and airplanes with μ g and μ rad/s sensitivity, but in general there are a few hurdles to deploying this technology in defense operations. This technology currently exists in the commercial market in the form of scalar quantum gravimeters (single-axis/1DOF accelerometers), but for the most part the technology has been funded and developed only for defense applications. In addition, navigation requires inertial measurement at frequencies well above 100

Hz, but atomic interferometer sensitivity decreases at higher frequencies, since atoms spend less time experiencing the acceleration or rotation. These devices must also have size, weight, and power, and cost (SWaP-C) low enough to be combined into a full inertial measurement unit (IMU) with gyroscopes and accelerometers along 3 spatial axes (for a total of 6 degrees of freedom). Other problems include the 2p-phase ambiguity, which limits the dynamical range of the atomic interferometer, wavefront curvature in lasers, and eliminating environmental noise.

An aspirational SWaP-C for a strategic-grade 6DOF IMU post-2020 is less than \$750,000, 40 liters, 250 Watts, and 40 kg. Previous efforts by DARPA include PINS/High Dynamic Range Atom Sensors and Systems (HiDRA II) and Chip-Scale Combinatorial Atomic Navigator (C-SCAN). C-SCAN sought to create a 6DOF strategic-grade IMU based on atomic interferometry within a 1 cubic inch and 1-Watt package. The result was the production of a 2DOF IMU with strategic-grade performance as an accelerometer and navigation-grade performance as a gyroscope. A related effort, Cold Atom Microsystems (CAMS) dramatically reduced the SWAP-C of atomic clocks relative to chip-scale atomic clocks. The technology sought should focus on either improving contrast to create a super strategic-grade IMU or on reducing SWaP-C to produce a chip-scale IMU with performance comparable to the PINS/HiDRA II 2DOF IMU.

The technology should target one of three areas: component development, strategic-grade IMU development, or 6DOF navigation-grade IMU development.

Component development should focus on R&D in the area of compact lasers, modulators, shutters, vacuum systems, or small-scale electronics. Lasers should have narrow linewidth (10 dB), or low wavefront curvature (<1 W) or pumpless. Electronics should be low power and ruggedized to support the other components.

Strategic-grade IMU development should improve the quality of existing atomic interferometer sensor technology by improving performance or reducing SWaP-C as defined hereafter. The ideal IMU achieves continuous-strategic grade measurements at an instability of 1 nrad/s, obtains continuous measurements at a high frequency (> 100 Hz), eliminates background noise at the μ rad/s level, and maintains contrast in a dynamic environment. These goals can be supported through many-photon momentum transfer, co-sensor integration, rotation compensation with mirrors, continuous-beam atomic sources, atom-number squeezing, atomic gradiometry, wave-front control, or other innovative methods. A proposed atomic interferometer sensor should be able to reduce SWaP-C without degrading performance or to improve performance without increasing SWaP-C. An IMU should cover as many degrees of freedom as possible.

The technology will undergo an independent evaluation at a Government-provided facility to show it will function in a maritime environment. An IMU should function to specification for an indoor ship-motion simulation test. Components should maintain performance for realistic variations in temperature, pressure, vibration, ship-motion, and supplied power but not ruggedized for warship shock and environmental conditions. System navigation performance shall be tested without continuous GPS aiding for a period of at least 100 hours to measure long-term performance and stability.

Navigation-grade IMU development should produce a fully functional 6DOF based on currently existing atomic interferometer technology. Steps in this direction would be combining currently existing single-axis and dual-axis technology to produce a 6DOF navigation-grade IMU or developing ultra-low SWaP-C single and dual-axis devices, which will later be combined to form the full IMU. It is also possible to construct a 6-axis inertial sensor directly as was done by Canuel et al. in 2008. However, the final product should be field deployable in the marine environment using modular construction to fit through 24" doorway. The device should function on a dynamic platform with angular rates up to 0.3 rad/s, tilting of up to 60 degrees, and accelerations as high as 5 m/s (with SWaP equal to or less than 1110 lbs., 600VA

max power draw with 600w max heat load, and 13 ft3 total volume, and functions in a shipboard environment. (0-95% humidity, 0-35oC). The technology sought will result in a resilient and accurate source of position and velocity information to U.S. Navy platforms. This information is needed to assure that platforms can meet mission need in the absence of GPS.

PHASE I: Develop a concept that characterizes atomic interferometry sensors that improves the inertial sensors for maritime platforms. Establish feasibility of an approach through analysis, modeling, and simulation to show the concept will meet the required parameters in the Description. 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: Design, develop, and deliver a prototype of the system described in Phase I. Demonstrate that the prototype meets the capabilities detailed in the Description during independent evaluation conducted at a Government-provided facility.

PHASE III DUAL USE APPLICATIONS: Assist the Navy in transitioning the technology to Navy use. The prototype will be tested on a maritime platform to demonstrate performance of the prototype and the associated system.

The technology will be highly valuable in the shipping industry and any at-sea situations where GPS is not always available and high accuracy is a requirement. If SWaP support is needed, aircraft and spacecraft are additional platforms that would benefit. R&D in supporting components will also enhance commercial electronics and the development of other next-generation sensors.

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KEYWORDS: Inertial Navigation Sensors; Cold Atom; Atomic Interferometry; Laser Pulse; Gyroscope; nano-g Accelerometer

N211-068 TITLE: S-Band Antenna System for Littoral Combat Ship Communications Relay

RT&L FOCUS AREA(S): General Warfighting Requirements

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 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: Develop a small, affordable, lightweight, and dynamic antenna system to be mounted on a remote aerial low-altitude relay that will enable Beyond Line-of-Sight (BLOS) communications between the Littoral Combat Ship (LCS) and the Mine Countermeasures (MCM) Unmanned Surface Vehicle (USV).

DESCRIPTION: The MCM USVs execute missions for LCS MCM Mission Package (MP). The network communication services between LCS and the MCM USVs are provided by the Multiple Vehicle Communications System (MVCS), which uses direct Line-of-Sight (LOS) communications in the S-Band – more specifically, in the 2.2 to 2.4 GHz frequency band. Results of a recent analysis performed at the Naval Surface Warfare Center Panama City Division (NSWC PCD) show that the Area Coverage Rate Sustained (ACRS) scores for the MCM USVs can be maximized by increasing the current maximum achievable range by a factor of 3-5. ACRS is one Measure of Effectiveness (MOE) typically used to evaluate MCM system performance, as shown in Reference 1.

Due to the antenna heights for LCS (90 ft for Independence variant, 65 ft for Freedom variant) and the MCM USV (18 ft), a 3x-5x increase in range using direct LOS communications is unrealistic, as it is severely limited by the radio horizon from the curvature of the Earth's surface. MCM MP data throughput requirements also effectively discard ground-wave propagation at lower frequencies as a possible solution, due to channel capacity limits. However, an intermediate relay node inserted between LCS and the MCM USV could enable a 3x-5x range increase and still meet MCM MP data throughput requirements without having to migrate to a different frequency band. This would allow having little to no change in communications equipment (i.e., radios, cables, amplifiers, and antennas) and configurations at the end nodes. Preliminary analysis and developmental test results have shown that an aerial relay at low altitudes – around 500 ft Above Sea Level (ASL) – should be sufficient to achieve the desired range increase. Not only would this be beneficial for the Navy, but also for the Marine Corps, who has shown an interest in developing a Long-Range USV (LR-USV) that can support its Expeditionary Advance Base Operations, as noted in Reference 2.

A currently existing prototype relay system uses an azimuth-plane omni antenna to establish a communications link with the MCM USV, and a gimbaled directional antenna that relies on actuators to physically steer the antenna's main beam towards LCS in the azimuth plane only – no direction finding in the elevation plane, as it always faces the horizon. Some of the concerns with the current prototype system include the following: Azimuth-plane omni antenna limits the communications range for the relay to MCM USV link and is susceptible to jamming from any direction; the gimbaled directional antenna can only scan as fast as the actuators allow, and is not expected to have good reliability or a long life cycle due to the actuators breaking down. These concerns open up the possibility of using other solutions,

such as switched array and phased array antennas, which should increase the life cycle by reducing/eliminating the need for moving parts, as well as allowing for faster scanning and/or tighter beamforming, so that directivity is maximized in any desired direction. Typical phased array antenna characteristics and design considerations are described in Reference 3.

The main objective of the technology is to produce a small, lightweight, and dynamic antenna system that can automatically beamform/beamsteer based on signal strength values reported from the radio. The antenna should be capable of handling fast beamforming/beamsteering to change beam directions between multiple end nodes. A secondary objective is for the antenna to implement null steering to avoid possible jamming sources.

There are multiple design constraints that should be observed, based on process modeling, operational experience, and optimization strategies:

antenna system - elements and switching/driving electronics

- should weigh less than 15 lbs
- should be able to achieve a gain of 15 dBi or more with a 20 dB minimum mainlobe-to-sidelobe ratio

• should have full 360-degree coverage in the azimuth plane and 40-degree coverage in the elevation plane centered at 10 degrees below the horizon

- should be able to handle 20 W average power (threshold) up to 40 W average power (objective)
- should cover the entire 2.2 to 2.4 GHz frequency band
- should not be more than 19 inches long and 15 inches in diameter
- Should have a response time of 20 microseconds or less
- should be environmentally sealed for protection against saltwater spray and continuous outdoor use

• in support of the secondary objective, the antenna should be able to create nulls at least 30 dB below the mainlobe and steer them towards jammers, while maintaining a communications link with the intended target/s.

Commercial antenna systems have been well developed for long-range communication systems in the S-Band, both for static and dynamic beam options. Switching/driving electronics for beamforming/beamsteering have also become robust. However, the challenge for this design, which necessitates innovative research & development, is being able to produce an antenna system with enough Effective Isotropic Radiated Power (EIRP) to close long-distance communications for link rates of 24 Mbps or more; minimizing Size, Weight and Power (SWaP) without exceeding cost constraints; minimizing response time for beamforming/beamsteering; and being able to survive harsh marine environments.

Any prototype antenna system developed as a result of this SBIR topic would be tested for its radiation characteristics – EIRP, directivity, beamsteering/beamforming, mainlobe-to-sidelobe ratio, mainlobe-to-null ratio – in a laboratory setup (anechoic chamber) during the Phase II effort. The optimized version of the antenna system would then go through environmental and electromagnetic interference (EMI) testing to applicable military standards (e.g., MIL-STD-810G and MIL-STD-461F). At the end of Phase III, a Seminal Transition Event (STE) will be conducted via an Over The Air (OTA) test in an operationally relevant environment onboard a relay system, with multiple active end nodes. The antenna system will be expected to not interfere with existing MVCS and endpoint certifications, and abide by established MVCS certification boundaries.

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 and/or subcontractor 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 an antenna concept that can meet the design constraints listed in the Description section. Establish feasibility by developing Computer-Aided Design (CAD) models that show the antenna concept and provide estimated weight and dimensions of said antenna concept. Feasibility will also be established by computer-based simulations that show the antenna array's beamforming/beamsteering 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 antenna system for test and evaluation. Test the prototype antenna system, first in a controlled laboratory environment, then in an operationally relevant environment, to determine its capability to meet all relevant performance metrics outlined in the Phase II SOW. Demonstrate the prototype system performance in both environments to the Government and present the results in two separate test reports. Use the results to correct any performance deficiencies and refine the prototype into a pre-production design that will meet Navy requirements. Prepare a Phase III SOW to transition the technology to Navy use. 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: Support the Navy in transitioning the technology to the LCS MCM MP relay system. Work with the Navy to integrate the antenna system onto the relay platform. Support test, validation, certification, and qualification of the system through environmental qualification testing, and with an STE at the culmination of the effort.

In the military/government sector, results from Phase II and Phase III for the relay platform antenna system can be leveraged to create variants of the antenna system for use on the MCM USV and LCS platforms, as well as demonstrate the MCM USV capabilities to perform missions at extended ranges for the Marine Corps LR USV concept. In the commercial sector, antennas with beamforming/beamsteering capabilities and anti-jam protection through null-steering could have potential for use in private communication systems set in urban environments, where spectrum congestion and interference – intentional or unintentional – can be prevalent issues.

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KEYWORDS: LCS MCM MP; Mission Package; Littoral Combat Ships; Mine Countermeasures; MCM USV; Unmanned Surface Vehicle; Multiple Vehicle Communications Relay System; MVCRS; BLOS Communications; Beyond Line-of-Sight; ACRS; Area Coverage Rate Sustained; Phased-Array A

N211-069 TITLE: Medium Voltage Direct Current (MVDC) Partial Discharge and Space Charge Test Apparatus for Cable and Insulated Bus Pipe (IBP)

RT&L FOCUS AREA(S): Directed energy

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop an affordable test apparatus and test method for detecting Partial Discharge (PD), measuring Space Charge (SC), and estimating remaining service life of Medium Voltage Direct Current (MVDC) cable and Insulated Bus Pipe (IBP) installed on naval ships, and to develop a Health Index and method to estimate remaining service life.

DESCRIPTION: An Integrated Power and Energy System (IPES) offers the potential to provide revolutionary warfighting capability at an affordable cost. An 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. Currently, IPES development is focused on a 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. MVDC IPESs will be used on future surface combatants to affordably improve warfighting capability to meet evolving threats over the ship's service life in an agile manner. As threat capabilities improve over the coming decades, the Navy is anticipated to rely more and more on high power, highly dynamic, and 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.

As described in the NPES Technology Development Roadmap, ensuring service life of MVDC insulation is required for naval power and energy systems to support multiple future high power, pulsed sensors and weapons on future surface combatants. The ability to evaluate the health of MVDC insulation in installed cabling, insulated bus pipe (IBP) and their connections is critical to the successful implementation of MVDC and to avoid unplanned outages due to failed insulation systems. An important enabler to an MVDC system is a method to detect PD and measure the SC in the cable and/or IBP that has been installed onboard the ship during ship acceptance testing and periodically during the ship's service life (Threshold) or continuously while the ship is operational (Objective). SC and voids in insulation of cables and IBP and their connections that operate above 1 kV can result in PD that can rapidly lead to failure of the cable / IBP insulation system. Traditional methods used for alternating current (AC) systems are not effective on MVDC systems. Existing methods for detecting PD in AC cables assume clean sinusoidal waveforms and are not suitable for MVDC systems with high frequency voltage ripple (See Ghosh, et al. [Ref 4] and Montanari, et al. [Ref 5]). SC in particular is unique to DC systems. Without an effective means to measure the health of the insulation system, the insulation system must incorporate large safety factors, resulting in thicker and heavier cables. Due to cable thickness limitations resulting from bend radius considerations, this conservative approach will require great expense and more cables of lower current capability to be paralleled together.

The power quality of MVDC on the shipboard distribution system shall be assumed to be in accordance with the "Preliminary Interface Standard, Medium Voltage Electric Power, Direct Current". The test apparatus shall be compatible with nominal system voltages of 6 kV, 12 kV, and 18 kV and steady-state current ratings up to 8,000 amps. The test is anticipated to be conducted shipboard during the acceptance testing of the ship and prior to ship delivery to the U.S. Navy, and periodically during the ship's service

life (Threshold) or continuously while operational (Objective) to verify continued PD-free operation and to measure SC.

MVDC systems are increasingly being used or considered for military and commercial applications (e.g., microgrids, offshore energy, wind farms, cruise ships). The test apparatus and test method will apply to these applications as well.

Initially, the test apparatus and test method are anticipated to be used by NSWC Philadelphia personnel to verify PD-free operation and to measure SC. Eventually, shipyards and repair facilities are anticipated to be required to use the test apparatus and test method on applicable MVDC systems. The test method is intended to be formalized in a Test Method Standard in accordance with MIL-STD-962. If the objective is met, PD-free operation and SC measurements will be continuously monitored onboard ship. Estimated remaining life of the insulation system will be presented to the operator for maintenance planning.

PHASE I: Develop a concept for an affordable method for detecting PD and measuring SC in MVDC distribution systems onboard naval ships. This concept must include a system design of the test apparatus and a draft test procedure. Develop and document a health index and method for estimating remaining service life of MVDC insulation in distribution system cabling / IBP. Demonstrate the feasibility of the concept through modeling and simulation. Identify the technical risks of the concept. The Phase I Option, if exercised, shall include the design of experiments to address the technical risks and the procurement of long lead experiment articles and associated test equipment for execution in Phase II.

PHASE II: Based on the results of Phase I efforts and the Phase II Statement of Work (SOW), conduct experiments to resolve technical risks. Employ the gained knowledge to develop a functional prototype of the test apparatus. Develop the test procedure, the health index calculation method, and the remaining service life estimate method. Validate performance of the test apparatus and test procedure initially through modeling and simulation, and then through testing.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. Develop the final production test apparatus suitable for use onboard naval ships and finalize the test method as a draft Test Method Standard in accordance with MIL-STD-962. Validate the performance of the production test apparatus and draft a Test Method Standard through testing. Deliver a test apparatus to the Government in accordance with the Phase III Statement of Work. Update and deliver to the Government the health index calculation method and the remaining service life estimate method.

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KEYWORDS: Medium Voltage Direct Current; MVDC Partial Discharge; PD; MVDC Space Charge; SC; MVDC Insulation; MVDC Test Apparatus; MVDC Cable; MVDC Insulated Bus Pipe; IBP

N211-070 TITLE: Lightweight Diver Handheld Underwater Hydraulic Friction Stud Welding System for 5000 Series Aluminum

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Materials / Processes

OBJECTIVE: Develop a lightweight diver handheld portable hydraulic friction stud welding system and welding procedures for 5000 series aluminum to support sustainment and readiness for underwater ship repairs and salvage on the Littoral Combat Ships (LCS).

DESCRIPTION: The Navy has a need to wet weld aluminum studs on aluminum hull vessels to support underwater ship husbandry and emergency ship damage control, specifically on the LCS. Current underwater friction stud welding technology has been limited to carbon steel studs welded to carbon steel base plate material. Underwater friction stud welding using aluminum studs and base material has not been achieved commercially or within the Government. The equipment, whether pneumatic or hydraulic, is heavy and not adequately designed for safe use by divers performing underwater ship husbandry. A lightweight, diver friendly system that does not require special training or qualifications, and which could be used by Navy divers and Navy diving services contractors worldwide, is preferred for use in the field and during emergency ship damage control.

Research and development is required to further this technology in order to fill the Navy's current gap to perform underwater wet welding on aluminum hull vessels. Development of this technology will give the Navy the capability to wet weld aluminum studs to aluminum hulls, which can be used to perform underwater ship husbandry that would normally require dry-docking. This technology can also be used to attach cofferdams to perform underwater hull maintenance and repairs, something that is not possible currently. Performing repairs in the water significantly reduces overall maintenance and life cycle costs in comparison to dry-dock repairs. Additionally, the technology could be used to support emergency ship damage control efforts, such as patch attachments.

The concept design should allow for 1/2-inch minimum stud diameter and 3/8-inch minimum plate thickness. The weld head (actual equipment operated by the diver) should be as light as possible with a dry weight of approximately 25 pounds and be mechanically driven with no electrical or digital requirements to operate. The design concept should allow for the weld head to be operated by a 150ft minimum umbilical length attached to a hydraulic power unit (HPU). The HPU would be located on the surface and not be required subsea. The HPU can have electrical/digital requirements.

The technology, along with the welded stud coupons, will be tested against the qualification requirements of NAVSEA Technical Publication, S9074-AQ-GIB-010/248, Requirements for Welding and Brazing Procedure and Performance Qualification and Department of Defense Manufacturing Process Standard, MIL-STD-1689A, Fabrication, Welding, and Inspection of Ship Structure.

PHASE I: Develop a concept that will support fabrication of a prototype lightweight diver held hydraulic friction stud welding system capable of wet welding 5000 series aluminum (5086 stud to 5083 plate).

The feasibility of the concept shall be demonstrated as much as practicable by bread board bench testing and equipment prototyping. In addition, during this phase, the feasibility of welding 5086 studs to 5083 plate shall be demonstrated by welding coupons on a controlled environment and testing them by Non-Destructive and Destructive Test methods.

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), a prototype system shall be developed and delivered to the Government for final test and evaluation. The system shall include the weld head (diver operated part of the system), umbilical, and hydraulic power unit. Perform initial evaluation of the system, including diver safety and ability to operate the weld head in the flat, vertical, and overhead positions, which can be in a shop environment without requiring any diving services. The system will also go through preliminary qualification testing based on a test plan developed by the Government IAW NAVSEA Technical Publication, S9074-AQ-GIB-010/248 and MIL-STD-1689A. Final test and evaluation will take place at the Navy Experimental Diving Unit, Panama City, FL.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use. Deliver an operational system to the Government for qualification testing in accordance with NAVSEA Technical Publication, S9074-AQ-GIB-010/248, Requirements for Welding and Brazing Procedure and Performance Qualification and Department of Defense Manufacturing Process Standard, MIL-STD-1689A, Fabrication, Welding, and Inspection of Ship Structure. Provide all studs and plate material required for qualification testing. Provide all required training to safely operate the system.

After successful qualification, deliver the systems to the Navy's Emergency Ship Salvage Material (ESSM) program where they will be maintained ready for issue. Train ESSM personnel in the operation, maintenance, and overhaul of the entire system. Provide all drawings of the system to support fabrication, maintenance, and overhaul.

Not only will this technology fulfill the Navy's gap for wet welding aluminum studs to aluminum hull vessels, the technology can be transitioned to industry for use wherever aluminum studs are required to be welded either on the surface or underwater.

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KEYWORDS: Underwater Welding; Friction Welding; Friction Stud Welding; Aluminum Welding; Aluminum Joining Processes; Underwater Ship Repair

N211-071 TITLE: Nondestructive Evaluation (NDE) of Coated Multi-layered Fiber Reinforced Polymer (FRP) Components

RT&L FOCUS AREA(S): General Warfighting Requirements

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 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: Develop a method to detect defects in thick-coated Fiber Reinforced Polymer (FRP) and hybrid/integrated laminate construction.

DESCRIPTION: Thick coated Fiber Reinforced Polymer (FRP) laminate and hybrid/integrated laminate composites are used in critical component applications which demand that the component be free of defects of defined dimension and location. These defects include porosity, voids, delamination, moisture intrusion and defects in bond-line integrity. The configurations include FRP laminate (e.g., E-glass/vinyl ester, E-glass/epoxy, carbon/epoxy), FRP hybrid laminates, FRP/viscoelastic polymer, FRP/foam, and FRP/wood. The defects have the potential to interfere with acoustic performance and structural integrity and generally degrade ship performance.

Shipyards are often required to remove coatings to permit inspection or remove components all together to permit inspection from both sides. Both of these scenarios are time-consuming and negatively affect the sustainment costs and maintenance schedule. An inspection method is needed that can identify defects in composite components through thick (>1/4") coatings and from a single surface, thus increasing efficiency of inspections and decreasing ship impact during maintenance periods.

Current nondestructive testing technologies (i.e., visual inspection [VT], ultrasonic testing [UT], eddy current testing [ET]) are limited in their ability to:

a) detect/quantify porosity in laminates/viscoelastic polymers

b) detect bond-line defects

c) detect water intrusion. The method to detect defects that the Navy seeks should be compatible with manufacturing, fabrication and in-service environments.

The method must be able to detect the range of identified defects and provide size and depth information, specifically, but not limited to:

- a) Delaminations/voids in FRP:1/4" through 6" of material
- b) Porosity in FRP/viscoelastic polymers: >1% in a cubic foot of material
- c) Water intrusion: >5% by weight per cubic foot of laminate or FRP/core material
- d) Bond-line defects: 1/4" through 3" of material.

The method must be non-invasive (as opposed to destructive sampling), should demonstrate inspection time efficiency, and provide clear presentation of anomalies in the material, specifically in the selected regions of the material(s), such as a bond-line. Detection of disbonds in the FRP/coating bond-line is a highly desired outcome and an in-service inspection need. Detection of moisture in cored FRP sandwich

construction is another desirable feature. These components are often accessible from one surface only, particularly for in-service inspection and covered with thick coatings. A nondestructive testing method applicable to these requirements is not commercially available.

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 and/or subcontractor 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, develop, and demonstrate an inspection capability to detect and characterize the identified defects in representative sample material including porosity, voids, delamination, defects in bond-line integrity and moisture intrusion. Actual inspection capability shall be demonstrated (supported by analysis and/or simulation) for a variety of sample materials including coated and uncoated FRP laminate and FRP hybrid laminate composites. The Phase I Option, if exercised, will include documentation of performance demonstration and conceptual specification of a practical nondestructive testing system to be developed in Phase II.

PHASE II: Develop, demonstrate, and qualify a robust nondestructive evaluation system for detection and characterization of the specified defects in coated and uncoated FRP laminates, FRP hybrid laminates, FRP/viscoelastic polymer, FRP sandwich construction including foam and wood cored construction. These defects include porosity, voids, delamination, defects in bond-line integrity and moisture intrusion. The detection capability must be quantifiable through demonstrations with representative samples. . Note: NAVSEA will define the defect characteristics; and specify equipment characteristics appropriate for use during fabrication, installation, and in-service inspection. Representative equipment will be demonstrated.

Work with NAVSEA to determine representative standards for each of the targeted defects. NAVSEA will provide samples incorporating various defects for laboratory validation by the contractor.

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: A portable, robust, efficient, and effective nondestructive inspection system for detection and characterization of defects in coated and uncoated FRP laminates, FRP hybrid laminates, FRP/viscoelastic polymer, FRP sandwich construction has a large potential commercial market. The capability validated in Phase II will translate directly into similar technical performance requirements in commercial market applications. As for Phase III transition, this work will benefit the following industrial applications:

a) Reinforced rubber products for volumetric inspection. Applications include expansion joints in power plants and chemical processing facilities.

b) Multi-layer armor, primarily for military applications (and some civilian law enforcement).

c) Multi-layer composites for wind turbine blade application.

d) Part quality of polymer composites for automotive and marine applications.

e) Ceramic matrix composites, primarily for aerospace applications, both military and civilian.

f) High density polyethylene (HDPE) joint inspections, specifically thermal butt fusion weld joining, for failure to properly fuse.

g) Fiber reinforced plastic (FRP) for absolute thickness and inter-layer disbond, specifically for FRP pipe and tank inspection in chemical processing, oil and gas as well as municipal infrastructure.

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KEYWORDS: Nondestructive testing; bond-line integrity; bond-line imaging; composite integrity; composite volume imaging; Fiber Reinforced Polymer laminate; FRP
N211-072 TITLE: Automated Anchor Handling System

RT&L FOCUS AREA(S): 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 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: Develop a capability that will enable the planning and execution of autonomous anchoring evolutions scalable in operation for both Medium Unmanned Surface Vehicle (MUSV) and Large Unmanned Surface Vessel (LUSV) applications.

DESCRIPTION: The current state-of-the-art in anchor evolutions is manpower intensive requiring a user in the loop to both choose the location as well as execute and monitor the sequence of actions such as, but not limited to, the lowering and securing of the anchor. Innovations in process and method by which the Navy conducts anchor handling evolutions are required to ensure both safety and reliability while eliminating the required manpower necessary to enable truly autonomous operations for future unmanned surface vehicles.

The Navy seeks to develop an autonomous anchor handling system able to conduct a routine anchoring event with no human intervention. This includes planning for and selecting the anchoring location and then securely placing the anchor while continuously monitoring and adjusting as needed based upon the needs of the vehicle. Proposers will likely need to address not only the automation of the anchor handling machinery onboard the USVs, but the decision making autonomy that would provide the oversight and control of the event itself.

Multiple factors are considered when planning an anchorage location. These factors include: location, anchor to be used, depth of water, type of bottom, scope of chain to be used, drag and swing circles, and planned route, heading, and velocity profile in order to arrive at an anchoring location at 1 knot or less to pay out chain. Proposed anchor planning system concepts should be able to command the anchor handling equipment to place the anchor in a safe [Ref 5] manner upon arriving at desired anchorage point. After dropping anchor, the anchor planning system should identify if the anchor is dragging, the chain is tending across the stem (lead around the ship's bow), or if other ships are entering the drag and swing circles and take appropriate action. If the anchor planning or handling system determines the anchor, directing the handling system to let out additional chain, or to weigh anchor and getting underway. The system shall autonomously manage and execute a plan on weighing anchor, including bearing and speed to ride the anchor chain, command the anchor machinery to lift the anchor, and provide confirmation to the vessel that it is safe to begin steaming. The system will need to include a troubleshooting function that indicates failure modes and system status as well as providing data to allow for the capability of remote operation.

An automated anchor handling system should be able to accept commands from a higher level system (autonomously as well as human in or on the loop) and be able to automatically handle, drop, and weigh

the anchor. Equipment shall be no smaller than Equipment Numeral U7 and no larger than Equipment Numeral U15 in Table 1, 2019 American Bureau of Shipping (ABS) Steel Vessel Rules (SVR) 3-5-1 (available at ww2.eagle.org – see p.346.) The largest anticipated anchor will weigh 1,590 kg, and will be a Stockless Bower type. Anchor chain is traditionally made up of 90 foot sections (or "shots") of solid links. Each shot is joined to its neighbor by a single detachable link. The largest anticipated anchor chain diameter is 40 mm, using Chain Cable Stud Link Bower Chain. The anchor chain will be 900 feet long. The maximum force on the anchor and chain can be calculated from the preceding information together with Section 4-5-1 (pp. 414-418) of the ABS SVR. When the vessel has paid out the desired scope of chain, it is positioned so that a detachable link is on deck. This practice facilitates leaving the anchor behind in an emergency ("slipping anchor") if the anchor windlass is inoperative and the vessel must get underway. Modifications to the traditional anchor, chain, and handling equipment in order to facilitate a fully automated process are to be considered within the design tradespace. Proposers should keep in mind the desire to have a scalable system that is Mobile Open Systems Approach (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; effects cross-domain interoperability of UxS vehicles; and allows for open architecture (OA) modularity of autonomy solutions, control systems, C2, and payloads. The Navy will provide the open standards for UMAA upon award of Phase I.

PHASE I: Develop a concept design for an anchor planning and handling system. The Government will provide the UMAA documentation in support of future Phase II proposal development. Deliver a concept design for reliable, safe, and repeatable operations, including any modeling and simulation, studies, or prototypes in support of concept risk reduction.

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. See paragraph 4-5-1/7 on p. 417 of ABS SVR part 4 for Shop Inspection and Testing, and see paragraph 3-7-2/1 on p. 371 of SVR part 3 for Anchor Windlass Trials.

PHASE II: Develop and deliver a critical design prior to fabrication of the system or major system components for company testing. The system developed under the Phase II shall comply with MOSA and UMAA. The detailed design must meet the performance, cost, and schedule requirements. It will also identify the necessary interfaces, dependencies, and risks. After a successful Critical Design Review (CDR), develop a prototype(s). Testing and certification of the planning portion of the system will consist of simulation with the vessel of opportunity's autonomy. Testing and certification of the handling portion of the system will consist of hardware-in-the-loop testing.

PHASE III DUAL USE APPLICATIONS: Successful anchor planning and handling systems will transition to either the MUSV program or the LUSV program. UMAA compliant anchoring planning software and anchoring 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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KEYWORDS: Automated Anchoring; Anchor Planning System; Anchor Handling System; Medium Unmanned Surface Vehicle; MUSV; Large Unmanned Surface Vehicle; LUSV; Energy Conservation

N211-073 TITLE: Intelligent Assistant for Anti-Submarine Warfare

RT&L FOCUS AREA(S): Machine Learning/AI

TECHNOLOGY AREA(S): Battlespace Environments

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: Develop an intelligent assistant that improves active sonar detection, classification, and tracking and enables operators to maximize the potential of the tactical sonar suite.

DESCRIPTION: Navy Cruisers and Destroyers engaged in anti-submarine warfare (ASW) often use active sonar to perform detection, classification, and localization (DCL) of submerged threats. Active sonar employment involves numerous operational modes and settings that enable operators to adapt the sonar suite to the environment and current tactical goals or operational posture. This includes employment decisions such as changing the operational mode between pulsed active sonar (PAS) and continuous active sonar (CAS) as well as changing waveform and various other system settings. Operators must conduct sonar analysis of resulting sonar returns and interpret them based on the sonar settings and the environment.

Intelligent assistants are now commonplace in commercial industry but cannot be used in Navy systems. Similar tools do not exist to support operators of the tactical sonar suite. Effective employment of the sonar suite and analysis of the information it presents in complex and changing conditions creates a significant cognitive demand for operators. The Navy seeks to develop an intelligent assistant through leveraging advanced artificial intelligence (AI) technologies to support operators in this complex decision-making process.

An innovative intelligent assistant utilizing AI would bring together environmental information from the on-board tactical decision aid (TDA), in-situ, real-time assessment of the environment, and machine-learning algorithms to provide operators situational awareness regarding key parameters such as primary propagation path(s), bearing-dependent complications (such as sea mounts that might obscure threats), significant topology features into which a threat might retreat to minimize detection, best tactical waveforms, and situational best practices to enable operators to maximize the potential of the tactical sonar suite for the specific conditions present at that time and location. This assistant would have a significant analysis component, but would also have a direct interface with the operator through additional display elements and/or updates to existing display elements. In addition to realizing performance gains of at least 25% on active sonar detection, active sonar classification, active sonar tracking and end-to-end metrics relative to naïve employment of the system, this will enhance affordability by reducing the training time needed to realize a given level of operational performance. The technology developed will be tested using the IWS 5.0 Advanced Capability Build (ACB) step testing process. The seminal transition event will be validation by the Government and show the technology performs as required.

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 and/or subcontractor 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 intelligent assistant utilizing AI that meets the requirements in the Description section. Show feasibility of the concept through analytical modeling, and developing and documenting the innovative algorithms, concepts, and architectures, and quantifying achievable performance gains. The Phase I Option, if exercised, will include the initial system specifications and a capabilities description to build a prototype in Phase II.

PHASE II: Develop and deliver a prototype intelligent assistant utilizing AI meeting the requirements in the Description for ASW. Demonstrate the prototype performance through the required range of parameters given in the Description. If needed, coordination with the Government will occur to conduct testing at a Government- or company-provided facility to validate the prototype's capabilities. Data sets from Cruise/Destroyer Hull Sonar and/or Littoral Combat Ship Variable Depth Sonar (LCS-VDS) will be used to validate the prototype's capabilities. The Government will provide the 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 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 used to update the AN/SQQ-89 Program of Record.

This technology can be used in the weather and marine industries where automated assistants help identify tasks to be accomplished at certain timing.

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KEYWORDS: Intelligent Assistant; Anti-Submarine Warfare; ASW; Active Sonar Detection; Active Sonar Tracking; Sonar Employment; Sonar Analysis

N211-074 TITLE: Efficient Data Management to Improve Navy Maintenance and Ship Operational Readiness

RT&L FOCUS AREA(S): Cybersecurity

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 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: Develop an efficient and secure data management software application to use Condition Based Maintenance (CBM) and Reliability Centered Maintenance (RCM) to sustain, maintain and modernize ships, aircraft carriers, and submarines.

DESCRIPTION: The Navy operates ships that are technologically advanced and dependent on the effective application of information. The Navy needs a data analytics system that provides real-time ship performance and component-level data to affordably sustain the Fleet. Integrating the two initiatives of monitoring ship performance and securely transmitting ship performance data promises to transform the conduct of maintenance and the relationship of the ship and the shipyard.

Comprehensive understanding of a ship's current material condition is critical to maintenance performance. Traditionally, shipyard personnel assess the ship's material condition through ship visits and ship checks, ship system logs, the Consolidated Ships Maintenance Plan, previous work packages of the ship and other ships in its class, along with other sources of maintenance information. Visits are performed during the planning phase through scheduled ship visits, and just prior to start of a planned maintenance availability. However, as a preparatory method for planning an availability, this is insufficient for preparing the shipyard when execution of the work package reveals unanticipated maintenance problems, which increases costs and delays in schedule.

The Navy needs a secure data management system to share performance data between ships at sea and shipyards. Ships, aircraft carriers, and submarines operating at sea produce a tremendous amount of information. CBM, as a predictive concept, utilizes engineered maintenance standards based on objective historical conditions and predicted failure windows in order to determine when a component is due for maintenance. There is a concern that CBM has gone too far and disrupted the shipyard's ability to properly plan for large maintenance availabilities. In a data-managed environment, ship CBM and RCM parameters could technically flag ship system components based on performance criteria, generate lists of system and component status, generate prioritized task lists and automated work packages, and based on actual conditions, work lists could be generated and assigned to either the ship's force or the shipyard. Where CBM and RCM is automated, maintenance in a continuum and planning for large maintenance availabilities could focus on delivering capability to the ship, modernizing systems, structures and conducting major upgrades and alterations.

The Navy is currently testing the Enterprise Remote Monitoring (ERM) System to monitor ship systems and components while at sea. In effect, it will function as a sensor that monitors and collects vital performance data on a ship's hull, mechanical and electrical systems and components. When hosted in

such a way as to securely transmit data, in effect, the operators are connected with the maintainers for continuous maintenance support anytime and anywhere. This specific effort looks to leverage the ERM by establishing an architecture option for a software solution or suite of software that orchestrates the movement and processing of the data in such a manner that it can be scaled to advance capabilities.

The secure sharing of performance data through the ERM between a naval shipyard and a ship will deliver enhanced capability, resources and life cycle support enabling the integration of advances in technology, and a continuous planning process that aligns the current material condition of the ship with the capabilities of the shipyard. In a future state, the Navy could expand its planning and execution capabilities through simulation in a digital environment using all available information to create an instance-based digital twin of the ship, enabled by its digital thread, a record of its life cycle support, and sustainment activities. A digital twin for a ship can help the shipyard community identify, plan, track and test its repair needs in advance of an availability.

The production solution should be able to meet security requirements consistent with the DoD Risk Management Framework at the appropriate level. See NIST SP 800-53 for detail requirements. If a cloud solution is used, the system must also meet the requirements of the DoD Cloud Computing Security Requirements Guide at Impact Level 4. It is not necessary to demonstrate compliance during the prototype effort; however, details of compliance capability should be provided in the deployment plan.

PHASE I: Define and develop a concept for secure sharing of ship performance data between naval shipyards and ships, aircraft carriers, and submarines using the Navy's ERM System. The Phase I Option, if exercised, would include the initial layout and capabilities description to build a prototype in Phase II. Phase I testing should align with industry standards and best practices to ensure that investments drive value to the predictive maintenance community.

PHASE II: Based on the results of Phase I efforts and the Phase II Statement of Work (SOW), develop a prototype for testing and evaluating the primary source data from a naval vessel and transmitted to a naval shipyard. This source data is expected to be sensitive and or classified, varied in type, and centrally available for further analysis, model building and visualizations to determine ship material condition and optimize planning activities for an upcoming major availability. Data interoperability and portability testing could include reports showing how historical source data matches the transmitted data for expected results, and demonstrate capability to efficiently implement business process and/or spatial data models for at least one identified system or asset as a starting point for replicating the physical world.

PHASE III DUAL USE APPLICATIONS: Assist the Navy in transitioning the technology for Navy use by working closely with the Naval Research Lab (NRL), NAVSEA, PEO Ships, Submarines and Carriers, and the naval shipyards. Implement the prototype for a secure means of sharing component and ship system performance data. Scale the technology to meet the demands of the Navy and so it can collaborate the dual use nature of the data construct with Transportation and Logistics, Energy, Manufacturing, and Telecommunications industries who use predictive maintenance or remote asset monitoring.

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KEYWORDS: Secure Data Management/Sharing; Condition Based Maintenance; Reliability Centered Maintenance; Digital Twin; Digital Threading; Ship maintenance information design.

N211-075 TITLE: Active Nano Antenna Emulator for Electromagnetic Simulation

RT&L FOCUS AREA(S): Directed energy

TECHNOLOGY AREA(S): Battlespace Environments

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: Develop a tabletop radar range leveraging high-resolution 3D printing and nanophotonics to serve as an optical emulator for complex electromagnetic (EM) systems.

DESCRIPTION: The Navy currently uses both simulation and measurement of a ship's Antenna- Radar Cross Section (RCS) to improve the design of new stealthy antenna on platforms and to ensure the accurate measure beam profile of the antenna in an environment. However, EM simulations are extremely challenging for large and complex objects that involve multiple constituent materials and fine details. Direct Antenna-RCS measurements may not be possible if the ship is part of an adversarial navy or if the ship is at sea. Currently DoD evaluates its antenna EM radiation beam profile using simulation and an actual measurement in anechoic chamber and field measurement. The process of doing such measurement is expensive and time consuming. It is also impossible to create a real-life scenario of EM reflection from other structure during actual operation of the system. This topic shall address such real-life scenarios with fabrication in nanophotonics and use nanaophotonic radiation to characterize and simulate the EM scattering map without any anechoic chamber or infield measurement. This approach shall also reduce cost two orders of magnitude and time reduction from a year to a week.

Submarines may be subjected to high power laser beams and microwave radiation, which may damage optics and sensors in beam directors and periscopes. The Navy is seeking a technology that would demonstrate the possibility to accurately measure the radar antenna cross section & beam profile of large and complex antenna with a scaling factor of 100,000 under different environments such as sea surface with varying degrees of wave action and other EM radiation interference from adjacent masts on own-ship and nearby vessels. The advantages of this scaling approach is its versatility, and the possibility to perform fast, convenient, and inexpensive measurements on structures whose sizes prevent simulation, even with today's computers. This proposed technique shall also reduce cost (two orders of magnitude) and time (from a year to a week). This technique, based on the scale invariance of Maxwell's equations, leverages nano-scale 3D printing, as well as the availability of a variety of laser sources and high resolution detectors in 1 micron near infrared wavelength.

Interaction with Naval Information Warfare Systems Command (NAVWAR) personnel has revealed that one of the difficulties facing the development of new Navy platforms is optimizing the placement of antennas to minimize interference between antennas. The proposed method of using small-scale models and plasmonic-nanoantennas to simulate the EM field is estimated to provide a reduction in cost by a factor 1/150, and time by a factor 1/365.

Instead of needing a large anechoic chamber, the RCS measurements are done on a tabletop setup with highly detailed micron scale model. The models are illuminated with an external source of light, and the

scattered energy is detected with a charge couple device (CCD), similarly to a monostatic radar configuration. The direct 2D imaging of the scattered field allows us to identify the parts of the structure responsible for the RCS signal. This information is similar to what is obtained with an Inverse Synthetic Aperture Radar (ISAR) measurement but without the back projection computation. Measurement reliability shall also be demonstrated by comparing the results with a theoretical EM model for any shape under different environments.

The EM signatures of an antenna in a platform, such as a ship or a submarine, are of particular importance for the Navy since they allow the detection and identification of the antenna system and its performance on the platform. The vessel's active EM signature (EM Antenna), known as its radar cross section (Antenna-RCS), is proportional to the reflectivity of the structure and varies with relative spatial orientation of the vessel and the radar source. Minimizing this reflection improves the antenna performance of a radar system. The observed Antenna-RCS can also be used to improve the platform antenna performance.

The goal of the Nano antenna compact radar range program is to design and develop a tabletop radarrange system capable of measuring the EM signature of large and complex structures, including the antenna emission (gain) and their interference.

PHASE I: Provide a concept and determine the feasibility of the concept for the EM emission of a nanoantenna in the framework of tabletop radar range as well as simulations of antenna emission in the presence of simple geometrical shapes. Provide an assessment on how the dipole plasmonic nanoantenna will be manufactured using liftoff microstructuring technique as well as characterize the antenna emission direction. Liftoff lithography is a method of creating structures (patterning) of a target material on the surface of a substrate (e.g., wafer) using a sacrificial material (e.g., photoresist). It is an additive technique as opposed to more traditional subtracting technique like etching. The scale of the structures can vary from the nanoscale up to the centimeter scale or further, but are typically of micrometric dimensions. The nanoantenna will potentially be transferred on a relevant model and the gain compared to its original profile as well as the simulation.)

The Phase I Option, if awarded, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop a prototype system for testing and evaluation based on the results of Phase I and the Phase II Statement of Work (SOW). Design, build, and demonstrate a prototype tabletop RCS system based on the proof of concept developed during Phase I. Demonstrate the ability to collect antenna emission measurements of a vessel of interest in near marine boundary conditions including realistic sea clutter. Fabricate a RCS system based on the prototype developed in the base period.

Field test the nanophotonic radar-range system at one of the Navy's facilities. Fabricate an active nanoantenna device that can be used to simulate the radar signal generated by the vessel's radar systems. The testing will consist of measuring the RCS of a specific model, of which the design will be provided by the Navy. A scaled model will be made using a nano-3D printer (not deliverable), and the RCS measurement will be measured using the nanophotonic radar-range. The result of the measurement will be a RCS polar plot that can used by the Navy to compare with life scale measurement and/or simulation.

PHASE III DUAL USE APPLICATIONS: Assist the Navy in transitioning the technology to Navy use for antenna performance evaluation and location of the antenna for best performance. Army and Navy can use this technology to simulate the environment scenario to optimize the EM beam profile and its performance.

The nanophotonic radar-range system can be used for emulating the RCS of a large variety of platforms, from small boats like the 4M RX Rigid Inflatable with 12ft length to much larger vessels like the Gerald R. Ford class super carrier. The system can also be applied to all classes of submarines in near boundary conditions, including the Virginia and Columbia classes, as well as to measure the RCS of the AN/BVS-1 photonic mast. The nanophotonic radar-range system can find commercial use with any DoD branches and contractors desiring to understand the radar cross section properties of their platforms. This technique can be used during any phase of construction: development, production or refurbishing. It can also be used to acquire the RCS of structures that are inaccessible such as non-friendly nation platforms. For example, a contractor such as General Dynamics can use the system to better understand the RCS of the next generation of ships such as the USS Zumwalt. A contractor such as Raytheon can use the system to better understand the RCS of an enemy target to better detect, acquire, and follow that target with radar.

The technology shall also be used in telecommunication industry and TV to survey the antenna site before they actually do the field survey to optimize the reception and service broader spectrum customers. The system can find dual use application for the development of the 5G telecommunication to better understand the propagation of the signal in cluttered environment such as dense urban center. A Global System for Mobile operator can potentially use the nanophotonic radar-range system to optimize the location of their antennas to avoid dead signal zone.

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KEYWORDS: Plasmonic; Nano-antenna; Antenna radar cross section; Antenna-RCS; electromagnetic; EM; NanoPhotonics; optical emulator

N211-076 TITLE: Autonomous Draft Determination

RT&L FOCUS AREA(S): Autonomy

TECHNOLOGY AREA(S): Sensors

OBJECTIVE: Develop a concept for an autonomous or unmanned method to determine a vessel's draft accurately (Objective 1/16"; Goal 1/8") during required naval architectural experiments in various weather conditions with various hull forms to support on-time delivery of ships and submarines.

DESCRIPTION: Naval architectural experiments (i.e., inclining experiment and displacement check) are conducted prior to ship delivery to the fleet; avoiding schedule delays of these experiments by removing the small boat portion prevents delays of on-time delivery. The existing method can be hazardous and requires a manned small boat to collect draft readings at four locations (port and starboard; bow and stern) using a draft tube. Draft readings with draft tubes rely on personnel judgment due to reading the meniscus in the equipment that is not standardized between shipyards and may result in inconsistencies in draft readings taken. As much as practicable, the system developed should be used by shipyards to standardize the process of taking draft readings during naval architectural experiments. The system developed should be more efficient with at least a 50% reduction in time and/or labor (reduced schedule risk and reduced labor and travel costs), accurate (Objective 1/16"; Goal 1/8"), safer, and completely autonomous method to determine the draft of a vessel when conducting naval architectural experiments. The system should reduce schedule risk to on-time delivery and reduce costs associated with these experiments. The system developed will require fewer people (less cost) for the experiment, reduce risk of experiment delay due to the weather conditions that prohibit the small boat from going in the water to measure drafts (could mean up to ~ 100 people wasting 8 hours waiting for weather and ~ 20 people staying an extra night to perform the experiment the next day), and shorten the duration of the process in its entirety. The system should be operable in various weather conditions, including several feet of chop on the water surface and wind; and be able to determine draft on various hull forms including flared (e.g., carrier) or tumble homed (e.g., submarine) hulls and draft marks. Draft marks have a projected height of six inches but can be longer on the hull depending on the hull's curvature. This SBIR topic will contribute to reducing life-cycle costs (these experiments are performed throughout a vessel's life) while leveraging technology and data analytics. Observation of the draft marks and water surface could be recorded and the video could be converted to data to perform statistical analysis to obtain the average draft while the water surface perturbates. The existing method relies on personnel judgment to average out the perturbations and record an average reading, which is not objective, repeatable or standardized. Additionally, an autonomous system will allow the data collected to be stored and analyzed later whereas with the existing method, the reading is taken and a photograph is taken but they are difficult to verify or analyze later due to the angle of the photograph, lighting conditions, and timing of the photograph with wave action. These experiments require the vessel to be nearly complete and occur within days or weeks of delivery so any delays in accomplishing these experiments can impact on-time delivery of ships and submarines. There are approximately 20-25 experiments per year across the submarine fleet and 10-15 experiments per year across surface ships and aircraft carriers. These experiments are necessary to ensure the stability and safety of US Navy ships and submarines, are required by NAVSEA, and are applicable to submarines, surface ships, and aircraft carriers. The technological solution would likely be a device that the shipyards (both public and private) would procure. Utilizing an autonomous method to determine the draft of a vessel would reduce the set-up time and equipment needed, streamlining the process and reducing cost and schedule risk, and would not put personnel at risk (personnel have fallen into cold water and have almost been crushed between boat and pier).

PHASE I: Develop a concept for reading draft marks to sufficient accuracy (as stated in the Description) on submarines and surface ships during naval architectural experiments. 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 based on Phase I work for demonstration and validation. Demonstrate the operation of the prototype to read draft marks with various hull forms and various weather conditions to sufficient accuracy as stated in the Description. The new system will be compared to results obtained using the traditional method by shadowing an experiment with the new system and/or using the ghost fleet in Philadelphia or a barge since they may provide easier access than an active Navy shipyard with commissioned boats. Deliver the tested device and associated software at the end of Phase II.

The prospective contractor may require access to U.S. shipyards (public and/or private) or other U.S. Naval facilities to demonstrate the capability. The system likely includes software so the software would have to meet applicable Navy requirements (e.g., IA, cyber, COTS).

PHASE III DUAL USE APPLICATIONS: Assist the Navy to integrate the Phase II-developed device and software into standard operating procedures at the shipyards and standards at NAVSEA for Fleetwide use on submarines, surface ships and aircraft carriers.

The commercial shipping industry also performs inclining experiments to meet U.S. Coast Guard and/or classification society standards so U.S. or foreign shipyards may be interested in this device.

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KEYWORDS: Navigational draft; draft marks; inclining experiment; displacement check; draft reading; draft analysis software.

N211-077 TITLE: Non-towed Broadband Acoustic Source

RT&L FOCUS AREA(S): Autonomy

TECHNOLOGY AREA(S): Battlespace Environments

OBJECTIVE: Develop an innovative, acoustic source for operation from an 11-m unmanned surface vehicle (USV) producing the required output.

DESCRIPTION: Unmanned surface vehicle (USV) -based systems require lighter weight, lower drag, and smaller footprint products than their legacy counterparts [Ref 1]. There are currently a number of technology development efforts for various types of sensors and emitters that will be suitable for integration with a Fleet-class (11-meter) USV. However, many of these sensors and emitters are towed systems, which result in increased drag and fuel consumption, as well as reduced capability in shallow water and constrained waterways [Ref 2]. By eliminating the towed system from the USV, a reduction in towed system drag on the craft will result in increased endurance for the system while operating at the same speed. This will increase system capability by potentially increasing the coverage rate and allowing its use in shallower water and constrained waterways than current towed systems.

The U.S. Navy is seeking an innovative acoustic source capable of generating a broad range of outputs that would be mounted either above the waterline, within the hull and structure of the USV, or if a solution were sub-surface, the acoustic generator would be stowed above the waterline or within the USV hull-form until performing operations. The acoustic source(s) will be capable of being operated in very shallow water (20-40 ft), have low/no-drag (drag is constrained by the propulsive power used), and be non-towed or easily deployed/retrieved from the USV (less than 10 below the keel of the vehicle). Use of USV propulsion and hull systems, as well as legacy methods (e.g., mechanical cavitation, spark gap) is encouraged. The system must be lightweight (less than 400 lb.); require minimal electrical or propulsion power (less than 30 kw electrical power; Propulsive Power 125 hp); have a high acoustical power radiation (minimum 175 dB re 1 μ Pa @ 1m (1/3 Octave Band Level), frequency range of 10 Hz to 32 kHz, broadband white noise or multiple tones distributed over the required bandwidth, omni-directional or forward hemisphere transmission from one or several generators); and mitigate the effects of craft speed and its variations (12-18 kts, ±5 kt speed variation). The acoustic generator will be autonomously activated by the USV's central command and control.

Offerors are encouraged to propose concepts that use waste energy from the USV (e.g., exhaust, propulsion noise, flow) that is amplified, controlled, and manipulated by the concept to generate the desired output. Legacy concepts (e.g., mechanical cavitation, spark gap) are also encouraged. Sets of transducers may not be viewed as novel technology for this topic unless of a new form or application, or offering unique capabilities in the operating environment is articulated. Offerors should note the likely presence of cavitation in the operation of their system and, if relevant, should address in their proposals how the system mitigates its effects, or uses it to a beneficial effect.

By eliminating towed items, the towed system drag to the Unmanned Surface Vehicle (USV) can be reduced by up to 50%. That savings will result in a lower fuel burn rate and an increased endurance. An increase in endurance will increase the capability of the USV and multiple payloads can be carried on the USV for multiple mission sets. Dragging these systems through the seawater increase the life-cycle cost based on the maintenance associated with the seawater environment. By removing the acoustic source from the water, the mean time before maintenance will increase which will reduce the life-cycle cost of these systems.

PHASE I: Develop a concept for an acoustic generator meeting the requirements in the Description. Feasibility of the concept for an innovative acoustic generator that meets the needs of the Navy as defined in the Description will be demonstrated by modeling and simulation, analysis, and/or laboratory experimentation, as appropriate. Acoustic output (frequency range, amplitude) will be the key quantitative performance parameter, with the level of speed independence, and size/weight/power being key system attributes. The effect of cavitation on the system performance, if relevant, should be clearly presented through the concept development and feasibility demonstration. 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 fabricate a prototype acoustic generator based on the Phase I work and Phase II Statement of Work (SOW) for demonstration and characterization of key performance parameters, key system attributes, and objectives. At the end of Phase II, prototype acoustic generator components shall be tested according to Navy requirements. Testing of the key performance parameters and key system attributes will be an at-sea test over an acoustic range to verify that the task objectives were met. Based on lessons learned in Phase II through the prototype demonstration, a substantially complete design of the acoustic generator should be completed and delivered that would be expected to pass Navy qualification testing.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Navy use. The final acoustic generator product will need to conform to all specifications and requirements. A full-scale prototype will be operationally tested at sea on an acoustic range and certified by the Navy to be integrated with an USV for further performance testing.

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KEYWORDS: Non-towed acoustic generator; unmanned surface vehicle (USV); acoustic frequency and amplitude; autonomous

N211-078 TITLE: Operator Analytics and Training Integration through Artificial Intelligence and Machine Learning

RT&L FOCUS AREA(S): Machine Learning/AI

TECHNOLOGY AREA(S): Human Systems

OBJECTIVE: Develop an analytical toolset that mines sonar operator performance data via the tactical system along with training data gathered from the Moodle Learning Management System (LMS).

DESCRIPTION: The AN/SQQ-89 A (V)15 system collects a large amount of data from which it is possible to infer sonar operator performance data. The interactions that the operators have with the system can provide valuable insights into the fleet's training readiness. Applying Big Data mining techniques, methodologies, and analysis to the sonar system of the SQQ-89 would enable more relevant and real-time decision-making. The Chief of Naval Operation (CNO) has stated that there is a need to "Establish data-driven decisions as a foundation for achieving readiness in our warfighting enterprises. Lead Type Commands (TYCOMs), supported by Systems Commands (SYSCOMs), Budget Submitting Offices, and higher echelons will develop and maintain authoritative and accessible data for decision-quality information." By coupling artificial intelligence (AI) that mines the SQQ-89's operator performance data with learning analytics mined via machine learning applied to the Moodle LMS, decision-makers would possess the data necessary to make more informed decisions.

Additionally, the CNO desires to "Focus Navy efforts for fielding artificial intelligence/machine learning (AI/ML) algorithms on areas that most enhance warfighting, training, and corporate decisions." The current state of learning analytics used in the Moodle LMS include simple metrics such as activity completion and quiz/exam scores but lack the power to contribute to the understanding of student learning. An AI/ML toolset would provide the power necessary to measure an operator's abilities and determine areas for improvement quickly and accurately over traditional assessments. Currently no tools exist that can provide this capability. Obtaining this toolset would benefit the Navy by decreasing operational costs. Training should use study time more efficiently than the chosen control conditions so participants did not waste time studying items they already knew and were able to concentrate on items that require more training maximizing the operator's time and increasing training efficiency.

The Navy seeks an AI/ML toolset that captures data generated by operators interacting with the SQQ-89 system as well as the Moodle LMS hosted on the tactical system. The AI/ML toolset must also be able to format that data using "strategies to transform data into appropriate forms, to include smoothing, attribute construction, aggregation, normalization, and discretization (Susnea, pg. 74)." Such formatting would show patterns and provide additional insights into an operator's performance and behavior while using the SQQ-89.

In addition to formatting the data, the toolset must be able to perform descriptive modeling, which is a mathematical process that describes real-world events and the relationships between factors responsible for them. The toolset must also perform data analysis through predictive modeling, which is a process that uses data mining and probability to forecast outcomes. The toolset must also visualize the data in an easily digestible format to ease a decision-maker's ability to make better and more informed decisions quickly and with high confidence in the data.

Initial testing of the AI/ML toolset may be demonstrated at the contractor facility but a more robust evaluation of a fully developed toolset will 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 toolset, the test should include data from a team of sonar operators and their interactions with the SQQ-89 tactical system. Ideally, the interactions would include real-world or synthetic scenarios that span the detect-to-engage timeline. In addition to the data derived from the tactical system, a fully populated Moodle LMS comprised of training data from each of the participants of the sonar team would be preferred as the AI/ML toolset will need to uncover findings and correlations between the two sets of data.

Metrics used to assess the AI/ML toolset will refer to data quality, which can be defined as the degree to which a set of characteristics of data fulfills requirements. Examples of characteristics include: completeness, validity, accuracy, consistency, availability, and timeliness. The toolset must be able to apply big data analysis to the information present in the Moodle LMS as well as the learning record store (LRS) present in the learning architecture on the SQQ-89.

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 and/or subcontractor 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 AI/ML toolset that mines data from the AN/SQQ-89A (V) 15 sonar system and Moodle LMS. Demonstrate the feasibly of the concept meets the parameters listed in the Description through modeling 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 of the AI/ML toolset and supporting architecture. Demonstrate at a Government- or company-provided facility that the prototype meets all parameters detailed in the Description. ASW personnel will conduct independent testing in the Fleet.

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 toolset prototype developed in Phase II. The AI/ML toolset prototype will be delivered to support a single transition event. Assist with the integration of the prototype into a future Advanced Capability Build of the AN/SQQ-89A (V) 15 Surface Ship Undersea Warfare Combat System.

The AI/ML toolset can be adapted to other technical fields including radio-frequency engineering and medical diagnostic tools. Big data and learning analytics are a relatively new field, but an architecture that allows adapting to different learning and training domains would be useful to the wider education and business community.

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KEYWORDS: Sonar Operator Training; High Velocity Learning; Big Data Analytics; Artificial Intelligence; Machine Learning; Moodle LMS

N211-079 TITLE: Enhanced Situational Awareness Through Smart Geospatial Comparative Analysis

RT&L FOCUS AREA(S): Machine Learning/AI;General Warfighting Requirements

TECHNOLOGY AREA(S): Battlespace Environments; 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 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: Develop geospatial analytical algorithms to increase speed and alignment to kill chain requirements, in support of a Common Operational Picture (COP). Develop a smart comparative analysis capability to manage data types associated with both geospatial and non-geospatial representations using advanced analytics such as Artificial Intelligence (AI) and Machine Learning (ML) algorithms.

DESCRIPTION: The U.S. Navy requires greater speed of analysis in support of Kill Chain requirements for greater assessment of the environment, positive Identification of threats, and predictive capability to meet growing threat challenges in theater. In order to meet these growing demands, the development of robust technologies for smart geospatial analytics, using modern big data analytics, is needed. Smart geospatial analytics include separation of data and styling information, robust pluggable presentation analytics, and tabular representations. These analytics will feed into a COP for the warfighter, headed by the Maritime Tactical Command and Control (MTC2) system.

The MTC2 system is the Navy's next generation command and control platform providing modernized, robust, secure, integrated, and interoperable network-centric capabilities. MTC2 will replace the legacy planning and decision aid systems and provide a COP in a geospatial display to visualize an operational environment to maintain Command and Control (C2) Situational Awareness (SA).

The Command and Control Acquisition Program Office, PMW 150, currently fields the Global Command and Control System Maritime (GCCS-M) to support COP representation. The current technology is extremely dated and only provides tracks on a map for viewing with some overlays. Modern, state-of-the-art technologies are providing greater depth and analysis geospatially to consumers.

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 and/or subcontractor 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 NAVWAR 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: Conduct a study to determine optimum algorithms to perform advanced analytics on geospatial and non-geospatial data to include AI and ML algorithms, and semantic reasoners. Identify the

developmental issues and formulate the methodology to include validation concepts which are technically feasible and achievable. The algorithms should be able to ingest geospatial and non-geospatial data to deliver renderings and visually present the data in multiple ways.

Describe the technical solution (i.e., software) based on the investigations and technical trade-offs. For the identified technical solution, develop the Phase II Project Plan to include a detailed schedule (in Gantt format), spend plan, performance objectives, and transition plan for the identified Program of Record (PoR).

Note: The Navy will provide samples of geospatial and non-geospatial data will be provided in Phase I to support an accurate feasibility study.

PHASE II: Develop a software prototype that is able to ingest various data sources and types, including textual and abstract such as Joint Message Handling System (JMHS) for textual and map representations for abstract data types; render geospatially; and evaluate the renderings with algorithms identified in Phase I. The software prototype will be deployable and used for concept validation allowing users to interact under operational condition. The prototype must run in a DEVSECOPS environment, gathering data from the users to feed into requirements for the Program of Record in order to validate concepts.

Provide insight into visual representations that can assess renderings, formulate understanding and provide the information directly to the user. Investigate themes like Semantics for incorporating attribute and computed values within filter criteria, provide dynamic filtering and linkback to external data sources, and automated drill down and queries based on user history. Provide a visualization environment that aligns with using Esri tools, such as the Commercial Joint Mapping ToolKit (CJMTK), and that is malleable to the warfighter's needs and learns from behavior.

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: Conduct further testing of the prototype on experimentation venues, such as Trident Warrior. Integration will be conducted by NIWC Pacific/Atlantic engineers. Initially, the technology will reside in the C2X environment being developed and fielded for test and evaluation. Once completed, integrate the technology into the existing MTC2 Configuration Management (CM) environment for inclusion in the MTC2 normal release update schedule to provide the warfighter the capability to have information analyzed continuously as the representation changes in the COP. The Smart Geospatial Comparative Analysis will provide significant increase in speed of understanding and will allow decisions to be more informed and analyzed to support the Kill Chain process. Commercially, these capabilities can be applied to current Geospatial Information Systems (GIS) to increase capability for industry use.

REFERENCES:

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KEYWORDS: Geospatial; analytics; AI; ML; Enhanced situational awareness; SA; comparative analysis; Common Operational Picture; COP; Maritime Operations

N211-080 TITLE: Wideband Interference Suppression for Dynamic-range OptiMization (WISDOM)

RT&L FOCUS AREA(S): Networked C3; General Warfighting Requirements

TECHNOLOGY AREA(S): 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 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: Develop digital and/or analog military HF (2 MHz to 30 MHz) wideband interference suppression system to yield significant improvements to SNR (>10 dB) and dynamic range (20+ dB).

DESCRIPTION: Battle Force Tactical Network (BFTN), AN/USQ-195(v) system provides tactical Radio Frequency (RF) networked communications for the Navy's afloat, airborne, ashore, and submerged U.S. Navy forces. BFTN currently transports critical Command and Control (C2) data with rates of 19.2 kbps over HF at up to 200 nm and 64 kbps over Ultra High Frequency (UHF) at up to 20 nm. BFTN is undergoing modernization, called BFTN Resilient Command and Control (RC2) System Enhancement, (BRSE), which will result in a significantly more capable system with a new waveform, Robust Communications for Challenging Environments (RoCCE). To provide optimal communications in a challenged environment or when operating with unintentional interference sources, BRSE with RoCCE will require significant effective increase in dynamic range across the full HF band of operation.

Communication signal interference sources can be intentional (e.g., "jamming") with wide variety of forms or unintentional. The latter includes Electromagnetic interference (EMI), Co-channel interference (CCI), Adjacent-channel interference (ACI), Inter-symbol interference (ISI), Inter-carrier interference (ICI), and Common-mode interference (CMI). Communications systems have various methods to deal with interferences such as adaptive equalization, Automatic Gain Control (AGC), analog filters, and advanced digital signal processing techniques. The communications systems, however, are limited in its ability to maintain the full dynamic range when the effects of interference cannot be fully addressed. The loss in dynamic range limits the effective data that can be transmitted in a communications channel.

Recent advancement in interference suppression and excision have resulted in commercially available stand-alone "appliances" such as iDirect's Communication Signal Interference Removal (CSIRTM) and the "Auto-tune Filter (AtF)" from Metamagnetics. While each of these systems work well on certain types of interference(s), there is not a single system that can properly categorize the interference(s) and orchestrate the activation of these interference suppression and excision to yield increased dynamic range and improved Signal to Noise Ratio (SNR) performance.

It is highly desirable for the WISDOM architecture to be realized in software and/or firmware hosted on the BFTN and its successors.

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 and/or subcontractor 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 NAVWAR 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: Define the Wideband Interference Suppression for Dynamic-range OptiMization (WISDOM) architecture that will detect and categorize the interference type(s) and produce a strategy to mitigate the interferences thereof. The architecture should assume that either an analog "tap" or a digital copy (e.g., VITA 49.2 format) of the raw signal received by the radio will be made available to the WISDOM system.

During the Phase I Option period, if exercised, develop the SBIR Phase II Project Plan to include a detailed schedule (in Gantt format), spend plan, performance objectives, and transition plan for BFTN and any other PMW/A 170 identified Program of Record (PoR) to include BRSE, when the program is established.

PHASE II: Develop the prototype WISDOM for demonstration and validation in BRSE. Conduct Preliminary Design Review (PDR) for the WISDOM prototype and commence development of an Engineering Development Model (EDM) system. Conduct Critical Design Review (CDR) prior to building the EDM.

Develop lifecycle support strategies and concepts for the WISDOM.

Develop SBIR Phase III Project Plan to include a detailed schedule (in Gantt format) and spend plan, performance requirements, and revised transition plan for BRSE and any other PMW/A 170 identified Program of Record (PoR) to include Digital Modular Radio (DMR) and, objectively, with a candidate radio system from PMA/W 101. The name of PMA/W 101 radio system will be provided during Phase II execution period; for proposal purpose, use BRSE as an interim substitute with operation in L band (900 MHz to 2100 MHz).

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: Refine and fully develop the Phase II EMD to produce a Production Representative Article (PRA) of the WISDOM and integrate into BRSE. Evaluate the potential to perform integration with other PMW/A 170 identified Program of Record (PoR) to include Digital Modular Radio (DMR) and PMA/W 101 radio system.

Perform Formal Qualification Tests (FQT) (e.g., field testing, operational assessments) of the PRA WISDOM, preferably embedded in BRSE.

Provide lifecycle support strategies and concepts for WISDOM potential as embedded in BRSE by developing an amended Life-Cycle Sustainment Plan (LCSP) for BRSE.

Investigate the dual use of the developed technologies for commercial applications such as in telecommunications. With 5G, new waveforms must be capable of supporting a greater density of users (e.g., up to a million devices per square kilometer) and higher data throughput (speeds in the Gbps), and provide more efficient utilization of available spectrum. WISDOM can potentially provide the high dynamic range and interference suppression capabilities to meet these needs.

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- 4. "Auto-tune Filter (AtF)." Metamagnetics, July 24, 2020. <u>https://www.mtmgx.com/resources/auto-tune-filter-mm-02c-0320.pdf</u>
- "Summary of the 2018 National Defense Strategy." U.S. Department of Defense, July 24, 2020. <u>https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf</u>

KEYWORDS: RF; Radio Frequency; Interference Suppression; Interference Excision; Interference Excision System; IES; Battle Force Tactical Network; BFTN; Robust Communications for Challenging Environments; RoCCE; BFTN Resilient Command and Control; System Enhancement

N211-081 TITLE: Novel Flow Control Strategies for High-Speed Inlets and Isolators

RT&L FOCUS AREA(S): Hypersonics

TECHNOLOGY AREA(S): Air 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 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: Conceive, develop, and demonstrate innovative flow control methodologies that increase inlet system recovery and operability while decreasing inlet-isolator length and combustor-entrance flow distortion without requiring bleed.

DESCRIPTION: The performance of high-speed air-breathing weapons is highly dependent on the inlet performance and operability under a range of inflow Mach numbers, altitudes, and vehicle angles-of-attack and yaw angles. [Ref 1]

Fixed-geometry inlets are desirable due to their mechanical simplicity, but on-design operation is limited to a narrow range of conditions. Off-design modes of inlet operation occurring during acceleration and maneuvers generate highly complex and potentially unstable flowfields that can lead to unpredictable consequences such as inlet unstart. [Refs 2, 3] The unstarted inlet flowfield is characterized by a large separated region and supersonic flow spillage. In general, an unstarted inlet captures less airflow with lower efficiency and higher aerodynamic and thermal loads compared to a started inlet. [Ref 1]

This SBIR topic aims to develop flow control strategies to improve the inlet flow delivered to scramjet or ramjet combustors. Promising control strategies are not limited to, but may include, mechanical protuberances and fluid injection devices [Ref 4], and their optimal placement in an inlet/isolator system in conjunction with inlet and isolator duct shaping. Figures of merit for flow control strategies include improved flow uniformity at the inlet throat and exit of the isolator, improved inlet flow stability, increased inlet compression efficiency or compression ratio capability, and reduced inlet-isolator system length. Solutions that enable or enhance the performance and operability of a fixed-geometry inlet without bleed are especially attractive. While an unstart detection system is not the focus of this SBIR topic, there is benefit in developing control methodologies that provide the ability to rapidly add pressure margin to the inlet operation if insipient unstart of the inlet is detected.

Recent improvement in high-fidelity simulations [Refs 5, 6] and optimization methodologies [Ref 7] provide new avenues to design, analyze and optimize novel inlet-isolator control devices. The design of the control devices needs to be guided by numerical simulations and optimization methodologies that includes aerodynamics and thermo-structural considerations. Validation of the analytical and numerical toolsets against wind-tunnel experiments under relevant high-supersonic and hypersonic flight conditions is also needed.

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 and/or subcontractor 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 innovative flow control strategies to improve the performance and operability of the inlet-isolator system. The proposed flow control solution(s) shall be developed using suitable computational methodologies to estimate improvements in the relevant performance metrics such as flow uniformity, inlet-isolator length and compression efficiency. The suitability of the computational methodologies for the design and analysis of inlet-isolator control solutions must be demonstrated. Therefore, validation against relevant experimental data for hypersonic inlets and isolators will be a key consideration towards successful phase transition. The analysis must show that the proposed flow control solution(s) enable a significant improvement in the performance metrics outlined above in the Description as the inlet-isolator design is driven toward more compact configurations. Develop a Phase II plan.

PHASE II: Refine, optimize and validate the proposed flow control strategies. Mature the computational design and optimization methods. Perform required validation against wind-tunnel experiments under relevant high-supersonic and hypersonic flight conditions to gain confidence in the design methodology and to accurately quantify the improvements to the performance metrics. Perform successful execution of ground tests validating the flow control solution(s), refinement of numerical simulation tools incorporating experimental data, and a detailed plan towards integrating the proposed concept(s) in a Navy relevant flight vehicle in Phase III all criteria for phase transition.

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: Seek further maturation of the flow control solution(s), including its manufacturability. Demonstrate the flow control solution(s) on a relevant Navy weapons geometry once a sufficient TRL is achieved.

In the near term, this technology is geared toward military applications, but in the longer term, it could be used to enable commercial hypersonic flight. Commercial hypersonic platforms will likely rely on a turbine-based combined cycle (TBCC) propulsion system that requires inlet operation over a wide range of Mach numbers and low flow distortion for turbine operation.

Commercialization can include both flow control devices, and the toolset for design, analysis and optimization (devices geometry, placement and integration) of these devices.

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KEYWORDS: Flow control; high-speed; hypersonics; inlet; isolator; air-breathing; weapons

N211-082 TITLE: Accelerated Learning Model for Increased Strategic and Tactical Decision Making Using Multi-player Games

RT&L FOCUS AREA(S): Machine Learning/AI; General Warfighting Requirements

TECHNOLOGY AREA(S): Human Systems

OBJECTIVE: Increasing complexity in many military roles may require increased cognitive agility in areas of situation assessment, strategic and tactical decision making and better skill interpreting information in order to evaluate the need for a change in plans. Significant research has shown that it takes years and many repetitions for an individual to gain the skills. This cultivated knowledge and decision-making capability is necessary to develop expertise in any of these areas. However, recent research suggests that skill acquisition can be accelerated. This proposal explores a learning model that may help military personnel develop the necessary capabilities much faster using virtual environments with granular feedback, which have been shown to accelerate learning.

DESCRIPTION: Significant research has shown that it takes years and many repetitions for an individual to gain the skills, knowledge, and decision-making capability necessary to become an expert in a field. Recent research suggests that this requirement can be accelerated. Two questions come to mind: 1. Given recent research on accelerated learning in specific domains [Ref 1], can expertise that traditionally required years to master take only days or weeks to achieve? 2. What are the implications for expertise in broad cognitive capabilities such as situation assessment, strategic thinking, and tactical or general cognitive agility? Understanding these questions is crucial and time sensitive since the world is maneuvering and innovating faster across key domains including technology, military, politics, business, and education.

The interest in accelerating the mastery of expertise has a long history [Refs 2, 3]. Schneider et al [Ref 4] posited that those considered experts are qualitatively different from novices and journeymen. The process of becoming an expert takes years. He claimed that training the traditional route would not enable novices and journeymen to achieve the highest levels of expertise. Rather than traditional methods of training, the instructional designer and trainer must plumb the depths of learning strategies of those who would be experts. However, recently there has not been interest in this area of research, as evident by the dates of the publications referenced. It is time to revisit this area with the research described in this SBIR topic. This research could support an updated model of expertise acquisition that would advance training environments.

PHASE I: Develop a concept for an advanced training environment in the form of a multi-player game. Identify learning design features that encourage rapid learning. Base the architecture of the game on a model of accelerated learning as applied to military personnel. Ensure that the intent of the game should be to train combat personnel to operate successfully in urban battle settings. Produce and submit a final report that is a design document that describes the multi-player game features and includes a Phase II plan that describes a technical approach to achieve the desired result/product; and includes key component technological milestones such as the proposed experimental design to validate the resulting accelerated learning algorithms within the context of relevant operational tasks and environments.

PHASE II: Apply the instructional design accelerated learning principles in Phase I to a proof-of-concept technical feasibility demonstration. Empirically test the learning model by applying it via a virtual learning environment to a complex military problem. The virtual learning environment should be game based and multiplayer. Junior officers and senior non-commissioned officers (NCOs) will be the target users for the proof of concept. Validate training scenarios. Develop a data collection plan that includes the number and type of subjects; control condition, assessment instruments, and analysis plan.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the resulting technology for use in operational environments. Private Sector Commercial Potential: This SBIR topic would provide much needed theory, principles and technology to help the Navy/USMC introduce accelerated learning principles to both instructional designers, instructional personnel, and military personnel. The principles and technology would have broad applicability to learning endeavors within the military and to civilian training interests, particularly commercial game developers.

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KEYWORDS: Multiplayer Game; Training; Accelerated Learning Algorithms; Advanced Training Environments; Rapid Learning; Operational Tasks and Environments; and Urban Warfare

N211-083 TITLE: Automated Formal Verification of Software Defined Network Implementations

RT&L FOCUS AREA(S): Cybersecurity; Autonomy

TECHNOLOGY AREA(S): Battlespace Environments; 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 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: Develop an automated tool suite to formally verify correctness of software defined networks (SDNs), from programming to network implementations, subject to Fifth Generation (5G) New Radio (NR) standards and protocols.

DESCRIPTION: Cybersecurity vulnerabilities commonly arise from flawed implementations. To minimize attack surfaces while harnessing the full power of Fifth Generation (5G) New Radio networks, innovative solutions that identify flaws and formally verify correctness of underlying SDNs are required. Furthermore, automation will relieve the burden on operators who often validate code empirically, and will facilitate rapid, secure reconfigurability of SDNs. This SBIR topic addresses the challenge of automating formal verification of code and network correctness, which has thus far limited such technology to Industrial Control System applications. The innovative solution sought is an automated tool suite that identifies SDN programming flaws or malicious content and employs formal techniques to prove correctness of network implementations.

PHASE I: Define and develop a concept framework for an automated tool suite that will formally verify correctness of complete SDN implementations, ensuring compliance with any applicable NIST and ISO/IEC 27000 standards. Evaluate the type and source of vulnerabilities that could potentially be exploited as a result of faulty SDN implementations from programming flaws and malicious code to the actual network instantiation, considering both accidental and malicious events. Provide measures of effectiveness for such tools, as well as attainable performance characteristics. The framework will need to be flexible and extensible across a set of hardware systems, with a proposed design for the hardware and software architectures that will be incorporated into 5G-enabled cyber physical systems for assured cyber resilience. The design should include a summary of any computing and power requirements for administering these cybersecurity tools. The feasibility of the concept will be established through modeling and simulation. Include, in a Phase II plan, the initial design specifications and capabilities description to build prototype tools in Phase II.

PHASE II: Fully develop, verify, and validate prototype automated tools that formally verify correctness of complete SDN implementations subject to applicable standards and protocols (e.g., 5G NR, NIST, and ISO/IEC 27000) for evaluation. Design the prototype tool suite to provide formal verification of code and network functionality prior to instantiation. Demonstrate the design performance through modeling and physical testing over a range of scenarios devised to test network vulnerabilities with and without the cyber resilient layer in place. Use evaluation criteria and results to refine the prototype tool suite into an initial design that can be deployed in relevant and/or operational environment settings, and that support mission requirements in the cyber domain, which ultimately ensures the confidentiality, integrity, and

availability of data. Develop a Phase III plan to transition the technology to a system that can be acquired by the Navy.

PHASE III DUAL USE APPLICATIONS: Support Navy system integration of the cybersecurity framework, hardware and software, employing any lessons learned from the Phase II evaluation. Incorporate the automated tool suite into security assessments that support both any existing and future SDN implementations. This integration will also include validation testing and demonstration on a representative 5G-networked system. The automated tool suite developed in this SBIR effort would support formal verification of correct SDN applications in 5G networks used by industry, infrastructure, energy, health care, and other applications where cyber attacks due to flawed implementation may be expected to interfere with the integrity or availability of data and analysis from 5G-enabled cyber physical systems.

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KEYWORDS: Software Defined Network; SDN; Automated Tools; Formal Methods; Formal Verification; 5G

N211-084 TITLE: Low Cost, Single Use Precision Aiming Device for Explosive Ordnance Disposal Disrupters and Tools

RT&L FOCUS AREA(S): Autonomy; General Warfighting Requirements

TECHNOLOGY AREA(S): Battlespace Environments; Ground / Sea Vehicles

OBJECTIVE: Develop and demonstrate a low cost, single shot, precision aiming device designed to fit onto multiple Explosive Ordnance Disposal Disrupters.

DESCRIPTION: Explosive Ordnance Disposal (EOD) disrupters and tools are used to remotely open or render safe a suspect item or improvised explosive device (IED). Current precision aiming systems utilize reusable lasers that are expensive and under certain recoil forces/conditions exhibit limited survivability. The EOD community has identified the need for a low cost, lightweight, precise aiming capability for one-time use (single shot) on a variety of disrupters and tools. The aiming capability should aim and hit a variety targets with different surfaces at a standoff distance threshold of 25 feet and objective of 50 feet. It should have an aim-spot accuracy of approximately 0.955 inches (the diameter of a U.S. quarter). The capability should be able to wrap around multiple disrupter/tool barrels with a threshold requirement of 1"-2" diameters and an objective requirement of 1"-6" diameters. Separate configurations to achieve the range of 1"-6" diameters is acceptable. Battery operation of the device is acceptable. A concept of employment that provides minimal setup time with no tools is preferred along with the smallest, lightest weight configuration. Operators should be able to see the aim-spot in daylight with their eyes and remotely through a camera interface. At night, the capability should be infrared (IR) or night vision compatible. Examples of evaluations and descriptions of some DoD, local and state bomb squad disrupters and laser aiming devices are provided in References (1) and (2).

The innovation of this research is in the development of a precision aiming device that is one use, lightweight, low cost and capable of easy operator set up on multiple diameter disrupters and tools. Novel laser or non-laser solutions are acceptable.

PHASE I: Define, develop and possibly validate the initial design concept for a low cost, single shot, precision aiming device. If requested, the Government can provide an inert 155mm round fuze as an exemplar validation target. Provide a final report of the initial work and results for the single shot precision aiming device, the concept of employment for the various disrupter sizes, a device cost forecast and Phase II implementation plan.

PHASE II: Produce prototype hardware. Develop, demonstrate and validate the design. The Government can provide test opportunities on actual systems if the validation work is mature enough to enable a viable test.

PHASE III DUAL USE APPLICATIONS: Transition the device to the Joint Service Explosive Ordnance program. Manufacture a sufficient number of devices to support a statistically relevant field test validation and verification using a variety of disrupters. Additionally, the device could transition to use by state and local bomb squads.

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KEYWORDS: EOD; disrupter; precision; aiming; device; single-use; low-cost

N211-085 TITLE: Developing Alloy Compositions Conducive to Additive Manufacturing

RT&L FOCUS AREA(S): Machine Learning/AI; General Warfighting Requirements

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

OBJECTIVE: Develop alloy compositions that enable additive manufacturing (AM) processes to produce properties that are not currently achievable such as materials with a preferred crystallographic orientation, dispersion-forming alloys that can either form the dispersion during AM or after AM through heat treatment. Alloy compositions should reduce defects in components, thus promoting them to be more resistant to fatigue, with potential increases in strength.

DESCRIPTION: Additive work is being done on current cast and wrought alloy compositions trying to achieve original alloy properties. Achieving such properties is difficult because of the varying solidification conditions inherent in different AM processes and part designs. AM alloys have a complex thermal history involving directional heat build-up and repeated melting and rapid solidification. AM usually results in a finer microstructure than conventional processing which gives the AM material better fatigue properties, but debited creep properties. Modifying alloy compositions to take advantage of AM solidification variables could take advantage of AM to improve alloy properties. The interaction of alloying elements is recognized in promoting desirable microstructural phases and solid-solution effects for development of properties. The use of Integrated Computational Materials Engineering (ICME) should relate AM processability with alloy chemistry in order to develop models that are able to predict alloy chemistry that minimizes defects while maintaining base alloy properties. This could be done by linking materials data sets, modeling, and AM variables in a machine learning framework to achieve properties. The condition under which solidification takes place determines the structural features that affect the physical and mechanical properties of an alloy. Melting and solidification are generally wellunderstood during casting processes, but melting and solidification profiles, effect of contamination, and alloy chemistry control during cyclic AM processing, particularly for complex and thicker components. are also not well characterized.

PHASE I: Explore the literature to determine the relationship of wrought alloys chemical compositions and the chemistries of its cast alloy corollaries, understand the underlining reasons for the different chemistries to enable an alloy to be similar by each process. The company should select an AM process which has a good understanding of the heat transfer, solidification variables, and factors which cause defects. Focus on IN 718 or Alloy 230 with the goal of producing properties equivalent to or greater than achieved by the wrought alloy. Develop conceptual models/algorithms that link alloy chemistry to AM processes and resulting alloy microstructure and subsequent mechanical properties. Company needs to show that alloy chemistry models can consistently predict the alloy physical and mechanical properties for the AM process selected. Consider powder chemistry and size distribution. Analysis of the defects is suggested to be done by non-destructive processes such as 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: Based upon Phase I effort, apply ICME tools to optimize metal AM processing and to predict design and processing parameter limits for a more complex component. Consider computational models and relevant databases. Since most AM metal processes are layer--by-layer, work need to model the change in heat transfer as the layers are added to previous layers in an effort to minimize microstructural changes within the component. Determine relative sensitivity of different chemistry variables within a property model; and determine which variable is "most important" in controlling property value. Work to optimize the alloy chemistry/processing/property model by selecting another nickel-base alloy or an iron-

based alloy to explore an alloy family. Collaborate with a powder manufacturer for powder size distributions for AM systems. Ensure that the program provides a means for capturing, sharing, and transforming materials data into a structured format that is amenable to transformation to other formats for use by ICME and other computational programs, modeling, and simulation methods. Demonstrate the functionality of this framework.

PHASE III DUAL USE APPLICATIONS: The AM process and alloy chemistries that are suited specifically for AM processes offers the opportunity of conformal, and unique design not possible with more conventional fabrication processes. Proven AM process optimization leading to a minimization of process - and materials - derived defects would improve acceptance of AM for producing component for the Navy and for private industry. The use of AM could lead to more innovative designs capable of more efficiently removing heat because such designs could eliminate or severely reduce joints. AM processing of components that are qualified for Navy use could also be applied to commercial use. The use of AM could lead to more innovative designs capable meet ever-increasing demands on components for the Navy as such designs could eliminate or severely reduce joints. AM processing of components that are qualified for Navy use could also be applied to commercial use more quickly. 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. The outcome of this technology development program 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 materials prediction. Transition the material production methodology to a suitable industrial material producer. The ICME code needs to be transitioned to the commercial entity for potential incorporation of a more comprehensive ICME code. Commercialize the alloys for use in DoD and commercial markets.

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KEYWORDS: Additive manufacturing; alloys; Integrated Computational Materials Engineering; ICME; solidification; processing; alloy chemistry; heat transfer; defects
N211-086 TITLE: N-Polar Gallium Nitride High Electron Mobility Transistor in Low-Cost Process Technology for mm-wave Transceiver Applications

RT&L FOCUS AREA(S): 5G; Microelectronics

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

OBJECTIVE: Demonstrate robust N-polar Gallium Nitride (GaN) E-band low noise amplifiers (LNAs) with <3.5 dB noise figure at 83 GHz, and device NFmin < 1 dB at 30 GHz. The device and LNAs must use a native growth N-polar epitaxy process on a low-cost substrate that can be scaled to diameters of 150 mm and above.

DESCRIPTION: N-polar GaN has demonstrated breakthrough high-power density performance in the Wband, and matched or exceeded power performance of traditional Ga-polar GaN at lower frequencies including X and Ka-band. GaN transistors and monolithic microwave integrated circuits (MMICs) today are expensive, with a significant portion of the cost coming from the Silicon Carbide (SiC) substrates and their smaller diameters (200 mm substrates will lower MMIC cost by 6X for low cost substrates). Alternate substrates will be lower thermal conductivity and/or increased microwave loss, the impact of which should be considered. A single epitaxial structure will lead to a 50% reduction in integration cost of an LNA, Power Amplifier (PA) and transmit / receive (TR) switch. Tradeoffs in performance of individual circuits is anticipated in order to meet the topic objectives in a single device epilayer structure. Examples for the current state of the art for Ga-polar GaN HEMT on SiC follow; HRL's T4A process provides excellent NFmin below 1 dB at 30 GHz and approximately 0.5 W/mm power density. Ga-polar GaN-on-SiC HEMT's data at 94 GHz at 2 W/mm and 22% power-added-efficiency (PAE) has been reported. Nitrogen polar (N-polar) GaN HEMTs, at 94 GHz, have demonstrated ~9 W/mm at 28% PAE on SiC and 4 W/mm, 30% PAE on Sapphire. N-polar GaN LNA's have not been reported. Availability of N-polar GaN device materials in substrate diameters from 100-200 mm is being established through DoD investment in technology transition and manufacturing.

PHASE I: Design and fabricate a low noise N-polar GaN HEMT device with noise figure (NF) min <3 dB at 83 GHz and <1 dB at 30 GHz, with epitaxy grown on a low-cost substrate and with an epitaxial design capable of supporting both power amplifier devices with >4 W/mm and >25% PAE and transmit/receive (T/R) switches. Characterize noise and S-parameters and extract noise and linear models. Develop a Phase II plan.

PHASE II: Refine the design of and fabricate a prototype E-band 81-86 GHz LNA demonstrating <3.5 dB NFmin and >15 dB gain. Characterize the noise and small-signal performance. On the same wafer, fabricate split path, double throw (SPDT) T/R switches and characterize their performance at small and large signal level under continuous wave (CW) conditions. Based on the measured performance, survey and identify E-band transceiver applications for the Phase II results.

PHASE III DUAL USE APPLICATIONS: There are many emerging transceiver applications for both DoD and commercial systems for E-band. The U.S. Federal Communications Commission has established that portions of E-band are available in the U.S. for high density, high data rate wireless services that will enable point-to-point communications, SATCOM, and 5G services. The International Telecommunication Union permits several bands for radio and satellite operations. For example, SpaceX has applied to use portions of E-band in their Starlink Gen2 satellite constellation. E-band will enable new high-resolution imaging and surveillance sensors for DoD systems and commercial applications such autonomous vehicles. In Phase III, transition and demonstrate the N-polar device fabrication to a full wafer fabrication at wafer diameters > 150 mm. Refine the designs developed in the Phase II. Based on the phase II application survey for an E-band transceiver application, develop the TR module

specifications to satisfy this application. Design and fabricate a prototype integrated TR module and package into a waveguide housing with all bias and control signals integrated. Characterize under relevant operating conditions. Based on the results, further refine the designs.

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KEYWORDS: GaN; Gallium Nitride; low noise amplifier; transceiver; High Electron Mobility Transistor; HEMT; Nitrogen Polar; Noise figure

N211-087 TITLE: Solid State High Voltage Power Module Development and Packaging for High Power Microwave Drivers

RT&L FOCUS AREA(S): Directed energy

TECHNOLOGY AREA(S): Electronics; Ground / Sea Vehicles; Weapons

OBJECTIVE: Develop and demonstrate compact power electronics modules capable of supporting power combining of solid state High Power Microwave (HPM) sources. Develop bond wireless technology to enable ultra-high voltage silicon carbide metal-oxide semiconductor field-effect transistor (SiC MOSFET), insulated-gate bipolar transistor (IGBT), Thyristor, and diode modules capable of higher pulse repetition rate operation for burst mode operation. Develop specialized test beds that have the ability to characterize the maximum di/dt and dv/dt limitations of SiC devices while determining the safe operating area (SOA) of the modules. Advance and verify switch characteristics such as fast rise time and low impedance to be able to drive specific HPM sources. Develop a compact, less than 1 ft^3, packaged switch module capable of delivering 50-100 kV outputs that also has the ability to be combined to scale driver power. Demonstrate low jitter module operations to facilitate phased element design. This phased multi module system design will show the ability for scalable power and subsequent beam steering operations.

DESCRIPTION: Commercial grade SiC power electronic devices are available in the market; however, high voltage (HV) SiC devices have not been developed, tested, or packaged specifically for HPM applications. Research grade SiC MOSFET and IGBT dies have been packaged individually, but the maximum di/dt and narrow pulse capability have not been determined. In addition, HV IGBTs have not been packaged in modules. Ultra-high voltage SiC MOSFET, IGBT, Thyristor, and diode modules can be developed for narrow pulse fast rise time applications, while requiring unique drivers to optimize performance. The power density, long term reliability, efficiency, and control of directed energy systems can be improved through the utilization of novel SiC device modules. The fabrication of SiC has rapidly advanced in recent years with defect density and average carrier lifetime vastly improved, enabling stable and reliable operation. However, the device packaging has not been optimized for pulsed power switching that has very short times while being very high in voltage. The bond wires are a known failure point during high current switching that will need to be addressed.

Simulations show that SiC MOSFETs can be capable of up to 15 kV while SiC IGBTs are suitable from 15 kV to 35 kV, while higher voltages from 35 kV to 50 kV SiC gate turn off (GTO) Thyristors are the optimal choice [Ref 1]. Cree-Wolfspeed has developed a 15 kV SiC MOSFET and a 24 kV SiC IGBT as of 2016, though they are not in their standard product inventory [Refs 2, 3]. The rise-time of the MOSFET was 102 ns for an 8 kV, 28 A pulse while the IGBT had a switching speed of 46 kV/ μ s. Photoconductive semiconductor switches (PCSS) SiC have been developed to show switching voltages of 50 kV in experimental setups for a radial topology [Ref 4]. Behlke has developed HV solid state switching modules capable of switching 200 kV with a 1.6 kA current and a rise-time of 300 ns (HTS 2000-160). Behlke also has Thyristors capable of switching 150 kV with a 10 kA current and a rise-time of 35 μ s (HTS 1500-1000-SCR).

PHASE I: Conceptualize, design, and model key elements for an innovative, all solid-state power modulator capable of a threshold 50 kV and objective 100 kV at pulse repetition rates of tens of kHz or higher. The design should establish realizable technological solutions for a module capable of driving various HPM sources that have certain requirements in rise-time and impedances.

Requirements:

• The technical solution should have a minimum pulse repetition rate on the order of tens of kHz or higher.

• The conceptual design should focus on rise times of 10's of ns, <100 Ohm impedance, and jitter <1 ns to be able to drive specific HPM sources and accurately phase multiple modules.

• The proposed design should be an 80% complete solution and include all auxiliary systems associated with the control system for the power electronics, power buffer/energy magazines and thermal management.

• The design should include circuit modeling and analysis of the HV driver.

• The proposed brassboard system should be designed for both laboratory and limited open air testing with sufficient ruggedization to transport the hardware to test sites.

Perform additional modeling and simulation to determine predicted efficiency, prime power draw, and thermal management requirements. Provide an overview of the current state of the art for each of the key prototype elements along with manufacturer information, focusing on the solid state components required for this application, packaging and power density. Provide a cost analysis as well as material development to ascertain critical needs not yet fully developed or readily available given current technology. Develop a Phase II plan.

PHASE II: Refine the design of the proposed technology. Complete procurement, integration, assembly, and testing of a proof-of-concept brassboard prototype leveraging the Phase I effort. Requirements:

• The Phase II brassboard prototype will be capable of greater than 50 kV and a rep rate above 50 kHz, while being able to support low jitter (<1ns), fast rise-time (10's of ns) operations.

• The brassboard system should be capable of operating in a laboratory environment, such as an anechoic chamber or Gigahertz Transverse Electromagnetic (GTEM) test cell.

• This brassboard prototype must demonstrate a clear path forward to a full scale concept demonstrator based on the selected technology.

PHASE III DUAL USE APPLICATIONS: A successful project will also showcase the ability of the technology to match evolving needs of commercial markets such as medical pulse power and sterilization. Recent progress in medical pulse power research, utilizing high voltage short pulses to increase immunology efficacy has driven the need of a low jitter, fast rep-rate, low impedance, solid-state HV pulse generator. Several medical areas benefiting from these HV modulators include wound healing, cancer treatment, and gene transfer. Various commercial markets ranging from environmental, sanitization, and food processing has also shown increased efficacy when utilizing short, high voltage pulses. These applications can be realized by the development of a reliable, long lifetime, solid-state HV modulator.

Within DOD, we seek to apply the knowledge gained during Phase I and II to further build, refine and demonstrate a full scale prototype device capable of transmitting an arbitrary waveform at power levels exceeding 10 MW and a rep-rate on the order of tens of kHz or more. To allow this, it is suggested to ensure that the prototype represents a complete power modulator with controls, thermal management, energy magazine or prime power buffer; and is ruggedized for, at a minimum, testing in an outdoor environment and be environmentally enclosed; and includes at least 2 or more modules that shows active control over phasing and power combining.

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KEYWORDS: High Power Microwave (HPM); Solid state switch; High Voltage (HV) switch; power modulator; power electronics

N211-088 TITLE: Live, Virtual, and Constructive Cyber Battle Damage Assessment for Training

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Electronics; Human Systems; Information Systems

OBJECTIVE: Research, design, and develop intelligent cyber sensors that can accurately detect cyber range-based state information and distribute to traditional training architectures to enable integrated cyber-kinetic training opportunities.

DESCRIPTION: Cyber ranges, as the primary environment for conducting cyber training, must be able to collect key cyber state information, also known as cyber Battle Damage Assessment (BDA), and share this information with traditional simulation architectures and systems. This ability is foundational to creating an integrated cyber-kinetic training environment and requires the development of sensors that can accurately detect Live, Virtual, and Constructive (LVC) cyber effects of interest such as Denial, Disruption, Degradation, Destruction, and Manipulation (4DM).

PHASE I: Identify shipboard C4I System interfaces and data flow vulnerable to a Great Power Competitor's Signal Intelligence (SIGINT) and the interfaces of these systems to the Navy Continuous Training Environment (NCTE). Develop the design of a system/software scheme that would allow "live" signals to effect "virtual" simulations of identified shipboard C4I system. Submit the scheme for validation by Fleet Information Warfare (IW) Subject Matter Experts (SME), NCTE Interface Engineers, and Fleet Training SMEs from Tactical Training Group Pacific (TTGP) for a review at Naval Simulation Center Pacific (NSCPAC) San Diego CA. Provide all software designs, a description of software and hardware to be developed in Phases II and III, and a demonstration plan and scenario that will be executed at NSCPAC. Develop a Phase II plan.

PHASE II: Build and test a usable prototype of the software and hardware to be tested in the NSCPAC lab to demonstrate the ability to bring live signals into a virtual ship's identified C4I systems. Ensue that the deliverable will be a test ready article (hardware and software), which will be used in Phase III to test and demonstrate in a Fleet Synthetic Training (FST) Unit level event. Ensure that this prototype will use the Research, Development, Test, and Experimentation (RDTE) NCTE architecture and Joint Semi-Automated (JSAF) simulation for scenario and transport inside of NSCPAC. Tactical Training Group Pacific (TTGP) will act as the Distributed Training Center (DTC) and will provide IW SMEs to evaluate the prototype for ease of use, representations of the injected IW signal on the virtual C4I system, and the output of the BDA to the C4I system. All software developed as part of this research will be provided to ONR and other identified government users without restriction.

PHASE III DUAL USE APPLICATIONS: Make available to the Navy all technologies developed under this SBIR topic. These technologies will be installed at Tactical Training Group Pacific (TTGP) and onboard an assigned Destroyer at sea during a LVC Composite Training Unit Exercise (COMPTUEX) offshore on the West Coast Tactical Training Range (WCTTR). Use of these technologies will help inform the Navy Fleet Training Program on how to use Operational/Tactical circuits to transport simulation & mentor data while at sea.

Private Sector Commercial Potential: Expansion of this technology for ship to and from aircraft, ship to and from submarines, and aircraft to and from submarines could be development opportunity for defense contractors, small businesses, and academia.

This technology could be expanded to improve operational and tactical capabilities that could be a "Game Changer" for the Navy.

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KEYWORDS: Cyber; Training; Information Operations; Shipboard Applications; Kinetic Operations; Damage Assessment; Live, Virtual, and Constructive; LVC; Electronic Systems

N211-089 TITLE: Airborne LIDAR Ocean Temperature Measurement

RT&L FOCUS AREA(S): General Warfighting Requirements

TECHNOLOGY AREA(S): Battlespace Environments; 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 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: Develop and demonstrate an airborne capability to measure with fidelity the temperature of the ocean across the upper part of the water column, where it is most variable - and therefore produces the greatest effects upon acoustic propagation. Fidelity will necessarily vary as a function of platform altitude, platform velocity, and atmospheric properties. Validate an understanding of the limits of performance and a hierarchical understanding of the underlying causes of limited performance.

DESCRIPTION: Active optical (LIDAR) techniques exist to measure sound speed in liquids remotely by spectrally resolving the Brillouin component of the backscatter. In contrast to Raman LIDAR techniques, which require assumptions about salinity to derive sound speed, Brillouin LIDAR techniques are capable of inferring sound speed directly. However, demonstrations of the Brillouin technique have so far been confined to the laboratory, and are not routinely employed in the field, nor do commercial sensors exist.

Any approach offered shall, at a minimum, enable the measurement of sound speed profiles in seawater remotely, along a line of sight, day and night, with an accuracy of at least 1.5 m/s, and an along-beam resolution of 5 m or better, to a total range in mesotrophic waters of at least 40 m. The approach must not depend on assumptions about salinity or temperature of the water, nor the amount of suspended particulates, and must be fieldable and hands-free.

This effort is focused on exploring novel techniques that exploit the Brillouin scatter process to directly measure sound speed in water. Any approach must show early promise for enabling routine operational measurements from seagoing and/or airborne vessels, and must not depend on regular human intervention to operate correctly. Candidate techniques include, but are not limited to, use of stable optical filters, spectrometers, or combinations thereof, to spectrally resolve Brillouin backscatter.

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 and/or subcontractor 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: Define and develop a concept to obtain profiles of sound speed through seawater that is compatible with deployment on seagoing vessels. The concept shall include a high level description of the

hardware and associated algorithms, description of a water tank demonstration, and corresponding performance simulations. All assumptions made for the performance modeling shall be clearly stated. Develop a Phase II plan.

PHASE II: Produce a laboratory water tank demonstration based on the Phase I work. The prototype shall demonstrate the form and function of the critical sensor elements as accurately as possible. The prototype shall be capable of validating key sensor performance parameters; laboratory validations shall be conducted and documented by the awardee using the prototype hardware. Sensor shall be delivered to the Government for 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: Interface with stakeholders in both ocean modelling and tactical communities to identify platform (ship, submersible, etc.) and performance needs, then scale and engineer the system appropriately to those needs.

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KEYWORDS: LIDAR; Brillouin; sound speed; Doppler; back-scatter; spatial heterodyne

N211-090 TITLE: Refrigerant Vapor Quality Sensor

RT&L FOCUS AREA(S): Directed energy; General Warfighting Requirements

TECHNOLOGY AREA(S): Ground / Sea Vehicles

OBJECTIVE: Develop a low-cost, high-speed sensor and instrumentation to measure refrigerant quality in an electronics cooling system.

DESCRIPTION: Two-phase cooling systems using pumped refrigerant loops are being developed to remove heat from high-powered electronic systems. These thermal systems would benefit from monitoring the relative mass fractions of liquid and vapor phases (quality) in a saturated mixture, for future system optimization and assurance of safe operation in harsh environmental and transient operational conditions. Capacitance and impedance techniques can be used for volume averaged void fraction measurements, but these techniques are limited by their relatively low spatial resolution and the accuracy of the reconstructed image, and are not readily available to utilize for platform applications. Laboratory experiments rely on complex, expensive instrumentation to measure quality, such as image analysis or liquid-vapor separators. Measurement of the spatial and temporal variation of quality also allow for a characterization of flow regimes, which can be used to predict heat transfer performance. Such techniques are not easily translated to fielded systems that may require hundreds of such sensors operating at frequencies greater than 100 Hz for integration into the control system.

The goal of this SBIR topic is to design and fabricate a non-invasive, high-speed instrument to measure refrigerant quality in an operational, military electronics cooling system. The electronics cooling system shall be able to use the instrument measured refrigerant quality as a controls parameters. The instrument shall be able to assess vapor qualities as high as 0.80 and operate under dynamic platform motion as defined by DOD-STD-1399/301a. The instrumentation shall be waterproof and vibration resistant and should be able to interface with control systems through standard software communication protocols such as Modbus.

PHASE I: Develop a design for an instrument to measure refrigerant vapor quality. The sensor should not exceed 25 lbs per-unit-weight and 1 cu ft volume size. Validate design performance through analytical modeling and subscale demonstration for vapor qualities up to 0.80. Ensure that the system maintains proper operation when subjected to ship motion dynamics (DOD-STD-1399/301a). Perform rough manufacturing cost analysis. Develop a Phase II plan.

PHASE II: Refine Phase I design and fabricate prototype instrument, including software interface to commercial platforms. Ensure that the system is capable of monitoring at least 10 independent sensors. Demonstrate operation in a pumped refrigerant loop using R134a over vapor qualities of 0.0 to 0.80. Perform more detailed manufacturing cost analysis.

PHASE III DUAL USE APPLICATIONS: Develop final design and manufacturing plans using the knowledge gained during Phases I and II in order to support transition of system to Navy platforms. Ensure that the final system meets Navy unique requirements, e.g., shock, vibration, and electromagnetic interference (EMI). The development of refrigerant quality sensors capable of operating under dynamic motion associated with shipboard installation has commercial applications that include cooling of electric vehicles and commercial vessels.

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KEYWORDS: Electronics Cooling; Two-Phase Cooling System; Vapor Quality; Pumped

N211-091 TITLE: Real-time Simulation of Radio Frequency (RF) Signal Returns from Complex Targets and Backgrounds

RT&L FOCUS AREA(S): Hypersonics

TECHNOLOGY AREA(S): Information Systems; 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 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: Develop a capability for high resolution real-time simulation of targets and cluttered backgrounds for active imaging Radio Frequency (RF) sensors during hardware-in-the-loop testing.

DESCRIPTION: Government hardware-in-the-loop (HWIL) facilities are used to evaluate closed-loop processes associated with weapon guidance and control. To close the guidance loop, the facility must realistically represent the input to sensors used to recognize, track, and guide to the target. In order to develop and test increasingly advanced radar seeker capabilities, there is a need to increase the resolution of the simulated RF scenes. One method of accomplishing this is by increasing the number of RF scatterers used to represent the RF scene. Imaging RF sensors using synthetic aperture radar technology might need on the order of one million scatters to represent the complexity targets and background characteristics.

This SBIR topic focuses on the algorithmic processes and computing architecture required to generate high resolution scenes in a real-time hardware-in-the-loop test environment. The modified return pulses must be calculated and generated based on a dynamic engagement where the engagement parameters and radar state for each update are changing in real time. The scene processing will receive updated state information from the engagement simulation computer at a specified update rate (i.e., 1200Hz). An appropriate computing architecture must be found, possibly graphics processing unit (GPU), field-programmable gate array (FPGA), RFSOC, central processing unit (CPU), digital signal processor (DSP), or combinations of the aforementioned, that provides required increases in processing speed to modify the returned pulse based on target and background interactions. Algorithmic techniques must be defined and implemented to capture the effect of scattered energy in a complex scene (e.g., method of moments, ray tracing) compatible with the real time HWIL test environment. Urban and natural terrains will be bounded pretest, but may extend for considerable distances if used to obtain navigation reference information or if considerable target uncertainty exists.

There are two key steps in creating the return pulse waveform: 1) scene generation that has to occur once per pulse repetition interval (PRI) based on engagement kinematics, and 2) waveform generation that involves convolving the scene with the digitized transmit pulse which has to occur within the time of flight from the radar to the target area and back (t = 2d/c). The goal is the equivalent of 1 million scatterers in the target scene at 10,000 Hz. Note that the use of discrete scatterers to modulate the pulse is used as an example, with understanding that there may be other methods of capturing the effect of complex backgrounds.

The developed technology will be transitioned to Navy and other DoD facilities. For proof of concept and evaluation, the processing architecture must be baselined to communicate/interface with the existing 6DOF engagement systems and the Navy system located in existing facilities. A requirements assessment during Phase I will determine whether any additional interface compatibility is required for other government systems. Designs with modularity that allow for incremental increase in fidelity are possibly of benefit to accommodate budgetary and programmatic constraints. The Phase I effort will not require access to classified information. If needed, data of the same level of complexity as secured data will be provided to support Phase I work. The Phase II effort will likely require secure access, and SSP will process the DD254 to support the contractor for personnel and facility certification for secure access.

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 and/or subcontractor 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: Bound the problem and develop a processing architecture that can meet the RF scene complexity/resolution goal. Attention will be paid to the best processing architecture or combinations of architectures that best meets the requirements. Document the design and trades made to reach the conclusions. Digital simulations should be executed to demonstrate the capabilities of the design. The software design should use best practices to provide for readability, modification, scalability, reproducibility and support constant evolution into new hardware (H/W) to allow for protection from obsolescence. A facility survey will be performed to determine compatibility requirements with relevant RF target simulators.

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 RF target simulation processing system and deliver for testing and evaluation as a component of the Navy Dynetics system. The prototype shall be based on the results of Phase I and the Phase II Statement of Work (SOW). The prototype shall be software (S/W) that runs on the existing Navy H/W, H/W that interfaces with the existing RF simulator hardware, or shall be some combination of both. Work with Navy subject matter experts, which may include Government personnel and contractors, to develop and demonstrate the prototype with the Navy RF simulator. Fully document the prototype design H/W, S/W and interfaces. The Government will provide the RF sensor and also develop a scenario or group of scenarios to act as test cases to be use to evaluate new scene generation capabilities. Collaborate with the Government to analyze the results of the test cases.

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 DoD use. In addition to the Navy system, other DoD and DoD contractor facilities will be identified as potential recipients of this technology. The final product shall be a processing architecture that can generate high resolution RF scenes that are calculated in real-time and interface with DoD facilities. The system needs to be fully supportable and maintainable by the government. The system needs to be adaptable and expandable as technology improves.

This technology can be used to support non-DoD industries such as automotive radar, survey and mapping equipment manufacturing, and simulation for Geographic Information Systems (GIS) satellite radar manufacturers.

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KEYWORDS: Synthetic target scene generation; Real-time RF Target Generation; Synthetic Aperture Radar SAR; Real-time SAR simulation; Radar Scatterers; Simulation of radar returns; Radar background modeling; RF target models

N211-092 TITLE: Onboard Flight Ablation Sensor

RT&L FOCUS AREA(S): Hypersonics

TECHNOLOGY AREA(S): Electronics; 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 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: Develop a sensor that can be integrated onboard a missile system to measure real-time surface temperature and ablation material response during hypersonic flight tests.

DESCRIPTION: A major technical challenge for hypersonic missiles includes managing the extreme heating environments experienced at hypersonic speeds. Current hypersonic systems have a Thermal Protection System (TPS) that includes expensive materials that are also difficult and time consuming to produce. Understanding the performance of these materials during developmental flight testing is key to providing an optimized system solution that can ultimately meet performance requirements while also reducing the cost to the US Government.

Critical TPS performance metrics that are required for full missile system performance in a flight test event include TPS surface temperatures and ablation data on critical components such as the nosecone, aeroshell and leading edges. Currently, sensor technology exists with the ability to capture critical TPS material information, including surface temperatures and ablation data, during laboratory testing. However, this sensor technology in its current state is not able to measure these parameters on a missile traveling at hypersonic speeds. The U.S. Navy is interested in a sensor that can be integrated onboard a missile system to measure real-time surface temperature and ablation material response during hypersonic flight tests.

This technology must be able to detect and measure parameters of the surface materials on the TPS from inside the missile. The design of the sensor will be required to have precise technical functionality as well as overcome the mechanical packaging and electrical integration challenges associated with an onboard missile system. This technology will enable critical test performance metrics to be captured that are not currently captured. The data collected from this enabling technology is critical to TPS modeling and simulation to further understand the capability of the current TPS design as well as future designs. This technology supports advanced system performance assessments such as understanding the maximum range capability of the current system. Also, this technology is key to reducing the robustness of the current TPS design in favor of an optimized design that focuses on system weight savings while maintaining performance requirements.

The Phase II effort will likely require secure access, and SSP will process the DD254 to support the contractor for personnel and facility certification for secure access. The Phase I effort will not require access to classified information. If needed, data of the same level of complexity as secured data will be provided to support Phase I work.

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 and/or subcontractor 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: Propose a solution for developing a sensor that can be integrated onboard a missile system to measure real-time surface temperature and ablation material response during hypersonic flight tests. Identify ablation sensor technology and demonstrate bread-board ability to resolve length change on representative material. Perform subsystem design and analysis addressing material and environmental requirements for the sensor. Specific requirements for ablator material and measurement implementation for the prototype design must be understood. Demonstrate a concept that can maintain mechanical and electrical packaging requirements given by the Government upon contract award during the Phase I period of performance. The concept must be able to detect parameters on the materials surface from inside the missile.

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 that meets the Government's design requirements based on the results of Phase I and the Phase II Statement of Work (SOW). The developed units must be suitable for proof-ofconcept demonstration and ensure the electronic devices used on the prototype are suitable for flight test environments. During this Phase, access to classified design data is required to gain the actual system requirements for the technical specifications of the sensor, as well as the exact mechanical and electrical constraints that the prototype must adhere to. A Phase II Option, if exercised, would require the conduction of an aerothermal ground test with the prototype to prove that the performance and integration requirements of the prototype have been achieved.

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: Qualify the prototype to system level vibration and shock environments. Develop and document assembly instructions for the Government and provide assembly training on a test unit. Implement the technology for Conventional Prompt Strike (CPS) developmental flight testing then utilized further on other Navy flight systems as required.

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KEYWORDS: Hypersonic ablation; Thermal Protection System; Real-time surface temperature; Ablation material response; Hypersonic recession; Sensors

N211-093 TITLE: Real Time Single-Shot AI Enhanced Coherent Wavefront Sensing for Intelligence, Surveillance, and Reconnaissance (ISR) and Directed Energy Applications

RT&L FOCUS AREA(S): Hypersonics

TECHNOLOGY AREA(S): Sensors; 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 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: Develop a real-time computational pipeline that meets the demanding latency and throughput requirements for real-time single-shot artificial intelligence (AI) enhanced accurate wavefront sensing in imaging and directed energy applications.

DESCRIPTION: The phase distortions caused by the propagation of coherent light through deep layers of atmospheric turbulence create fundamental physical limitations for the problems of both optical imaging and directed energy (DE) in long-range air-to-ground and ground-to-air applications. As coherent light passes through many layers of atmospheric turbulence, the wavefront is distorted in a way so that a traditionally formed image is blurred with a space-variant distortion. Emerging methods in digital holographic (DH) imaged together with the fusion of advanced AI methods with advanced physics-based sensor models offer the possibility of recovering a model of the propagation distortion, so that the wavefront can be corrected. However, in order for these technologies to have impact, novel algorithms and integrated software/hardware systems must be created and implemented that allow for real-time closed-loop recovery and correction of optical wavefront distortion from a single-shot of data.

This SBIR topic looks to develop a volumetric wavefront sensing (WFS) computational pipeline that meets the latency, throughput, and accuracy requirements required for integration into a real-time imaging (i.e., Intelligence, Surveillance, and Reconnaissance (ISR)) or directed energy system. The end goal of this SBIR topic is to design (Phase I) and demonstrate (Phase II) a volumetric WFS prototype computational pipeline that can operate in the presence of extended non-cooperative targets and distributed-volume aberrations. The Phase I effort shall develop the integrated theoretical algorithms, software, and computational hardware systems required to meet the demanding throughput and latency requirements of closed-loop volumetric-wavefront sensing for both imaging and DE applications. The Phase II effort shall then implement these approaches in a prototype demonstration system to achieve the target performance on a scaled-laboratory optical system.

The outcomes of the proposed work are:

1) Integrated theoretical algorithms, software and computational hardware systems that can meet the throughput and latency requirements of closed-loop volumetric-wavefront sensing for both imaging and DE applications; and

2) A demonstrated prototype system, which can achieve the specified target performance on a scaled-laboratory optical system.

The Phase I effort will not require access to classified information. If needed, data of the same level of complexity as secured data will be provided to support Phase I work. The Phase II effort may require secure access; if so, SSP will process the DD254 to support the contractor for personnel and facility certification for secure access.

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 and/or subcontractor 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: Create theoretical methods for integrating AI with coherent optical sensor models for accurate estimation of volumetric phase distortion in long-range imaging and DE applications. Perform feasibility analysis of software/hardware pipeline for real-time implementation meeting latency and throughput requirements. 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 an integrated algorithmic, software, and hardware prototype system that performs low latency and high throughput computation of accurate wavefront parameters for compensation in imaging and DE applications. Demonstrate real-time system performance on a scaled-laboratory optical system.

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: Developing a real-time computational pipeline with real-time single-shot AI enhanced accurate wavefront sensing can be applied to other systems associated with long-range missions at increased speeds that utilize imaging and directed energy applications.

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Denoising Using Plug and Play Inversion Framework." Applied Optics 56.16, 1 June 2017, pp. 4735-4744. <u>https://engineering.purdue.edu/~bouman/publications/orig-pdf/AO3.pdf</u>

KEYWORDS: Digital Holography; Coherent optical sensing; Wavefront sensing; Deep turbulence; Anisoplanatic turbulence; Adaptive optics; Beam control; Artificial Intelligence; Deep Neural Networks.

N211-094 TITLE: Compact Phase Locked Laser System for Atom Interferometric Inertial Sensors

RT&L FOCUS AREA(S): Nuclear Modernization

TECHNOLOGY AREA(S): Electronics; Materials / Processes; 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 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: Develop a compact and low power laser system capable of agile generation of all light frequencies required in an atom interferometry application. Demonstrate that the lifetime of all lasers in the optical system is sufficient to support extended periods of operation before required maintenance, and characterize robustness of the system to shock and vibration input.

DESCRIPTION: Light pulse atom interferometry (LPAI) [Ref 1] has been used to perform the most sensitive inertial measurements to date. It is emerging as a candidate technology for inertial sensors (such as gravimeters, accelerometers, and gyroscopes) with unprecedented performance. One obstacle for the development of atom interferometers is the need for further development of compact, robust, and stable laser systems that are capable of producing the requisite laser frequencies for LPAI as well as performing the ancillary functions of atom cooling, state preparation, and state readout.

Compact and robust laser systems for atom interferometry will facilitate the adoption of this technology in multiple application areas including inertial guidance and navigation and gravity mapping. Shipboard navigation using gravity measurements [Ref 2] to aid a traditional inertial navigation system is a typical use case. These systems may also find use in geophysical surveys for resource exploration.

These systems must also have the capability for fast frequency adjustment and shuttering on microsecond timescales. One promising approach is to perform these functions using a number of separate laser sources (such as Distributed Feed Back (DFB)) that are mutually offset-phase locked to a frequency stabilized master laser. The use of agile phase locking enables each output frequency to be adjusted throughout the measurement cycle while enabling the generation of phase-stable Raman pairs for LPAI while reducing the reliance on optical modulators that can be a driver of system power consumption. The Navy's need is the further development and testing of compact phase-locked laser sources to ensure they can maintain sufficient phase stability for LPAI, can be tuned over 1 GHz repeatedly in a measurement cycle, support long laser lifetimes, and are capable of recovery from shock and vibration.

PHASE I: Develop a design for a compact laser system meeting the following requirements:

- Master laser locked to a saturated absorption feature of an alkali D line
- Two slave lasers phase locked to the master with offsets ranging from 0 to 5GHz
- Over 50 mW output power in each frequency component
- Capable of switching between multiple offset frequencies with switching time under 1ms
- Volume of optical module under 50 c.c. (not including drive electronics)
- Power consumption under 3W

Perform a study of laser lifetimes using laser sources similar to those in the proposed design. Develop a roadmap for achieving system lifetime over 50000 hours. 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 a prototype laser module with support electronics meeting the requirements for the design developed in Phase I. Characterize per MIL-STD-810 [Ref 3] for the response of the module to mild vibration and shock inputs. Perform a study of laser lifetimes using similar laser sources to characterize the expected lifetime of the module. Deliver the prototype by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Compact and robust laser systems for atom interferometry will facilitate the adoption of this technology in multiple application areas including inertial guidance and navigation and gravity mapping. Shipboard navigation using gravity measurements [Ref 2] to aid a traditional inertial navigation system is a typical use case. These systems may also find use in geophysical surveys for resource exploration.

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- Bidel, Y. et al. "Absolute marine gravimetry with matter-wave interferometry." Nature Communications volume 9, Article number: 627, 2018. <u>https://doi.org/10.1038/s41467-018-03040-2</u>
- 3. "Environmental Engineering Considerations and Laboratory Tests." ASSIST-QuickSearch Document Details. 2020. <u>https://quicksearch.dla.mil/qsDocDetails.aspx?ident_number=35978</u>

KEYWORDS: phase locked laser system; atom interferometry; inertial sensor; laser; navigation; image sensor

N211-095 TITLE: Age Effect Evaluation: Test Methodology

RT&L FOCUS AREA(S): Nuclear Modernization

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 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: Develop an innovative approach to measure aging effects on electronics piece parts accurately, with an ability to predict the degradation in electrical performance of deployed electronics in the fleet.

DESCRIPTION: Strategic Systems Programs (SSP) needs an innovative approach of testing hardware to expediently gain insight on effects of aging on electronic piece parts (including MicroElectrical Mechanical (MEM) sensors) on current missile systems, in lieu of typical life test approach. Current methods implemented in the program, and those currently used in the industry, are typically time-consuming. Typical present reliability techniques subject a part to elevated temperatures for a period of time to accelerate the aging mechanism. Electrical measurements are (1) functionality, (2) AC parameters, and (3) DC parameters, combined with radiation testing and destructive analysis to determine any alterations in the radiation response and doping process. These techniques are not usually perceptive to small changes in a device. Usually the measurements are taken from outside the part (higher resolution) and the equipment used do not have adequate resolution or sensitivity to discriminate electrical changes within the device itself.

The following potential methods are far more superior than previous techniques. They use advanced technology approaches; are far more sensitive than previous methods; and use real-time measurements. Some are noninvasive. This SBIR topic seeks research to apply these methods and determine the sensitivity of these techniques to changes in a semiconductor or electronic component due to aging. A method of transmitting the measurements to a monitoring system will also need to be developed.

(1) A more advanced noninvasive technique should evaluate an accurate sensor, using solid state electromechanical technologies. [Refs 1,2]

(2) Another method could be to develop a radio frequency (RF) technique to evaluate the aging effects based on the detection of electromagnetic signature changes from a device. [Refs 3, 4]
(3) Another acceptable approach should consider an electrical measurement that could detect 1 ppm changes or better with advanced semiconductor technologies. [Ref 5]

Aging of electronics that affect the radiation hardness of a device is a concern. Two effects are (1) Negative Bias Temperature Instability (NBTI) affecting p channel transistors in advanced Complementary Metal-Oxide-Semiconductor (CMOS) technologies less than 300 nm in feature size, and (2) gold ion diffusion impacting the dose rate threshold performance of a part. The first effect can be monitored via a p channel transistor that can be integrated on the same device. To maximize the sensitivity of detection, different sizes of p channel transistors, channel length and width dimensions would need to be fabricated and tested for NBTI. The second effect is more challenging to measure.

Typically, one would irradiate a part at a prompt dose rate facility like an electron beam accelerator or a Flash X-ray machine. Another technique has been to expose a part to a laser tuned to penetrate into the substrate of the part and measure the upset threshold of the part. The upset threshold is compared with a "Gold" standard such as one that did not have gold diffusion or has been aged.

The proposed R/D effort is to determine a method of detecting the movement of gold from the die attachment substrate into the silicon bulk substrate and quantify the location of these gold atoms. The spatial resolution needs to be 5 micron or better. One possibility is to leverage on medical imaging techniques used in identifying cancer tumors or in detecting blood clots as in X-ray tomography or radiography. Gold and silicon vary vastly in mass absorption, so the detection of gold is easy with X-rays. Neutron radiography is another approach used in the detection of banned weapons of mass destruction. These are some of the techniques that would be examined to determine the spatial resolution and the sensitivity to identifying the movement of a gold atom in silicon.

PHASE I: Define and develop the concept(s) for a test approach(es) or method(s) that will accurately and expediently (80% of typical duration of current/standard tests defined in the applicable standards/specifications for each part technology) measure the aging effects on electronics piece parts as defined in the Description. Provide description(s) of the approach(es), along with corresponding preliminary evidence supporting each approach. Validate the method selected. Identify technical challenges as well as risks and opportunities for the selected method that will be addressed 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. Prepare a Phase II plan.

PHASE II: Develop a physical prototype of the proposed test approach or method that meets the capabilities listed in the Description. Demonstrate and validate the test approach or method. Demonstrate the ability of the prototype to meet or exceed the accuracy of current test method results. Identify, document, and demonstrate the time reduction achieved by using the prototype over standard life testing. Identify and document any opportunities for improvements for future iterations.

PHASE III DUAL USE APPLICATIONS: Support in transitioning the technology for Navy use in SSP. Support the Navy with certifying and qualifying the system for SSP use. Navy SSP will provide the assets and test support as Government Furnished Equipment and Services. The accelerated age assessment evaluation test method will be adopted for use in evaluating electronic piece parts currently deployed in missiles. The technology developed can be commercialized into the automotive industry electronics where such devices could be used to determine when a car begins to have aging problems. Another area would be in the commercial airline industry to help diagnose the degradation of aging electronics. Other areas include embedding smart chips either within appliances, smart phones, security systems, and commercial transportation systems to monitor their health. With the miniaturization of microchips, we are seeing the utilization of these devices in humans as well as in electronics to monitor the vital signs and to detect changes rapidly and invasively in an affordable way.

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KEYWORDS: MEM; MicroElectrical Mechanical Sensors; NBTI; Negative Biased Temperature Instability; Sensors; Age Effects; Material Age Testing; Electronic Materials

N211-096 TITLE: Producible Radiation-hardened Interconnects Technology

RT&L FOCUS AREA(S): Nuclear Modernization

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 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: Develop and evaluate cable manufacturing techniques and compatible connectors that are easy to produce, reliable, and can function in strategic radiation environments. Designed with lifecycle and maintenance costs in mind. Designed with producibility/manufacturability in mind.

DESCRIPTION: With a new ballistic missile submarine under development (OHIO-Replacement Class SSBN), the capability delivered by the Trident II (D5) missile will be needed into the 2080s. Current D5 missile performance will remain a top priority for life extension efforts while achieving Navy Strategic Systems Programs (SSP) affordability objectives. Currently, hand-built filled and unfilled cables are used, which represent a significant production cost for D5. Finding approaches to improve the producibility of radiation hardened cables and connectors while reducing the impact of nuclear-event induced effects on electronics has the potential for reducing program lifecycle costs.

Missile modernization will result in avionics architectures that are highly data bus-centric, with electrical connections consisting primarily of power lines and data lines. Such data bus-centric designs require higher data rates over longer distances and require unique interconnect (cables and connectors) interfaces to achieve maximum data transmission while operating in a harsh environment. Operation in a nuclear environment imposes many design challenges, one of which is reducing cable System Generated Electromagnetic Pulse (SGEMP) effects on interface electronics. Current cable designs reduce SGEMP/radiation; however, fabrication is labor-intensive and difficult to replicate in large quantities, since they are hand-built. Because all conductors are point-to-point copper wire throughout the missile, the current design carries a high weight penalty. Producibility and manufacturing repeatability of radiation-hardened interconnects are the subjects of this SBIR topic. An ideal solution must be efficient, reliable, and meet the requirements defined below.

Using readily available and common interconnect hardware across the Avionics subsystem will reduce interconnect complexity, thereby reducing overall cost. Rigid flex cabling, fiber optic cabling, and new, robust cable manufacturing techniques must be considered for potential applicability.

Requirements of the solution:

• Data transmission rates in excess of 100Mbps (Goal of 10 Gb/s)

• Radio Frequency (RF)/Electromagnetic Interference (EMI)/SGEMP shielding protection (radiation-hardened)

• Ruggedness/space flight environment survivability (nuclear, shock, vibration, extreme heat, temperature/humidity cycling)

- Ease of integration with small form factor and RF-sensitive electronics
- Design architecture flexibility (low and high current capacity, modular, easily-adaptable interconnects)

Current technology analysis includes:

• Feasibility of modern printed circuit "Flex Cable" manufacturing techniques for missile applications. o Maximum "Flex Cable" length practical with current manufacturing techniques

o Feasibility of using "Trapped Electron Reduction cable" SGEMP control techniques, or other alternatives, in Flex cabling

o Feasibility of Incorporating SGEMP terminal protection means (e.g., resistors, caps, diodes) in cable itself

o Ability to support high speed data (>100Mbps) over 40 feet with SGEMP mitigations

o Effectiveness of SGEMP control techniques

o Producibility and cost assessment relative to alternatives

• Discrete Wire cable techniques (e.g., Trapped Electron Reduction cable [Ref 4]) and potential limitations

o Incorporate SGEMP terminal protection means (e.g., resistors, caps, diodes) in cable itself

o Ability to support high speed data (>100Mbps) over 40 feet with proposed SGEMP mitigations

o Effectiveness of SGEMP control techniques

o Producibility and cost assessment relative to alternatives

• Fiber/Ethernet/Datalink for high speed data communications and potential limitations

o Application considerations in a Strategic Missile environment

Radiation darkening of fiber

Fiber connector contamination concerns/mitigation

Fiber Transmitters/Receivers survivability for Strategic radiation-hardened environments o Explore inclusion of fiber with copper in same cable to reduce cable quantity

o Producibility and cost assessment relative to alternatives

o Effectiveness of SGEMP control techniques

o Maintenance cost risk associated with repair/rework/replace compared to traditional copper

o Consider and assess existing high bandwidth/speed cable options (i.e., fiber vs. Ethernet vs. Datalink) and assess risks/tradeoffs

• Analysis of new/emerging technologies, to include:

o Ultra-miniature connectors that provide robust capability in smaller form factor

o Ability to integrate high speed data transmission contacts with traditional copper contacts

o Explore options in connector grommet seal techniques/processes to reduce well-known fleet issues (e.g., silicone migration, damaged pins/tines, Foreign Object Damage (FOD) contamination)

o Producibility/repeatability of EMI-shielding techniques and processes

o Producibility of new connectors that meet or exceed the current solution functionality and reliability

o Alternate backshell/connector accessories. Current configuration requires special tooling and difficult processes

PHASE I: Develop approaches for the fabrication and production of radiation-hardened cables and connectors that reduce the effects of SGEMP while maintaining the performance characteristics of a high bandwidth interconnect for use in strategic missile environments. With the basic cable design understood, construct a decision matrix and analyze several feasible interconnect solutions. Utilize aforementioned analyses to begin connector down-select process. Ensure that the proposed approaches are low cost and use high-reliability interconnect hardware and simple, proven fabrication techniques.

Conduct a feasibility assessment for the proposed application, assessing benefits and drawbacks of various approaches that address, at a minimum, the capabilities/limitations listed in the topic description. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II. Develop a Phase II plan.

PHASE II: Fabricate and produce radiation-hardened interconnect prototype(s) in sufficient quantities to accomplish the following:

-Assess manufacturing costs, time constraints/limitations, and ease of consistent, controllable repeatability for scaling up to a future production environment.

-Simulate/test producible interconnects in relevant "Test Like You Fly" (TLYF) environments.

-Collect performance data that can be used to characterize feasibility and application for use over a long production lifecycle.

Prepare a Phase III development plan to transition the technology for Navy combat systems and potential commercial use.

PHASE III DUAL USE APPLICATIONS: Missile cables and interconnects will be manufactured, demonstrated, and transitioned into the missile and submarine. Provide support in transitioning the technology for Navy use in SSP. Support the Navy with certifying and qualifying the system for SSP use with assets and test support provided by the Navy as Government Furnished Equipment and Services.

Radiation-hardened interconnects required for Navy SSP that are developed under this SBIR topic will be applicable to many commercial satellite and rocket programs, especially in applications that have restrictive physical space and/or harsh EMI/Radiation environment requirements.

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- Maher, Michael. "AN-926 Radiation Design Considerations Using CMOS Logic." Texas Instruments, National Semiconductor Note 926, January 1994. <u>http://www.ti.com/lit/an/snoa254a/snoa254a.pdf</u>
- Fang-Chichton, Su. US Patent 6,093,893 Radiation Hardened Electrical Cable Having Trappedelectron Reducers. https://patentimages.storage.googleapis.com/43/7a/07/afea80a66c2955/US6093893.pdf
- Girard, Sylvain et al. "Recent advances in radiation-hardened fiber-based technologies for space applications." Journal of Optics 20, 2018. <u>https://iopscience.iop.org/article/10.1088/2040-8986/aad271/pdf</u>

KEYWORDS: Materials Development; Cables; Interconnect; Connectors; Production Techniques; Producibility; Radiation Hardened

N211-097 TITLE: Radar Seeker Model for Hypersonic Weapon Full Life Cycle Support

RT&L FOCUS AREA(S): Hypersonics

TECHNOLOGY AREA(S): 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 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: Develop a high-fidelity design-level modeling environment for radar seeker subsystems that captures the relevant operational and environmental constraints of hypersonic flight. The model will be configurable to perform low level design tradeoffs in a standalone environment or operate as a subsystem in closed-loop 6DOF architectures for end-to-end integrated performance evaluation.

DESCRIPTION: In order to develop and simulate advanced radar seeker concepts at the extreme conditions associated with hypersonic flight, there is a need to develop a modeling capability that considers the mission-specific challenges for the potential seeker concepts. Government laboratories need a robust seeker modeling capability to perform research involving fundamental design tradeoffs for future concepts, as well as to efficiently predict operational performance. Seeker models are used at all stages of the weapon simulation process. In flight simulations of an integrated munition, the seeker may provide an alternative means of navigation and directly feed guidance, acquiring the target and selecting an aimpoint in the presence of target location error. For modeling and simulation to be relevant, DoD acquisition guidance stresses the need to continually refine the model based on results from experimental data collection. The acquisition trend toward validated "digital twins" further emphasizes the need for a high-fidelity seeker model operating with Radio Frequency (RF) that follows a concept from inception through operational deployment. The desire for conforming to Weapon System Open Architecture interface standards also benefits from high-fidelity models that allow the assessment of standard conformity and data validity.

Hypersonic weapons in particular provide challenges that stress the functional performance of the seeker subsystem. Current modeling tools do not integrate the effects of the aero-thermal and thermo-elastic impacts of the hypersonic environment on measurement accuracy. It is essential to model the impact of aerodynamic heating for specific radome/antenna placement and deformation of exotic airframes built of materials such as Inconel and titanium alloys. It is also important to model the in-depth heating, static deformation, and modal dynamics of the structure when they impact measurement accuracy. The ability to interface with Government-developed Fluid-Thermal-Structural-Interaction (FTSI) models, even during real-time hardware-in-the-loop simulation, is desired to capture the impact of the environment on guidance performance. The required tool should not only allow for front end design signal processing simulation, but also backend processes such as image formation and target identification. The ability to impart and assess the impacts of kinematic constraints on data acquisition and signal processing functions is essential. An RF sensor on a weapon that plans to use Synthetic Aperture Radar (SAR) or Doppler Beam Sharpening (DBS) will need to pick a different waveform than a sensor flying at more conventional speeds. RF seekers on weapons do not have the favorable squint angle of a side-looking radar and will be expected to operate in steep, extended, terminal dives. Conventional "stop and hop" radar models may

have errors when they assume the beginning of the transmit pulse and end of the receive pulse are close in space and the speed of the weapon is far from the speed of light.

The developed technology will be transitioned to Navy and other DoD facilities. For proof of concept and evaluation, the processing architecture must be baselined to communicate/interface with the existing 6DOF engagement systems, FTSI modeling capabilities, and radar scene modeling capabilities. Detailed knowledge of RF seeker design, seeker functional requirements in a munition environment, and hypersonic environmental constraints is critical. Understanding and modeling of the impact of emerging technologies will be required. A requirements assessment during Phase I will determine Use Cases and required interface compatibility with other government systems. Designs with software modularity that allow for incremental increase in fidelity are possibly of benefit to accommodate budgetary and programmatic constraints.

The Phase I effort will not require access to classified information. If needed, unclassified data of the same level of complexity as classified data will be provided to support Phase I work. The Phase II effort will likely require access to classified information, and SSP will process the DD254 to support the contractor for personnel and facility certification for secure access.

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 and/or subcontractor 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: Establish Use Cases and develop a simulation architecture that can meet the RF seeker modeling goals identified. Physical models and dependencies will be determined along with fidelity requirements associated with each Use Case. Document the design and trades made to reach the conclusions. Design risks will be determined and to the extent possible proof of concept for the approach taken will be accomplished. The software design should use best practices to provide for readability, modification, scalability, maintenance, and verification. In Phase I, model limitations will be identified that need to be addressed during Phase II. Phase II objectives and demonstration plans will be identified. 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 model for a subsystem of a hypersonic seeker based on a hardware design. The prototype shall be based on the results of Phase I and the Phase II Statement of Work (SOW). The prototype shall be in a language such as C++ or other highly efficient, stable, executable form. The Government shall have access and full Government purpose rights to all source code. Work with Navy subject matter experts, which may include Government personnel and contractors, to develop and demonstrate the prototype and integrate this prototype into a standalone design environment and 6DOF simulation forms. Fully document the prototype design and interfaces. Work together with the Government to analyze the results of all models that are integrated into the hypersonic seeker model as it performs relevant hypersonic engagement scenarios and vignettes.

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 and Air Force in transitioning the technology to DoD use. In addition to NSWC Crane and AFRL/RW, other DoD and DoD contractor facilities will be identified as potential users of this technology. The final product supports multiple applications from early conceptual design through mature validated digital representation of an operational seeker. The end product will allow evaluation of software changes and will allow for planning of mission compatibility of the seeker technology. The system needs to be fully supportable and maintainable by the government so that models can be moved between Use Cases for a given weapon system application. The system needs to be adaptable and expandable as technology improves. This technology can also be used to model other problems where high speed maneuvering with radar sensor data collection is needed. Example applications are collision avoidance and terrain mapping for both commercial airplanes and future autonomous cars.

REFERENCES:

- Clive, Peter. "Advanced Framework for Simulation, Integrating, and Modeling (AFSIM)." International Conference on Scientific Computing (CSC'15). <u>www.worldcomp-proceedings.com/proc/p2015/CSC7058.pdf</u>
- Director, Systems and Software Engineering Deputy Under Secretary of Defense (Acquisition and Technology) Office of the Under Secretary of Defense (Acquisition, Technology and Logistics). "Systems Engineering Guide for Systems of Systems", August 2008 (recently revised). acqnotes.com/wp-content/uploads/2014/09/DoD-Systems-Engineering-Guide-for-Systems-of-Systems-Aug-2008.pdf
- Balz, T. "Real-time SAR simulation of complex scenes using programmable graphics processing units." Proceedings of the ISPRS TCVII Mid-term Symposium. <u>https://www.researchgate.net/publication/200148298_Real-</u> time_SAR_simulation_of_complex_scenes_using_programmable_Graphics_Processing_Units

KEYWORDS: Guidance, Navigation, and Control GNC; Advanced Framework for Simulation, Integration, and Modeling AFSIM; Synthetic Aperture Radar SAR; hypersonics; airframe modeling; RF seeker; RF image processing

N211-098 TITLE: Unconventional Navigation Approaches Using Signals of Opportunity

RT&L FOCUS AREA(S): Hypersonics

TECHNOLOGY AREA(S): 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 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: Develop navigation approaches that take advantage of non-Global Positioning System (GPS) signal of opportunity, both natural and man-made, to determine earth relative location.

DESCRIPTION: Current navigation systems are heavily reliant on GPS signal technology for both commercial and military applications. While GPS has become a pervasive technology for military uses, it has security and availability challenges. In recent years, the ability to compromise GPS has been demonstrated by adversaries using jamming techniques that interfere with military mission execution. The research on this SBIR topic is intended to explore alternative technology solutions that would utilize natural or man-made signals of opportunity that may be available throughout the world to provide navigation precision comparable to GPS. Proposed approaches should be appropriate for the high-velocity and challenging environmental conditions associated with hypersonic flight or low earth orbit. The proposed approaches must be demonstrated in analysis or simulation to be able to provide precision equaling that of GPS in all weather conditions, at high altitude, at high velocity (hypersonic speeds), and must be broadly applicable throughout the world. Additional challenges include consistent reliability and size, weight, and power that would be compatible with current and future weapon systems, and communicate signals similar to GPS output codes (PY-code and M-code). Research and development is needed to demonstrate the feasibility of natural and man-made signals to satisfy these requirements. The research should be conducted with the goal of designing and demonstrating a prototype navigation system, and as such a system design for the use of these alternate signals should be considered.

The Phase I effort will not require access to classified information. If needed, data of the same level of complexity as secured data will be provided to support Phase I work. The Phase II effort is anticipated to require secure access, and SSP will process the DD254 to support the contractor for personnel and facility certification for secure access.

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 and/or subcontractor 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: Propose specific innovative solutions for an alternative navigation approach, as opposed to simply proposing to study the problem. Specific natural or man-made signals should be identified along with the approach used for meeting the requirements stated in the Description. Demonstrate the feasibility of the approach to provide required accuracy, and the usefulness to military applications, including those associated with hypersonic weapons and space. Provide mathematical descriptions of the physical processes and signal processing being performed. In addition, modeling and simulation should be used to demonstrate feasibility for required applications. The required sensing maturity and signal processing requirements should be addressed in light of future size, weight, and power requirements.

The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II. Develop a Phase II plan that includes a Phase II Statement of Work (SOW) that identifies a work plan that provides proof of concept that the technology has the potential to meet the military performance goals highlighted in Phase I.

PHASE II: Design and build a prototype with enough detail for development and demonstration of a navigation system based on the non-conventional signals addressed in Phase I. Use a combination of hardware, software, and modeling and simulation to maximize demonstration of feasibility to meet military objectives within the cost constraints of the program. Experimental data collection of the navigation signal sources is desired where appropriate and cost-effective.

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 Government in transitioning the technology for Government use. The transitioned product is expected to be able to support current and future weapon and space systems, as well as a wide range of other air, land and sea-based systems. Commercial applications should be considered for transition (e.g., telecommunications, ocean transportation, commercial satellite and mapping systems). Depending on the technology, it may apply beyond navigation on earth. The primary objective of this project is for transition to defense contractors for high speed weapons and space systems. To meet these needs, maturation and packaging of the technology to meet practical size, weight, and power constraints will be required. Extreme environments may require special considerations to conform to airframe shape and shielding from the aerothermal environment.

REFERENCES:

- Raquet, John F.; Miller, Mikel M.; and Nguyen, Thao Q. "Issues and Approaches for Navigation Using Signals of Opportunity." Proceedings of the 2007 National Technical Meeting of The Institute of Navigation, San Diego, CA, January 2007, pp. 1073-1080. <u>https://www.ion.org/publications/abstract.cfm?articleID=7203</u>
- McEllroy, Jonathan A. "Navigation Using Signals of Opportunity in the AM Trans-Mission Band." Master's Thesis, Air Force Institute of Technology, 2006. <u>https://apps.dtic.mil/dtic/tr/fulltext/u2/a456511.pdf</u>
- Shamaei Kimia; Khalife, Joe: and Kassas, Zaher M. "Exploiting LTE Signals for Navigation: Theory to Implementation." IEEE Transactions on Wireless Communications, Vol. 17, Issue. 4, April 2018. <u>https://ieeexplore.ieee.org/document/8255823</u>

KEYWORDS: Alternate navigation; nonconventional signals; pulsar; Low Earth Orbits (LEO) satellites; Positioning, Navigation, Timing (PNT); Guidance

N211-099 TITLE: Photon-Counting Image Sensors Using Complementary Metal-oxide Semiconductor (CMOS) Foundry Processes

RT&L FOCUS AREA(S): Nuclear Modernization

TECHNOLOGY AREA(S): Electronics; Materials / Processes; 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 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: Develop a high-density, high-speed image sensor using Complementary metal-oxide semiconductor (CMOS) foundry processes that is capable of photon counting without deep cooling, and is also strategically radiation-hardened, for use in star trackers.

DESCRIPTION: The performance requirements for star trackers used in strategic navigation applications continue to become more stringent, necessitating continued innovation for image sensor technologies. Examples of existing research on photon-counting image sensors can be found in the Refs 1-5. In terms of idealities, these image sensors should be capable of high-speed (>1000 frames per second), low-noise (sub-electron) readout in a photon-counting mode without the need for deep cooling; have high-density (approx. 1 μ m) pixel pitch; be radiation-hard at strategic levels; have low power consumption, and be able to be fabricated using CMOS foundry processes.

PHASE I: Perform a design and performance modeling study aimed at image sensors with improved performance for strategic star trackers as compared to the current state of the art. Assess performance and environmental sensitivity of parameters including responsivity, speed, noise, and defective pixels; consider all aspects of fabrication; and justify the feasibility/practicality of the approach. A goal of quantum efficiency greater than 70% from 400 to 640 nm and read noise < 0.3 electrons RMS is desired. 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 and characterize a small lot (up to a quantity of 3) of prototype image sensors. Characterization using EMVA1288 standard, shall comprise various parameters including responsivity, speed, noise, and defective pixels. The prototypes shall be delivered by the end of Phase II.

PHASE III DUAL USE APPLICATIONS: Continue development to lead to productization of image sensors suitable for star trackers. While this technology is aimed at military/strategic applications, image sensors are heavily used in numerous other applications. An image sensor that can meet the stringent performance requirements of strategic instrumentation is likely to bring value to many existing commercial applications. Commercial applications for low light imaging applications include spectroscopy, optical scattering, and quantum communications.

REFERENCES:

1. Fossum, E. R. "Modeling the performance of single-bit and multi-bit quanta image sensors." IEEE Journal of the Electron Devices Society, 1(9), 2013, pp. 166-174.

http://ericfossum.com/Publications/Papers/2013%20Modeling%20Single%20Bit%20and%20Mul ti%20Bit%20QIS.pdf

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- 4. Ma, J. and Fossum, E. R. "Quanta image sensor jot with sub 0.3 e-rms read noise and photon counting capability." IEEE Electron Device Letters, 36(9), 2015, pp. 926-928. <u>http://www.ericfossum.com/Publications/Papers/2015%20IEEE%20EDL%20Jot%20Letter.pdf</u>
- Gnanasambandam, A.; Elgendy, O.; Ma, J. and Chan, S. H. "Megapixel photon-counting color imaging using quanta image sensor." Optics express, 27(12), 2019, pp. 17298-17310. <u>https://www.osapublishing.org/oe/fulltext.cfm?uri=oe-27-12-17298&id=413534</u>

KEYWORDS: image sensor; star tracker; navigation, Complementary metal-oxide semiconductor; foundry; radiation-hard

N211-100 TITLE: GPS Alternative for Reentry

RT&L FOCUS AREA(S): Nuclear Modernization

TECHNOLOGY AREA(S): Electronics; Nuclear Technologies; 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 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: Perform research to identify position sensing solutions for times in endoatmospheric flight where Global Positioning System (GPS) is unavailable in a denied flight environment to improve navigation and fuzing. Reliance on GPS is not considered an acceptable option for use in tactical environments.

DESCRIPTION: Navigation and fuzing capability of reentry bodies improves by aiding the inertial system with external location information. There are times where GPS is unavailable and denied solutions are of increasing interest to the strategic community.

Proposals are solicited that address the following capabilities:

• Evaluate suitable technology for position observability in times of flight when GPS is unavailable in denied and GPS jammed/spoofed environments

- Develop concept implementation for <4-minute atmospheric reentry
- Design, build, lab test system prototype
- Improve fidelity of selected system design and perform lab test
- Assess other limiting factors and areas of concern

Proposed solutions should support the following:

• Radiation-Hardened Electronics (suitable for exo-atmospheric space environments including the South Atlantic Anomaly)

- System operation for up to 6-minute reentry time
- Reliable system dormancy of at least 25 years

• Capable leverage/use of existing power supply or the specifications and requirements of an alternative power solution

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 and/or subcontractor 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: Develop a proof of concept of a system able to provide accurate position observable to aid a current tracking technology in the place of GPS within the following parameters:

- Accurate to within 20 feet
- Accurate at sea level to 400,000 feet altitude
- Accurate at speeds up to at least Mach 4

Present the solution concept with the following support documentation through the Concept Development phase which should build confidence that the system can naturally mature in line with customer (Navy SSP) expectations to be ready for engineering development:

- Technology Assessment
- Operational Analysis
- Feasibility Experiments
- System CONOPS
- Functional Decomposition
- Functional Block Diagram
- Functional and Physical architecture
- Expected Performance

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: Mature the proven concept into the engineering development phase and build a prototype or engineering unit. Create a test profile for laboratory testing, and display system performance capability. Provide deliverables that should include but are not limited to:

- Subsystem Definitions
- Component Specifications
- Component Test Results
- System Integration Interfaces

PHASE III DUAL USE APPLICATIONS: Demonstrate flight worthiness of prototype and produce a Flight Test Article, ready for integration into next higher assemblies. Support future production of units if the solution is selected to be incorporated into a larger system.

For commercial markets the satellite industry would be able to benefit from this technology.

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- Russell, J.S.; Ye, M.; Anderson, B.D.O.; Hmam, H. and Sarunic, P. "Cooperative Localization of a GPS-Denied UAV Using Direction-of-Arrival Measurements." IEEE Transactions on Aerospace and Electronic Systems, vol. 56, no. 3, June 2020, pp. 1966-1978. doi: 10.1109/TAES.2019.2942704
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KEYWORDS: GPS Alternatives; Navigation; SAASM; LIDAR; Inertial Aiding; Hypersonic; Radiation-Hardened Electronics
DEPARTMENT OF THE NAVY (DON) 21.1 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:
 N211-D01 to N211-D02
- 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, will be available to assist small businesses to generate a Phase I Technical Volume (Volume 2). The template will be located on https://www.navysbir.com/links_forms.htm.
- DON provides notice that Basic Ordering Agreements (BOAs) or Other Transaction Agreements (OTAs) may be used for Phase II awards.
- The Supporting Documents Volume (Volume 5) is available for the SBIR 21.1 BAA cycle. The Supporting Documents Volume is provided for small businesses to submit additional documentation to support the Technical Volume (Volume 2) and the Cost Volume (Volume 3). Volume 5 is available for use when submitting Phase I and Phase II proposals. DON will not be using any of the information in Volume 5 during the evaluation.

INTRODUCTION

The Director of the DON SBIR/STTR Programs is Mr. Robert Smith. For program and administrative questions, contact the Program Manager listed in Table 1; do not contact them for technical questions. For technical questions about a topic, contact the Topic Authors listed within the topic during the Pre-release period. During the Open period the DoD SBIR/STTR Topic 0&A platform (https://www.dodsbirsttr.mil/submissions) must be used for any technical inquiry. Review section 4.13 of the Department of Defense (DoD) SBIR/STTR Program Broad Agency Announcement (BAA) for further information related to Direct Contact with Topic Authors and the Topic Q&A platform. For general inquiries or problems with electronic submission, contact the DoD SBIR/STTR Help Desk at 1-703-214-1333 (Monday through Friday, 9:00 a.m. to 5:00 p.m. ET) via or email at dodsbirsupport@reisystems.com.

Topic Numbers	Point of Contact	<u>SYSCOM</u>	<u>Email</u>
N211-D01	Mr. Jeffrey Kent	Marine Corps Systems Command (MCSC)	jeffrey.a.kent@usmc.mil
N211-D02	Ms. Donna Attick	Naval Air Systems Command (NAVAIR)	navair.sbir@navy.mil

TABLE 1: DON SYSTEMS COMMAND (SYSCOM) SBIR PROGRAM MANAGERS

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 <u>www.navysbir.com</u>. Additional information pertaining to the DON's mission can be obtained from the DON website at <u>www.navy.mil</u>.

During government fiscal years (FY) 2012 through 2022, the Department of Defense (DoD) including the Department of the Navy (DON) may issue an award to a small business firm under Phase II of the SBIR program with respect to a project, without regard to whether the firm was provided an award under Phase I of an SBIR program with respect to 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.

Each eligible 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:

<u>STEP ONE</u>: 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. <u>The Phase I Feasibility Proposal must</u>: 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. <u>Demonstrating proof of feasibility is a requirement for a DP2 award</u>. 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 refuse to make any awards under this DP2 BAA. All awards are subject to availability of funds and successful negotiations. Proposers are to read the topic requirements carefully.

The Government is not responsible for expenditures by the proposer prior to award of a contract. For 21.1 topics designated as DP2, DON will accept only Phase I Feasibility Proposals (described below).

DP2 PROPOSAL SUBMISSION REQUIREMENTS

The following <u>MUST BE MET</u> or the proposal will be deemed noncompliant and shall be <u>REJECTED</u>.

- 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 section 4.2 of the DoD SBIR/STTR Program BAA
 - During the Phase II award, primary employment of the principal investigator (PI) must be 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 section 4.14 of the DoD SBIR/STTR Program BAA. To register, visit <u>https://beta.sam.gov</u>
- **Proposal Cover Sheet (Volume 1).** As specified in DoD SBIR/STTR BAA section 5.4(a).
- **Technical Volume (Volume 2).** Technical Volume (Volume 2) must meet the following requirements:
 - Content is responsive to evaluation criteria as specified in DoD SBIR/STTR Program BAA section 6.0
 - $_{\circ}$ $\,$ Not to exceed 30 pages, regardless of page content $\,$
 - Single column format, single-spaced typed lines
 - Standard 8 ¹/₂" 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*

*For headers, footers, listed references, and imbedded tables, figures, images, or graphics that include text, a font size smaller than 10-point is allowable; however, proposers are cautioned that the text may be unreadable by evaluators.

Volume 2 is the technical proposal. Additional documents may be submitted to support Volume 2 in accordance with the instructions for Supporting Documents Volume (Volume 5) as detailed below.

The Technical Volume (Volume 2) should include the following sections:

- Phase I Proof of Feasibility (NTE 20 pages)
 - 1. Introductory Statement
 - 2. Phase I Proof of Feasibility
 - 3. Commercialization Potential/Transition Plan Summary
- Snapshot of Proposed Phase II Effort (NTE 10 pages)
 - 1. Description of Proposed DP2 Technical Effort and Objectives
 - 2. DP2 Work Plan
 - 3. Key Personnel Resumes should be submitted for the Principal Investigator and up to 4 additional individuals. Resumes are limited to one page per person, and should be limited to only information relevant to the work to be performed under the project

- 4. Subcontractors/Consultants
- 5. Order of Magnitude Cost Estimate Table (example provided below in the Cost Volume (Volume 3) section).

It is recommended that proposers follow the DP2 Phase I Feasibility Template as a guide for structuring the DP2 Phase I Feasibility proposal. The template is located on <u>https://www.navysbir.com/links_forms.htm.</u>

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 or any subsequent 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. Simply identifying fundamental research in the proposal does NOT constitute acceptance of the exclusion. All exclusions will be reviewed and noted in the award. NOTE: Fundamental research included in the technical proposal that the proposer is requesting be eliminated from the requirements for prior approval of public disclosure of information, must be uploaded in a separate document (under "Other") in the Supporting Documents Volume (Volume 5).

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 for 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 2 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		

Торіс	Base		Option	Total	
Number	Cost (NTE)	POP (NTE)	Cost (NTE)	POP (NTE)	(NTE)
N211-D01	\$1,000,000	24 mos.	\$500,000	12 mos.	\$1,500,000
N211-D02	\$800,000	24 mos.	\$300,000	12 mos.	\$1,100,000

TABLE 2: COST & PERIOD OF PERFORMANCE

- **Company Commercialization Report (Volume 4)**. DoD requires Volume 4 for submission to the 21.1 DP2 BAA. Please refer to instructions provided in section 5.4.e of the DoD SBIR/STTR Program BAA.
- **Supporting Documents (Volume 5)**. Volume 5 is available for use when submitting Phase I and Phase II proposals.

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 proposals must include as a part of their submission a written certification in response to the NDAA clauses (Federal Acquisition Regulation clauses 52.204-24, 52-204-25 and 52-204-26). 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 instructions provided in section 5.4.g of the DoD SBIR/STTR Program BAA.

A proposal that has an answer of "Yes" to any question regarding foreign investment disclosure in the Firm Certifications section of Volume 1 (Proposal Cover Sheet) must then include as part of their submission a Foreign Disclosure Addendum. The Foreign Disclosure Addendum can be found in Attachment 2 of the DoD SBIR/STTR Program BAA. The addendum, if required, must be completed by the authorized company representative and uploaded as a separate PDF file in Volume 5. Please refer to instructions provided in section 5.4.h of the DoD SBIR/STTR Program BAA.

Volume 5 is available for small businesses to submit additional documentation to support the Technical Proposal (Volume 2) and the Cost Volume (Volume 3). A template is available on https://navysbir.com/links_forms.htm. DON will not be using any of the information in Volume 5 during the evaluation.

- Letters of Support relevant to this project
- Additional Cost Information
- SBIR/STTR Funding Agreement Certification
- Data Rights
- 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
- Majority-Owned VCOC, HF, and PEF Certification, if applicable

NOTE: The inclusion of documents or information other than that listed above (e.g., resumes, test data, technical reports, publications) may result in the proposal being deemed "Non-compliant" and REJECTED.

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 to the 21.1 DP2 BAA. Please refer to instructions provided in section 5.4.i of the DoD SBIR/STTR Program BAA.

DON SBIR PHASE I FEASIBILITY PROPOSAL SUBMISSION CHECKLIST

- Subcontractor, Material, and Travel Cost Detail. In the Cost Volume (Volume 3), proposers must provide sufficient detail for subcontractor, material and travel costs. Enter this information in the "Explanatory Material" field in the online DoD Volume 3. 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. 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).
- **Performance Benchmarks.** Proposers must meet the two benchmark requirements for progress toward Commercialization as determined by the Small Business Administration (SBA) on June 1 each year. Please note that the DON applies performance benchmarks at time of proposal submission, not at time of contract award.
- **Discretionary Technical and Business Assistance (TABA).** If TABA is proposed, the information required to support TABA (as specified in the TABA section below) must be added in the "Explanatory Material" field of the online DoD Volume 3. If the supporting information exceeds the character limits of the Explanatory Material field of Volume 3, this information must be included in Volume 5 as "Additional Cost Information" as noted above. Failure to add the required information in the online DoD Volume 3 and, if necessary, Volume 5 will result in the denial of TABA. TABA may be proposed for a DP2 effort which will be included as part of the award amount and limited by the established award values for Phase II by the SYSCOM. The total value may not exceed \$25,000 under this DP2 contract.

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 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 application by the SBIR/STTR awardee 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.

Approval of direct funding for TABA will be evaluated by the DON SBIR/STTR Program Office. A detailed request for TABA must include:

- 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 <u>NOT</u>:

- Be subject to any profit or fee by the SBIR applicant
- Propose a TABA provider that is the SBIR applicant
- Propose a TABA provider that is an affiliate of the SBIR applicant
- Propose a TABA provider that is an investor of the SBIR applicant
- 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 must be included in the Cost Volume (Volume 3) as follows:

• Phase II: The value of the TABA request must be included in the Order of Magnitude Cost Estimate Table in the Snapshot of Proposal Phase II Effort section of the Technical Volume (Volume 2). The detailed request for TABA (as specified above) must be included as a note in the Order of Magnitude Cost Estimate Table and be specifically identified as "Discretionary Technical and Business Assistance".

Proposed values for TABA must <u>NOT</u> exceed:

• A total of \$25,000 per award, not to exceed \$50,000 per Phase II project

NOTE: Section 9(b)(5) of the SBIR and STTR Policy Directive requires that a firm receiving technical or business assistance from a vendor during a fiscal year submit a report with a description of the technical or business assistance received and the benefits and results of the technical or business assistance provided. More information on the reporting requirements of awardees that receive TABA funding through the DON can be found on <u>https://www.navysbir.com/links forms.htm</u>. Awardees that receive TABA funding through the DON will upload the report to <u>https://www.navysbirprogram.com/navydeliverables/</u>.

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 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: <u>https://navystp.com</u>. 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.

EVALUATION AND SELECTION

The DON will evaluate and select Phase I Feasibility proposals and DP2 proposals using the evaluation criteria in Sections 6.0 and 7.0 of the DoD SBIR/STTR Program BAA respectively, with technical merit being most important, followed by qualifications of key personnel and commercialization potential of equal importance. As noted in the sections of the aforementioned Announcement on proposal submission requirements, proposals exceeding the total costs established for the Base and/or any Options as specified by the sponsoring DON SYSCOM will be rejected without evaluation or consideration for award. Due to limited funding, the DON reserves the right to limit awards under any topic.

Approximately one week after the DP2 BAA closing, e-mail notifications that proposals have been received and processed for evaluation will be sent. Consequently, the e-mail address on the proposal Cover Sheet must be correct.

Selected Phase I Feasibility proposers will be notified to submit Full DP2 Proposals. SYSCOM-specific Full DP2 Proposal guidance will be provided at the time of this notification.

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 of the Phase I Feasibility evaluations and DP2 selections and awards must be directed to the cognizant Contracting Officer for the DON Topic Number, or filed directly with the Government Accountability Office (GAO). Contact information for Contracting Officers may be obtained from the DON SYSCOM Program Managers listed in Table 1. If the protest is to be filed with the GAO, please refer to instructions provided in section 4.11 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 section 4.11 of the DoD SBIR/STTR Program BAA.

CONTRACT DELIVERABLES

Contract deliverables are typically progress reports and final reports. Required contract deliverables must be uploaded to <u>https://www.navysbirprogram.com/navydeliverables/</u>.

AWARD AND FUNDING LIMITATIONS

<u>Awards.</u> The DON typically awards a Cost Plus Fixed Fee contract for DP2; but, may consider other types of agreement vehicles, such as an Other Transaction Agreement (OTA) or a Basic Ordering Agreement (BOA) 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 II awards. DP2 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).

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. Please refer to instructions provided in section 7.2 of the DoD SBIR/STTR Program BAA.

ADDITIONAL NOTES

<u>Majority Ownership in Part.</u> 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.

For proposers that are a member of this ownership class the following <u>must</u> be satisfied for proposals to be accepted and evaluated:

- a. Prior to submitting a proposal concerns must register with the SBA Company Registry Database.
- b. The proposer within its submission must submit the Majority-Owned VCOC, HF, and PEF Certification. The SBIR VC Certification must be included in the Supporting Documents Volume (Volume 5). A copy of the SBIR VC Certification can be found on https://navysbir.com/links_forms.htm.
- c. Should a proposer become a member of this ownership class after submitting its application 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.

<u>Human Subjects, Animal Testing, and Recombinant DNA</u>. If the use of human, animal, and recombinant DNA is included under a DP2 proposal, please carefully review the requirements at: <u>http://www.onr.navy.mil/About-ONR/compliance-protections/Research-Protections/Human-Subject-Research.aspx</u>. This webpage provides guidance and lists approvals that may be required before contract/work can begin.

System for Award Management (SAM). It is strongly encouraged that proposers register in SAM, <u>https://beta.sam.gov</u>, 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.

<u>International Traffic in Arms Regulation (ITAR)</u>. 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).

<u>Support Contract Personnel for Administrative Functions.</u> 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.

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, which includes assigning SBIR/STTR Data Rights to any noncommercial technical data and/or noncommercial computer software delivered in Phase III that was developed under SBIR/STTR Phase I/II effort(s). Government prime contractors and/or 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.

NAVY 21.1 SBIR Direct to Phase II Topic Index

N211-D01	DIRECT TO PHASE II Size/Weight Optimized Compact-Prime Power
	Generator (CPPG) Technologies

N211-D02 DIRECT TO PHASE II – Cartridge Actuated Devices/Propellant Actuated Devices Digital Twin

N211-D01 TITLE: DIRECT TO PHASE II Size/Weight Optimized Compact-Prime Power Generator (CPPG) Technologies

RT&L FOCUS AREA(S): Directed energy;General Warfighting Requirements

TECHNOLOGY AREA(S): Air Platforms;Ground / Sea Vehicles;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 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: Develop high power density, small heavy fuel prime power generator technology for next generation directed energy weapons. The technology should be highly optimized for size and weight, and should be scalable to enable development of a family of small generators, with designs including power ratings ranging from 5kW to 25kW in 5kW increments, and capable of supporting 100% of duty cycle requirements.

DESCRIPTION: Currently available prime power sources that power directed energy weapon systems are very large and heavy and preclude integration on small tactical vehicles and unmanned systems. These power systems today are primarily composed of hybrid power systems of very large/heavy (100's of pounds) high voltage batteries and/or large 1000 pound+ high voltage gas-diesel generators. Payload volumes and weight margins on most small tactical vehicles/platforms simply cannot accommodate or support these large payload volumes nor the extra weight. An example of this would be the current Light Marine Air Defense Integrated System (LMADIS) which employs 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 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 pounds (lbs) and would result in the vehicle weighing 100 to 150 lbs. over maximum GVW. Compact and lightweight power generation systems are needed to power these directed energy weapon, surveillance, and C2 systems and keep the vehicle safely within its allowable GVW. The system requirements are:

Scalable prime power generator designs are to include 5kW, 10kW, 15 kW and 20kW designs and support 100% duty cycle requirements and range in size and weight from (for the 5kW generator design).Size and Weight (exclusive of fuel tank and mounting frames):

o For a 5kW genset, Volume Threshold of 1,300 cu in. and Objective of 1,000 cu in.; Weight Threshold of 40 lbs (8 lb/kW) and 30 lbs (6 lb/kW) Objective

o For a 25kW genset, Volume Threshold of 3,500 cu in. and Objective of 3,000 cu in.; Weight Threshold of 175 lbs (7 lb/kW) and 150 lbs (6 lb/kW) Objective

• Fuel Efficiency: For all ratings, Threshold fuel consumption rate of 275 g/kWh and Objective of 240 g/kWh

- Fuel: JP-8
- Electrical Output: 28VDC, less than 1% ripple
- Noise: Less than 70 dbA at 30 feet, at full (rated) power
- Duty cycle: Eight (8) hours of operation at rated (100%) power

Generators designs are based on optimized overall system size and weight and with overall system efficiency to achieve very high fuel efficiency such as < 250 gm/kW-h;

o Composed of lightweight materials such as Aluminum, be air-cooled, run on JP-8 (heavy fuels) o Be extremely quiet (< 70 dbA at 30 feet at full power)

o Have a compact form-fit of less than 500 cu inches (with fuel tank) o Run 100% power for an 8 hour mission

o Run close to diesel engine efficiencies but with much less mass than a standard diesel generator – weight/power goal of < 0.5 lbs/hp o Run with realistic prop speeds of less than 1000rpm o Run with low exhaust noise o Have a long lifetime with a mean time between failures (MTBF) of > 3000 hours;

o Be compatible with 24-VDC tactical electrical systems and 12-VDC vehicle electrical systems; o Incorporate 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;

o Have a modular design that can be inspected, serviced, and repaired in the field

The program requires the development at least one small heavy fuel generator set (genset) in the required power range, which shall be scalable (up and or down in power rating) in order to enable the development of the small generator family described above, through the entire power range of 5kW to 25kW. The design shall be optimized for weight and size, utilizing light weight, durable materials, and shall be designed to have a mean time between failure (MTBF) of at least 3,000 hours. A complete, fully operational prototype genset shall be constructed and tested to demonstrate compliance with the technical requirements, including, size, weight, and performance.

Currently only diesel powered generators within the desired power range can achieve fuel consumption at the required rates; however, their large size and weight make them unsuitable for the intended application. A compact, lightweight, efficient, JP-8 fuel capable, reliable, and very quiet system is necessary to meet the mobility and compatibility requirements of potential platforms for the directed energy weapon systems. For higher power ratings, advanced gas turbine engine driven, high speed generators now under development can achieve near diesel efficiency; however, as the power rating and size decrease below about 40kW, their efficiency falls substantially, hence the need to develop new technologies for the high power density, small generators as described in these requirements.

Note: The current active Phase II USMC SBIR N132-086 to develop a Compact Prime Power Generator (CPPG) for Non-Lethal Directed Energy Weapons supports the development of a 40 kW to 1.6MW recuperated gas-turbine generator design. The generator design supports higher power directed energy weapon requirements. Its size and weight is optimized over this 40kW to 1.6MW power region. The Phase II SBIR prototype will produce 300 kW, support a 100% duty cycle, consume the same fuel as a standard gas-diesel generator (19.3gph) – same fuel burn rate as the MEP-809 at rated power, weigh only 480 lbs., and have a compact form-fit of < 20 cu ft. This SBIR topic requests an optimized scalable minimum size and weight lower power prime power source (generator) for the following NL DEW power requirements: 5kW, 10kW, 15 kW, and 20 kW. The current USMC Phase II SBIR design which employs a scalable recuperator gas-turbine generator design does not provide the smallest and lightest design at these lower power levels. A different more optimized generator design is required to fully optimize size and weight at these lower power requirements.

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 and/or subcontractor 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 MCSC 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 this Direct to Phase II (DP2) topic, the Government expects that the small business would have accomplished the following in a Phase I-type effort. It must have developed a concept for a workable prototype or design to address at a minimum the basic requirements of the stated objective above and it must have already developed a commensurate prototype in hardware, i.e., developed a large number of the components necessary to achieve the required Power Output per pounds and per cubic feet of form-fit.

Documentation showing a prime power gas-diesel power generation system is feasible and that the system requirements discussed in the Description are in the realm of possible. The small business should have produced a model to evaluate different approaches to optimize powering directed energy weapons on a small tactical vehicle/platform. The small business should show they have identified higher power density electrical efficiencies with lightweight materials and long MTBF to meet this SBIR DP2 topic's scalable output power goals of 5kW, 10 kW, 15 kW, and 20 KW and weight ~50 lbs; and a compact form-fit of < 100 lbs and 1500 cu inches (e.g., the size of a small Honda 1 kW generator).

FEASIBILITY DOCUMENTATION: Proposers interested in participating in Direct to Phase II must include in their responses 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 feasibility documentation MUST NOT be solely based on work performed under prior or ongoing federally funded SBIR/STTR work) 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 proposer and/or the principal investigator (PI). Read and follow all of the DON SBIR 21.1 Direct to Phase II Broad Area Announcement (BAA) Instructions. Phase I proposals will NOT be accepted for this BAA.

PHASE II: Based on the Phase I equivalent effort and the Phase II plan, develop and use analytical modeling to assist in design and integration of high power density, small heavy fuel prime power generator technology for next generation directed energy weapons. Build scalable prime power generator prototypes for both fitment and functionality of power generation to support directed energy weapon systems. Support evaluation of prototypes to determine if the performance goals defined in the Phase II development plan and the requirements outlined in MIL-STD-1275E and MIL-STD-810H have been met. Demonstrate system performance through modeling and generator testing under full electrical load conditions. Refine the design based on the results of testing/modeling to facilitate integration on small tactical vehicles (such as the JLTV) and or other DoD Platforms as well as facilitate integration on small unmanned systems. Support full power tests of these directed energy weapon systems on DoD platforms. Prepare a Phase III plan to transition the technology to the Marine Corps and the commercial marketplace.

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: Provide support to the Marine Corps in transitioning the technology for Marine Corps use. Refine a prime power generation system for evaluation to determine its

effectiveness in an operationally relevant environment. Support the Marine Corps test and evaluation program to qualify the system for Marine Corps use.

Commercial applications include Department of Homeland Security and civilian law enforcement missions. The need for the use of directed energy weapon systems on small tactical vehicle/platforms is high for many government agencies – beyond just the DoD.

REFERENCES:

- "MIL-STD-810H Environmental Engineering Considerations and Laboratory Tests." U.S. Army Test and Evaluation Command, January 31, 2019. https://guicksearch.dla.mil/gsDocDetails.aspx?ident_number=35978
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- "Test Operations Procedure (TOP) 2-2-601 Electrical Systems (Vehicles and Weapon Subsystems)." U.S. Army Developmental Test Command Test Operations Procedure, US Army Aberdeen Test Center, June 20, 1977. <u>https://apps.dtic.mil/dtic/tr/fulltext/u2/a045343.pdf</u>
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KEYWORDS: Compact/Lightweight Prime Power Systems; Directed Energy Weapons Systems Prime Power; Tactical Vehicle Power Generation; Prime Power Weight Reduction; Prime Power Size Reduction; Mobile Expeditionary Power; Small Heavy Fuel Generators

N211-D02 TITLE: DIRECT TO PHASE II – Cartridge Actuated Devices/Propellant Actuated Devices Digital Twin

RT&L FOCUS AREA(S): General Warfighting Requirements; Machine Learning/AI

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

OBJECTIVE: Develop, validate, and migrate to the cloud a digital twin of Cartridge Actuated Devices/Propellant Actuated Devices (CAD/PAD) that use double-base propellants while providing real-time health monitoring of deployed devices based on the environmental exposure.

DESCRIPTION: The Navy requires digital twin technologies, which allow the digital footprint of any product to permeate throughout the CAD/PAD devices' entire service life from design inception, through development, sustainment, and finally to disposal. Digital twin technology is viable and allows access to the digital image of the asset in real time, leading to secure actionable information that will improve a process, product, or service of any organization [Ref 1]. The concept has been around for a while, as shown during the disaster of the Apollo 13 mission. NASA demonstrated the technology with a mirrored system on the ground, which rescued the flight, and is further illustrated in [Ref 2]. Digital twin technology involves creating a virtual representation of a physical product. Digital twins are powered by machine learning algorithms and are continuously learning systems. The products are connected in a cloud-based environment that receives the data from the sensors or other available data sources. The input data is analyzed and compared to the CAD/PAD device baseline data to identify actionable information.

The goal for the CAD/PAD digital twin technology is to design, test, and develop a product in a virtual environment and to monitor product health to identify potential degradation. This will allow real-time monitoring and replacement of the product utilizing its maximum safe life, which will reduce product's life cycle costs. In the future, the goal is to have a digital twin model for selected CAD/PAD devices hosted in the cloud and updated with historical deck plate data to make the model more robust. The frequency of the digital twin updates will coincide with approved for release historical deck plate and sensor data.

Because of the large variety of CAD/PAD devices and the numerous failure modes associated with these devices, this topic seeks to pursue a digital twin model for CAD/PAD items that employ double-based propellants. Double-based propellants will deplete its stabilizer at a faster rate when exposed to high temperature. A comparative study of the thermal decomposition of naturally- and artificially-aged double-based propellants has been carried out at five different heating rates and the results show that there is only one decomposition peak on differential scanning calorimetry (DSC) curves, and this decomposition has been accelerated by ageing. The influence of the heating rate on the DSC behavior of the propellants was verified. The kinetic parameters such as activation energy and frequency factor and the thermodynamic parameters were obtained from DSC data [Ref 3]. The aging of CAD/PAD items containing double-based propellants are dependent on the environmental conditions, such as temperatures, to which they are subjected. The digital twin being developed will take these environmental conditions and determine the stabilizer content of the CAD/PAD items. The environmental conditions are dependent upon the operational location and duration of the aircraft at the location.

In order to determine the environmental exposure of the CAD/PAD items, the developed digital twin should all be able to use both collected sensor data and a combination of deck plate data and available weather data, such as National Oceanic and Atmospheric Administration (NOAA) or local installation data, in order to determine stabilizer content. The developed digital twin predicted stabilizer content should be validated against measured stabilizer content of fleet return assets with known environmental exposure.

Upon successful demonstration, the contractor should assist in obtaining the necessary approvals for use of the developed digital twin and migration into a cloud-based environment compliant with all applicable Navy Marine Corp Internet (NMCI) and applicable Operations Security (OPSEC) requirements.

Digital twin technology is not widespread due to the requirements of prohibitive computing power needs, accessibility, bandwidth, and storage issues. Lack of robust data analytics aided by artificial intelligence, machine learning techniques, and visualization tools is impeding technology development. Digital twin technology has the potential to improve supply chain integrity, flight safety, in-flight service, Condition Based Maintenance (CBM), foreign object detection, and predictive maintenance. For example, developing any predictive maintenance algorithm requires sensor data, which can be utilized to train a classification algorithm for fault detection. This algorithm is used for verification and is installed as a code to the control unit of the product. It is nearly impossible to create the fault conditions necessary for training a predictive maintenance algorithm on the actual product. A solution to this challenge is to create a digital twin of the product (a model), and apply simulation and analysis of sensor data for various fault conditions. A neural network detects abnormal patterns of the sensor data, reflects the trends in predictive models, which are then used to predict failures, and allows tests for all fault conditions with severity. The entire procedure should be automated, thereby allowing tests of "what-if" scenarios on the digital twin model. Predictive maintenance helps to determine when an aircraft product needs maintenance or replacement. It reduces downtime and prevents product failure by enabling maintenance or replacement of the CAD/PAD device to be scheduled based on the actual need rather than at predetermined intervals. It can be used to calculate maintenance-related parameters (i.e., MTBR - Mean Time Between Replacement), forecast the behavior of the product under different circumstances, and simulate different maintenance scenarios. Thus, predictive maintenance capability helps to extend the product life and reduce total ownership costs. Collectively, it will contribute significantly to improving the Navy's mission readiness and sustainment. It is envisioned that the CAD/PAD program will be able to develop a virtual integrated, model-based representation of a physical product, allow the simulation of the product in a real setting in a dynamic fashion, and demonstrate closed loops between the virtual and physical space.

Challenges for this effort include developing an accurate model that precisely reflects the physical twin's properties. For predicting failures, detailed blueprints of a product's failure modes are required. Since the digital twin is a replica of the physical product itself, the requirements, qualification, and certification necessary to determine the flight worthiness of the product are the same for the virtual model as well. The expected outcomes of the effort are real-time monitoring and health status of the deployed CAD/PAD items. This will enable prolonged product life to deliver capabilities continually. For the proof of concept, the Parachute Deployment Rocket Motor (PDRM) [DODIC MT29], the Under Seat Rocket Motor (USRM) [DODIC MD68], and the Catapult Primary Cartridge [DODIC WB15] will be used for the demonstration of the digital twin model.

The developed digital twin model should be capable of predicting remaining stabilizer content within 20% of measured values. The developed digital twin should be migrated into a cloud-based environment and be capable of meeting all NMCI and OPSEC regulations and requirements. The developed digital twin should be capable of utilizing both historical aircraft location/weather data and sensor data.

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:

Designed and developed a digital twin capable of predicting stabilizer content based on environmental exposure of deployed devices.

Determined and demonstrated the model's prediction of the cockpit temperature gradient based on aircraft location and available weather data.

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 21.1 Direct to Phase II Broad Agency Announcement (BAA) Instructions. Phase I proposals will NOT be accepted for this topic.

PHASE II: Build, refine, enhance, and validate (against measured stabilizer content of fleet returned assets (MT29 and WB15) with known environmental exposure) a prototype product (a high-fidelity model) by integrating the physical asset to the digital twin and demonstrate the closed loop between physical - virtual - physical space. Demonstrate the applicability of readiness and sustainment influencing factors such as CBM, predictive maintenance, and flight safety with quantifiable metrics. Quantify the cost benefits, such as reduction in the operation cost and total lifecycle cost, as applicable. Demonstrate the applicability of Navy provided "what-if" scenarios tested against factors such as product performance management, Navy-unique harsh environmental operating conditions, and future operating environments. Assist in obtaining approvals for the developed digital twin's use and migrate the digital twin into a cloud-based environment. Demonstrate compliance with NMCI requirements and end user access.

PHASE III DUAL USE APPLICATIONS: Develop robust architecture, showing the linkage between connectivity and services. Demonstrate the integration of the product into naval aircraft and perform final testing. Successfully transition, implement, and insert the technology for warfighter benefits. Develop mobile application solutions as applicable. Aerospace industry employs cartridges that use double-based propellants and will benefit from the digital twin technology. The successful demonstration of the digital twin of the product that is operationalized will enable the applicability of the approach to any product/process/service industry to achieve cost benefits.

The private sector (e.g., commercial aerospace industry and private military fleets) use similar cartridges as the ones used in military aircrafts. Some of these cartridges employ double-based propellants as their energy source and experience similar propellant-stabilizer depletion issues. The digital twin model developed under this SBIR topic will provide those industries a mean of tracking the health of the installed devices and assist them in making replacement decisions based on the environmental exposure of the devices. The digital twin model will enable the private sector to utilize maximum safe life of the devices and enhance the safety of their operations.

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KEYWORDS: Digital Twin; Stabilizer depletion; Navy Marine Corp Internet; NMCI; DODIC WB15; DODIC MT29; National Oceanic and Atmospheric Administration; NOAA; Parachute Deployment Rocket Motor; PDRM; Under Seat Rocket Motor; USRM; DODIC MD68; Catapult Primary Cartri

AIR FORCE (AF) 21.1 Small Business Innovation Research (SBIR) Direct to Phase II (D2P2) Proposal Submission Instructions Amendment 2 1 February 2021

The subject instructions are specifically changed as follows:

Section I, Direct to Phase II: The comparison chart for "Traditional Process" versus "D2P2 Process" is deleted in its entirety due to outdated information and conflicting guidance with the remainder of the instructions.

Section III, Proposal Submission: Third paragraph, third sentence is changed **FROM** "AF D2P2 efforts are awarded at an initial value of \$750K" **TO** "Proposals under topics AF211-D001, D002, and D003 will be awarded at an initial amount not to exceed \$1,705,000."

<u>Section VII, Feedback</u>: Third sentence is changed to read "Written feedback requests shall be submitted in accordance with directions in the notification letter."

<u>Topics AF211-D001, D002, and D003</u>: Amendment 1 "Phase I" descriptions for all three topics are hereby incorporated into the topics within the instructions. As a result, **Amendment 1, dated 14 January 2021, is hereby deleted in its entirety**. Additionally, the Government points of contact (POCs) for Topics AF211-D001 and D002 have changed.

AF D2P2 proposal submission instructions are intended to clarify the Department of Defense (DoD) Broad Agency Announcement (BAA) as it applies to Topics AF211-D001, D002, and D003. Firms must ensure proposals meet all requirements of the BAA currently posted on the DoD SBIR/STTR Innovation Portal (DSIP) at the proposal submission deadline date/time.

For general information related to the AF SBIR/STTR program, contact the AF SBIR/STTR One Help Desk at <u>usaf.team@afsbirsttr.us</u>. For inquiries or problems with the DSIP electronic submission, contact the DoD SBIR/STTR Help Desk at <u>dodsbirsupport@reisystems.com</u> or (703) 214-1333, 9:00 a.m. to 5:00 p.m. ET, Monday through Friday. For technical questions about the topics during the pre-announcement and open period, please reference section 4.13 of the DoD 21.1 SBIR BAA. Complete proposal <u>must</u> be submitted via https://www.dodsbirsttr.mil/submissions/ on or before the date published in the DoD 21.1 SBIR BAA.

General information related to the AF Small Business Program can be found at the AF Small Business website, <u>http://www.airforcesmallbiz.af.mil/</u>. 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), <u>www.sba.gov</u>, and the Procurement Technical Assistance Centers (PTACs), <u>http://www.aptacus.us.org</u>. These centers provide Government contracting assistance and guidance to small businesses, generally at no cost.

All D2P2 proposals must be prepared in and submitted via DSIP, <u>https://www.dodsbirsttr.mil/submissions/</u>. 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. To initiate a D2P2 proposal, click "Start New Phase II Proposal" from the "My Portal Page". After uploading the full proposal, click "Submit".

This action will notify the agency submission is complete and the proposal ready for evaluation. Once submitted, no further changes may be made to the proposal. **Note: If the proposal is not properly submitted by the identified solicitation close date/time, it will not be considered for evaluation/award.** 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. <u>Please assure contact information, i.e., point of contact 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 site address, usaf.team@afsbirsttr.us. Firms must ensure their proposal meets all requirements of the BAA and AF-specific instructions posted on DSIP at the proposal submission deadline date/time. Incomplete proposals will be not be considered.</u>

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 this 21.1 SBIR topic and does not guarantee D2P2 opportunities will be offered in future solicitation. Each eligible topic requires documentation to determine Phase I feasibility described in the Phase I section of the topic has been met.

II. <u>INTRODUCTION</u>:

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 in section 5.4.a. 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: Offerors are required to provide information demonstrating scientific and technical merit and feasibility has been established. AF will not consider the offeror's D2P2 proposal if the offeror fails to demonstrate technical merit and feasibility has been established or fails to demonstrate the feasibility effort was substantially performed by the offeror and/or the principal investigator (PI). Refer to the Phase I description within the topic to review minimum requirements needed to demonstrate feasibility. **Feasibility documentation MUST NOT be solely based on work performed under prior or ongoing Federally funded SBIR and/or STTR work.**

III. PROPOSAL SUBMISSION

The complete proposal, i.e., DoD Proposal Cover Sheet, technical volume, and cost volume, must be submitted electronically at <u>https://www.dodsbirsttr.mil/submissions/</u>. 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 15 months, including 12 months for technical performance and three months for completion of the final report. Proposals under topics AF211-D001, D002, and D003 will be awarded at an amount not to exceed \$1,705,000. 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 21.1 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; pent 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 the Federal Criminal Statement Act, 18 U.S.C. Section 1001, punishable by a fine up to \$250,000, up to five years in prison, or both.

IV. PHASE II PROPOSAL PREPARATION INSTRUCTIONS AND REQUIREMENTS

The technical proposal shall not exceed 15 pages. The advocacy letters, if any; SBIR / STTR Environment, Safety and Occupational Health (ESOH) Questionnaire; and the additional cost proposal itemized list, 17.a-I, should be included in Volume 5, Supporting Documentation. This documentation and the Cover Sheet will not count toward the 15-page limit. The D2P2 proposal shall include a technical proposal NTE 15 pages, uploaded as Volume 2, and a pitch deck NTE 15 slides, uploaded in Volume 5. The technical volume and slide deck will be reviewed holistically. There is no set format requirement for either document. It is recommended, but not required, more detailed information be included in the technical volume and higher level information be included in the slide deck.

Please note the Fraud, Waste and Abuse Training must be completed prior to proposal submission. This is accomplished under Volume 6 within DSIP at https://www.dodsbirsttr.mil/submissions//. When the training is complete and certified, DSIP will indicate so in the proposal, completing the Volume 6 requirement. If the training has not been completed, the offeror will receive an error message. The proposal cannot be submitted until the training has been completed. The Fraud, Waste, and Abuse Certificate of Training website is found under Section 3.6 of the DoD 21.1 SBIR BAA. The complete proposal <u>must</u> be submitted via the submissions DSIP on or before the date published in the DoD 21.1 SBIR BAA. Submissions outside DSIP including, but not limited to, email, hardcopy, or other media will not be accepted.

A. <u>Proposal Requirements</u>. 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. <u>Proprietary Information</u>. 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. See Section 5.3 of the DoD BAA regarding proprietary information marking.

C. <u>General Content</u>. Proposals should be direct, concise, and informative. Type shall be no smaller than 11-point on standard 8 $\frac{1}{2}$ 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) <u>Proposal Cover Sheet</u>: Complete the proposal Cover Sheet in accordance with the instructions provided at <u>https://www.dodsbirsttr.mil/submissions//</u>. 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 proposal research, and a list of key words/terms. The technical abstract of each successful proposal will be submitted to the Office of the Secretary of Defense (OSD) for publication and, therefore, <u>must not contain proprietary or classified information</u>. The term "Component" on the Cover Sheet refers to the AF organization requesting the Phase II proposal.
- (2) <u>**Table of Contents:**</u> A table of contents should be located immediately after the Cover Sheet.
- (3) **<u>Glossary</u>**: 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) <u>Phase II Technical Objectives</u>: 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) **<u>Proposer-Prepared Work Plan</u>:** 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) <u>Deliverables</u>: 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) <u>Scientific and Technical Reports</u>: 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 a royalty-free license to use such technical data for Government purposes during the period commencing with contract award and ending five (5) years after submission of the last contract deliverable. Upon expiration of the five year restrictive license, the Government has unlimited rights to the SBIR data, unless the firm receives another contract under which the SBIR data rights may be asserted.
 - i. <u>Final Report</u>: The draft is due 30 days after completion of the 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 results 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. <u>Status Reports</u>: Status reports are due quarterly at a minimum.
 - iii. <u>Small Business Online Success Stories</u>: Success Story submissions are due at the end of the technical effort via <u>http://launchstories.org</u>. If selected, refer to the Contract Data Requirements List (CDRL) in the contract for submission instructions.
 - b) <u>Additional Reporting</u>: AF may require additional reporting or 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) <u>Related Work</u>: 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) Contractor Commercialization Report (CCR)/Commercialization Potential:

- a) A Volume 4: CCR is required to be submitted with proposals in response to AF 21.1 SBIR topics. Please refer to the DoD 21.1 SBIR BAA for full details.
- 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?
 - a) 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.
 - b) If awarded a D2P2, the contractor is required to periodically update the commercialization results of the project at <u>https://www.dodsbirsttr.mil/submissions//</u>. 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.
- c) <u>Military Applications</u>: 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 involve not more than one to two paragraphs. Include

agency point of contact names and telephone numbers.

d) <u>Relationship with Future R/R&D Efforts</u>:

- a) State the anticipated results of the proposed approach, specifically addressing plans for Phase III, if any.
- b) Discuss the significance of the D2P2 effort in providing a basis for the Phase III R/R&D effort, if planned.
- e) <u>Key Personnel</u>: 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
- b. a national permanent resident; or
- c. a protected individual as defined by 8 U.S.C. § 1324b

ALL offerors proposing to use foreign nationals MUST follow Section 5.4. c. (8) of the DoD Program Announcement 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) <u>Facilities/Equipment</u>: 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) <u>Consultants/Subcontractors</u>: 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 (13) 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) <u>Cost Proposal</u>: 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) <u>Direct Labor</u>: 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) <u>Direct Materials</u>: 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) <u>Other Direct Costs:</u> 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) <u>Subcontracts</u>: 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, realism, and completeness, 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) <u>Consultants</u>: 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) <u>Travel</u>: 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, <u>www.defensetravel.dod.mil.</u>

- g) <u>Indirect Costs</u>: 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) <u>Non-SBIR Governmental/Private Investment</u>: Non-SBIR Governmental and/or private investment is allowed. However, it is not required nor will it be a proposal evaluation factor.
- <u>DD Form 2345</u>: 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, <u>http://www.dlis.dla.mil/jcp/</u>. DD Form 2345 approval will be verified if the proposal is selected for award.
- 18. Feasibility Documentation Should be uploaded to Volume 5, Supporting Documents
 - a. Maximum page length for feasibility documentation is 25 pages. If appropriate, include a reference or works cited list as the last page. This will count toward the 25 page limit.
 - 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 appropriate licensing rights to 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 20.3 BAA section 11.5 for technical data rights information.
 - c. DO NOT INCLUDE marketing material. Marketing material will NOT be evaluated and WILL be redacted.

V. METHOD OF SELECTION AND EVALUATION CRITERIA

- A. <u>Introduction</u>: 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. <u>Evaluation Criteria</u>: Phase II proposals will be reviewed for overall merit based on the following criteria in descending order of importance:
 - (1) Technical Merit The soundness, technical merit, and innovation of the proposed approach and its incremental progress toward topic or subtopic solution.
 - (2) Potential for Commercial Application The potential for commercial (Government or private sector) application and the benefits expected to accrue from this commercialization.
 - (3) Qualifications of the Principal Investigator (and Team) Qualifications of the proposed principal/key investigators, supporting staff, and consultants. Qualifications include not only the ability to perform the R&D but also ability to commercialize results.

Cost reasonableness and realism shall also be considered to the extent appropriate. The primary basis for selecting proposals for award will be overall merit, importance to agency programs, and funds availability. Other factors considered during the selection process include appropriate

demonstration of feasibility of the technology, equivalent to that resulting from Phase I type efforts; commitment for Phase III funding; possible duplication with other R/R&D; program balance; budget limitations; and potential, if successful, of leading to a product of continuing interest to DoD. D2P2 evaluations may include on-site assessment of the offeror's research results to date, or of the Contractor's facility, by Government personnel. The reasonableness of proposed costs for the D2P2 effort will be examined to determine proposals offering the best value to the Government.

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 Officer, Kris Croake, <u>kristina.croake@us.af.mil</u>, with concerns about any of these contractors.

VI. CERTIFICATIONS

In addition to the standard Federal and DoD procurement certifications, the SBA SBIR/STTR Policy Directives require the collection of certain information from firms at the time of award and during the award life cycle. Each firm must provide this additional information at the time of the Phase II award, prior to receiving 50% of the total award amount, and prior to final payment.

VII. <u>FEEDBACK</u>

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 address(es) or points of contact after proposal submission, the information must be provided to the AF at usaf.team@afsbirsttr.us.

<u>Feedback requests will be provided to offerors with proposals determined "Not Selectable" ONLY</u>. Requests shall be submitted in writing within 30 calendar days after non-selection notification receipt. Written feedback requests shall be submitted in accordance with directions in the notification letter. Requests for feedback shall include the company name and the telephone number/e-mail address for a specific point of contact, as well as an alternate. Additionally, the request shall include the proposal number. A separate request must be submitted for each proposal feedback desired.

Attachment 1: SBIR/STTR Environment, Safety and Occupational Health (ESOH) Questionnaire

Company Name:

Title:

1. Will hazardous materials (as defined by Federal Standard 313D, Material Safety Data, Transportation Data and Disposal Data for Hazardous Material Furnished to Government Activities and 40 CFR Part 260 - 279) be used in the contract?

Yes

No If the answer is "yes," list materials:

2. Will explosives or ammunition be used in research? (See definitions listed below before answering.) Yes No

Explosives and ammunition mean:

(a.) Liquid and solid propellants and explosives, pyrotechnics, incendiaries and smokes in the following:

- i. Bulk:
- ii. Ammunition;
- iii. Rockets;
- iv. Missiles;
- v. Warheads;
- vi. Devices: and
- vii. Components of (1) through (6), except for wholly inert items.
- (b.) This definition does not include the following, unless the contractor is using or incorporating these materials for initiation, propulsion, or detonation as an integral or component part of an explosive, an ammunition or explosive end item, or of a weapon system.
 - 1. Inert components containing no explosives, propellants, or pyrotechnics;
 - 2. Flammable liquids;
 - 3. Acids;
 - 4. Oxidizers:
 - 5. Powdered metals; or
 - 6. Other materials having fire or explosive characteristics.
 - If the answer is "yes," list items:
- 3. Will any hazardous processes be performed under the contract? Examples include operation of heavy equipment or power tools, operation of lasers or radio frequency radiation emitters, use of high voltage (greater than 600 volts) equipment, or use of equipment operating at high pressure (greater than 60 psig) or high temperature (greater than 50°C).

Yes No 🗌

If the answer is "yes," list processes:

4.	Will this research be com	pleted on a U.S. Air Force installation?

Voc		No
res		INO

If the answer is "yes," list facilities:

No

5. Will the contract require the purchase, storage use or delivery of any chemicals or hazardous material to USAF facilities?

Yes

If the answer is "yes," list chemicals or hazardous materials:

6. Will any hazardous chemical or waste be generated during the course of this research?

Yes [No
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If the answer is "yes," specify the hazardous chemical or waste to be generated:

Will any Class I ozone depleting substances (ODSs) be required in this research?
 A list of Class I ODSs is located at the following website: <u>http://www.epa.gov/ozone/ods.html</u>

Yes	

If the answer is "yes," list substances:

No

- 8. Does this effort involve the purchase or use of any radioactive materials?
- Yes 🗌 🛛 No

If the answer is "yes," specify the radioactive materials:

9. Will this effort involve any asbestos, radiation, or chemical generating/using components that will be delivered to USAF facilities?

Yes 🗌 No 🗌

If the answer is "yes," specify the components:

10. Are there any special atmospheric or water resource requirements?

Yes 🗌 No 🗌

If "yes" specify the requirements:

AIR FORCE DIRECT TO PHASE II SBIR 21.1 Topic Index

AF211-D001	Ultra-Low Latency Mixed Reality Environments for Real Time End to End Collaboration
AF211-D002	Radical Improvements in Personnel Performance through Enhanced Development (RIPPED)
AF211-D003	Satellite and Space Mission Design

AF211-D001 TITLE: Direct to Phase II: Ultra-Low Latency Mixed Reality Environments for Real Time End to End Collaboration

OBJECTIVE: Develop and demonstrate a cost-effective system that provides an ultra-low latency mixed reality environment for end-to-end real-time collaboration between two geographically separated teams.

TECH FOCUS AREAS: Network Command, Control and Communications

TECHNOLOGY AREAS: Information Systems; Human Systems

DESCRIPTION: To provide increased situational awareness and decision-making capability, there is a desire to create an environment where the senior leaders and decision makers can have face-to-face collaborations in a virtual environment while sharing real-time critical information. The initial intended application is in the collaboration between senior leaders and remote ground control stations for unmanned systems operations.

Science fiction has presented examples of holo-decks where a person can become immersed in a virtual environment. Real world experiments have created advanced Cave Automatic Virtual Environments (CAVEs) which provide an immersive experience but, in the past, due to size, cost, and complexity they were not viable options for operational use. Mixed reality (MR) where real and virtual worlds are merged is rapidly advancing and entering the consumer markets.

The solution should provide the ability for the senior leader to enter an environment where they feel that they are in the remote operations center and can interact with the remote team as if they were in the same room. This includes but is not limited to viewing and interacting with individuals, sensor feeds, air vehicle status, GIS data, etc. The solution should provide an ultralow latency interface to reduce or eliminate the risk of virtual reality sickness and well as other off-putting side effects of virtual and mixed reality use.

The solution could be, but not limited to, a device that can be worn, entered, sat in, or sat in front of, to immerse and engage with users and data. The solution must be capable to transmit and display classified data. The solutions could have a permanent install system capable of meeting all the needs with a portable version transportable onboard aircraft and set-up in remote areas of the globe.

PHASE I: This is a Direct to Phase 2 (D2P2) topic. Phase 1 like proposals will not be evaluated and will be rejected as nonresponsive. For this topic, the Government expects the small business would have accomplished the following in a Phase I-like effort via some other means, e.g., independent research and development (IRAD) or other source, a concept for a workable prototype or design to address, at a minimum, the basic capabilities of the stated objective above. Proposal must show, as appropriate, a demonstrated technical feasibility or nascent capability of virtual reality and/or telepresence and techniques compatible with low latency communications and/or data transfer. Proposal may provide example cases of this new capability on a specific application. The documentation provided must substantiate the proposer's development of a preliminary understanding of the technology to be applied in their Phase II proposal in meeting topic objectives. Documentation should comprise all relevant information including, but not limited to, technical reports, test data, prototype designs/models, and performance goals/results.

PHASE II: The contractor will develop, install, integrate and demonstrate an affordable prototype system capable of ultra-low latency mixed reality environment for end-to-end real-time collaboration between two geographically separated teams.

PHASE III DUAL USE APPLICATIONS: Several government agencies (military and civil) require this capability to provide real-time collaboration in a mixed reality environment. Commercial interest in such a system for collaboration and data sharing is also anticipated.

REFERENCES:

- Ladwig P., Geiger C. (2019) A Literature Review on Collaboration in Mixed Reality. In: Auer M., Langmann R. (eds) Smart Industry & Smart Education. REV 2018. Lecture Notes in Networks and Systems, vol 47. Springer, Cham. <u>https://doi.org/10.1007/978-3-319-95678-7_65</u>.
- 2. Manjrekar, S., Sandilya, S., Bhosale, D., Kanchi, S., Pitkar, A., & Gondhalekar, M. CAVE: An Emerging Immersive Technology-A Review.

KEYWORDS: Virtual Reality; Mixed Reality; Ultra-Low Latency; Data; Ground Control Stations; Unmanned Systems

AF211-D002 TITLE: Direct to Phase II: Radical Improvements in Personnel Performance through Enhanced Development (RIPPED)

OBJECTIVE: Develop and demonstrate radical improvements to warfighter cognitive and physical performance through advancements in physiology, nutrition, neuroscience, and engineering. The effects should last for a short time period, i.e., 2-3 days, and be reversible with no long-term effects.

TECH FOCUS AREAS: Biotechnology

TECHNOLOGY AREAS: Bio Medical

DESCRIPTION: "New advances in physiology, nutrition, neuroscience, and engineering now offer a significant potential to prevent (or reduce) the degradation of a warfighters cognitive and physical capabilities during conflict and substantially increase the performance of both combat personnel and the larger systems of which they are part" [1].

Warfighters are exposed to, and engage in, environments and activities where degradation of cognitive and physical performance can have grave consequences. Conversely, advantages in speed, strength, surprise, and aggression will help achieve dominance against the enemy.

This topic solicits solutions radically improving and providing advantages to speed, strength, surprise, and aggression for warfighters through physiology, nutrition, neuroscience, and engineering. The topic is interested in big gains in capability versus minor improvements. These areas of interest include but are not limited to the following examples:

- Methods to unlock increased human potential to provide increased endurance.
- New and emerging trends in nutrition and supplementation increasing physical and cognitive performance.
- "Soft-Exo Skeletons" powered clothing to reduce fatigue and provide additional capabilities.
- New equipment and concepts radically improving warfighter performance.

The solution's effects, if supplementation or stimulation based, should last for a short time period, i.e., 2-3 days, and be reversible with no long-term effects.

Any Human Subjects Research (HSR) must be conducted within the applicable guidelines associated with DoD funded research. Title 32, Code of Federal Regulations Part 219, "Protection of Human Subjects", and DoD Instruction 3216.02, "Protection of Human Subjects and Adherence to Ethical Standards in DoD Supported Research". It is strongly recommended if proposing HSR, the work be conducted late in the Direct to Phase II performance period to provide sufficient time to prepare and submit human use approval documentation to the Institutional Review Board.

PHASE I: This is a Direct to Phase 2 (D2P2) topic. Phase 1 like proposals will not be evaluated and will be rejected as nonresponsive. For this topic, the Government expects the small business would have accomplished the following in a Phase I-like effort via some other means, e.g., independent research and development (IRAD) or other source, a concept for a workable prototype or design to address, at a minimum, the basic capabilities of the stated objective above.

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Proposal must show, as appropriate, a demonstrated technical feasibility or nascent capability of cognitive or physical performance improvement or degradation reduction. Proposal may provide example cases of this new capability on a specific application. The documentation provided must substantiate the proposer's development of a preliminary understanding of the technology to be applied in their Phase II proposal to meet topic objectives. Documentation should comprise all relevant information including, but not limited to, technical reports, test data, prototype designs/models, and performance goals/results.

PHASE II: The contractor will develop, build, integrate, and demonstrate the proposed solution for cognitive or physical performance improvement or degradation reduction, as well as testing and approval of proposed supplement or augmentation.

PHASE III DUAL USE APPLICATIONS: Several Government agencies, both military and civil, require this capability to improve human performance through physiology, nutrition, neuroscience, and engineering. This technology will have wide ranging application to all services and Government agencies involved in dismounted operations.

REFERENCES:

- 1. Lewis, M. D., & Bailes, J. (2011). Neuroprotection for the warrior: dietary supplementation with omega-3 fatty acids. Military medicine, 176(10), 1120-1127. ;
- Lovalekar, M., Sharp, M. A., Billing, D. C., Drain, J. R., Nindl, B. C., & Zambraski, E. J. (2018). International consensus on military research priorities and gaps—Survey results from the 4th International Congress on Soldiers' Physical Performance. Journal of Science and Medicine in Sport, 21(11), 1125-1130.

KEYWORDS: human augmentation; ketones; military performance improvement; human performance improvement; performance enhancement; performance degradation reduction or prevention; nutrition; supplementation; resilience

AF211-D003 TITLE: Satellite and Space Mission Design

OBJECTIVE: Develop and apply a capability for rapid design of space missions / satellites leveraging new and evolving space services, commodity components, and emerging technologies.

TECH FOCUS AREAS: Space

TECHNOLOGY AREAS: Space Platforms

DESCRIPTION: In the last several years, new developments in space access, small satellites and components, and software and communications, combined with the investment of risk capital and other funding, have produced new space services capabilities. These new services and the infrastructure enabling them have, in turn, created a fast-changing environment for further development. Mission planning and design now takes place in this dynamic context. The Air Force continues to deliver traditional capabilities but could do so more effectively and by wholly different approaches through exploiting and repurposing rapidly emerging space systems, services, components, and supporting infrastructure.

In previous generations, Air Force missions have been planned over extended time periods, assuming the availability of certain Government assets, products, and supporting services, with the Government funding new developments that were required. Techniques for analyzing missions and performing trades were created and honed with each new application. Now, mission planners are presented with a fast-changing array of commercial services and unconventional mixes of commercially driven and Government-driven capabilities including new technology and software-defined systems, commodity spacecraft components, small satellite buses, and launch and ground systems services. The environment is dynamic, choices are greater, and mission development, including rapid progression from concept to systems requirements to preliminary design, should adapt as well.

Given a set of needs and goals in a broad space-related area, the Air Force will benefit from a rapid capability to interpret needs and opportunities, structure candidate mission architectures, assess available and emerging services and technologies that may be relevant to solutions, and proceed systematically through trades to arrive at multiple feasible approaches for satellite and system designs. These in turn can be considered with respect to cost, schedule, and risk, and the likelihood and degree of meeting goals. In most cases, the mission and satellite development capability will rapidly access and combine insight from multiple sources and companies.

Overlaps in different space-related domains have blurred the lines of simpler, focused mission development. Communications now involves geosynchronous earth orbit (GEO), medium earth orbit (MEO), and low earth orbit (LEO) over multiple wavelengths, with different antenna types and more use of relays. Satellites have greater on-board processing, increased potential for coordinated operation, more options for deployed subsystems and in-space changes. Launch services are lower cost, more frequent and agile, with emerging options for orbit insertions and transfers. Payloads are more programmable, adaptable and compact. In addition, information management for space systems increasingly leverages software-defined systems and the cloud, from data management to scheduling and operations.

Mission and satellite design should keep pace with and help manage the complexity brought by these fast-evolving developments. It is envisioned this will involve model-based design processes, techniques and methodologies to develop conceptual designs that include expedient leveraging of the best new commercially-available and open source tools. A robust but flexible approach accessing knowledge across organizations will take appropriate advantage of software-driven automation and optimization.

PHASE I: This is a Direct to Phase 2 (D2P2) topic. Phase 1 like proposals will not be evaluated and will be rejected as nonresponsive For this topic, the Government expects the small business would have accomplished the following in a Phase I-like effort via some other means, e.g., independent research and development (IRAD) or other source, a concept for a workable prototype or design to address, at a minimum, the basic capabilities of the stated objective above. Proposal must show, as appropriate, technical feasibility or nascent capability of space mission and satellite design approach and techniques compatible with new modes of space development and operation. Proposal may provide example results from this new and enhanced mission design capability on a specific Air Force mission area. Demonstrate reduced time from concept to system requirements, flexible use of evolving architectures and services, and increased options for Air Force programs. Identify capability gaps slowing development. The documentation provided must substantiate the proposer has developed a preliminary understanding of the technology to be applied in their Phase II proposal to meet the objectives of this topic. Documentation should comprise all relevant information including, but not limited to, technical reports, test data, prototype designs/models, and performance goals/results.

PHASE II: Develop and enhance the rapid space mission and satellite design capability, and demonstrate the utility in several Air Force need areas for missions that are at different stages of conceptual maturity, including where conceptual development has not yet begun. Provide intermediate products to be assessed by planning teams, summarizing information capturing sensitivity of mission-level outcomes, including schedule, cost and risk, to key architecture and implementation decisions. Carry at least one mission through to system and satellite design and development, working with other performers to rapidly assess mission-level impacts of spacecraft, payload, operations, data processing, and other elements.

PHASE III DUAL USE APPLICATIONS: The contractor will pursue commercialization of the technologies developed in Phase II for potential Government and commercial applications. Government applications include rapid concept development and maturation for emerging military space missions. There are potential commercial applications to space system design, and evaluation and assessment of new business ventures.

REFERENCES:

- 1. Martin, Gary, (2016) NewSpace: The Emerging Commercial Space Industry, https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20160001188.pdf;
- 2. Datta, Anusuya, (2017) The NewSpace Revolution: The emerging commercial space industry and new technologies, https://www.geospatialworld.net/article/emerging-commercial-space-industry-new-technologies/;
- Malaek, Seyed. (2018). A Generic Method for Sizing Satellites Conceptual Design and Rapid Sizing Based on "Design for Performance" Strategy. IEEE Aerospace and Electronic Systems Magazine ;

 Jones, Melissa & Chase, James. (2008). Conceptual Design Methods and the Application of a Tradespace Modeling Tool for Deep Space Missions. IEEE Aerospace Conference Proceedings. 1 – 15

KEYWORDS: Space mission design; concept development; new space; Concurrent Engineering Models; commercial space; mission planning; simulation

DEFENSE HEALTH AGENCY 21.1 Small Business Innovation Research (SBIR) Program Proposal Submission Instructions

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 <u>https://www.dodsbirsttr.mil/submissions/login</u>

Specific questions pertaining to the DHA SBIR Program should be submitted to the DHA SBIR Program Management Office (PMO) at:

Email - <u>usarmy.detrick.medcom-usamrmc.mbx.dhpsbir@mail.mil</u> Phone - (301) 619-7296

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 General Dynamics Information Technology (GDIT), Leidos, and Oak Ridge Institute for Science and Education (ORISE) who will provide technical analysis in the evaluation of proposals submitted against DHA topic number:

- DHA211-006 Portable Computerized Dynamic Posturography and Balance Training System to Deliver Sensory Organization Tests in Clinic and Field Environments
- DHA211-007 Radioprotector Medical Countermeasure to Prevent the Effects of Acute Radiation Syndrome
- DHA211-008 Novel Antibiotic for the Treatment of Multidrug-resistant Pseudomonas Aeruginosa Infections
- DHA211-012 Handheld Non-Contact Laser Ultrasound Medical Scanner
- DHA211-013 Body-Conformal Terahertz Medical Imager

PHASE I PROPOSAL SUBMISSION

Follow the instructions in the DoD SBIR Program BAA for program requirements and online proposal submission instructions.

DHA SBIR Phase I Proposals have three Volumes: Proposal Cover Sheets, Technical Volume, and Cost Volume. **Please note that the DHA SBIR will not be accepting a Volume Five (Supporting Documents) as noted at the DoD SBIR website.** 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. Do not 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 20-page limit.

Only the electronically-generated Cover Sheets 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.

PLEASE NOTE: The Company Commercialization Report (CCR) is required to be submitted with proposals in response to DHA 21.1 SBIR topics. Please refer to the DoD 21.1 SBIR BAA for full details. Fraud, Waste and Abuse (FWA) training is required for Phase I and Direct to Phase II proposals. Please refer to the DoD 21.1 SBIR BAA for full details.

Companies submitting a Phase I proposal under this BAA must complete the Cost Volume using the online form, within a total cost not to exceed \$250,000 over a period of up to six months.

The DHA SBIR Program will evaluate and select Phase I proposals using the evaluation criteria in Section 6.0 of 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.

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.

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 will significantly delay the performance of the Phase I award. For example, the ability to obtain Institutional Review Board (IRB) and Human Research Protection Official (HRPO) approval for proposals that involve human subjects can take 3-6 months, and that lengthy process can be at odds with the Phase I goal for time-to-award. Before DHA 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 subjects, human specimens/date or research with animals. It will not impact DHA'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.

The offeror is 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's (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. Furthermore, modifications to already approved protocols require 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 authorization that the research protocol may proceed. Written approval to begin 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%20 Reference%20Guide_DoD-CIO_Final_2020FEB07.pdf

PHASE II PROPOSAL SUBMISSION

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 (<u>https://www.dodsbirsttr.mil/submissions/login</u>). 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 (1-703-214-1333) or Help Desk email at DoDSBIRSupport@reisystems.com.

The DHA SBIR Program will evaluate and select Phase II proposals using the evaluation criteria in Section 8.0 of 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 (please refer to DoD Instructions, section 7.4) 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 may be presented side-by-side on a single Cost Volume Sheet.

DHA SBIR Phase II Proposals have four Volumes: Proposal Cover Sheets, Technical Volume, Cost Volume and Company Commercialization Report. The Company Commercialization Report may only be

submitted if available at time of submission. 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.

PHASE II ENHANCEMENTS

The DHA SBIR Program has a Phase II Enhancement Program which provides matching SBIR funds to expand an existing Phase II contract that attracts investment funds from a DoD Acquisition Program, a non-SBIR government program or eligible private sector investments. Phase II Enhancements allow for an existing DHA SBIR Phase II contract to be extended for up to one year per Phase II Enhancement application, and perform additional research and development. 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 acceptance, review, and selection of candidate projects, are subject to availability of funding, and successful negotiation and award of a Phase II Enhancement contract modification.

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.

PROTEST PROCEDURES

Please refer to the DoD Program Announcement for procedures to protest an 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

DHA 21.1 SBIR Phase I Topic Index

DHA211-001	Efficient Measurement of Intermediate-Level Impulse Noise and Sub-concussive Blast Exposure on Service Members in Operational Military Environments
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DHA211-001 TITLE: Efficient Measurement of Intermediate-Level Impulse Noise and Subconcussive Blast Exposure on Service Members in Operational Military Environments

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: To develop a personal sampling device that allows novice users to accurately measure and document intermediate-level impulse noise and sub-concussive blast exposures experienced by Service Members in realistic operational environments.

DESCRIPTION: Recently there has been a great deal of concern in the US military about the potential cumulative health effects of repeated exposures to sub-concussive blasts. There is a short-term need to collect information about the frequency and intensity of blast exposures that Service Members are being exposed to when they conduct operational training using high-powered weapon systems and other military equipment. There is also a long-term need to develop enduring monitoring systems that can be used to measure all blast and impulse noise exposures a Service Member experiences over the entirety of his or her military career.

Current impulse-noise measurement systems to measure personal exposures are not well-suited to meet these needs. Typically, impulse noise assessments are conducted on individual weapon systems prior to the fielding of that system. These measurements use laboratory grade equipment that is neither compact enough nor durable enough to be used for exposure measurements during field training events. Additionally, this sort of evaluation may not address real world use scenarios where personnel maneuver around the weapon system during firing according to changes in the tactical environment. Changes in position can significantly change noise exposure. Additionally, evaluations of the individual system rarely, if ever, take into account exposure to multiple noise sources concurrently.

Most current technology for measuring long-term exposures to acoustic noise are focused on continuous noises, like the sounds generated by engines or machinery. This type of noise can be measured with noise dosimeters, which are relatively inexpensive, compact, lightweight, and durable enough to be attached to a Service Member's uniform and left in place for an entire multiday training exercise.

High-level blast exposures that are potentially concussive (i.e. > 180 dB) are more difficult to measure, but the DoD has made a huge investment in the development of wearable blast gauges that can be attached to the helmet or uniform of a Service Member and maintain a count of the number of exposures that occur over a period lasting multiple weeks or even months.

The current gap in measurement systems is in the intermediate range of impulse noises with peak levels between 140 and 180 dB. These impulses are intense enough to saturate the microphones of conventional noise dosimeters, which are unreliable for measuring peak levels above 140 dB. But those levels are not high enough to trigger most current blast gauges, which cannot register impulse noises below 170 dB. A further complication is that Service Members may potentially be exposed to hundreds or even thousands of mid-level impulse noises in a single training session This means that a mid-level impulse noise monitoring system will require much more sophisticated data handling than a blast gauge that may only need to record the five loudest exposures in a two month period.

At present, mid-level impulse noise exposures can only be recorded with relatively fragile and expensive test measurement equipment that has to be set up and analyzed by expert personnel, who are often researchers rather than occupational hygienists or safety personnel. The immediate need is a test measurement system that is---

a) Portable and rugged enough to be worn on the body by a Service Members in operational training environments;

b) At a minimum, capable of measuring impulses in the range from 140 dB to 174 dB, with a desired dynamic range from 120 dB to 184 dB.

c) Capable of providing an immediate report of the number and intensity of the impulse noise exposures experienced by a Service Member over a single 8-12 hour training exercise;

d) Simple enough to be used by safety personnel who do not have specific expertise in impulse noise exposure.

PHASE I: The contractor will develop and demonstrate a prototype system that is---

a) Rugged and compact enough to be worn on the body during operational training. Mechanical characteristics of acceptable field-tested noise dosimeters are listed below.

- 1. Dimensions: 5 in. x 2.7 in. x 1.5 in
- 2. Weight: 14 oz

b) Capable of recording all impulse noise events in the range from 140 dB (minimum-182 dB. Data and settings should be stored in nonvolatile memory.

c) Capable of running continuously for a minimum of an 8 hour period.

d) Capable of downloading data and generating a report to include:

- 1. The number of impulses
- 2. The magnitude of each impulse
- 3. The A and B durations of each impulse

The prototype system should be compared to laboratory grade impulse noise equipment when exposed to controlled impulsive noises from sources such as cold gas shock tubes, arc gap generators, or small arms fired from fixed positions. Ideally, the prototype system should be able to match the gold-standard systems within ± -2 dB for impulses within the dynamic range of the system.

PHASE II: The contractor will build and deliver 10 prototype systems meeting the Phase I specifications. These prototypes will be evaluated by occupational hygiene professionals to assess their usability and suitability for impulse noise monitoring. Prototypes at this stage should be usable during military training operations by personnel who do not have specific expertise in impulse noise exposure. Criteria evaluated will include size, weight, durability, and user friendliness (both in affixing the system to personnel for monitoring and in downloading/reviewing the resulting exposure data).

In addition to the 10 prototypes, the contractor will provide advanced software which generates a report that includes the following risk analyses, in accordance with requirements laid out in MIL-STD-1474E. The report should include Phase I (d) and,

1. AHAAH unwarned (the warned reflex has been widely repudiated as not reliably protective);

- 2. LAeq 8 Hr; and,
- 3. LAeq 100 ms

This software should be evaluated by occupational hygienists and safety personnel without impulse noise measurement experience, and will be judged based on user friendliness in downloading, reviewing, and organizing the resulting data.

PHASE III DUAL USE APPLICATIONS: In Phase III, the contractor will focus on manufacturing, sustaining, and refining the noise dosimeter and software systems. Both the Army and Navy Public Health Centers have requirements to monitor occupational noise exposure and have hearing conservation programs that focus on noise hazard identification, hearing protection, and monitoring audiometry. Thus,

these intermediate-level impulse noise dosimeters and its associated software systems would be well suited for Government use. These Public Health Centers, as well as installation safety and occupational hygienists, are examples of potential government customers that are interested in acquiring this type of technology. Additional customers for these products may include police departments to monitor for noise exposure during firearms training, and other occupational hygienists and safety professionals which monitor processes with impact or impulse noise such as mining, hammer forging in manufacturing sector, and jackhammering and pneumatic nail gun use the construction industry as examples.

REFERENCES:

- 1. Meinke, D., Flamme, G., Murphy, W., Finan, D., Stewart, M., Tasko, S., and Lankford, J. Measuring Gunshots with Commercial Sound Level Meters. 2016. Presented at the National Hearing Conservation Association Conference.
- 2. Smalt, C. Acoustic Measurements for Low Level Blast and Auditory Injury. 2020.
- Department of Defense (US). MIL-STD-1474E—Design criteria standard noise limits. 2015 Apr 15.

KEYWORDS: Impulse Noise, Subconcussive Blast, Noise Dosimetry

DHA211-002 TITLE: Prevention Device Suitable for Exposure to Blast or Concussive Forces

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: To develop a preventive technology to reduce the risk of brain injury from blast that is relevant to operational and/or training settings. The technology developed should be portable, light-weight and have low footprint without additional burden/impedance to Warfighter operations/duties and comfort. The end-product should be easily worn/carried by the Warfighter and the device can be an active or passive system in nature.

DESCRIPTION: Injury to brain from blast related trauma has been a critical problem for Warfighter brain health and performance (e.g. traumatic brain injury). Although the current personal protective equipment, up to an extent, is designed to protect against shrapnel and projectiles from explosive events and low caliber ammunition, there is still risk stemming from the blast overexposure and technologies that provide protection/prevention against blast are highly desirable. The need to accelerate and develop these types of technologies, which can work as an either active/passive systems, has been further realized from the numerous traumatic brain injuries experienced by US forces following recent bombing of Ain al-Asad air base attack by adversaries (Military times, Feb 10, 2020). There is a likelihood that these issues could be further complicated due the new requirement of Maneuverability Center of Excellence to develop lighter weight personnel protective equipment to meet the demands of the Warfighter in future multi-domain operations 2028 (MDO). Unfortunately, there are no preventative technologies to reduce the risk of Warfighters' brain health during combat and training operations. (Pratt NJ., 2017; Review of Department of Defense Test Protocols for Combat Helmets, 2014). Potentially injurious mechanical forces of blast include, but are not limited to, overpressure, accelerative forces, and impact forces on the subject from dislodging. Technologies that can mitigate the risk of injury by triggering preventive mechanisms from these forces associated with blast such as overpressure and/or impact are highly desired. Blast overpressure is in the order of nanoseconds for initial peak rise time with a total event time-scale less than 5-6 milliseconds for improvised explosive device (IED). This is a near instantaneous environmental exposures, thus any innovative technology should quickly respond to mitigate injury. Non-invasive innovative technologies that can either protect the brain by reducing the loading forces of blast or biologically insulating the brain from overpressure/accelerative forces for impact (secondary/tertiary blast) are highly desirable. The medical system or technology is highly desirable to integrate on to the Warfighter without compromising the performance of the individual and the other technologies/systems (e.g. GPS or communication equipment) carried by the Warfighter. The medical system or technology should be non-invasive, safe, wearable, non-pharmaceutical/nutraceutical, portable, light-weight, and user-friendly that can trigger physiological responses to make brain less susceptible to injury from the mechanical forces of blast. The medical system or protective technology is desired (but not required in Phase I) to perform well under field rugged conditions such as extreme temperatures, humidity and dust/wet conditions. Overall, this topic desires to develop/identify a technology and/or a medical system to mitigate the risk of blast related traumatic brain injury that can be accelerated towards fieldable use.

PHASE I: To develop/demonstrate the feasibility of the prototype under limited blast loading conditions (e.g. overpressure) to identify viable functionalities (activation/trigger of sensing systems) of the prototype. Blast loading conditions simulation should replicate ecologically valid "free-field" blast exposures from an IED-like blast exposure. WRAIR has an advanced blast simulator and the performer may coordinate with WRAIR to leverage blast simulation capabilities for prototype feasibility demonstration. A demonstration will be achieved by subjecting the prototypes to dynamic loading of blast overpressure exposure at different pressures (e.g. 4psi – 24 psi in steps of 4psi). At the end of the phase, a working prototype/device should demonstrate the feasibility/application of the system by providing a

road-map or experimental plan for pre-clinical testing to test the efficacy of the system in laboratory setting. No animal and/or human studies are required during this phase.

PHASE II: An iterative process can be used to develop a prototype by sensing blast or blunt trauma and activating of the medical/preventive system against a biological organism (e.g. use of animal models). Blast and animal research capabilities at WRAIR may be leveraged to test the efficacy of the prototype. Consideration should be given to large animal models for prototype testing that may include pig, sheep, or non-human primates. Prototype should not significantly burden the soldier with weight and should be comfortable to wear. Prototype should be easy to use and operate. In addition, it should not interfere with any communication system used by the Warfighter. The efficacy of the technology requires testing in a pre-clinical setting against a wide range of blast overpressures (primary blast) and/or blast overpressure + impact scenario (tertiary blast). The technology should demonstrate protective-ness against blast related traumatic injury under the testing conditions in the laboratory. The prototype effectiveness can be shown through the assessment of injury reduction (e.g. reduction in brain hemorrhage, lesions, axonal injury and/or inflammation). Technology should also demonstrate that the prototype (s) can withstand the field rugged conditions such as extreme temperature, humidity and/or dry/wet environments in the laboratory. At the end of this phase, the prototype should demonstrate a clear path to show efficacy in pre-clinical testing and future readiness for testing in scaled human conditions to show the protectiveness of the product. An FDA regulatory plan will be provided during Phase II to illustrate the technology's pathway as a medical device to protect against blast related traumatic brain injuries.

PHASE III DUAL USE APPLICATIONS: The performer should refine and implement their regulatory strategy for obtaining FDA approval (if necessary) based on the initial feedback from FDA (if necessary). The prototypes developed should provide protective efficacy and operational viability on Warfighters in the blast conditions where blast-induced performance deficits are expected/identified (e.g. breaching training) or conduct clinical trials to conclusive demonstrate protective capabilities of the product. The performer may coordinate with WRAIR/USAMRDC/USAMMDA for this objective for advanced development. The performer can seek additional funding from other government sources and/or private investors to commercialize the project. Plans for large-scale product are sought through the funding from government sources and/or private organizations. This technology can be used to prevent impact TBI that can occur in civilian populations such as sports concussive, blast exposure in law enforcement personnel, and bicycle/motorcycle accidents.

REFERENCES:

- 1. Prat NJ, Daban JL, Voiglio EJ, Rongieras F. Wound ballistics and blast injuries. J Visc Surg. 154:S9-S12. (2017)
- 2. Review of Department of Defense Test Protocols for Combat Helmets, Washington (DC): National Academies Press (US), ISBN-13: 978-0-309-29866-7, (2014).
- 3. Military Times. 109 US troops diagnosed with TBI after Iran missile barrage says Pentagon in latest update. Feb 12, 2020.

KEYWORDS: Blast, traumatic brain injury, protective technology, non-pharmaceutical, injury, overpressure, impact, portable, light-weight

DHA211-003 TITLE: Underwater Blast Lung Computational Model

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: The objective of this SBIR is to develop a computational model of the human lung as it responds to underwater blast insult in order to predict injury in explosive ordnance disposal (EOD) personnel exposed to underwater explosion (UNDEX). To meet this objective, a finite element model (FEM) that accepts UNDEX metrics and outputs lung physiological response and/or injury from the blast insult will be developed. Development of the underwater blast lung model will improve existing injury predictions and provide actionable injury assessment to mission planners as they evaluate operational risk management.

DESCRIPTION: FEM is a valuable tool in a number of industries (e.g. automobile) for predicting human injury to a variety of traumas. The Department of Defense (DoD) has sponsored the development of computational models that predict how the human body will respond to in-air blast insult. The focus of this SBIR is to identify a software modeling approach that can characterize the physiological response of human lungs to underwater blast insult. The model must be able to compensate for the lungs being under hydrostatic pressure (up to 200 ft seawater) for divers operating on scuba equipment. In addition, the interactions between the blast wave and lung response with the surrounding bone, muscle, and tissue in and around the thoracic cavity needs to be incorporated into the model. As divers may be using different gas mixes other than air (e.g. heliox, tri-mix), incorporation of this variable would be highly valuable, but is not mandatory. This model will provide predictive physiological responses to underwater blast to improve risk modeling for establishing safe standoff distances for EOD divers working around explosives.

The software models developed by this SBIR can be marketed for use by the DoD and other communities, who have divers working with explosives or other impulsive noise sources (e.g. seismic airguns, pile driving, underwater construction tools). Early adopters of the software modeling products from this SBIR may include surface and undersea warfare operators and undersea construction and salvage crews. In addition, these models would also be valuable to environmental protection groups within the DoD as well as industry for use in predicting injury to marine mammals and other aquatic life. Companies have had success being able to commercialize high fidelity human anatomy models for the scientific community.

PHASE I: In Phase I, researchers will identify the physical modelling requirements and physics that must be solved related to the properties of the model. Researchers will identify an appropriate code base that is suitable for solving the response physics. A simple model (e.g. lung-sized sphere) will be created that responds appropriately to the underwater blast physical properties. Model outputs shall be validated against theoretical predictions or experimental data. The physiological variables that will need to be incorporated into the model to transition from the simple spherical model to an anatomically correct version of the model shall be characterized. The performance and capabilities of the final model for Phase I will be demonstrated. Finally, researchers will identify the recommended approaches that will be used in Phase II. These approaches will be identified in consultation with the COR and subject matter experts.

PHASE II: In Phase II, the model will be made more complex by transitioning to an anatomically-correct lung shape and incorporating specific tissue and material properties of the lungs and surrounding tissues. Specifically, an upper torso model shall be created that incorporates bone, soft tissue, lungs, and diaphragm at sizes accurate to a 50th percentile male. As with Phase I, this model should respond appropriately to the UNDEX physical properties. The model outputs shall be compared to experimental data from physical models to be provided by the COR. Each of the tissue layers should show a response

to the underwater blast insult. However, the interactions between tissues, being much more complex can be planned for Phase III. The Phase II model and data will be demonstrated and delivered to the COR for further evaluation and analysis.

PHASE III DUAL USE APPLICATIONS: In Phase III, a complete underwater blast lung and thorax computational model will be developed. This will include high fidelity anatomical structures as well as the interactions between all structures (e.g. lungs interaction with rib cage; diaphragm interaction with lungs). The model should be able to respond to a variety of UNDEX scenarios including explosives with different charge weight, explosive type, and location of explosive relative to lungs in water column. Also, the model should incorporate lungs at different depths and orientations in water column, as well as with the lungs at different inflation volumes (e.g. due to inhalation/exhalation). The Completed model and data will be delivered to the sponsor for further evaluation and analysis. Additional Phase III follow-on work may include extending the modeling techniques to marine mammals or diving birds.

This model will provide immediate value for DoD entities such as Naval Surface Warfare Center Indian Head and the Naval Submarine Medical Research Laboratory, who support the development of safe standoff requirements for divers operating around underwater explosives. The Army Simulation and Training Technology Center (STTC) could potentially want to integrate this model into their simulation platforms. Additional non-DoD customers that this model could be marketed to would be industries that employ divers for explosive work, construction, and other infrastructures in which divers are subjected to high energy underwater sources such as explosives, pile driving, or seismics. Numerous companies have developed high fidelity human models that are available for commercial use (e.g. Zygote, Biodigital, 3D4Medical). There is a strong potential of interest from academia and scientific institutes for evaluating effects on animal models (i.e. diving birds, marine mammals). Joint Program Committee (JPC)-1 has also expressed an interest in tracking the model's development towards a completed product to evaluate its potential as a training component [5].

REFERENCES:

- 1. Richmond, D. R., Yelverton, J. T., & Fletcher, E. R. (1973). Far-field Underwater-Blast Injuries Produced by Small Charges. Lovelace Foundation for Medical Education and Research,
- 2. Cudahy, E. A. & Parvin, S. J. (2001). The Effects of Underwater Blast on Divers. Naval Submarine Medical Research Laboratory, Report 1218, Groton, CT, USA.
- 3. Lance RM, Capehart B, Kadro O, & Bass CR (2015) Human Injury Criteria for Underwater Blasts. PLoS ONE 10(11): e0143485.
- 4. Chanda, A., & Callaway, C. (2018). Computational modeling of blast induced whole-body injury: A review. Journal of Medical Engineering & Technology, 42(2), 88-104.
- 5. Personal communication with Joint Program Committee (JPC) -1, 2 October 2020.

KEYWORDS: UNDEX (Underwater Explosion), Lung, Thoracic, Computational Model, Finite Element Model

DHA211-004 TITLE: Algorithm and Associated Integration Hardware for Capturing Contextsensitive Metadata for Health Risk Assessments

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: Demonstrate technology for automatic association of environmental conditions and activities with chemical and physical exposures based on feedback from body worn and area monitors to augment health risk assessments.

DESCRIPTION: The collection of context-sensitive metadata during health risk assessments is critical to understand the circumstances that are associated with exposures and health outcomes. In a traditional occupational environment, an industrial hygienist or technician manually observes and logs events and work activities that are associated with exposure levels of concern. By automating the identification of activity and environmental conditions using feedback from body worn and area sensor systems and leveraging the internet-of things, the industrial hygienist can more readily provide specific feedback to workers to mitigate potentially hazardous exposure conditions. Further, context-sensitive data can be used to augment existing DoD environmental and biomonitoring programs, such as the Joint Health Risk Management (JHRM) program and the Army's Health Readiness and Performance System (HRAPS). Activity data of interest include specific information about operational tasks, including operation of specific machinery in a maintenance shop, or various actions associated with flight line maintenance, such as pre-flight checks and refueling actions. Environmental data of interest include information such as indoors versus outdoors, local ventilation conditions and weather. Chemical and physical exposures of interest include particulate matter, total volatile organic compounds, ozone, carbon monoxide, carbon dioxide, nitrogen oxides, noise, and heat/cold stress. The algorithm and integration hardware should be designed to incorporate data from commercial off-the-shelf sensors, such as MultiRAE gas monitors (present at most military bases), standard noise dosimeters, weather monitors, smart wearable technologies (e.g. smart watches, smartphones), as well as next generation sensor technologies currently in development. The final algorithm and associated integration hardware must store logged data locally, incorporate a user-interface, and operate for at least 10 hours on battery power. The device will also incorporate user-configurable alarm settings and an option for the user to provide feedback to the device regarding notable activities. The data should be exportable in formats compatible with DoD environmental and biomonitoring programs.

PHASE I: During the phase I effort, a prototype system will be developed to demonstrate the technical feasibility for an algorithm and interface for context-sensitive environmental monitoring. The algorithm and associated integration hardware will be demonstrated for its ability to automatically identify maintenance-related tasks, such as painting, stripping, and sanding, completed in a controlled environment (e.g. laboratory or shop), as well as simple environmental conditions, such as indoors versus outdoors and location. An interface will be designed where the worker being monitored can provide feedback to train the algorithm and contextual information can be provided back to worker.

PHASE II: During the phase II effort, a robust system will be demonstrated that is capable of automatically and accurately identifying specific work tasks, such as welding, drilling, sanding, stripping, and painting, as well as basic environmental conditions, in a military field environment. The government will provide parameters for metadata needed. The 711th Human Performance Wing will test the prototype independently during this effort and provide feedback back to the small business in order to accelerate the development of a product that is practical to transition to an operational environment.

PHASE III DUAL USE APPLICATIONS: The context-sensitive sensor system should demonstrate

connectivity with DoD programs, such as the Army's Health Readiness and Performance System (HRAPS), Joint Health Risk Management (JHRM) program, and other comparable systems. In addition to providing value to the DoD, context-sensitive technology capable of automatically associating environmental conditions and activities with chemical and physical exposures would be valuable to industrial hygienists working in construction, manufacturing, and maintenance industries where workplace exposures require consistent monitoring to ensure health and safety of workers. The final product will be relevant for research applications where activities and locations linked with exposure levels could be associated with epigenetic markers or chronic health outcomes, such as noise-induced hearing loss, heart disease, and cancer.

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KEYWORDS: Environmental Exposure, Environmental Monitoring, Exposure Science, Smart Sensors, Health Outcomes, Worker Health, Machine Learning, Internet-of-Things

DHA211-005 TITLE: Wearable Radio Frequency Weapon Exposure Detector

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR); Directed Energy

TECHNOLOGY AREA(S): Bio Medical; Sensors

OBJECTIVE: Develop a low cost, low weight, small size wearable radio frequency (RF) weapon exposure detector.

DESCRIPTION: Directed energy weapons, including radio frequency (RF) weapons, are a growing threat on the battlefield. Determinants of RF weapon antipersonnel effects are multifactorial and RF injuries will be situation dependent and very hard to predict. Without known patterns of RF injury to guide diagnosis, it will be difficult to differentiate RF injury from other common sources of illness and injury such as heat stroke. This ambiguous symptomology is aggravated by the transient nature of RF energy. Without a sensor it is possible that no residual evidence of RF attack will be available. A wearable RF detector to signal and document exposure to injurious levels of RF energy will allow personnel to take timely and appropriate protective measures, enable confident diagnoses of RF exposure injury, and serve as a critical intelligence resource for defining current battlefield threats. However, to be useful, the wearable RF weapon exposure detector must, in order of importance, have an extremely small footprint in terms of space, weight and power (SWaP), be very low cost, have a very low false positive rate, and be easy to interpret. The topic does not seek a replacement for sophisticated instruments used for measuring occupational hazards. This RF detector concept is analogous to passive M8 and M9 paper used in the detection of chemical weapon hazards.

PHASE I: Analyze RF bioeffects in relation to common US and ally military RF equipment and potential enemy weapon system emission levels and frequencies. The spectrum of interest includes IEEE UHF through Ka bands. Determine optimal detector threshold sensitivity for signaling immediately dangerous to life and health (IDLH) exposure while minimizing false positives. Because irradiance levels needed to injure personnel are orders of magnitude higher than required to damage electronics, designing a broad band absorber with appropriate response characteristic will require substantial innovation. Integration of an antenna into an affordable system which will survive in the extreme irradiance environment is a significant challenge, therefore the offeror may need to identify novel broad band RF detection materials and alarm/signaling mechanisms. Design a low cost, low SWaP, low false positive, easily readable, wearable detector would be smaller than a M4 magazine pouch and attach to a tactical vest by the Pouch Attachment Ladder System/MOLLE mount. High cost, high complexity sensors are not desired for this solicitation.

PHASE II: Develop and test sensor components. Model expected system performance from component testing. Integrate components into breadboard/brassboard level prototype and compare measured performance against modeled predictions. Review non-open source information regarding military RF systems and RF bioeffects provided by government. Refine design and build production representative prototypes and validate detection performance in laboratory environment. Provide prototypes for operational utility evaluations. Conduct environmental testing.

PHASE III DUAL USE APPLICATIONS: If there is a proliferation of RF weapons, it is expected that a Wearable RF Weapon Detector will be generally useful for a wide variety of military operations. In Phase III the contractor will work with a program office, such as the Air Force Medical Readiness Agency's Advanced Development Office or PEO Soldiers' Program Manager for Soldier Survivability to finalize the detector as a military product. Desired end state would be to establish the Wearable RF Weapon Detector as a standard military equipment supply item distributed through Defense Logistics

Agency. Additional commercial applications include medical, industrial, manufacturing, and test facilities in which personnel may be inadvertently exposed to high power RF sources.

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KEYWORDS: Directed Energy Weapon, Radio Frequency Injury, Detector

DHA211-006 TITLE: Portable Computerized Dynamic Posturography and Balance Training System to Deliver Sensory Organization Tests in Clinic and Field Environments

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: Develop a portable, customizable, computerized dynamic balance and measurement system that allows programmable levels of instability to deliver accurate Sensory Organization Tests in clinic, home, or field environments.

DESCRIPTION: Traumatic brain injuries (TBI) and musculoskeletal injuries (MSKI) account for a significant proportion of limited duty days and nondeployable classification in military service members 1,2. TBI and MSKI both cause short-term disability, but can have lasting consequences such as loss of strength and motor control, chronic pain, cognitive deficits, and permanent neurological damage. Postural stability is the ability to control center of mass (COM) in relation to an individual's base of support and requires integration of an individual's visual, vestibular, and somatosensory systems. Balance training is used to improve postural stability after injury and must target all three systems for optimal effectiveness. Currently, the most common form of balance testing and training in clinics uses a balance board or stability ball to create an unstable surface to train the somatosensory system. More recent efforts have engaged the visual system by integrating virtual reality (VR) with static force measurement platforms to assess COM motion in various VR environments. While integrated VR systems have expanded the types of visual and vestibular perturbations available, use of a static force platform means the motor control system is not challenged or perturbed in a controlled manor. Systems with dynamic platforms would be beneficial for assessment and rehabilitation from vestibular and musculoskeletal injuries.

More traditional balance testing systems incorporate programmable moving platforms capable of perturbing and measuring COM movement (e.g. computerized dynamic posturography (CDP) systems) in a systematic and measurable way. Their ability to concurrently or independently manipulate the visual, vestibular, and somatosensory systems make them an invaluable tool for delivering an objective Sensory Organization Test (SOT), which can help the clinician to determine if therapy is needed and which sensory system to focus on. Indeed, a large amount of normative and clinical SOT data exists for military personnel across various branches5. Though considered the gold standard for vestibular physical therapy assessments, the utility of current CDP systems are undermined because of their large size, high cost, and limited functionality (i.e. pre-programmed tests for evaluation only, not modifiable for targeted training), and thus are usually found only in large medical centers and specialty clinics.

The goal of this SBIR is to develop a product that maintains the strengths of traditional CDP systems, but that takes advantage of the developments in portable balance measurement devices and portable display technology (e.g. VR), thereby creating a lower cost and portable balance assessment and training system. Currently, there are no commercially available portable platforms that combine COM measurements with computerized dynamic control of platform stability; these are essential for conducting SOTs and targeted training. The development of such a platform in conjunction with VR, or similar technology, can be used to not only provide balance perturbations seen in SOTs (i.e. a sway referenced support surface) but also provide graded training that can be used during post-TBI rehabilitation or to mimic a specific dynamic environment for physical training purposes. The purpose of this SBIR is to create a portable, computerized dynamic balance and measurement system.

PHASE I: In Phase I, the performer will first define specifications for the device that must be met to deliver physical perturbations used in standard SOTs. This includes the platform's maximum/minimum

tilt angles, speed of tilt changes, speed at which data must be streamed (input and output frequencies), platform weight limits, and COM measurement accuracy. The mechanism (e.g. springs, balls, actuators) of inducing instability at various tilt levels should be established. Although no defined standards need to be met for the following aspects of the system, specifications such as platform translation, and the number and increment of instability levels should be pre-determined by the performer.

To be effective, the device should be able to:

1) Be portable (weight, size) such that only a power source, computer, and VR headset (or similar portable display system) is required for additional setup.

2) Include a portable platform capable of controllable tilt in at least two axes (minimum $\pm 20^{\circ}$ in each axes).

3) Provide controllable instability (or fluctuation) at all levels of tilt.

4) Collect and stream accurate and reliable COM and platform movement data to a computer.

5) Stream platform data to a development platform (e.g. Unity), for integration within custom gaming applications.

6) Integrate with software, capable of controlling the platform's movement and instability levels and collecting data.

7) Allow for easy administration of the SOT and instant test results to the clinician.

An initial proof-of-concept design will be developed to demonstrate that the product is able to meet minimum functional capability. The design will include the device's basic architecture and components. While creating this proof-of-concept design, the performer must keep in mind the potential customer's settings. The technology should be designed for use, at minimum, in a research or clinical setting (i.e. require minimal setup and an easy software user-interface), with potential setup capacity for in-home therapy or field-based setups. Additionally, the dynamic response of the proposed device should be mathematically outlined and numerically simulated, showing the limits and expected response of the device in terms of user mass, platform acceleration, and deflection angle. A working prototype of the physical design is preferred to demonstrate eventual full system capabilities.

Together, Phase I deliverables include:

1) Design and use specifications that the proposed device should meet.

2) CAD model and system integration diagrams of proposed device.

3) Mathematical representation and numerical simulations demonstrating ability to provide varying levels of tilt and instability in different use cases (e.g. body mass of user) including those of the SOT testing conditions.

PHASE II: In Phase II, the performer will construct and test a prototype balance training system based on requirements from the original solicitation and specifications identified in Phase I. The performer must validate the accuracy and precision of COM measurements, tilt angles, and instability levels under varying conditions (e.g. amount of platform instability, user mass, etc). As stated above, traditional CDP systems are not portable and typically require a dedicated space of ~25-30 ft2. One of the improvements of the current development is that it should only require a power source, computer, and a flat surface ~4-9 ft2. As such, the performer will demonstrate that the system is portable and can be used in a variety of settings, while providing accurate measurements. An initial FDA regulatory plan should be provided if applicable. Finally, in Phase II, the performer will also develop the software that accompanies the physical device. The software should be capable of defining and controlling tilt angles and instability levels. It should also provide real-time visualization of COM movement and platform tilt angles. A software application should be designed to showcase the system's ability to stream COM movement and tilt angles for integration with a virtual environment within acceptable delay times. An application

should also be designed that will deliver the SOT, collect accurate COM information, and provide composite measurement results as well as individual scores for each of the SOT conditions.

Phase II deliverables include:

1. The physical working prototype balance platform capable of varying levels of tilt and instability.

2. Instruction manual for setup and usage.

3. Accompanying software that allows the user to connect a computer (wired or wirelessly) for data streaming and visualization.

4. Demonstrative software application, compatible with gaming/development platforms that support major VR devices in the current market.

5. Software infrastructure (SDK) that can be used to stream data into custom VR applications.

6. Specifications document that details limitations of the device (e.g. user weight, tilt levels, life-time, etc.).

7. Application that delivers the SOT and provides composite and individual condition scores.

PHASE III DUAL USE APPLICATIONS: The expected Phase II end-product is a well-designed, portable balance training and testing system for use in research or clinical settings that is able to deliver the SOT with the same standards of commercially available dynamic posturography systems. To move this SBIR work towards operational- and commercial-readiness, Phase III efforts should focus on validating the device's repeatability and reliability against current devices used for SOT in targeted populations and further development for clinical use (production, delivery/setup, software, durability). This will support future commercialization efforts in both military and civilian markets. It is anticipated that DoD customers will include clinical rehabilitation settings that address TBI diagnosis and symptom treatment (vestibular dysfunction, dizziness, oculomotor system dysfunction) and clinics for MSKI injuries (chronic ankle instability, knee/ankle injury, ligament injury). Key customers may include facilities that currently own CDP systems, including large military treatment facilities (e.g. Naval Medical Center San Diego, Walter Reed National Military Medical Center), Department of Veterans Affairs hospitals (e.g. Palo Alto, Minneapolis, Seattle), and academic universities (e.g. University of Wisconsin system, University of California System, University of Pittsburgh). Additionally, a portable and lowercost system would enable medical facilities to purchase and use more than one balance system in different clinics. It would also enable access to objective assessment and rehabilitation tools at military clinics (e.g. Twentynine Palms) and civilian outpatient clinics. A successful device could also have implications for use in deployed settings if ruggedized. Commercial markets that could benefit from this novel product would include: private rehabilitation centers, sports training centers, and research organizations.

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KEYWORDS: Postural training, vestibular assessment, physical rehabilitation, performance, traumatic brain injury, musculoskeletal injury

DHA211-007 TITLE: Radioprotector Medical Countermeasure to Prevent the Effects of Acute Radiation Syndrome

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: To provide a radioprotector medical countermeasure (MCM) to the Joint Force with effective prophylactics to recover from and survive Acute Radiation Syndrome (ARS) resulting from ionizing radiation exposure. In concert with resuscitative intervention and supportive care, MCMs would improve survival and reduce recovery times for the individual contributing to a higher level of unit readiness.

DESCRIPTION: The current Joint Force requires Medical Counter Measures (MCMs) against threats to sustain the full range of military operations. The Joint Force must effectively protect the maximum number of personnel against the greatest number of hazards as far forward as possible, and sustain the casualty from the point of exposure to the point of definitive care. These MCMs will be administered at the lowest echelon of health care possible. They will work in concert with other medical products to lessen performance degradation and increase survival for the individual contributing to a higher level of unit readiness.

The Department of Defense requires MCMs for Acute Radiation Syndrome (ARS) that are safe and effective prophylaxes and therapeutics. To be effective, any prophylaxes must be available to Joint Force personnel prior to ionizing radiation (IR) exposure. It will reduce the likelihood of developing severe adverse health effects associated with ARS to increase survival. Prophylaxes would be administered to the Joint Force prior to operating in a known, high risk Ionizing Radiation (IR) environment. ARS encompasses a spectrum of pathophysiologic changes caused by exposure to high doses of penetrating radiation in a relatively short time period. Injuries sustained depend on the dose and extent of radiation exposure (e.g., whole- or partial-body). Radiation exposures exceeding 2 Gray (Gy) in adults can result in the depletion of hematopoietic stem cells and cellular progenitors in the bone marrow, which may lead to severe neutropenia, thrombocytopenia, and death from infection or hemorrhage. Higher radiation doses can cause gastrointestinal (GI) complications, including mucosal barrier breakdown, bacterial translocation, and loss of GI structural integrity, which can lead to rapid death. Individuals who survive ARS may suffer from the delayed effects of acute radiation exposure (DEARE), which can include pulmonary, renal, cardiovascular, immunological, and cutaneous complications occurring weeks to months after radiation exposure.

There are three FDA-approved post-exposure therapeutic drugs to treat the hematopoietic subsyndrome of ARS. There are no FDA-approved prophylactic MCMs for IR exposures resulting in ARS. Future pharmaceuticals will be used in concert with the most appropriate and cost effective mix of existing protocols for treating radiation injuries and could be used at any role of care. Together, future pharmaceuticals and existing medical management protocols (e.g., supportive care, antioxidants, antiemetics, antibiotics, colony stimulating factors, blood/bone marrow transplants, isolation) will provide the means to effectively treat the maximum number of personnel.

For the purpose of this effort, the terms "MCM(s)" and "drug(s)" will include drugs, biologics, and cellular therapies. The objective of a prophylactic MCM is to reduce the likelihood of developing severe adverse health effects associated with ARS to increase survival. The prophylactic MCM must work in concert with other medical products to lessen performance degradation and increase survival for an individual contributing to a higher level of unit readiness. A prophylactic MCM will need to be given pre-exposure, pre-symptomatic and be administered at the lowest echelon of heath care possible to the Joint

Force (age range of 18 - 62 years) prior to operating in a known, high risk irradiated environment. To achieve this effect the method of administration must be tailored to optimize ease of administration in an operational environment.

PHASE I: Offerors must propose proof-of-concept experiments to demonstrate the efficacy of proposed ARS prophylactic MCM against a relevant susceptible cell populations such as hematopoietic progenitors. Demonstration of efficacy in some form of an in vivo model is also acceptable, but not required for Phase I. Technologies of interest include, but are not limited to, drugs, but can include biologics or cellular therapies. Exit criteria for successful completion of Phase I research would be the demonstration of efficacy at the LD70/30 or greater radiation dose levels. The LD70/30 represents a radiation dose that would result in 70% mortality over 30 days in vehicle treated mice. Information garnered from Phase I experiments may be more qualitative than quantitative.

PHASE II: With successful completion of Phase I experiments, Phase II would further evaluate the medical countermeasure (MCM) in a small animal study. A Phase II effort will test effective prophylactic ARS MCMs at the LD70/30 dose level or greater in an appropriate animal model. In these studies, the MCM would be administered to animals prior to radiation exposure. The animal model should be of sufficient size and scope to demonstrate a statistically significant increase in survival in animals receiving the MCM. The SBIR Phase II studies shall include experiments of a manner that facilitates the collection of non-clinical GLP pharmacokinetic (PK) and pharmacodynamic (PD) data. The PK and PD information will be of paramount importance to inform subsequent Phase III studies. Optimized formulation studies involving development of a preparation of the drug should be conducted during this phase II effort. Responders to this SBIR should provide a test plan for in vivo evaluation prior to the start of Phase II studies. An initial FDA regulatory plan will be provided in Phase II.

PHASE III DUAL USE APPLICATIONS: Phase III studies would further refine the animal model and the compound/drug dosing regimen. The goal would be to work toward FDA approval of a MCM for one or more radioprotector MCMs against ARS. The studies in Phase III should support FDA approval/ licensure to include entry into clinical studies, cGMP manufacturing scale up, and pivotal efficacy studies. FDA licensure/approval is not necessary for the project to be deemed successful. One means for the offeror to document progress is through a Technology Readiness Assessment (TRA) of the technology using the harmonized Quantitative Technology Readiness Level (QTRL) guidance document as described by the Public Health Emergency Medical Countermeasures Enterprise (PHEMCE). A second means for demonstrating success is the establishment of funding and partnering with commercial companies (if necessary) to facilitate bringing the product to market, as resulting products may be applicable to various medical (e.g. oncology) or technical fields. A third potential course for Phase III development would be potential transition to advanced product development by JPEO-CBRND, subject to JPEO funding priorities at the time of transition.

Successful radioprotector MCM products directed against ARS will clearly have use by other government agencies, hospitals/ emergency departments, first responders, and others providing responses to nuclear and radiation dispersal incidents.

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Countermeasures Enterprise (PHEMCE) Harmonized Q-TRL List for Medical MCMs, MCS-BAA14-01, December 2013.

KEYWORDS: Radioprotectors, Prophylaxes, Medical Countermeasures (MCM), Acute Radiation Syndrome (ARS), Ionizing Radiation (IR), Sub-syndromes

DHA211-008 TITLE: Novel Antibiotic for the Treatment of Multidrug-Resistant Pseudomonas Aeruginosa Infections

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: Development of a small molecule, antibacterial drug candidate for the treatment of service members in the Military Health System infected by multidrug-resistant (MDR) Pseudomonas aeruginosa to include in vitro and in vivo efficacy in models of wounds, burns, sepsis and/or ventilator-associated pneumonia (VAP).

DESCRIPTION: Successful treatment and recovery of service members/warfighters wounded in the line of duty is frequently complicated by multidrug-resistant (MDR) bacterial infections. In the best medical evacuation systems spanning the past 18 years of conflict in Iraq and Afghanistan, U.S. troops injured in combat and moved to higher echelons of care were still at a high risk of developing post-injury infections. Wound infections can develop days following injury and are largely attributed to Gram-negative organisms acquired in the hospital setting (1). Pseudomonas aeruginosa is one of the most frequent causes of wound infections and can result in significant morbidity and mortality. A 2017 surveillance summary of P. aeruginosa infections in military treatment facilities reported 47.9% of P. aeruginosa infections were healthcare-associated cases and that none of the strains tested displayed 100% susceptibility to any antibiotic tested (2).

Moreover, in the present coronavirus disease 2019 (COVID-19) era, patients on mechanical ventilation due to the disease can become coinfected with hospital-acquired P. aeruginosa strains leading to ventilator-associated pneumonia (VAP). VAP is estimated to occur in 9-27% of all mechanically-ventilated patients (3), and colonization by hospital-acquired MDR strains carries a mortality rate up to 60% (4). Given the morbidity and mortality rates associated with drug-resistant infections of P. aeruginosa the desired output of this project will be a novel chemical matter prototype for further preclinical development, with utility to treat antimicrobial-resistant P. aeruginosa in wounds, traumatic injury, sepsis and/or VAP.

The development of an oral, injectable, and/or topical, small molecule therapeutic agent for the treatment of MDR P. aeruginosa infections in service members will provide a valuable therapeutic addition to the current standard-of-care in the Military Health System. The desired product will have efficacy against clinically-relevant, MDR strains of P. aeruginosa. The product will demonstrate effectiveness in in vivo bacterial infection models (e.g., thigh, wound, pneumonia, burn, trauma, sepsis). Activity against P. aeruginosa biofilms and/or antibacterial coverage of other priority pathogens such as Acinetobacter baumannii and Klebsiella pneumoniae is desirable, but not required. Corresponding in vitro and in vivo pharmacokinetics, pharmacodynamics, and toxicity profiles must be both developmentally and clinically acceptable for oral, injectable, and/or topical administration. Prototype compounds may include small molecules, peptidomimetics (both up to MW 1000), or peptides (up to MW 2000). We will not accept proposals for antibody, bacteriophage, nor vaccine solutions.

PHASE I: Phase I will center on defining a set of small molecules that are effective at inhibiting in vitro growth of MDR P. aeruginosa strains at low toxicity. The awardee should be able to demonstrate that the selected molecules perform similarly or better in vitro to current standard of care antibiotics in the treatment of MDR P. aeruginosa infections. Required Phase I deliverables will include 1) a practical chemical synthesis of small molecule antibiotic candidate compounds amenable to scale-up; 2) demonstration of in vitro efficacy against military-relevant, MDR strains of Pseudomonas aeruginosa to include minimum inhibitory concentrations (MICs); and 3) assessment of in vitro toxicity in relevant cell

lines.

PHASE II: Required Phase II deliverables will include 1) demonstration of in vivo efficacy equivalent or superior to current standard-of-care against military-relevant, MDR strains of P. aeruginosa in validated, clinically-relevant models of wounds, burns, sepsis and/or VAP. In vivo models must include at least one clinically-relevant, higher order animal species model of wounds, pneumonia, burns and/or sepsis for one of the small molecule solutions which successfully completed Phase I of this SBIR. Porcine models of wound infection, sepsis (peritonitis or intravascular infusion of live bacteria), and/or VAP is preferable, but any clinically-relevant models of these indications would be acceptable; 2) demonstration of safe and clinically-acceptable in vivo pharmacokinetics and pharmacodynamics profiles; 3) demonstration of an acceptable resistance profile following standard protocols; 4) demonstration of safety in acute toxicity and safety pharmacology assessments in a rodent species (non-Good Laboratory Practices [GLP]); 5) a plan for declaration as a preclinical candidate in order to proceed toward the assembly of an investigational new drug (IND) submission package in Phase III; 6) development of a safe, scalable, reproducible synthesis of the small molecule antibiotic candidate compound; and 7) development of a safe and clinically-acceptable formulation for the intended route of administration of said small molecule solution. An initial FDA regulatory plan should be submitted during Phase II.

PHASE III DUAL USE APPLICATIONS: The vision or end state for this product is FDA approval as a small molecule therapeutic agent for the treatment of patients with wounds and/or burns infected with MDR P. aeruginosa. Additionally, the product may also or alternatively be approved for the treatment of VAP and/or sepsis. Phase III will require the completion of a preclinical data package, to include preclinical toxicity assessment in a higher order species following Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP), for inclusion in an investigational new drug (IND) submission to the United States Food and Drug Administration (FDA) in order to commence clinical trials. A possible funding source for these studies and early clinical trials is the Joint Warfighter Medical Research Program (JWMRP) through the Joint Program Committee-2 (JPC-2) under the Congressionally Directed Medical Research Program (CDMRP), which offers focused support for early clinical testing of medical solutions. The Biomedical Advanced Research and Development Authority (BARDA) is an additional potential funding source as its focus is mainly on countermeasures for public health threats. A viable commercial technology transfer partner would be required to complete the full FDA-approval process. Potential commercial applications for this product include analogous applications, as mentioned above, in public, medical treatment facilities, as well as potential Gram-negative biothreat indications.

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KEYWORDS: Antibiotic, bacteria, Gram-negative, infection, resistance, therapeutic, COVID-19

DHA211-009 TITLE: Oxygen Generation for Deployed Army Casualty Care

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: To develop a lightweight device that generates medical grade oxygen for deployed medical facilities and personnel.

DESCRIPTION: The ability to deliver oxygen to patients requiring supplemental oxygen is an essential capability for deployed medical facilities that provide treatment primarily to combat casualties who incur traumatic injuries. The Army based its current oxygen generating capabilities on the American College of Surgeons trauma treatment guidelines, which recommended that all trauma patients receive oxygen at a rate of at least 10 liters per minute (L/m).1 To meet this high demand for oxygen, the Army developed its current centralized oxygen generating and distribution system that is extremely heavy, maintenance intensive and requires large dedicated generators to operate. These characteristics limit the organizations' mobility to support combat operations, and are incompatible with the austere, far-forward battlefield anticipated in multi-domain operations. Multiple studies strongly suggest that the actual oxygen requirements for trauma patients is much less that the 15 L/m previously recommended; they indicate that the majority of trauma patients may not need any supplemental oxygen to sustain adequate blood oxygen levels, 2, 3 and patients with TBI may be significantly harmed by hyperoxia. 4 Therefore, the Army plans to replace the current centralized oxygen production and delivery system with a system of individual oxygen generators that are distributed to individual patients throughout the facility. These devices would be lightweight devices that produce oxygen at a variable rate up to 5-6 L/m and would operate on standard 110/220 VAC power with an internal battery back-up that would enable the device to operate up to 4 hours without external power. The outflow of oxygen from two of these devices could be merged (stackable) to provide higher flows of oxygen for the 12-15% of trauma casualties and other patients whose oxygen requirements are above 6 L/m.5

PHASE I: Phase I will consist of designing schematics and diagrams along with limited testing of a prototype for a lightweight oxygen generating device that will produce a 90-95% purity medical grade oxygen at a continuous, variable rate of up to 6 L/m from ambient air. The device will be designed to operate effectively in a deployed setting that will include static, dismounted medical units as well as medical transport vehicles (ground and rotary-wing ambulances). Specific emphasis will be placed on portability, reliability, and design for the particular challenges of the battlefield environment (to include no- or low-light, loud or noise-discipline conditions, cramped space, extreme temperature environments, elevation, etc.) and use by all providers to include the combat medic. While the size, weight, power, and performance constraints will not be as rigid for a Phase I prototype, the ultimate goals for Phase II should be considered and attainable. Long-term need for stacking capability will be considered. Though water has been shown a viable feedstock for oxygen generation, water of adequate purity is a logistical constraint in the prolonged field care environment. However, possible alternative non-liquid feedstocks to transiently supplement the fundamental oxygen delivery capacity of the device are not excluded nor required (any hazardous byproducts must be mitigated). An argument for the approach chosen, to include recognized open questions in the literature, will be included.

PHASE II: This phase will consist of further development of a portable oxygen generating device demonstrating its utility, and validating the prototype(s) through relevant testing. During the first year, the prototype(s) will be tested in simulated environments (>40oC, <0oC, humidity > 90%, 10,000 ft elevation) in order to determine practical viability. The second year will involve refinement and more rigorous testing of the chosen design in contractor-arranged laboratory studies to determine purity of the oxygen produced and accuracy of flow rates. Testing and refinement will involve the device's adherence

to battlefield constraints; the device must be portable, lightweight (~2 kg), self-contained, have low power requirements (i.e. can operate continuously for 4 hours on a single battery), quiet (<45db), have stacking capability, and perform to all needed parameters concurrently. The phase II commercialization plans should include a regulatory plan for FDA clearance. The contractor would ideally identify appropriate potential commercialization partners (manufacturing, marketing, etc.) to facilitate technology transition.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR effort will have applicability to both civilian and military emergency medicine; for military application the contractor will coordinate with the US Army Medical Material Development Activity (USAMMDA) Warfighter Expeditionary Medicine and Treatment Office to maximize capability gap mitigation. Phase III will consist of finalizing the device design and delivering manufactured devices (in their final form) for military-relevant testing such as airworthiness/performance testing (e.g. Joint Enroute Care Equipment Test Standards [JECETS], AR 70-62) and FDA-related testing (e.g. oxygen purity, accuracy of flow rates, etc.) under design freeze. The device will be functional for use by medics, physician assistants, nurses, and physicians in far forward environments (roles 1-3 of care and ambulances). Phase III will also include developing and finalizing training methods and protocols for the new device. In addition, the regulatory package should be in its final form ready for submission to the FDA, including all relevant test data.

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KEYWORDS: Oxygen; oxygen generator; oxygen therapy; FDA; combat casualty care

DHA211-010 TITLE: DNA-encoded Antibody Gene Transfer for HIV Immunoprophylaxis or Maintenance Therapy

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: Development of a platform for DNA-encoded monoclonal antibody delivery in large animal models of HIV infection and a prototype delivery device for use in humans.

DESCRIPTION: U.S. military personnel are exposed to and impacted by the diverse global HIV epidemic. Despite advances in non-vaccine prevention, the US military experiences a steady epidemic of approximately 350 new HIV infection every year. Effective prevention and therapeutic modalities are of utmost importance in combatting HIV/AIDS in the DoD. The US Military HIV research program (MHRP) is engaged in collaborative research with multiple academic, corporate, and governmental partnerships to develop and test immunologic approaches to prevention and therapy.

Monoclonal antibodies have great potential for use in prevention and treatment for many infectious diseases including HIV. However, current approaches to monoclonal antibody delivery are limited by price and durability of effect. MHRP seeks to develop innovative ways by which broadly neutralizing monoclonal antibodies (mAbs) can be delivered to overcome these challenges. Delivery of gene encoded mAbs by electroporation (EP) is a potential approach. EP has been used in basic research for the past 25 years to aid in the transfer of DNA into cells in vitro. EP in vivo enhances transfer of DNA vaccines and therapeutic plasmids to the skin, muscle, tumors, and other tissues resulting in high levels of expression. EP delivery of vaccines has been demonstrated to induce immune responses in numerous pre-clinical animal models and in human clinical trials for many different infectious diseases and cancer. Delivery of gene-encoded antibodies differs from these active vaccination approaches in that it seeks to minimize immune response to mAb delivery. The method of delivery by using EP technologies and a device capable of delivering selected mAbs will be the desired end product for this effort.

PHASE I: The awardee will demonstrate the scientific, technical, commercial merit and feasibility of a platform technology that relies on delivery of DNA-encoded mAbs. Research could be built upon similar existing technology for other products such as DNA vaccines and therapeutic plasmids. Phase I will focus on technology conceptualization of DNA-encoded mAbs including performance parameters. The performer will develop rapid methods of delivery of DNA-encoded mAbs. These methods may include the administration of DNA via an intramuscular injection followed by very short electrical pulses (electroporation or EP) that enable the efficient uptake of the DNA by the muscle cells, leading to much higher levels of expression of the delivered genes than with an injection alone. MAb-encoding DNA should be delivered in a way that minimizes tissue perturbation, avoiding any immune responses and enabling stable, long-term gene expression. Upon completion of Phase I the awardee will have developed, demonstrated and validated the delivery method for DNA-encoded mAbs.

PHASE II: After successful completion of the Phase I, the awardee will focus on finalizing and refining delivery method and use the results from Phase I studies to optimize the capability of gene encoded mAb technology in small and large animal models. Phase II efforts will focus on developing methods for manufacture of the delivery device for clinical use. The awardee will develop and optimize large animal model for the evaluation of DNA/EP as their musculature permits the evaluation of a human-sized prototype EP device, their larger size and proportionally increased blood volume better mimics what would be observed in humans in terms of dilutional effects of muscle cell-produced mAb. Further the studies should be conducted to demonstrate proof-of-concept that therapeutically relevant serum mAb levels can be achieved in animal models with large blood volumes using human-sized prototype of EP

devices. The awardee will then design a prototype device that will be easy to use in delivering mAbs in clinical settings and/or field testing and ready for transition to manufacturing. The prototype specifications will be defined based on feedback from large animal data to meet the requirements of the delivery system in humans. An initial FDA regulatory plan should be submitted at this stage if appropriate to the product development effort.

Upon completion of Phase II of this project, the awardee will be able:

 (1) to develop, optimize and manufacture the desired EP device prototype for mAb gene transfer based on Phase I modeling and design. Conduct life cycle and environmental testing with the prototype.
(2) to develop processes and demonstrate feasibility of a large scale manufacturing of the EP device that can be ready for a future proof-of-concept clinical trial in human volunteers.

PHASE III DUAL USE APPLICATIONS: The expected Phase II end-state is qualified, easy to use device to deliver clinically relevant mAbs of interest. The awardee is expected to obtain funding from non-SBIR/STTR government sources and/or the private sector to develop or transition the prototype into a viable FDA-regulated product or service for sale in the military or private sector markets. The performer will provide data package plan required for application to the FDA after successful large field testing of the assay prototype.

For HIV applications, the technology and/or product generated from the Phase III SBIR may be integrated in MHRP's objective of developing broad spectrum and potent mAbs for prevention and treatment of HIV/AIDS. A potential method of transition for this product will be through the Army futures command following the decision gate process which includes a technology transfer agreement with U.S. Army Medical Materiel Development Activity (USAMMDA). In addition, civilian commercialization of this product is likely to include GLP production and GMP manufacture and distribution.

The end-state for this product is a commercially viable technology that will be incorporated into the Army's strategy of developing countermeasures against HIV/AIDS.

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KEYWORDS: Human Immunodeficiency Virus; Autoimmune diseases syndrome; vaccine; therapeutics; antibodies; electroporation; delivery; DNA

DHA211-011 TITLE: Advanced Blood Transportation Container

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: To develop a container or container system for transporting blood to and throughout the battlefield.

DESCRIPTION: Traumatic hemorrhage remains the leading cause of combat deaths, and rapid resuscitation with blood and/or blood products is necessary to restore volume, maintain hemostasis, and prevent coagulopathy and other morbidities.[1-3] Therefore, blood and blood products must be present at or near the battlefront.[4-7] To facilitate this rapid deployment of blood, inventories must be bolstered through transportation of blood and blood products from donation centers to forward locations. This need is not limited to theaters of war; maintaining blood bank inventories around the globe is critical, but as biologics, these products must be transported with proper cold chain maintenance in containers that can withstand arduous journeys and austere environments and can minimize breakage of storage bags for peak logistical efficiency.[8-11]

There are multiple points of potential failure: for instance, after a donation at a blood drive, blood must be packaged and transported to the blood bank where it is required to be tested, processed, and stored until laboratory results are obtained. Then, the blood must be inventoried, packaged, and sent to distribution. It must be maintained cold during shipment overseas (potentially with multiple stops) before receipt and storage at local facilities. Additionally, it must be maintained cold for in-country ground and air shipping to Role of Care 2 or 3 facilities (see [12] for descriptions of Army Roles of Care), at which it must be stored until used or until packaged for carrying by a medic prior to a high risk mission (Role of Care 1). At each step, temperature control is critical if blood is to remain in compliance with established standards; very little variance is allowed. Thus, along with the capability of maintaining these temperatures, a careful record demonstrating the unbroken cold chain is required. Development of a standardized low- or nopower advanced transportation container or container system for blood and blood products that will maintain the cold chain with confirmation and minimize breakage and waste is of critical importance. Specific emphasis should be placed on the following parameters: scalability for different Roles of Care, minimizing weight for each step of the transport process; stackability for usage on military aircraft; ruggedness and reusability justified by the relative cost; integrating or easily used temperature monitoring; size appropriate for required capacity (e.g., two 500 ml whole blood units for medic, 20-40 units at Role of Care 2); minimized power requirements; potential for integration into air, sea, and land vehicles including unmanned aerial systems; and cost must be reasonable versus current operational standards.

PHASE I: Phase I will consist of designing schematics and diagrams along with limited testing of technology to be used for a low- or no-power advanced transportation container or container system for blood and blood products, to include techniques for maintaining temperature over lengthy travel times (10+ days), descriptions for monitoring temperature with notification of excursions, and designs for protecting products from breakage. The device will be designed such that usage can be standardized across a variety of environmental factors. Specific emphasis will be placed on weight, stackability, ruggedness, temperature monitoring capability, capacity, power requirements, potential integration into vehicles including unmanned aerial systems, and cost. An argument for the approach chosen will be included.

PHASE II: This phase will consist of further developing the low- or no-power advanced transportation container or container system for blood and blood products, demonstrating its utility, and validating the

prototype(s) through relevant testing. During the first year, the prototype(s) should be demonstrated by the proposer in simulated temperature-controlled and vibration stress-controlled environments and/or in transportation to mimic expectations to determine practical viability. The second year will involve refinement and more rigorous testing of the chosen designs in simulated field tests. Testing and refinement will involve the devices' functionality within battlefield constraints; the devices must be portable, lightweight if intended for medic kit, stackable if intended for shipping, self-contained, have low or no power requirements, compatible with vehicles including unmanned aerial systems, and have planned production costs that are justifiable against current standards. The phase II commercialization plans should include a regulatory plan for FDA clearance if required.

PHASE III DUAL USE APPLICATIONS: The technology developed under this SBIR effort will have applicability to both civilian and military emergency medicine. Phase III will consist of finalizing the device design(s) and delivering manufactured devices (in their final form) for military-relevant testing (e.g. environmental, operational, etc.) and FDA-related testing (e.g. blood impact, validation, etc.). The device will be functional for use by blood bank personnel, logisticians, medics, physician assistants, nurses, and physicians in far forward environments (roles 1 and 2 of care). Phase III will also include developing and finalizing training methods and protocols for the new device(s). In addition, the regulatory package should be ready for submission to the FDA, including all relevant test data. The contractor should begin establishing relationships with appropriate commercialization partners (manufacturing, marketing, etc.) to facilitate technology transition.

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KEYWORDS: Blood transportation; blood container; cold chain; battlefield transfusion; trauma; hemorrhage; military transportation; unmanned aerial vehicles

DHA211-012 TITLE: Handheld Non-Contact Laser Ultrasound Medical Scanner

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: Design and build a non-contact Laser Ultrasound (ncLUS) imaging scanner in the form of a stand-alone lightweight handheld device. The acquired images are to be displayed in real- time using a handheld screen, archived and accessible for reviewing on demand in retrospective analyses.

DESCRIPTION: Ultrasound (US) imaging is a real-time medical imaging technique developed in the 1960's that involves the transmission and reception of high frequency (2-15MHz) sound waves (i.e. acoustic waves) via a piezoelectric transducer located in the US probe that is moved while in contact with the patient skin. US is able to show location and movement of internal organs and blood flow through vessels in the human body by using the amplitudes and travel times of the received reflected sound waves that are reconstructed into an image. This original 'conventional Ultrasound (US)' approach is limited by the attenuation of the acoustic waves by air. To yield acceptable image results, conventional US requires a coupling medium (gel/water) added between the US probe and the patient skin.

Laser Ultrasound (LUS) employs a completely different signal acquisition technology, with advantages for the battlefield, compared to conventional US. LUS uses the light of two low powered lasers transmitted through air to measure acoustic vibrations. It supports rapid use as it only needs to be moved above the patient, with no connecting medium required, no physical contact. This is advantageous in cases where skin contact is prohibited due to burns or, e.g. blast debris wounds. In contrast, conventional US requires contact of a probe with the patient surface accompanied by a contact medium.

ncLUS has recently been demonstrated by Zhang et.al. [1] who acquired in vivo human ultrasound images in a laboratory setting using experimental table-top optics. Zhang et.al. used 1540 nm pulsed source laser to deliver the optical pulses to excite acoustic waves on the tissue surface, and a 1550 nm continuous wave (CW) laser Doppler Vibrometer to measure returning acoustic vibrations on the tissue surface, 1m distant. The optical source for the reported LUS system minimizes tissue penetration, specifically to convert optical energy to acoustic energy at the tissue surface. LUS uses very low power laser light and does not use ionizing radiation, so it is very safe, and safe for eyes.

With an appropriate optical design and interferometry, any exposed tissue surfaces can become viable acoustic sources and detectors. Employing skin surface photoacoustic sources in combination with laser interferometric detection (i.e. an optical detector) generates image features in human studies shown by Zhang et.al. to be comparable to images acquired with a conventional US commercial imaging system. This project involves redesigning the ncLUS to have a compact, lightweight, portable format; a shirt-pocket-size handheld imaging scanner similar in size to a cellular phone, with visualization via a wired or wireless handheld screen. The back of the device would contain the scanning lasers. Sides of the device would have connected components, either hinged to flip down, or telescoping. These would assist operating the ncLUS to stand off the body surface as it is moved over the body surface. This project will necessitate innovative engineering. In this physical format, ncLUS can become a powerful asset to evaluate trauma and plan optimal treatment in cases of internal injury. Secondly, the ncLUS can provide a useful training device [2].

US, of all medical imaging modalities, has favorable use advantages which include: its reliance on nonionizing radiation; its real-time cine imaging capability; and, its ability to be built into portable systems having simple power needs (e.g. [3]). ncLUS's unique additional advantages are: no patient contact; potential for miniaturization; potential for fabrication using low cost solid state electronics; and, no
requirement for probes and gels whose use and availability at the POI may be problematic. US trauma imaging includes several standard US examination techniques: Focused assessment with sonography for trauma (FAST) examination - to screen for blood around the heart or abdominal organs; and, extended FAST (eFAST) - to detect pneumothorax, hemothorax, pleural effusion, or a foreign object. Military use [4] of portable conventional US (i.e. probe with US transducer, processor and screen, gels) in the field currently includes identifying blood in the abdomen, finding fractures, skin infections, and collapsed lungs.

PHASE I: The main goal of Phase I is a feasibility study in the development of a handheld ncLUS scanning device. Initially, to prove feasibility, a physical, electronics, optical and circuit design of the final handheld ncLUS product 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 ncLUS must have a form factor of approximately the width and height of a cell-phone, but may be slightly thicker. It should fit in a shirt breast pocket. Weight should be minimized. The physical design should also include fold-out sides or similar simple, easy to manipulate mechanism in order to provide the key separation between the handheld ncLUS and the body of the subject being scanned. The ncLUS should be designed to operate by battery for a minimum of one hour prior to battery recharging. The scanning device should contain an Android computer capable of performing the computations that reconstruct an image in near-real-time, i.e.>5 updates per second, from the acquired laser signals. This computer should also be able to transmit the images wirelessly or by wire to an external device for display, or use the native screen. Storage of images for replay and archiving should be accomplished using the device, and perhaps an external computer. Innovation is encouraged in each design aspect to create a lighter, more rugged, longer charged device. A second deliverable is a CAD computer model of the scanner, accompanied by a physical mock-up of the scanning device. A third deliverable is a description of the image acquisition and reconstruction methodology. This is necessary because of the innovative role of lasers in signal acquisition. A detailed software schematic must be produced to indicate the real- time computational path leading from the acquired laser signals as they are converted to greyscale image, and as the image is displayed. Specific existing software, or a plan to program new software, must be identified that can accomplish each step involved in the software path. All image data must be compliant with DICOM standards.

PHASE II: The overall objective of Phase II is to produce a fully operational prototype handheld ncLUS scanner in the specified form factor that can acquire human images in tests, archive and display the images on external devices, retrieve the images from the archive and redisplay them. The first goal of Phase II is to produce prototype hardware based on the electronics and optical design of Phase I. The emphasis should be focused on hardware integration and operation during this stage. This task will produce the first deliverable, a 2x or 4x size prototype of the ncLUS that acquires laser signals that can be observed on an oscilloscope. The prototype should initially adhere to the Phase I design except for its physical size. Testing of improvements and changes is then encouraged in order to take advantage of the state-of-the-art in electronics, computers, and optics. The signals should be acquired from an inanimate phantom at this early stage.

The next aim is to expand the emphasis to the programming and testing of software for the scanner. The aim of this stage is to produce a second deliverable that is a modified form of the first deliverable, except replete with fully operational software for the acquisition of laser signals, reconstruction of the greyscale images, and transmission of the images to an external handheld computer. Innovation in the transmission, storage and display of images is encouraged. All image data must be compliant with DICOM standards. This system and software should be tested extensively with inanimate phantoms. Power deposition must be demonstrated to not exceed FDA guidelines. Modifications to the electronics, optics and/or acquisition

function should be made at this point. Next, the focus should shift to the production of a fully functional prototype ncLUS scanner in the desired form factor, complete with the computer software needed to perform signal acquisition and all functions for display, archiving and retrieving the acquired images. This scanner should be demonstrated to acquire human images, under an IRB-approved research protocol. One fully functional prototype will constitute the third deliverable, accompanied by validation test reports and other relevant reports and designs. Provide an FDA regulatory plan to illustrate the pathway to clearance.

PHASE III DUAL USE APPLICATIONS: Develop training software, sample input and manuals for the system. Due to the device's small size and likely modest price, the main target for the product is the mass commercial market, i.e. primary care physicians, clinics, and EMT use. The contractor should refine and implement their regulatory strategy for obtaining FDA approval of their technology for use as an US device based on their initial FDA feedback. This phase should culminate in submission to the FDA of the developed technology for approval. In conjunction with FDA submission, the contractor should develop scaled up manufacturing of the technology that follows FDA quality regulations. In addition, the work may result in technology transition to an Acquisition Program managed by the Service Product Developers. The contractor can also propose use to the Services. Utility would be enhanced if the device was easily able to transmit images from phone internet application(s), enabling teleradiology and potentially integrate with artificial intelligence. The ability to provide a non-contact ultrasound device to the battlefield space will enable better visualization of injuries without the need to remove clothing and protective gear before it's necessary to treat.

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KEYWORDS: Laser, ultrasound, handheld, scanner, imager, medical imaging, portable, non- contact

DHA211-013 TITLE: Body-Conformal Terahertz Medical Imager

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: Design and build a Terahertz (THz) medical imager in the form of a small, flexible, layered rectangular blanket, with internal functional components, that can be wrapped around the torso of a wounded patient and provide images of internal anatomy.

DESCRIPTION: THz radiation has a potentially game-changing role in military medical imaging because emerging technology offers the possibility to create portable, lightweight flexible THz imagers. THz radiation has frequencies in the range 0.3-30 THz (1 THz = 1012 Hz), with wavelengths in the range 1 mm (below microwave) to 0.1 mm (above infrared). THz waves can penetrate clothing, among other solid objects, and are now used in some airports to scan passengers and detect dangerous items. THz radiation is an advantageous electromagnetic frequency band for medical imaging due to its low probability of causing tissue damage, since low energy THz photons are non- ionizing and are strongly absorbed by water. THz radiation can produce extremely high resolution images, and is able to image subtle tissue differences due to its high sensitivity to water content.

Previously, technical issues prevented construction of practical THz medical imagers. Recently, though, several critical technology advances in THz transmitters and detectors have appeared in the literature. These advances include flexible terahertz detectors using nanotube [1] and graphene [2] and nanowire technologies [3], and a flexible terahertz transmitter [4] using nanoscale technology. In combination, these technologies make it possible to design a flexible, lightweight, portable THz medical imager. One can envision that such an imager can be easily carried and used in many situations to provide imaging capability [5,6]. The THz imager may provide medical images that can reveal acute traumatic injury, e.g. organ damage, internal bleeding, imbedded objects. THz imaging methodology challenges still exist. Scientists have devised a number of methods to extract biomedical information using different forms of THz imaging, as reviewed in [6]. THz phase contrast imaging seems the most successful [6] for biomedical imaging since it offers information about interior density, while absorption techniques are limited to surface imaging due to the strong water absorption of THz waves.

This project involves designing a THz imager in the form of a lightweight flexible blanket-like cover composed of a 'sandwich' of fabric or flexible plastic, and transmitter and detector components. Imaginative design is encouraged, to minimize weight, increase signal-to-noise ratio (SNR), and guarantee robustness in demanding conditions. The imager is to be sized 60 cm long x 100 cm wide to wrap and provide medical images from the torso, showing internal organs. Smaller prototypes can be used in testing. Image reconstruction and display should occur on a handheld computer or IVAS (Integrated Visual Augmentation System) goggles. The THz imager has value in primary care, trauma care, and image-guided interventions. This project involves much innovation and state-of- the-art science, but the THz imager product has the potential to open up a new field and business in medical imaging. Military applications of the imager for trauma care also exist, presenting special challenges particularly in the rapid assessment of internal injuries and hemorrhage, and medical monitoring.

PHASE I: The main goal of Phase I is a feasibility study in the development of a flexible THz imaging device. To prove feasibility, a physical, electronics, and circuit design of the flexible THz imager product should be completed as the first deliverable. The electronic and circuit designs should include the latest in scientific components for THz transmitter and detector. It must be shown in the feasibility study that the THz imager can be fabricated. Battery power should accommodate two hours of use prior to recharging and comply with Army field battery usage. An added benefit would come from the computer simulation

of the first deliverable showing expected operation. Subcontractor(s) should be identified and give written proof of abilities and cooperation if component construction is out-sourced. The second deliverable is the physical design of the imager. The physical design of the THz imager must accommodate the scientific and technical elements identified in the first deliverable. Component costs may limit the size of the demonstration product. The THz imager must be a lightweight flexible blanket-like cover composed of, for example, a 'sandwich' of transmitter and detector components sealed within a rugged flexible plastic or synthetic fabric cover. It must have a disposable sterilized cover or be able to be easily cleaned and sterilized. A good example is a flexible MRI receiver coil. Imaginative design and fabrication ideas are encouraged. The imager must be able to operate under normal environmental conditions but it would be an added plus if the product could be designed to operate under extreme temperature conditions experienced by the military (see [7]). The third deliverable is the technical design of the data acquisition – that is, the data acquisition methodology, image reconstruction, filtering options, display, image transmission and archiving using DICOM format. The imaging methodology must be robust and efficient, e.g. THz phase contract imaging that can acquire and display internal anatomy, i.e. organs, tissue and vessels. The imaging methodology must be designed for power deposition within FDA guidelines. Subsequent signal processing steps must be identified or designed. Image reconstruction, filtering, and display should occur on an Android handheld computer or IVAS goggles. The handheld computer must be capable of performing the image reconstruction computations at a rate of approximately 1 image per second or faster if possible, from the acquired data. This computer should also be able to transmit the images by wire or wirelessly to an external device.

PHASE II: The overall objective of Phase II is to produce a fully operational prototype of the flexible THz imager, scaled in size, that can acquire in vivo human images in tests, archive and display the images on external devices, retrieve the images from the archive and redisplay them. Experimental proof of power deposition will be required to show compliance with FDA guidelines. The first goal of Phase II is to produce scaled prototype imager hardware based on the design of Phase I. The emphasis should be focused on hardware integration and operation during this stage. This task will produce the first deliverable, a prototype of the THz imager that acquires signals from an inanimate phantom that can be observed on an oscilloscope. Testing of improvements and changes is then encouraged in order to take advantage of the state-of-the-art in electronics, computers and other components of the prototype. Next the focus should be expanded to the programming and testing of software for the imager operation, data acquisition and image reconstruction. Produce a second deliverable that is a modified form of the first deliverable, except replete with fully operational software for transmission, detection, and reconstruction of 2D projection greyscale images, and, if possible, 3D tomographic image data (i.e. signals containing depth information). Demonstrate transmission of the images to an external handheld computer and IVAS. The third and final deliverable is the (perhaps modified) prototype THz imager, with handheld computer and all software needed for operation, used to acquire in vivo images from a human limb and torso. Images should be acquired under an IRB-approved research protocol. The fully functional prototype should be accompanied by validation test reports and other relevant reports and designs. Document and deliver a proposed regulatory strategy. Initiate pre-submission discussions with the FDA regarding approval for use. Deliver an FDA proposed regulatory strategy, and a manufacturability plan.

PHASE III DUAL USE APPLICATIONS: Develop software, sample input and manuals for the imager so that it can be disseminated to medical professionals and training provided for its use. Due to the imager's flexibility, portability and (likely) ease of use, private sector commercial potential can be initially directed at facilities and medical professionals lacking available standard Radiology modalities. The contractor should refine and implement their regulatory strategy for obtaining FDA approval of their technology for use as medical imaging device based on their initial FDA feedback. This phase should culminate in submission to the FDA of the developed technology for approval. In conjunction with FDA submission, the contractor should develop scaled up manufacturing of the technology that follows FDA quality regulations. In addition, the work may result in technology transition to an Acquisition Program managed

by the Service Product Developers. The contractor can also propose use to the Services. Utility would be enhanced if the device was easily able to transmit images from phone internet application(s), enabling teleradiology.

REFERENCES:

- 1. D. Suzuki, S. Oda, Y. Kawano, A flexible and wearable terahertz scanner, Nature Photonics, 10, 809-813 (2016).
- 2. X. Yang, A. Vorobiev, A. Generalov, M. A. Andersson, J. Stake, A flexible graphene terahertz detector, Appl. Phys. Lett. 111, 021102 (2017);
- K. Peng, D. Jevtics, F. Zhang, S. Sterzl, D.A. Damry, M.U. Rothmann, B. Guilhabert, M.J. Strain, H.H. Tan, L.M. Herz, L. Fu, M.D. Dawson, A. Hurtado, C. Jagadis, M.B. Johnston, Three-dimensional cross-nanowire networks recover full terahertz state, Science 368, 510-513 (2020).
- 4. M. Samizadeh Nikoo, A. Jafari, N. Perera, M. Zhu, G.Santoruvo, E. Matioli, Nanoplasmaenabled picosecond switches for ultrafast electronics, Nature, 579, 7800, 534-539, Mar 25 2020.
- 5. M. Jacoby, Medical Imaging Turns to Oft-Neglected Part of Light Spectrum, Chemical & Engineering News 93(44), 10-14 (2015).
- 6. M. Wan, J. Healy, J.T. Sheridan, Terahertz phase imaging and biomedical applications. Optics and Laser Technology 122, 1-12 (2020).
- 7. Department of Defense Test Method Standard: Environmental Engineering Considerations and Laboratory Tests (15-APR-2015) MIL-STD-810G.

KEYWORDS: Terahertz, non-ionizing radiation, imager, flexible, non-invasive, wrap-around, medical imaging

SBIR 21.1 DEFENSE LOGISTICS AGENCY (DLA) SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

Proposal Submission Instructions

GENERAL

The Defense Logistics Agency (DLA) implements, administers, and manages the SBIR/STTR Program as part of the Small Business Innovation Programs through DLA J68 Information Operations / Research, and Development (R&D) Division. Consult the program website at the following location: <u>http://www.dla.mil/SmallBusiness/SmallBusinessInnovationPrograms</u> for general information about the DLA SBIP Program and its mission. If you have any questions regarding the administration of the Program, please contact the DLA SBIR Program Manager (PM):

Denise Price email: DLASBIR2@dla.mil

TECHNICAL QUESTIONS

For questions regarding the SBIR/STTR topics during the pre-release period, contact the Topic Technical Point of Contact (TPOC) listed for each topic on the DSIP website at <u>https://www.dodsbirsttr.mil/submissions/login</u> prior to the close of the pre-release. To obtain answers to technical questions during the open period; submit your questions through the online DSIP Topic Q&A System <u>https://www.dodsbirsttr.mil/submissions/login</u>.

For general inquiries or problems with electronic submission, contact Department of Defense (DoD) SBIR Help Desk at <u>DoDSBIRSupport@reisystems.com</u> or 703.214.1333 between 9:00 am and 5:00 pm ET.

PHASE I KEY DATES The Dates and times on <u>https://www.dodsbirsttr.mil/submissions/login</u> are official. Complete proposal must be submitted on or before the date published in the DoD 21.1 SBIR BAA.

PROGRAM BROAD AGENCY ANNOUNCEMENT (BAA) 21.1

PHASE I GUIDELINES

DLA is committed to improving the time to award new projects. As such, all DLA Phase I topics are subject to pilot efforts intended to meet legislative goals.

A list of the topics currently eligible for proposal submission is included in the Topic Index, followed by full topic descriptions. Additional guidance is as follows:

- Proposal period of performance should follow the guidelines listed in the topic.
- Proposal Cost Estimates are topic dependent, and each topic has a specified ceiling.
- Phase I proposals may not exceed the 20-page limit.
- Volume 5 Proposal attachments, appendices, or references are not included in the Page count.
- Volume 6 FWA Training Certificate is required for proposal submission
- Notification of selection and non-selection occurs electronically via e-mail (NLT 15 Jan 2021).

For detailed proposal submission guidance, refer to U.S. Department of Defense (DoD) Instructions 21.1 SBIR at: <u>https://www.dodsbirsttr.mil/submissions/login</u>

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 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 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 <u>not</u> 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. The DLA Page Limit is 20 Pages, anything beyond 20 pages will not be evaluated.
- (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) site 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 3.5 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 according to the <u>Cost Breakdown Guidance</u>. 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:
 - 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 principal investigator 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 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 Guidance 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.

- (1) List all key personnel by name as well as by number of hours dedicated to the project as direct labor.
- (2) 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.
- (3) Cost for travel funds must be justified and related to the needs of the project.
- (4) 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.
- (5) A Phase I Option (if applicable) should be fully costed separately from the Phase I (base) approach.
- (6) 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. Enter this information in the Explanatory Material section of the on-line cost proposal form. The Supporting Documents Volume (Volume 5) 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 <u>http://www.dcaa.mil</u>. Click on "Guidance" and then click on "Audit Process Overview Information for Contractors".

e. Company Commercialization Report (Volume 4)

CCR is required to be submitted with proposals in response to DLA 21.1 SBIR topics. Please refer to the DoD 21.1 SBIR BAA for full details. No Commercialization Achievement Index

(CAI) will be generated.

f. Supporting Documents (Volume 5)

Volume 5 is provided for small businesses to submit additional documentation to support the Technical Volume (Volume 2), and the Cost Volume (Volume 5).

Documents that are acceptable and may be included in Volume 5 are:

- 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

Refer to the Component-specific instructions for Volume 5 requirements.

g. 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 21.1 SBIR BAA for full details.

PHASE II GUIDELINES

Phase II eligibility is based on the following guidance:

- All Phase I awardees may submit a Phase II proposal without invitation.
- Proposal period of performance not to exceed 24 months, follow the guidelines listed in the original Phase I Topic
- Volume 2 of Phase II proposals may not exceed the 40-page limit.
- Volume 5 Proposal attachments, appendices, or references are not included in the Page count.
- Commercialization Strategy Requirements:
 - Business Case highlighting benefits to the DoD/DLA.
 - Transition Strategy and Key Tasks
 - o Time-Phased Transition Plan
 - Projected Transition Cost Analysis

DLA Phase II proposals must follow the detailed proposal submission guidance in the original Phase I BAA. Refer to DoD Instructions at <u>https://rt.cto.mil/rtl-small-business-resources/past-announcements/</u>

Phase II Proposal format is the same as Phase I with the exception of the page limit in Volume 2. The Phase II Limit is 40 pages.

EVALUATION CRITERIA

Phase I see Section 6 in the OSD BAA Phase II see Section 7 in the OSD BAA

TECHNICAL AND BUSINESS ASSISTANCE (TABA)

The DLA 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.

DELIVERABLES / REPORTS

All DLA SBIR and STTR awardees are required to submit reports in accordance with the deliverable schedule. The recipient must provide all reports to the individuals identified in Exhibit A of the contract. Milestones: Each phase of the project will be milestone driven. The Principal Investigator will propose milestones prior to starting any phase of the project.

Phase I Proposals should anticipate a combination of any or all of 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
- The TPOC and PM will determine a meeting schedule at the PAC. Phase I awardees can expect Monthly (or more frequent) Project Reviews C)
- 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)
- Phase II Proposal is optional at the Phase I Awardee's discretion (as Applicable)
- Applicable Patent documentation
- Other Deliverables as defined in the Phase I Proposal

Phase II Proposals should anticipate a combination of any or all of 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.

PRE-RELEASE COMMUNICATION: During the pre-release period it is highly recommended that applicants communicate with the Technical Points of Contacts (TPOCs) provided in this topic. Best method of scheduling the dialogue is via e-mail.

DLA 21.1 SBIR Phase I Topic Index

DLA211-002	Lubricating Oil Study
DLA211-003	Alternative to Single Use Plastic Packaging
DLA211-004	Research and Testing of Artificial Intelligence (AI) at Defense Logistics Agency (DLA) Distribution Center Warehouse
DLA211-005	Recycling and Reuse of Powders, Test Specimens, and Scrap Materials in Additive Manufacturing

DLA211-002 TITLE: Lubricating Oil Study

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): 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 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: Due to thermal, physical, chemical and oxidative stressors, in-service lubricants may undergo a variety of changes, possibly causing it to exceed specification limits and negatively impacting lubrication performance for various engine applications.

Although this may be typical for in-service lubricating oils, we are starting to see a slight uptick in recently procured lubricating oil going off-spec, while in Storage tanks (during a duration of 6 months or less). Physical test properties, such as Foaming Characteristics (ASTM D892), Demulsibility (ASTM D1401), Appearance (ASTM D4176), and Moisture Content (ASTM D6304) are valuable quality measures that are impacted by additive packages.

In an effort to understand, screen, prevent and/or mitigate premature degradation of lubricating oil, there is interest in studying lubricating oil additive packages, its effectiveness and impact on oil properties (i.e., foaming, demulsibility, moisture content, etc.), and an initiative to determine if there are causal analysis steps the end user can implement to bring LTL products back on-spec.

The overall goal of this study is to prevent product replacement. The interim goal is to build a "fingerprinting" profile database on the MIL-PRF-17331 commodity for future characterization of the LTL lubricating oil.

DESCRIPTION: The goal of this study will be two-fold:

1 Monitor lubricating oil physical test properties, per its relevant specification (i.e., MIL-PRF-17331), as a function of shelf-life time, contaminant intrusion, and additive concentration.

2. Build a lubricating oil Fourier Transform Infrared Spectroscopy (FTIR) library, to monitor and screen lubricating oil conditions, and to establish correlative data between IR spectra and physical test properties.
Specification: MIL-PRF-17331, Steam Turbine Lubricating Oil

o Test Plan

- " Lab Participation (i.e., Quality Test Labs, R&D Lab, JOAP Lab, etc.)
- " Data Repository (i.e., historical data, Refinery data, spectroscopy library creation, etc.)
- " Instrumentation Info (i.e., Type, Model, etc.)
- " Test Methods (TM)
- o Sample Plan (on select Batches/Lots)
 - " Refinery Retain Sample
 - " Truck Retain Sample
 - " Tank Receipt Sample
 - " Tank Storage Sample (1-month, 3-month, or 6-month)
 - " In-Service Lube Sample (Used Oil sample -NAVSEA, JOAP)

PHASE I: The intent of PHASE I is to establish a baseline with the Refinery Retain Sample. Measure and correlate the physiochemical properties and spectroscopy properties (as a function of time and/or sample location) of the Refinery Sample from production to end use (ideally).

· Plan

- o Correlation Study, Plan A:
 - " Refinery data vs Lab test data
 - Refinery provide additive package data. Check mfr. proprietary restrictions
 - SBIR Test Lab(s) provide physiochemical properties of the finished lube & additive concentration via spectroscopy (IR, MS, etc.)
- o Correlation Study, Plan B:

Test data

- SBIR Test Lab(s) provide physiochemical properties of the finished lube & additive concentration via spectroscopy (IR, MS, etc.)
- Sample Batch/Lot (Traceability, Sample Location)
- Refinery sample, Truck Retain, Tank Receipt, Tank Storage (In-Service Lube, if traceable from production to end use)
- o Additives to Monitor (examples)
 - " Oxidation Inhibitors
 - " Anti-foam agents
 - "Anti-wear agents
 - "Viscosity Index improvers

o Physiochemical Properties (examples)

- " Foaming
- " Demulsibility

" Total Acid Number (TAN)

" Total Base Number

PROJECT DURATION and COST:

PHASE I: NTE 12 Months \$150K- Base NTE \$100K base 6-9 Months, - Option 1 NTE \$50K base 3-6 Months

PHASE II: - NTE 24 Months \$1.6M - Base 12-18 months, \$1M Option 6 Months NTE \$.6M

PERIOD OF PERFORMANCE: The phase one period of performance is not to exceed 12 months total. Options are not automatic. Approval is at the discretion of the DLA SBIP Program Manager. The decision is based on Project Performance, Priorities of the Agency, and/or the availability of funding.

PHASE II: The Phase II proposal is optional for the Phase I awardee. Phase II selections are based on Phase I performance, Priorities of the Agency and available funding.

The intent of Phase II is to build a lubricating oil Fourier Transform Infrared Spectroscopy (FTIR) library, to monitor and screen lubricating oil conditions, and to establish correlative data between IR spectra and physical test properties.

The expectation of Phase II is the development of a working lab prototype (TRL 6) and a demonstration of your proposed solution.

PHASE III DUAL USE APPLICATIONS: No specific funding is associated with Phase III. The successful awardee must plan to deliver a fully functional product to DLA Energy and NAVAIR

COMMERCIALIZATION: The firm 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.

DLA - 11

REFERENCES:

Product Specification: MIL-PRF-17331L(SH): LUBRICATING OIL, STEAM TURBINE AND GEAR, MODERATE SERVICE

• Applicable product grade: Industrial Oil, Steam Turbine (LTL)

Applicable Test Methods:

- ASTM D892 Foaming Characteristics of Lubricating Oils
- ASTM D1401 Water Separability of Petroleum Oils and Synthetic Fluids
- ASTM D4176 Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)
- ASTM D6304 Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration

KEYWORDS: MIL-PRF-17331, LTL lubricating oil

DLA211-003 TITLE: Alternative to Single Use Plastic Packaging

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): 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 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: Develop and promote solutions and alternatives to single use plastic packaging. With the European Union (EU) enacting a ban on the import of items with plastic packaging, alternatives materials need to be identified and tested.

DESCRIPTION: Defense Logistics Agency (DLA) Troop Support (TS) Subsistence topic of interest is research focused on finding alternatives to single use plastic packaging for military customers Outside of the Continental United States (OCONUS). Disposal of single use plastics packaging as well as the amount of waste generated by this packaging is a major aspect leading to the EU taking action. This research project shall involve identifying alternative packaging:

1. That is environmentally friendly upon disposal

2. Preserves the shelf-life of the item(s) in the packaging

3. Provides security against tampering or altering the product in the packaging

4. Reduces the US environmental footprint in OCONUS by decreasing the amount of single use packaging in landfills

PROJECT DURATION and COST:

PHASE I: NTE 12 Months \$150K- Base NTE \$100K base 6-9 Months, - Option 1 NTE \$50K base 3-6 Months

PHASE II: - NTE 24 Months \$1.6M - Base 12-18 months, \$1M Option 6 Months NTE \$.6M

PERIOD OF PERFORMANCE: The phase one period of performance is not to exceed 12 months total. Options are not automatic. Approval is at the discretion of the DLA SBIP Program Manager. The decision is based on Project Performance, Priorities of the Agency, and/or the availability of funding.

PHASE I: The research and development goals of Phase 1 are to provide Small Business eligible Research and Development firms the opportunity to successfully demonstrate how environmentally friendly packaging or natural alternatives can reduce costs to DLA. The Vendor should identify and propose new types of environmentally friendly packaging. The Vendor should also propose how the packaging will preserve and protect the food product as well as how the qualities of the materials will not contribute to landfills or harm the environment upon disposal.

At the end of Phase I, a final report defining the proof of concept is required.

PHASE II: Based on the research and development results of Phase 1, the goals of Phase 2 will emphasize the testing and evaluation of various packaging alternatives. The testing and evaluation may occur at a location in the Continental United States (CONUS) and Outside Continental United States (OCONUS) with an emphasis on the issues faced in OCONUS with regard to the ban established by the European Union (EU). Testing locations will be mutually agreed upon by DLA Troop Support Subsistence, DLA Troop Support Europe & Africa (E&A) and the vendor.

The Vendor should discuss research and development efforts of Phase I and Phase 2 in the technical proposal as well as the proposed cost in Phase II.

The expectation of Phase II is the development of a working lab prototype (TRL 6) and a demonstration of your proposed solution.

PHASE III DUAL USE APPLICATIONS: At this time, no specific funding is associated with Phase 3. Develop a plan for moving the prototype into an operational environment. Progress documents from Phase 1 and Phase 2 should result in a vendor's qualification as an approved source of alternative packaging in future procurements.

COMMERCIALIZATION: The vendor will pursue commercialization of the various processes and technologies associated with the alternative packaging methods identified and/or developed during earlier phases as well as potential commercial sales of any parts or other items

REFERENCES:

- 1. Department of Defense Food Service Program (DFSP). https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodm/133810m.pdf?ver=2019-08-26-085742-383. December 2, 2014.
- Defense Material Disposition: Disposal guidance & Procedures. https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodm/416021_vol1.pdf?ver=2019-10-02-080613-750. October 22, 2015.

KEYWORDS: Environmentally friendly, Bio-degradable, Alternative materials, non-plastics

DLA211-004 TITLE: Research and Testing of Artificial Intelligence (AI) at Defense Logistics Agency (DLA) Distribution Center Warehouses

RT&L FOCUS AREA(S): Artificial Intelligence/ Machine Learning

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 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: Develop an innovative Artificial Intelligence (AI) solution with a state-of-the-art capability that operates within the DLA Distribution Warehouse environment. The warehouse AI system may use various sensors (e.g., Internet of Things (IoT)) where applicable. It should minimize the need for infrastructure modifications to enable an artificial intelligence system within the warehouse environment. The goal of this objective is for the vendor to develop a capability for a warehouse AI system that addresses the requirements for integration with a Warehouse Management System (WMS) and a Warehouse Execution System (WES) as specific warehouse infrastructures dictate. This capability will provide for the seamless execution of AI and interactions with Smart Warehouse systems such as 5G Networks, IoT Sensors, Blockchain technology, Quantum Computers, and Machine Learning (ML).

The state-of-the-art AI solution must integrate into the existing warehouse communications systems to communicate with WES systems when installed. This integration allows Autonomous Guided Vehicles, Autonomous Mobile Robots (AMRs), Robotic Arms, IoT Sensors to receive tasking in an automated fashion to operate frequently and report success or failure at tasking. In support of routine warehouse operations, this research seeks to identify and test AI technology that can be used uninterruptedly and continuously within the DLA Distribution Warehouse environment. This research effort addresses DLA identified cybersecurity requirements through the test and evaluation of government security controls. It leverages current technologies in the AI industry. This research project will operate in locations at designated DLA Distribution Centers in the United States.

DESCRIPTION: Defense Logistics Agency (DLA) Distribution Modernization Program (DMP) topics of interest are research focused on a Continental United States-based Artificial Intelligence (AI) solution in support of the routine warehouse operations. This research project will involve the use of Commercial/Industry AI technology that can meet the demands of warehouse operations, can be integrated with autonomous warehouse vehicles, robots, and warehouse communications, and be integrated with warehouse navigation systems, 5G Networks, IoT Sensors, Quantum Computing architecture, and warehouse based Machine Learning (ML) that:

1. Support a joint effort between DLA Research and Development (R&D) and DLA J4 Distribution Headquarters to conduct research and test a warehouse AI system that works with various autonomous platforms, 5G Networks, IoT Sensors, Quantum Computing systems, and ML applications during warehouse operations.

2. Significantly addresses the AI capabilities of AI within a distribution warehouse operations environment.

3. Features an AI system able to implement high precision data for regular use in warehouse operations.

4. Can be integrated into warehouse communications systems such as a WMS or a WES to receive tasking and report status.

5. Demonstrates a state-of-the-art operational capability when operating within the distribution warehouse environment through the application of AI technology and facilitates a robust communications network technology used in a working environment shared with warehouse workers.

6. It is a reliable and robust technology solution that allows DLA Distribution Warehouses to perform automated tasks without significantly lower operating speeds per existing industry trends.

7. Demonstrates compatibility with a Government data cloud environment to store and retrieve warehouse-generated data without relying on a separate commercial data cloud environment to navigate successfully.

8. Conclusively demonstrates the use of new AI technology and concepts for application and integration in the distribution and delivery of material and goods during representative distribution warehouse operations in an innovative way.

PROJECT DURATION and COST:

PHASE I: NTE 12 Months \$150K- Base NTE \$100K base 6-9 Months, - Option 1 NTE \$50K base 3-6 Months

PHASE II: - NTE 24 Months \$1.6M - Base 12-18 months, \$1M Option 6 Months NTE \$.6M

PERIOD OF PERFORMANCE: The phase one period of performance is not to exceed 12 months total. Options are not automatic. Approval is at the discretion of the DLA SBIP Program Manager. The decision is based on Project Performance, Priorities of the Agency, and/or the availability of funding.

PHASE I: Perform a design study to determine how to use artificial intelligence to optimize DLA Distribution Warehouse operations, sustainment, and logistics support. Deliver a final design of AI's capabilities, a simulation model of DLA Distribution assets, and a demonstration of an AI-infused model capable of making intelligent trade-off decisions to meet specified PM requirements. A successful design will optimize support, minimize DLA Distribution Warehouse system downtime, and maximize system availability, using logistics inputs (component failure rates, shipping times, repair times, maintenance man-hours, and warehouse staffing).

The research and development goals of Phase I provide Small Business eligible Research and Development firms the opportunity to successfully demonstrate how their proposed warehouse AI concept of operations (CONOPS) improves the distribution of goods and materials within the DLA distribution enterprise and effectively lessens the time to provide needed supplies to the Warfighter. The selected vendor will conduct a feasibility study to:

1. Address the requirements described above in the Description Section for warehouse AI operations.

2. Identify capability gap(s) and the requirement for DLA to use AI in the DLA Distribution Operations environment.

3. Develop the vendor's Concept of Operations (CONOPS) to utilize warehouse AI and describe clearly how the requirements develop from it.

Note: During Phase I of the SBIR, testing is not required.

The vendor must create a CONOPS for Warehouse AI in support of both routine and wartime distribution warehouse operations. The concept of operations will cover the utilization of artificial intelligence within distribution warehouses during routine procedures, describing precisely all operational requirements as part of this process. This artificial intelligence requirement intends to operate inside distribution

warehouses successfully.

The deliverables for this project include a final report, including a cost breakdown of courses of action.

PHASE II: Based on the research and the concept of operations developed during Phase I, the research and development goals of Phase II emphasizes the execution of the Warehouse AI system following the typical DLA Distribution Warehouse concept of operations for materiel handling. During Phase II, the vendor will:

1. Address the specific user requirements, functional requirements, and system requirements as defined and provided by DLA.

2. Develop a prototype Warehouse AI system for Developmental Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E).

3. Implement government cybersecurity controls in the prototype design and secure all necessary cybersecurity certifications to operate the equipment in the DLA warehouse environment with DOD cloud connections.

4. Design the prototype equal to the technology maturity of Technology Readiness Level (TRL) 9 after Phase II.

5. Deliver a final Distribution Warehouse AI prototype system to DLA capable of successfully executing the operational concepts established in the Phase I CONOPS.

The DLA Warehouse Artificial Intelligence system will operate across the United States at various DLA Distribution Center sites mutually agreed upon between DLA R&D and DLA Distribution HQ. This project's deliverables include a final report, including a cost breakdown of courses of action (COAs).

PHASE III DUAL USE APPLICATIONS: PHASE III: Dual Use Applications: At this point, there is no specific funding associated with Phase III. During Phase I and Phase II, the progress made should result in a vendor's qualification as an approved source for a Warehouse Artificial Intelligence system and support participation in future procurements.

COMMERCIALIZATION: The manufacturer will pursue the commercialization of the Warehouse Artificial Intelligence (AI) technologies and designs developed to apply to the warehouse environment. The processes developed in preliminary phases and potential commercial sales of manufactured mechanical parts or other items. The first path for commercial use will be at DLA's twenty-six Distribution Centers and twenty Disposition Centers. When fielded, DLA estimates 20 - 26 units, but the number of units could be more.

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- 2. Andrew G Howard, Menglong Zhu, Bo Chen, Dmitry Kalenichenko, Weijun Wang, Tobias Weyand, Marco Andreetto, and Hartwig Adam. Mobilenets: Efficient convolutional neural networks for mobile vision applications. arXiv preprint arXiv:1704.04861, 2017.
- 3. Chunyuan Li, Heerad Farkhoor, Rosanne Liu, and Jason Yosinski. Measuring the intrinsic dimension of objective landscapes. Proceedings of ICLR, 2018.
- Devansh Arpit, Stanisław Jastrz, ebski, Nicolas Ballas, David Krueger, Emmanuel Bengio, Maxinder S Kanwal, Tegan Maharaj, Asja Fischer, Aaron Courville, Yoshua Bengio, et al. A closer look at memorization in deep networks. In International Conference on Machine Learning, pp. 233–242, 2017.

- 5. Kaiming He, Xiangyu Zhang, Shaoqing Ren, and Jian Sun. Deep residual learning for image recognition. In Proceedings of the IEEE conference on computer vision and pattern recognition, pp. 770–778, 2016.
- Min, Hokey. (2010). International Journal of Logistics 13(1):13-39, "Artificial intelligence in supply chain management: Theory and applications." February 2010. DOI: 10.1080/13675560902736537
- 7. Misha Denil, Babak Shakibi, Laurent Dinh, Nando De Freitas, et al. Predicting parameters in deep learning. In Advances in neural information processing systems, pp. 2148–2156, 2013.
- 8. Rosienkiewicz, Maria. (2013). "Artificial Intelligence Methods in Spare Parts Demand Forecasting. Logistics and Transport." 2013.
- Song Han, Jeff Pool, John Tran, and William Dally. Learning both weights and connections for efficient neural network. In Advances in neural information processing systems, pp. 1135–1143, 2015.
- 10. Yann LeCun, Léon Bottou, Yoshua Bengio, and Patrick Haffner. Gradient-based learning applied to document recognition. Proceedings of the IEEE, 86(11):2278–2324, 1998.

KEYWORDS: Artificial Intelligence, AI, Wi-Fi, Warehouse, Distribution, Logistics, Simulation, Modeling and Simulation, Sustainment, Availability, Reliability, Maintainability, Supportability, Software Development, Machine Learning, Neural Networks, Real-time Computational Intelligence, Data Science, Software Architecture, Deep Learning.

DLA211-005 TITLE: Recycling and Reuse of Powders, Test Specimens, and Scrap Materials in Additive Manufacturing

RT&L FOCUS AREA(S): Nuclear, and General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Materials

OBJECTIVE: The Defense Logistics Agency (DLA) seeks technologies and processes in Additive Manufacturing (AM) to enhance recycling and reuse of powders, test specimens, and scrap materials to produce additional material feedstock domestically. All the areas of recycling and manufacturing technologies provide potential avenues toward achieving breakthrough advances. Proposed efforts funded under this topic may encompass any specific discrete-parts or materials recycling, manufacturing, or processing technology at any level resulting in a unit cost reduction, availability of feedstock material, and reduced environmental impact from the manufacturing of products.

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: The DLA Research & Development (R&D) is looking to develop the capability to recycle and recover AM powder, test specimens, and scrap materials produced during the part manufactruing process throughout the Department of Defense (DoD) facilities and domestic manufacturers. As AM continues to mature and the demand for AM powder increases, new innovative ways to collect and recycle scrap metal/powder into a useable AM grade powder as well as recycling AM powder not utilized in the build process are needed to reduce the production unit cost and secure feedstock supply. The goal is to identify and recover AM powder, at a suitable purity level, suitable to be reused and in a form that it could be reintroduced into manufacturing at a later point in time. Developing an economically viable, environmentally friendly process for recycling of AM powders from the existing manufacturing process could facilitate the establishment of a viable, competitive domestic supply chain. If this produces a viable reclamation methodology and sustainable process it may lead to follow-on efforts at the discretion of the US Government. The R&D tasks include identifying potential additional feedstock sources in the existing DoD supply chain and developing processes for AM recycling. The process should be amenable to the scale of operation required in AM manufacturing, and will improve the economics of AM powders from recovered material for reuse, rather than depend on costly foreign reliance.

PROJECT DURATION and COST:

PHASE I: NTE 12 Months \$150K- Base NTE \$100K base 6-9 Months, - Option 1 NTE \$50K base 3-6 Months

PHASE II: - NTE 24 Months \$1.6M - Base 12-18 months, \$1M Option 6 Months NTE \$.6M

PERIOD OF PERFORMANCE: The phase one period of performance is not to exceed 12 months total. Options are not automatic. Approval is at the discretion of the DLA SBIP Program Manager. The decision is based on Project Performance, Priorities of the Agency, and/or the availability of funding.

PHASE I: Determine, insofar as possible, the scientific, technical, and commercial feasibility of the concept. Include a plan to demonstrate the innovative recycling process and address implementation approaches for near term insertion into the manufacture of Department of Defense (DoD) systems, subsystems, components, or parts.

PHASE II: 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 and DoD. 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 DoD, 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 DoD 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.

KEYWORDS: Additive Manufacturing; Recycling: Powder Engineering

REFERENCES:

1. EMERGENT III Research & Development Broad Agency Announcement (BAA0002-20)

CONTACT INFORMATION:

DMEA SBIR 21.1 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). If you have any questions regarding the administration of the DMEA SBIR/STTR Program, please contact the DMEA SBIR/STTR Program Manager (PM), Mr. Greg Davis, at <u>osd.mcclellan-park.dmea.list.smbus@mail.mil.</u>

For general inquiries or problems with electronic submission, contact the DOD SBIR/STTR Help Desk at 1-703-214-1333 or email <u>dodsbirsupport@reisystems.com</u> between 9:00 am to 5:00 pm ET. For questions about the topic during the pre-release period (Please refer to the DoD 21.1 SBIR BAA for dates), contact the Technical Point of Contact (TPOC) listed under each topic on the DOD SBIR/STTR Innovation Portal (DSIP) website (<u>https://www.dodsbirsttr.mil/submissions/login</u>) prior to the Open phase of the DOD SBIR Program Broad Agency Announcement (BAA) FY 21.1. The Topic Q&A (formerly SITIS) will be open to questions during pre-release and close to new questions two weeks prior to the announcement close date. More information on Topic Q&A, can be found at <u>https://www.dodsbirsttr.mil/topics-app/</u>. Information regarding the DMEA mission and programs can be found at <u>https://www.dmea.osd.mil/</u>.

PHASE I GUIDELINES

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 (TABA) amount).

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.

<u>Please ensure that your e-mail address listed in your proposal is current and accurate</u>. <u>DMEA cannot be</u> responsible for notification to companies that change their mailing address, e-mail address, or company official after proposal submission.</u>

PHASE I PROPOSAL SUBMISSION

<u>Read the DOD SBIR Program BAA FY 21.1 for detailed instructions on proposal format and program</u> <u>requirements.</u> 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.

The technical period of performance for the Phase I effort should be no more than six (6) months. DMEA will evaluate and select Phase I proposals using the evaluation criteria contained in Section 6.0 of the DOD SBIR Program BAA FY 21.1 Preface Instructions. 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.

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.

If you plan to employ NON-U.S. citizens in the performance of a DMEA SBIR contract, please identify these individuals in your proposal as specified in Section 5.4.c(8) of the DOD SBIR Program BAA FY 21.1.

It is mandatory that the ENTIRE Technical Volume, DOD Proposal Cover Sheet and Cost Volume are submitted electronically through the DOD SBIR website at https://www.dodsbirsttr.mil/submissions/.The DOD proposal submission site submission will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents is submitted separately through the website. If you have any questions or problems with the electronic proposal submission, contact the DOD SBIR/STTR Help Desk at 703-214-1333 or email dodsbirsupport@reisystems.com. DMEA established page limits for the Technical and Cost Volumes are 20 pages each.

A Company Commercialization Report (CCR) is required to be submitted with Phase I proposals in response to the DMEA 21.1 SBIR topics. Firms must complete this report by logging into the firm's account on SBIR.gov and starting a new Company Commercialization Report. Once the firm completes and submits this report within the SBIR.gov website, it should download a PDF copy and include the PDF as an upload in Volume 4: CCR of its DSIP proposal submission. Please refer to the DoD 21.1 SBIR BAA for full details.

Volume 6: Fraud, Waste and Abuse (FWA) training is required for Phase I and Direct to Phase II proposals. Please refer to the DoD 21.1 SBIR BAA for full details.

Your proposal submission <u>must</u> be submitted via the submission site on or before the date published in the DoD 21.1 SBIR BAA.

<u>Proposal submissions that are not complete or that are received after the closing date and time will not be considered for award.</u>

PHASE II 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 (TABA) amount). The technical period of performance for the Phase II effort should be no more than twenty-four (24) months.

PHASE II PROPOSAL SUBMISSION

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. Complete electronic submission includes the submission of Cover Sheet, Cost Volume, the entire Technical Volume, and any appendices via the DOD submission site (https://www.dodsbirsttr.mil/submissions/). The DOD proposal submission site will lead you through the process for submitting your technical volume and all of the sections electronically. Each of these documents is submitted separately through the website. Your proposal must be submitted via the submission site on or before the DMEA-specified deadline or it will not be

considered for award. DMEA established page limits for the Technical and Cost Volumes are 20 pages each.

A Company Commercialization Report (CCR) is required to be submitted with Phase II proposals in response to the DMEA 21.1 SBIR topics. Firms must complete this report by logging into the firm's account on SBIR.gov and starting a new Company Commercialization Report. Once the firm completes and submits this report within the SBIR.gov website, it should download a PDF copy and include the PDF as an upload in Volume 4: CCR of its DSIP proposal submission. Please refer to the DoD 21.1 SBIR BAA for full details.

The technical period of performance for the Phase II effort should be no more than twenty-four (24) months. DMEA will evaluate Phase II proposals based on the Phase II evaluation criteria listed in Section 8.0 of DOD SBIR Program BAA FY 21.1 Preface. Please reference the DOD SBIR Submission site FAQs for more information on generating Phase II proposals. 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.

COST VOLUME GUIDELINES

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 <u>not</u> 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 teased 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.

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 (TABA)

DMEA does not provide Discretionary Technical and Business Assistance (TABA).

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria <u>must be met</u> or your proposal will be **REJECTED**.

1. Your Technical Volume, the DOD Cover Sheet, the DOD Company Commercialization Report (required even if your firm has no prior SBIRs), and the Cost Volume have been submitted electronically through DSIP on or before the date published in the DoD 21.1 SBIR BAA.

2. The Phase I proposal does not exceed \$167,500 (excludes Discretionary Technical and Business Assistance (TABA) amount).

DMEA 21.1 SBIR Phase I Topic Index

DMEA211-001	SiC BiCMOS Platform Development
DMEA211-002	Robotic Microelectronic Planar Serial Sectioning System

DMEA211-001 TITLE: SiC BiCMOS Platform Development

RT&L FOCUS AREA(S): Microelectronics

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: To develop a BiCMOS platform utilizing SiC wafer to achieve high temperature operation and high voltage/power integration.

DESCRIPTION: As a result of almost four decades long investment on SiC technology by DoD and technical breakthroughs achieved by private sectors, affordable high-voltage SiC MOSFETs debut in the market recently [1][2]. The 650+V SiC MOSFETs become popular switching devices in data center, renewable energy, and even electric vehicle applications thanks to excellent energy efficiency and reduction in the power conversion system size and weight.

While discrete SiC power devices are successfully commercialized, separate efforts to develop SiC integrated circuits (ICs), that can be used in high temperature and high radiation environments, have continued for a decade. Those ICs were mostly based on non-CMOS, (i.e. bipolar transistor [3], MESFET [4] and JFET [5][6]) due to many technical barriers in SiC CMOS technology such as low channel mobility, uneven performance of NMOS vs. PMOS, forming resistive ohmic contacts, and gate oxide reliability.

More recently, advantages such as convenient digital circuit design using standard libraries and low power consumption of CMOS configuration drive big corporations [7][8] and small businesses [9][10] to jump into the SiC CMOS IC development competition. Despite these aspirations and effort, decent SiC CMOS technology development will not be easy to overcome the fundamental material properties of SiC including high gate oxide/SiC interface states.

The goal of this solicitation is to develop and demonstrate a SiC BiCMOS platform that can be applied up to 300°C ambient temperature. Base materials for this solicitation include, but are not limited to bulk or epitaxial SiC wafer, Si/SiC direct bonding (Si/SiC DB) wafer, or Si-epitaxial grown on SiC substrate (Si-epi/SiC) wafer.

PHASE I: Perform a Feasibility Study that addresses the gate oxide related parameters such as channel mobility, gate tunneling current, time-dependent dielectric breakdown (TDDB), bias temperature instability (BTI), and yield (extrinsic failure rate). Key parameters related to the gate oxide should meet requirements as below.

- NMOSFET channel mobility > $50 \text{ cm}^2/\text{V} \cdot \text{s}$

- PMOSFET channel mobility > $10 \text{ cm}^2/\text{V} \cdot \text{s}$

- Threshold voltage shift (for NMOSFET and PMOSFET) < ± 500 mV at bias-temperature stress during mean time to failure

When Si/SiC DB or Si-epi/SiC wafers are used, Si/SiC interface and across-wafer uniformity should be characterized by various imaging tools and spectroscopy. All junction combinations between (n and p-type) Si and (n and p-type) SiC have to be characterized electrically to monitor the ohmic and p-n junction behavior. Key parameters related to SiC/Si interface should meet requirements as below.

- Void free and continuous SiC/Si interface throughout entire wafer

- Bonding interface thickness (thickness of SiO₂, amorphous Si or carbon rich region) < 10 nm

- Bonding interface state density $< 1 \times 10^{12} \text{ eV}^{-1} \text{cm}^{-2}$

If those key parameters are not met the requirements, detailed plans for improvement of those reliability and performance parameters during phase II must be proposed.

PHASE II: Prototype deliveries of phase II are development of wafer fabrication process and Process Design Kit (PDK). Based on the process, statistical data of critical parameters and reliability (mostly gate oxide related) data for technology qualification are to be reported. For CMOS transistors and high-voltage LDMOS, BSIM (or BSIM equivalent or modified BSIM) models incorporating statistical data shall be included in the PDK.

During the first year of phase II, TCAD simulations on n-channel and p-channel LDMOS (45V, 120V, and 650V) and other active and passive devices are necessary to define device architecture, dimension, and doping profile. Wafer processing modules (gate/field oxidation, isotropic/anisotropic etch, implant, activation/annealing, and contact/interconnect/pad metallization) on SiC or Si/SiC wafer should be developed. When SiC bulk or epitaxial wafer is used, process development should be carried out including efforts to improve gate oxide integrity, PMOS transconductance, source/drain/body ohmic contacts, and passive components temperature dependency. When Si/SiC wafer is used, wafer bonding or Si epitaxial processes, which can reproduce Si/SiC wafers, must be identified. All the process modules should be matured and stabilized.

During the second year of phase II, all BiCMOS platform device components, which comprise of core logic CMOS transistors, analog MOSFETs (for current mirrors, differential pairs, etc), bipolar transistors, passives (diffusion and poly resistors, gate oxide or MIM capacitors), and high-voltage (45V, 120V, and 650V) LDMOSs are to be fabricated on a single die, and characterized at temperature range over -55C to 300C. Performance of those devices are to be improved/optimized though multiple test vehicles.

PHASE III DUAL USE APPLICATIONS: Continuous efforts may be needed to further stabilize the process flow which ensures product reliability to embody strong business case. Variations of the baseline flow are to be developed, for example, different technology nodes, gate oxide thickness, and LDMOS voltage ratings. The BiCMOS platforms could be utilized for smart power IC production, second source manufacturing or licensing.

SiC wafer platform is advantageous for high-temperature and radiation hardened ICs (when semi-insulating SiC substrates are used). On the other hand, Si/SiC wafer platform allows hybrid integration of high density Si CMOS logic and SiC high-voltage power devices. The platform could take advantage of Si/SiC heterojunction properties to enhancing LDMOS performance [11][12].

Those platforms are highly attractive to NASA's space programs, Air Force's aircrafts, Army's combat electric vehicles and nuclear facilities where harsh environment electronics are required. Analog Devices' AD8229 and ADXL206 are notable commercialized Si based products available in the market targeting oil/gas drilling, aerospace, and geothermal applications under 200°C ambient temperature. Many defense and civilian industries are anticipating SiC IC products that can operate above the Si temperature limit.

The Si/SiC DB wafer has not been commercialized simply due to lack of demand. If the Si/SiC platform development is successful, it would create demand for Si/SiC DB wafers as a base material for the BiCMOS IC production. Therefore, Si/SiC wafer manufacturing business will be a promising derivative from the platform development.

POTENTIAL VALUE TO DoD: Because weapon systems operate under unexpected theatrical conditions, the systems have to be small, light, and energy efficient to meet size/weight/power (SWaP) goal of DoD.

SiC BiCMOS ICs help to achieve the goals by making electronic modules simple, highly functional, and intelligent.

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- 12. Qi Li, "Novel SiC/Si heterojunction LDMOS with electric field modulation effect by reversed L-shaped field plate," Results in Physics, 2020

KEYWORDS: SiC, BiCMOS, Si/SiC heterojunction, integrated circuit, high-temperature, high-voltage

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.

RT&L FOCUS AREA(S): Microelectronics

TECHNOLOGY AREA(S): Battlespace, Electronics, Sensors

OBJECTIVE: Develop a tool for automated, procedural planar serial sectioning of semiconductor microelectronic devices.

DESCRIPTION: Serial sectioning Integrated Circuits (ICs) to perform Failure Analysis (FA), Fault Isolation (FI), Reverse Engineering (RE), and Design Validation (DV) is time-consuming and repetitive work that is well suited for human-robot collaboration and robotic automation. Frontside, backside, and crosswise serial sectioning of IC samples often requires operators to maintain a serial sectioning precision to within less than twenty nanometers for multiple hours or days, often leading to operator fatigue and error. The wet chemistry, polishing slurries and pressurized nitrogen flows involved in serial sectioning do not easily lend themselves to bench-top systems. A larger, human-scale processing space oriented around an extended robotic arm with the ability to transition samples between acid baths of etchant, colloidal silica polishing slurries, liquid-soaked cleaning pads, sonicating baths of cleaning solvents, and compressed nitrogen gasses for drying samples is a realistic approach to both automating these processes and to minimizing the cost of maintaining equipment. The physical separation between each serial sectioning process that a robotic arm affords will prevent cross-contamination of materials, allow ease of access for preventative maintenance and routine equipment cleaning, and prevent liquids and corrosives from damaging mechanical and electrical equipment. A robotic arm also allows for the possibility of automatically inserting samples into a Scanning Electron Microscope (SEM) after each successive serial sectioning step. Current technology is limited to automatic frontside, backside, and crosswise serial sectioning to within accuracies of approximately one micron. Defense Microelectronics Activity needs the capability to do this to within tens of nanometers. While humans are able to perform all three of these processes, repeatability between sample preparation is often inconsistent, and both the great length of time it takes to perform coupled with limited numbers of personnel makes it impossible to validate the designs of and perform failure analysis on the large quantity of microelectronics employed by DoD. It is critical to national security and to the work being done by multiple DoD initiatives across different agencies that these processes become automated in the near future.

PHASE I: Feasibility study of automatic serial sectioning an IC to an arbitrary metal layer in a planar manner that results in all vias being present, along with a relatively uniform interlayer dielectric material (ILD), and all metal lines beneath it. Having all three of these present in a single image: vias, the ILD to hold the vias in place, and the metal lines beneath the ILD is the first preliminary benchmark of the automatic serial sectioning system. The following requirements should be met:

1) Material removal with an accuracy of less one-hundred nanometers across a one square centimeter IC with reference to the initial planar surface of the IC, or less than 0.0006° tilt.

2) Highly perpendicular crosswise serial sectioning to within $90^{\circ}\pm 0.0006^{\circ}$.

3) Serial-sectioning to a target location with accuracy of less than a micron.

4) Microscope images should be taken while serial-sectioning. All vias and metal lines of the layer of interest should be present at time of imaging, and the microscope should be capable of imaging these vias and metal lines up to 500x magnification.

5) A study should be done on how to make all equipment and machinery self-contained, requiring no external plumbing, drainage, or ventilation. Details should be provided on how this will be achieved in Phase II.

6) Detailed recipes, stating rates or times taken to serial section, and clean IC samples should be provided. All equipment, chemicals, materials, and supplies employed in the process should be stated.

7) DMEA users of the tool should have the full ability to program the machine to suit their needs. The software should include flexibility to modify serial sectioning recipes and parameters.

8) Detailed plans of all mechanical parts designed for this contract should be furnished to DMEA in original digital format.

Deliver a feasibility report of research and innovation, including a list of possible components, a storyboard of software that will control the tool and a program plan for system development. If any of the above restraints cannot be adhered to, the report must include relevant research and rationale. If adhering to the above constraints is possible, but not financially feasible, the report must include relevant research and rationale.

PHASE II: Based on the aforementioned study and applicable innovation,

1) Produce a fully functioning self-contained prototype that adheres to all the constraints listed in Phase I.

2) Test the prototype and deliver along with at least (3) samples for each application, for a total of (9) samples. The applications are: Frontside, backside, and crosswise serial sectioning. The samples should all be the same device (to be determined during Phase I) and should show the process repeatability between both samples.

3) Deliver a complete Bill of Materials (BOM), including all part numbers used, manufacturers, quantities, technical datasheets, facility requirements, and deliver CAD files and digital designs of all mechanical parts designed for this SBIR.

4) Provide multiple images showing individual IC metal layers, along with ILD, and all vias intact showing that the process is repeatable. For example, only seven of these types of images for a seven metal layer device are required to obtain all data of the entire integrated circuit design layout. Due to time constraints, this requirement is not mandatory, although this is one of the intended purposes of the equipment. It will do a great service to the reputed capability of the system if it demonstrates that it can validate the design of an entire IC by frontside serial sectioning.

PHASE III DUAL USE APPLICATIONS: There may be opportunities for further development of this system 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.

The Robotic Microelectronic Planar Serial Sectioning would be applicable to both commercial and

government semiconductor device research and FA. Government applications include FA, FI, DV and RE of semiconductors. Commercial applications include FA and FI of semiconductors.

POTENTIAL VALUE TO DoD: High throughput serial sectioning of integrated circuits for the purposes of failure analysis, fault isolation, reverse engineering, design validation and counterfeit inspection is critical to national security. Given the sheer quantity of microelectronics employed by DoD, automation is a realistic approach to performing these tasks at scale.

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KEYWORDS: Serial Sectioning, Failure Analysis, Reverse Engineering, Microelectronics, Sample Preparation, Design Validation, Fault Isolation, Counterfeit Inspection
VERSION 2 UNCLASSIFIED

NATIONAL GEOSPATIAL-INTELLIGENCE AGENCY 21.1 Small Business Innovation Research (SBIR) Proposal Submission Instructions

GENERAL INFORMATION

The National Geospatial-Intelligence Agency 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 <u>http://www.nga.mil/</u>.

Inquiries of a general nature or questions concerning the administration of the SBIR Program should be addressed to:

National Geospatial-Intelligence Agency Attn: SBIR Program Manager, RA, MS: S75-RA 7500 GEOINT Dr., Springfield, VA 22150-7500 Email: <u>SBIR@nga.mil</u>

For technical questions and communications with Topic Authors, see DoD Instructions, Section. 4.15. For general inquiries or problems with electronic submission, contact DoD SBIR Help Desk at DoDSBIRSupport@reisystems.com or 1-703-214-1333 between 9:00 am and 5:00 pm ET.

DIRECT TO PHASE II PROPOSAL INFORMATION

Follow the instructions in the DoD SBIR Program BAA for program requirements and proposal submission instructions at <u>https://rt.cto.mil/rtl-small-business-resources/sbir-sttr/</u>.

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. NGA is conducting a "Direct to Phase II" implementation of this authority for this 21.1 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.

NGA has developed topics to which small businesses may respond to in this fiscal year 2021 SBIR Direct to Phase II iteration. These topics are described on the following pages. **The maximum amount for a**

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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 the either the Commercialization Readiness Program (CRP), Technical and Business Assistance (TABA) or Phase II Enhancement programs.

The entire SBIR proposal submission (consisting of a Proposal Cover Sheet, the Technical Volume, Cost Volume, and Company Commercialization Report) must be submitted electronically through the DoD SBIR/STTR Proposal Submission system located at <u>https://www.dodsbirsttr.mil/submissions</u> 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 0 **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 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, 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. 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 be delivered. The methods planned to be delivered 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) 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.
- (5) 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.
- (6) 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.
- (7) Foreign Citizens. Identify any foreign nationals you expect to be involved on this project.
- (8) 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
- (9) 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.
- 10) 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

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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."

- (11) 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

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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):** CCR is required to be submitted with proposals in response to NGA 21.1 SBIR topics. Please refer to the DoD 21.1 SBIR BAA for full details.
- **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, advocacy letters, etc.
- 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 21.1 SBIR BAA for full details.

Selection of Direct to Phase II proposals will be in accordance with the evaluation procedures and criteria discussed in this BAA (refer to Section 6.0 and 7.0 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?

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.

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.

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 level of effort contract for Direct to Phase II awards. The type of contract is at the discretion of the Contracting Officer.

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 7¹/₂ months after award. These reports shall include the following sections:

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- A monthly summary of the results of the Phase I research to date
- A monthly 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.
- 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 $8\frac{1}{2}$ " by 11" paper. The pages shall be numbered.

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 PROHIBITTED, 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 publically 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 (<u>https://www.archives.gov/cui/about</u>).

CERTICATE 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 <u>https://www.gsa.gov/forms-library/certificate-pertaining-foreign-interests</u>.

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 21.1 SBIR Direct to Phase II Topic Index

- NGA211-001 Annotation Pipeline Designed for Quantitative Performance Analyses
- NGA211-002 Targetable geospatial information extraction from webpages

NGA211-001 TITLE: Annotation Pipeline Designed for Quantitative Performance Analyses

RT&L FOCUS AREA(S): Autonomy, Artificial Intelligence/Machine Learning

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: This announcement seeks proposals that offer to use existing pipelines for creation of training data for artificial intelligence/machine learning systems to perform quantitative analyses of various annotation pipeline approaches. In this context the term "annotation" refers to the marking and commenting of overhead imagery of all types and resolution for the purposes of using the image and associated comments as training data for an artificial intelligence/machine learning system (AI/ML) to perform tasks such as object detection or change detection in imagery.

DESCRIPTION: The National Geospatial-Intelligence Agency (NGA) collects and analyzes multiple types of GEOINT data with a wide range of type and quality. NGA is interested in utilizing artificial intelligence (AI) technologies to assist in analysis of this GEOINT data. It is clear that the type and quality variations in imagery can impact AI application performance and the ability of AI/ML approaches to effectively "learn" how to detect objects and assess other image information. Additionally, data annotation methodologies can differ in precision simply due to the annotation process, i.e. drawing a bounding box vs point localization of objects. The individual abilities and subject matter expertise of annotators also affects annotation accuracy, which impacts both the quality and manpower cost of the training data creation process.

NGA is seeking proposals to exploit existing annotation pipelines and deliver (1) research into multiple data annotation curation, conditioning, and annotation methodologies to determine which approaches best balance data annotation efficiency, accuracy, AI model performance, manpower costs, and confidence needs of NGA missions; and (2) continuous quantitative evaluation of the annotation pipeline once standard approaches are identified and adopted.

Proposers should have an existing annotation pipeline or process flow that enables the acquisition and analysis of a comprehensive set of metrics quantitatively describing most or all critical steps in the annotation process. Representative data should be provided in the proposal to show that their existing pipeline can provide the appropriate metrics.

Critical metrics may include the following:

- -Analysis of raw data types, quality, and variability and impacts on data annotation accuracy and speed
- -Costs and benefits of basic vs. detailed data annotation taxonomies

-Cost / benefit analysis of increasing subject matter expert and quality assurance review on data annotation speed, accuracy, efficiency, and cost

-The quality of the annotated data for AI/ML applications

-The ability of various IT infrastructure constructs to sufficiently and securely manage classified data sets and annotation

-Other criteria deemed critical and justified by the offeror

Direct to Phase II proposals only are being accepted under this topic. A direct to Phase II proposal should include a concise description of the pre-existing annotation pipeline and relevant quantitative metrics. Phase II proposals should also propose a set of milestones and demonstrations that will establish the process flow as a viable commercial offering that delivers quantitative clarity on most or all relevant aspects of performance and cost.

PHASE I: The performer shall use a pre-existing annotation pipeline to assess the performance differences between various approaches and complete a cost-benefit analysis of the trialed approaches. A set of candidate approaches should be provided in the proposal.

PHASE II: Representative imagery data should initially be obtained by the proposer from open or commercial sources in consultation with NGA. NGA may provide additional data if necessary, but the preference is for the proposer to obtain and control their own data sources so that they may freely use that data when engaging with commercial customers. Proposals should describe multiple options for data annotation processes and teams of trained annotators and subject matter experts (SMEs) and the analysis process that will enable quantitative comparisons. Proposals should also describe how the data transfer, handling and annotation process using available COTS software and hardware (if necessary) will be designed to ultimately meet NGA requirements for data security, cyber security, and data accuracy. If successful, implementation will require ability to handle and annotate both unclassified and sensitive classified data. At the conclusion of the Phase II period a final report highlighting approaches evaluated, performance differences in efficiency, accuracy, and data usefulness for AI development should be provided.

PHASE III DUAL USE APPLICATIONS: Follow-on activities are expected to be aggressively pursued by the offeror, namely in seeking opportunities to build more efficient annotation pipelines for the benefit of commercial entities.

REFERENCES: None

KEYWORDS: artificial intelligence (AI), machine learning (ML), training, annotation of training data, cost, design trades

UNCLASSIFIED NGA DP2 - 13 NGA211-002 TITLE: Targetable geospatial information extraction from webpages

RT&L FOCUS AREA(S): Artificial Intelligence (AI)/ Machine Learning (ML)

TECHNOLOGY AREA(S): Information Systems Technology

OBJECTIVE: Develop an adaptable AI system to extract entities and linked geospatial information from web-pages in multiple languages, and learn to identify new entity and relation types given very few (<10) examples.

DESCRIPTION: A large amount of geographic information resides on web-pages, but exists in the form of un-structured data and is therefore difficult to extract automatically. The problem is compounded by the varied geographic questions with which military users approach the data. Information extraction systems are often limited to a fixed set of entity and relation types (e.g. GDELT1), but military components may need to extract information on a wide variety of entities, events, and relations to inform questions related to critical infrastructure, humanitarian assistance, and situational awareness. Recent academic advances in AI/ML provide many enabling technologies needed to access web data automatically, including fine-grained entity extraction,2 relation extraction (both within sentences3 and at the document level4), entity linking,5 cross-lingual methods,6 and geocoding/parsing.7 In addition, new methods to rapidly re-train the models used in these applications, such as weak-supervision8 and low-shot learning approaches,9 have made huge strides in recent years. However, advanced development efforts are needed to integrate these technologies and apply them to the real-world problems faced by the military, academic, and industrial geospatial community. This effort will leverage these recent advances to improve rapid learning of new entity and geographic relation types, more accurately extract and disambiguate information, and create a system that is robust to the variety of formats, languages, and standards that exist on the web.

PHASE I: Due to the fact that a large amount of open-source academic work exists in this area, the project can proceed directly to Phase II

PHASE II: Develop a prototype information extraction system to be demonstrated to potential users and validated using open-source and government datasets. Demonstrate adaptability to novel entity and relation types suggested by potential users and government partners. The desired system will be capable of transition and integration into other government systems and pipelines.

PHASE III DUAL USE APPLICATIONS: Extraction of geospatial information from the web will be of wide commercial applicability. The system could be integrated into search engine technology or used by digital services that deliver point-of-interest data to users, such as restaurants, car mechanics, or any number of other sites. This technology would be particularly useful for under-served areas and businesses that are not well represented in the most common digital point-of-interest platforms. Finally, this capability would be widely used in the non-profit and humanitarian assistance sector to map political event data.

REFERENCES:

- 1. Leetaru and Schrodt (2013) "GDELT: Global Data on Events, Location and Tone"
- 2. Ling and Weld (2012) "Fine-grained Entity Recognition" AAAI
- 3. Li et al. (2019) "Entity-Relation Extraction as Multi-turn Question Answering" ACL2019
- 4. Yao et al. (2019) "DocRED: A Large-Scale Document-Level Relation Extraction Dataset" arXiv
- 5. Kolitsas and Ganea (2018) "End-to-End Neural Entity Linking" arXiv
- 6. Sil et al. (2018) "Neural Cross-Lingual Entity Linking" AAAI

- 7. Karimzadeh et al. (2018) "GeoTxt: A scalable geoparsing system for unstructured text geolocation" Trans. in GIS
- 8. Bringer et al. (2019) "Osprey:Weak Supervision of Imbalanced Extraction Problems without Code" ACM
- 9. Hsu et al. (2019) "Unsupervised Learning via Meta-Learning" arXiv

KEYWORDS: Information retrieval, relation extraction, fine-grained named entity recognition, low-shot learning, weak supervision, meta-learning, entity linking, geocoding, geoparsing

UNITED STATES SPECIAL OPERATIONS COMMAND 21.1 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 21.1 Program Broad Agency Announcement (BAA). A thorough reading of the "Department of Defense Small Business Innovation Research (SBIR) Program, SBIR 21.1 Program Broad Agency Announcement (BAA)" prior to reading these USSOCOM instructions is highly recommended.

These USSOCOM instructions explain USSOCOM specific aspects that differ from the DoD Announcement and its instructions.

Торіс	Technical	Additional	Period of	Award	Contract
	Volume (Vol 2)	Info. (Vol 5)	Performance	Amount	Туре
Phase I	Not to exceed 5	15 page	Not to exceed	NTE	Firm-Fixed-
SOCOM211-	pages	PowerPoint	6 months	\$150,000.00	Price
001					
Phase I	Not to exceed 5	15 page	Not to exceed	NTE	Firm-Fixed-
SOCOM211-	pages	PowerPoint	6 months	\$150,000.00	Price
002					
Phase I	Not to exceed 5	15 page	Not to exceed	NTE	Firm-Fixed-
SOCOM211-	pages	PowerPoint	6 months	\$150,000.00	Price
003					

Table 1: Consolidated SBIR Topic Information

Contract Awards:

SBIR awards for topic SOCOM211-002 will 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. SOCOM211-002 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 SOCOM211-002 proposals. The Government will award all SBIR contracts for SOCOM211-001, and SOCOM211-003.

Proposal Submission:

Firms must upload their proposals to the Defense SBIR/STTR Innovation Portal Proposal Submissions at <u>https://www.dodsbirsttr.mil/submissions/login</u>. Additional USSOCOM specific submission requirements for each volume are detailed below.

Technical Inquiries:

During the <u>Pre-release Period</u> of the DoD SBIR 21.1 Program BAA, all questions must be submitted in writing either by e-mail to <u>sbir@socom.mil</u> or to the online Topic Q&A (formerly SITIS). All questions

and answers submitted to 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 Section 4.13.c. of the DoD SBIR 21.1 Program BAA instructions). All inquiries must include the topic number in the subject line of the e-mail.

During the <u>Open Period</u>, follow the instructions in section 4.13.d of the DoD SBIR 21.1 Program BAA Instructions.

Site visits will not be permitted during the Pre-release and Open Periods of the DoD SBIR 21.1 Program BAA.

Proposal Volumes:

Volume 1: Cover page required per DoD instructions.

Volume 2: Technical Volume

The Technical Volume page count will include all the required items under section 5.4.c of the DoD SBIR 21.1 instructions and shall not exceed 5 pages. Offerors shall also submit a slide deck not to exceed 15 PowerPoint slides in Volume 5 and there is no set format requirements for the two documents. 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. The Cost Volume (Volume 3) for the Topics will cover the total effort.

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 in paragraph 3.7 entitled "Foreign Nationals" of the DoD SBIR 21.1 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 plus Technical and Business Assistance (TABA) cost (if applicable) not to exceed \$6,500 over a period of up to six months.

USSOCOM may provide TABA funds in Phase I awards to firms to meet Cybersecurity Maturity Model Certification (CMMC) Level 1 certification requirements. Draft of the CMMC is located at https://www.acq.osd.mil/cmmc/draft.html.

The TABA information must be included in the firm's cost proposal specifically identified as "Discretionary Technical and Business Assistance" and cannot be subject to any profit or fee by the requesting SBIR firm. In addition, the provider of the TABA 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, consultant, tester, or administrative service provider). Proposed TABA will be evaluated by the USSOCOM SBIR Program office. The proposed amount is in addition to the award amount for Phase I and cannot exceed \$6,500. The firm's proposal must (1) clearly identify the need for assistance (purpose and objective of required assistance); (2) provide details on the provider of the assistance proposed); and (3) the cost of the required assistance (costs and hours proposed or other details on arrangement that would justify the proposed expense).

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 is required to be submitted with proposals in response to SOCOM 21.1 SBIR topics. Please refer to the DoD 21.1 SBIR BAA for full details.

Volume 5: Supporting Documents

Potential Offerors shall submit a slide deck not to exceed 15 PowerPoint slides.

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 21.1 SBIR BAA for full details.

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.

Phase I Evaluations:

USSOCOM evaluates Phase I proposals using the evaluation criteria specified in section 6.0 of the DoD 21.1 SBIR Announcement except for:

The Technical Volume and slide deck will be reviewed holistically. Proposals missing the slide deck will not be evaluated. The two-part evaluation process is explained below:

Part I: The evaluation of the Technical Volume will utilize the Evaluation Criteria provided in Section 6.0 of the DoD SBIR 21.1 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 will receive an invitation to present their slide deck (30 minute presentation time / 30 minute question and answer) in a technical question and answer forum to the USSOCOM evaluation team via electronic media within the evaluation period. This is usually within 15 to 30 days after BAA closure. Selected Offerors shall restrict their presentations to only the 15 page PowerPoint presentation that were submitted with their proposals. There will be no changes or updates to the presentations from what was proposed. This presentation will be evaluated by a panel against the criteria listed under Section 6.0 of the DoD SBIR 21.1 BAA. This will follow with a selection/non-selection notification in a timely manner.

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 SOCOM211-002 the Defensewerx (also known as SOFWERX) will notify each Offeror whether they have been selected for award. The e-mail notification will be sent to the Corporate Official (Business) identified by the Offeror.

For topics SOCOM211-001 and SOCOM211-003, the Government Contracting Officer will notify each Offeror by e-mail whether they have been selected for award. 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 paragraph 4.10, entitled "Debriefing," of the DoD SBIR 21.1 Announcement.

USSOCOM SBIR Program Point of Contact:

Inquiries concerning the USSOCOM SBIR Program should be addressed to sbir@socom.mil.

SOCOM 21.1 SBIR Phase I Topic Index

SOCOM211-001	Antenna Distribution System
SOCOM211-002	Enterprise Data Fusion Visualization
SOCOM211-003	Wideband and Analog Radio Frequency Fingerprinting At a Distance

SOCOM211-001 TITLE: Antenna Distribution System

TECHNOLOGY FOCUS AREA: Microelectronics; Network Command, Control and Communications

TECHNOLOGY AREAS: Sensors; General Warfighting Requirements (GWR)

ACQUISITION PROGRAM: Joint Threat Warning System

OBJECTIVE: The objective of this effort is to conduct a feasibility study to develop a capability by which a series of Radio Frequency antennas and access to these antennas can be electrically distributed among a series of Radio Frequency receivers/transmitters in a manner in which the Radio Frequency receiver connected to the antenna distribution system can be connected to any of the antennas connected to the distribution system quickly and efficiently.

DESCRIPTION: Special Operations Forces (SOF) personnel operate a number of mobility platforms and frequently establish fixed deployment sites where a number of Radio Frequency systems must be installed for use in support SOF operations. This results in a requirement for numerous antennas designed to work in different sections of the Radio Frequency spectrum to be installed. This is typically done with each available receiver/transmitter planned for the operation in mind being connected to a single antenna, the design of which is optimized for operation in the section of the spectrum for which the associated receivers/transmitters are configured to operate. This does not support flexibility of the Radio Frequency sensing system. In cases where receivers/transmitters must be reconfigured to operate in different frequency ranges, cables must be reconnected and often new antennas installed in an effort to meet ever changing mission requirements. This often results in a lack of equipment needed to make necessary changes and delay in reconfiguration which may affect the ability to support emergent SOF missions.

PHASE I: Conduct a study to determine the technical feasibility of developing a system that will allow multiple radio receivers/transmitters to access multiple antennas with configuration and reconfiguration accomplished by remote means. USSOCOM has a requirement to distribute Radio Frequency energy received by a number of antennas, each of which is designed to operate optimally in a specific section of the Radio Frequency spectrum, to different Radio Frequency receivers/transmitters, each of which will be configured to operate in a specific section of the Radio Frequency spectrum. Additionally, the requirement is for the receivers/transmitters to be able to retune and switch between antennas for periodic use of any of the antennas connected to the distribution network. The general requirement for this SBIR topic is to enable a series of receivers/transmitters to access various antennas, each designed to operate most efficiently in a specific section of the Radio Frequency spectrum, electrically, electronically or mechanically by a remote operator using control software.

The Offeror shall develop a means by which a series of Radio Frequency antennas, each optimized for performance within a specific section of the Radio Frequency spectrum, can be accessed by a series of Radio Frequency receivers / transmitters:

- 1. Antennas shall be proposed by the Offeror with the primary focus being electrical performance of each individual antenna. Size, weight and Power consumption (SWaP) are also under consideration as a secondary attribute of each antenna.
- 2. Receivers/transmitters hardware shall be proposed by the Offeror. It shall be fully compatible with each proposed antenna.

- 3. This technology pursuit is to develop a method by which each receiver/transmitter in a series can be remotely, a method that does not require "touch maintenance", configured to operate with any of the proposed antennas. There may be cases where more than one receiver/transmitter must access a single antenna and each time this occurs, the secondary receivers/transmitters shall automatically be configured for receive only.
- 4. This topic automates the reconfiguration process necessary to attach receivers/transmitters to different antennas from its current manual labor method.
- 5. A final feasibility study report and preliminary design shall be delivered to allow Government acquisition officials the opportunity to make future acquisition decisions on a fully informed basis.

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 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 OSOCOM 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 an Antenna Distribution System. The prototype will be tested with sensors currently in the SOF inventory to determine level of performance and in an attempt to make the test articles ready for testing in a pseudo-operational environment.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military applications where radio devises are used. For example, this antenna distribution system could provide a means by which communications devices on a mobility platform, such as an airplane or ship, could make use or an antenna distribution system to reduce the requirement for a number of individual antennas currently required on the platform. In this case, limited physical space can be opened up to other devices as antennas are removed due to the distribution system providing the capability to map specific radios to specific antennas remotely when the connection is needed. This capability can easily be applied to sensor systems such as those used to detect distant RADAR systems or unknown radio transmitters. Upon completion of a successful demonstration of this capability with radio sensors, other Methods of Employment such as RADAR detection of communications support can be tested.

REFERENCES:

1. Technical Standard for Sensor Open System Architecture (SOSA) Reference Architecture, Edition 1 Version 3 Copyright 2020. This document is valid through 28 February 2021: https://publications.opengroup.org/standards/sosa

KEYWORDS: Antenna Distribution System; Antenna

SOCOM211-002 TITLE: Enterprise Data Fusion Visualization

TECHNOLOGY FOCUS AREA: General Warfighting Requirements (GWR); Artificial Intelligence/ Machine Learning;

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: SOF Digital Ecosystem

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 to a user interface application providing an intuitive user interface for entering search criteria and presenting search results based on a wide range of data sources. The interface network will provide obfuscated connection services. Results will be correlated, relationships identified, relevant anomalies highlighted and graphical presentation utilized to allow rapid assessment by users. This product will also assist with the US Government's compliance to applicable laws and regulations for data collection and retention.

DESCRIPTION: As a part of this feasibility study, the proposers shall address all viable overall system design options with respect to optimization of man-to-machine interface, potential benefits to be gained through the use of machine learning, and tools/techniques for masking the source of a data query.

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." Identify how machine learning might enhance the proposed capability.

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 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 OSOCOM 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 data fusion and visualization application.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military applications where current publicly available and commercially available information can assist with

decision making. In these instances, an element of non-attribution is important not to project a specific area of focus. The commercial market likely have similar instances where rapidly analyzing information on a specific topic from a wide variety of sources would aid in business decision making.

REFERENCES:

1. "How to Stay Anonymous on Line": <u>https://www.digitaltrends.com/computing/how-to-be-anonymous-online/</u>

KEYWORDS: Publicly Available Information; Commercially Available Information, Data Correlation, Data Fusion, graphical data presentation, anonymous data search

SOCOM211-003 TITLE: Wideband and Analog Radio Frequency Fingerprinting At a Distance

TECHNOLOGY FOCUS AREA: Artificial Intelligence/ Machine Learning; Network Command, Control and Communications;

TECHNOLOGY AREAS: Sensors; Electronics; Battle Space

ACQUISITION PROGRAM: Near Vertical Direction Finding

OBJECTIVE: The objective of this topic is to develop applied research toward an innovative capability to dramatically increase Radio Frequency (RF) sensitivity, with the purposes of developing a method to preform passive, analog RF fingerprinting of individual, modern communications devices in real-time at a standoff range.

DESCRIPTION: As a part of this feasibility study, the proposers shall address all viable overall system design options with respective specifications on RF linearity, frequency resolution, operational ranges, discrimination capability and protocols and standards in which specified techniques are effective or ineffective. Specifically, this SBIR topic is asking for technologies which go beyond protocol identification by analog characteristics, but rather asking for technology candidates which can delineate individual emitters, within a given protocol. The potential proposers will then study the feasibility of these techniques of a list of the most widely used commercial protocols. Of additional interest is the ability to perform this discrimination across a wide instantaneous bandwidth, across multiple protocols simultaneously. The detection and discrimination should be performed at a standoff range which is to imply that the device being identified is at a distance in which visual identification is not possible.

The attached reference presents a good overview, but this SBIR is asking to preform one level deeper of discrimination and at a standoff range.

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 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 OSOCOM 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 stand-alone system. The device should be capable of determining individual emitters by their analog characteristics in real-time. These systems may be considered for shipboard, airborne or ground-based applications.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military applications where the need for additional sensitivity of RF emissions is required. This could be used to

develop unique broadband signatures using unique broadband signatures (URE) of non-RF devices – (i.e Broadband signature of Tesla vs Honda by unique URE of engine systems) or to increase detection ranges.

REFERENCES:

 Laput, G., Yang, C., Xiao, R., Sample, A. and Harrison, C. 2015. EM-Sense: Touch Recognition of Uninstrumented, Electrical and Electromechanical Objects. In Proceedings of the 28th Annual ACM Symposium on User interface Software and Technology (Charlotte, North Carolina, November 8 – 11, 2015). UIST '15. ACM, New York, NY. 157-166: <u>https://la.disneyresearch.com/publication/emsense/</u> or <u>https://dl.acm.org/doi/10.1145/2807442.2807481</u>

KEYWORDS: RF Fingerprinting; EMI analysis; RF technology; Radio Frequency; RF

UNITED STATES SPECIAL OPERATIONS COMMAND 21.1 Small Business Innovation Research (SBIR) Direct to Phase II Proposal Submission Instructions

Introduction:

The United States Special Operations Command (USSOCOM) 21.1 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.

A thorough reading of the "Department of Defense Small Business Innovation Research (SBIR) Program, SBIR 21.1 Program Broad Agency Announcement (BAA)", located at https://rt.cto.mil/rtlsmall-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 SDIN Tople Information								
Торіс	Technical Volume	Additional	Period of	Award Amount				
	(Vol 2)	Info. (Vol 5)	Performance					
Direct to Phase II	Not to exceed 10	15-page	Typically 18	Not to Exceed				
SOCOM211-D004	pages not including	PowerPoint	months	\$1,650,000.00				
	Feasibility Appendix							
Direct to Phase II	Not to exceed 10	15-page	Typically 18	Not to Exceed				
SOCOM211-D005	pages not including	PowerPoint	months	\$830,000.00				
	Feasibility Appendix							

Table 1: Consolidated SBIR Topic Information

Contract Awards: (Updated as of January 22, 2021)

SBIR awards for topic SOCOM211-D005 will 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. SOCOM211-D005 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 SOCOM211-D005 proposals. All supporting documents to include the Statement of Objectives (SOO) are available at <u>https://www.socom.mil/SOF-ATL/Pages/SBIR-21-1.aspx</u>

SBIR awards for these topic SOCOM211-D004 will be awarded as a fixed price (level of effort type), Other Transactions Agreement (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 <u>https://www.socom.mil/SOF-ATL/Pages/SBIR-21-1.aspx</u>. The terms and conditions as well as the requirements are included in the OTA template provided in this solicitation. The terms and conditions of the Template OTA and the latest version of the OTA may change prior to execution. The document deliverables required for the effort are

at attachment 2 of the OTA and the SOO is in attachment 3 of the OTA template. Offerors must review these documents to develop their proposal. The template needs to be filled only by those Offerors selected to present. Those selected to present 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 SOO (Attachment 3). The Government will evaluate only responsive proposals.

Proposal Submission:

Firms must upload their proposals to the Defense SBIR/STTR Innovation Portal Proposal Submissions at <u>https://www.dodsbirsttr.mil/submissions/login</u>. Additional USSOCOM specific submission requirements for each volume are detailed below.

Technical Inquiries:

During the <u>Pre-release Period</u> of the DoD SBIR 21.1 Program BAA, all questions must be submitted in writing either by e-mail to <u>sbir@socom.mil</u> or to the online Topic Q&A (formerly SITIS). All questions and answers submitted to 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 Section 4.13.c.of the DoD SBIR 21.1 Program BAA instructions). All inquiries must include the topic number in the subject line of the e-mail.

During the <u>Open Period</u>, follow the instructions in section 4.13.d of the DoD SBIR 21.1 Program BAA Instructions.

Site visits will not be permitted during the Pre-release and Open Periods of the DoD SBIR 21.1 Program BAA.

Proposal Volumes:

Volume 1: Cover Page is created as part of the DOD Proposal Submissions process.

Volume 2: Technical Volume

2.1 The Technical Volume shall not exceed 10 pages and will include all required items under section 5.4.c. of the DoD SBIR 21.1 instructions. Any additional pages will be deleted from the proposal prior to evaluation.

Note: The Phase I feasibility Appendix (Appendix A) is required for the Direct to Phase II proposal and is specified in **Volume 5**.

The technical proposal shall include a Statement of Work (SOW) with the planned tasks and descriptions to meet the Statement of Objectives (SOO) and Contract Data Requirement Lists (CDRLs) detailed in Attachments 2 and 3 of the OTA Template. Do not upload the SOO or CDRLs with your proposal. The SOO, and CDRLs will be provided in the OTA Template and can be downloaded from https://www.socom.mil/SOF-ATL/Pages/SBIR-21-1.aspx. The proposal must also include a completed Section K which does not count toward the page limit. Any templates are provided to help the Offerors consider the required work/deliverables when developing the proposal, but it is an Offeror's responsibility to provide fully responsive, complete, and clear submissions. 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. If the offeror is selected for

award, the provided SOW will become Attachment 3 of the resulting OTA, incorporating any agreed upon changes. The SOW attached to the OTA shall include no proprietary information, data, or markings

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 21.1 Announcement) to work on a USSOCOM ITAR topic must possess an export license to receive a SBIR Phase II contract.

Volume 3: Cost Volume

Offerors must complete the cost volume using the Phase II OTA Cost Proposal template posted on the USSOCOM Portal at <u>https://www.socom.mil/SOF-ATL/Pages/SBIR-21-1.aspx</u>, and read instructions 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 topics in this announcement, the 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 (not including TABA) will not be considered for award.

USSOCOM may provide TABA funds in Phase II awards to firms to meet up to Cybersecurity Maturity Model Certification (CMMC) Level 3 certification requirements. Draft of the CMMC is located at <u>https://www.acq.osd.mil/cmmc/draft.html</u>. Technical and Business Assistance (TABA) cost (if applicable) may be provided, not to exceed \$50,000 over the period of performance.

The TABA information must be included in the firm's proposal specifically identified as "Discretionary Technical and Business Assistance" and cannot be subject to any profit or fee by the requesting SBIR firm. In addition, the provider of the TABA 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, consultant, tester, or administrative service provider). Proposed TABA will be evaluated by the USSOCOM SBIR Program office. The proposed amount is in addition to the award amount for Phase II and cannot exceed \$50,000. The firm's proposal must (1) clearly identify the need for assistance (purpose and objective of required assistance); (2) provide details on the provider of the assistance proposed); and (3) the cost of the required assistance (costs and hours proposed or other details on arrangement that would justify the proposed expense).

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. 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.

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.

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 -

CCR is required to be submitted with proposals in response to SOOCOM 21.1 SBIR topics. Please refer to the DoD 21.1 SBIR BAA for full details.

Volume 5: Supporting Documents

Potential Offerors shall submit a slide deck not to exceed 15 PowerPoint slides. Must be separate and clearly marked. Any additional slides will not be evaluated only slide 1-15 will be evaluated.

Offerors must provide documentation to satisfy the Phase I feasibility requirement as specified in the direct to Phase II topic. The documentation shall be included as a Feasibility Appendix in **Volume 5**. 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).

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 21.1 SBIR BAA for full details.

Direct to Phase II Evaluations:

USSOCOM evaluates Direct to Phase II proposals using the evaluation criteria specified in section 7.4 of the DoD 21.1 SBIR Announcement with the following exceptions:

- 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 consider 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 Section 7.4 of the DoD SBIR 21.1 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 in Section 7.4 of the DoD SBIR 21.1 BAA. 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 evaluation team, in November 2020 using a virtual teleconference. All selected firms will be required to provide a teleconference information for the presentation. This presentation will be evaluated by a panel against the criteria listed under Section 7.4 of the DoD SBIR 21.1 BAA. Notifications of selection/non-selection for Phase II award will be completed within a timely manner.

4. The Cost Volume (Volume3) evaluation:

For this direct to phase II, the award amount is set at a not to exceed (NTE), a technical evaluation of the proposal cost will be completed to assess the probability of success to obtain a working prototype. Proposal above the set NTE for the 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, equipment, subcontractors and consultants (scope of work, expertise, participation and proposed effort), travel and other direct cost as proposed.

The resulting award/s will be a fixed price OTA prototyping agreements 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 Officer notifies the Offeror by e-mail of selection/non-selection for award. The e-mail notification will only be sent to the Corporate Official (Business) identified by the Offeror.

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 paragraph 4.10, entitled "Debriefing," of the DoD SBIR 21.1 Announcement.

USSOCOM SBIR Program Point of Contact:

Inquiries concerning the USSOCOM SBIR Program should be addressed to sbir@socom.mil.

SOCOM 21.1 SBIR Direct to Phase II Topic Index

SOCOM211-D004Integrated Cyber and Electronic Warfare InfrastructureSOCOM211-D005Next Generation Field Computing Device - Wearable

SOCOM211-D004 TITLE: Integrated Cyber and Electronic Warfare Infrastructure

TECHNOLOGY FOCUS AREA(S): Network Command, Control and Communications; General Warfighting Requirements (GWR); Directed Energy

TECHNOLOGY AREA(S): Sensors; Information Systems; Battle Space

ACQUISITION PROGRAM: Special Operations Mission Planning & Execution

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 in Probability of Detection (LPD)/Low Probability of Intercept (LPI) communications network operating in a "zero trust" environment that can be integrated with Electronic Warfare, Information Warfare, and/or Cyber Reconnaissance and Surveillance (R&S) tools to include using commercial off the shelf technologies (COTS) in order to blend into the operational environment.

DESCRIPTION: As a part of this feasibility study, the proposers shall address all viable overall system design options with respective specifications on the key system attributes. This platform must have the ability to integrate tools that can sense, detect, locate, characterize and catalog unintended and intended signals/emissions from non-alerting sensors, and either store the data locally on the sensor for later download or have the ability to rapidly and securely move the sensor data back to a base location without using local cellular networks. Secondary, but required in the overall design, the platform must have the ability to take the sensor data and immediately identify threat related signals for immediate Electronic Warfare or wireless disruption to protect Special Operations Forces (SOF) personnel from potential discovery, improvised explosive device/Vehicle-Borne Improvised Explosive Devices (IED/VBEID) devices, or support assault forces conducting actions on an objective. Lastly, the platform must demonstrate the ability to operate as a full spectrum cyberwarfare weapons platform for defensive and offensive operations. In this capacity, the platform must provide options as a rapidly configurable, Android Tactical Assault Kit (ATAK) compatible (secure ATAK traffic), attributable or non-attributable, disposable communications network and cyber weapons platform.

PHASE I: Conduct a feasibility study to assess what is in the art of the possible that satisfies the requirements specified in the above paragraph entitled "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 a prototype system determined to be the most feasible solution during the Phase I feasibility study on a virtual private network/virtual private server (VPN/VPS) certificate based secure COTS communications system with the ability for rapid establishment (within 15 minutes or less) for use as an Electronic and Cyber Warfare reconnaissance and surveillance platform with the ability to conduct rapid tear down (within 15 minutes or less) to significantly reduce overall risk to exposure or compromise upon the conclusion of conducting electronic or cyber warfare attacks or disruption.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military applications where communication security is a high priority and early warning of adversary electronic warfare or intelligence, surveillance and reconnaissance threat is high. These tools provide for emergency communications for operations in high threat areas where non attributable, LPI/LPD communications are an absolute requirement.

REFERENCES:

1. USSSOCOM S&T SOF "Hard Problems" https://www.socom.mil/SOF-ATL/Pages/SOF-Hard-Problems.aspx

KEYWORDS: Non Attributable Communications; LPI/LPD communications; Cyber Electromagnetic Activities (CEMA); Electronic Warfare (EW); Information Warfare (IW); Cyber, Full Spectrum Cyber Warfare; Virtual Private Networks (VPN); ATAK

Email: sbir@socom.mil

SOCOM211-D005 TITLE: Next Generation Field Computing Device - Wearable

TECHNOLOGY FOCUS AREA(S): Biotechnology Space; Network Command, Control and Communications; Cybersecurity; General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): INFORMATION SYSTEMS; MATERIALS; SENSORS; ELECTRONICS; HUMAN SYSTEMS; BIOMEDICAL

ACQUISITION PROGRAM: Specific Acquisition Program(s) this effort transitions to is directly related to the Tactical Local Area Network program.

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.

OBJECTIVE: The objective of this topic is to develop applied research toward an innovative capability to replace the current Field Computing Device – Wearable (FCD-W) with open system architecture. Specific focus of this topic investigates improving human factors as a result of excessive cabling, developing a smart hub for plug and play use of peripheral devices, integrating a secure personal area network on the smart hub capable of being certified for processing higher levels of classification, and integrating additional processing capabilities into the smart hub.

DESCRIPTION: The FCD-W variant was adopted in the TACLAN program back in 2016 in response to a Combat Mission Needs Statement. Since the inception of the FCD-W, several incremental changes have been made to replace the End User Device and upgrade versions of the Android Tactical Assault Kit (ATAK) but the overall functionality of the system has remained the same. USSOCOM is seeking a direct to phase II SBIR to advance the FCD-W capability while meeting the following high level objectives:

- 1) Design a rugged tactical USB cabled solution
- 2) Develop a tactical hub and prove feasibility of smart hub features
- 3) Implement power and data management
- 4) Develop connections to tactical radios, peripheral equipment, and tactical batteries for system power

PHASE I: The Offerors shall conduct requirements analysis and perform design trade-offs, feature feasibility risk reduction, design validation prototyping, and developmental testing to achieve the stated development objectives.

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 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 OSOCOM 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.
VERSION 4

PHASE II: Develop and demonstrate a prototype system determined to be the most feasible solution. In addition, as a system intended for comparative operational evaluation, the Phase II prototype may be required to satisfy security requirements that will allow its implementation and use on the SOF information enterprise.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and private sector applications to enhance mission planning and execution.

REFERENCES:

- 1. https://ndiastorage.blob.core.usgovcloudapi.net/ndia/2018/sofic/PEOC4Woods.pdf
- 2. https://www.militaryaerospace.com/unmanned/article/16707347/military-wearable-computing-hits-the-mainstream

KEYWORDS: Hyper Enabled; Personal Area Network; Secure Communications; Edge Compute; Field Computing Device; ATAK; Tactical Mission Networking

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