DEPARTMENT OF DEFENSE
SMALL BUSINESS TECHNOLOGY TRANSFER (STTR) PROGRAM
STTR 22.B Program Broad Agency Announcement (BAA)

April 20, 2022: DoD BAA issued for pre-release
May 18, 2022: DoD begins accepting proposals
June 15, 2022: Deadline for receipt of proposals no later than **12:00 p.m. ET**

Participating DoD Components:

- Department of Army (Army)
- Department of Air Force (Air Force)
- Chemical and Biological Defense (CBD)
- Defense Health Agency (DHA)
- Defense Threat Reduction Agency (DTRA)
- Missile Defense Agency (MDA)
- Office of the Secretary of Defense – Basic Research Office (OSD – BRO)

IMPORTANT

Deadline for Receipt: Complete proposals must be certified and submitted in DSIP no later than **12:00 PM** ET on **June 15, 2022**. Proposals submitted after 12:00 p.m. ET will not be evaluated. The final proposal submission includes successful completion of all firm level forms, all required volumes, and electronic corporate official certification. Please plan to submit proposals as early as possible in order to avoid unexpected delays due to high volume of traffic during the final hours before the BAA close. DoD is not responsible for missed proposal submission due to system latency.

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

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

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

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

On April 4, 2022, the DUNS Number will be replaced by the Unique Entity ID (SAM) to identify organizations doing business with the Government. If the firm has an entity registration in SAM.gov (even if the registration has expired), a UEI (SAM) has already been assigned. **For firms with established DSIP accounts, update the firm profile with the UEI (SAM) as soon as possible.** See section 4.15 for more information.

Questions: Please refer to the DSIP Customer Support Document for general information regarding the DoD SBIR/STTR process in DSIP. For additional assistance with the DSIP application, please visit the Learning & Support section of the DSIP at https://www.dodsbirsttr.mil/submissions/learning-support/. Email DSIP Support at DoDSBIRSupport@reisystems.com only for further assistance with issues pertaining directly to the DSIP application. Questions submitted to DSIP Support will be addressed in the order received during normal operating hours (Monday through Friday, 9:00 a.m. to 5:00 p.m. ET). **See section 4.14 for further information on where to direct questions regarding instructions and topics in this BAA**.

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ATTACHMENTS

1.0 INTRODUCTION

Army, Air Force, CBD, DHA, DTRA, MDA, OSD - BRO, hereafter referred to as DoD Components, invite small business firms and research institutions to jointly submit proposals under this BAA for the Small Business Technology Transfer (STTR) 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.

The STTR Program, although modeled substantially after the Small Business Innovation Research (SBIR) Program, is a separate program and is separately financed. Subject to availability of funds, DoD Components will support high quality cooperative research and development proposals of innovative concepts to solve the listed defense-related scientific or engineering problems, especially those concepts that also have high potential for commercialization in the private sector. Partnerships between small businesses and Historically Black Colleges and Universities (HBCUs) or Minority Institutions (MIs) are encouraged, although no special preference will be given to STTR proposals from such proposers.

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

2.2 Technology and Program Protection to Maintain Technological Advantage

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

determine risks posed by STTR contract awardees and their subcontractors to the DoD and the defense industrial base.

OUSD(R&E) Modernization Priorities

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

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

2.3 Three Phase Program

The STTR 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 STTR 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-STTR 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. STTR Phase III refers to work that derives from, extends, or completes an effort made under prior STTR funding agreements, but is funded by sources other than the STTR Program. Phase III work is typically oriented towards commercialization of STTR research or technology.

3.0 DEFINITIONS

The following definitions from the SBA STTR Policy Directive and the Federal Acquisition Regulation (FAR) apply for the purposes of this BAA:

Commercialization

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

Cooperative Research and Development

For the purposes of the STTR Program this means research and development conducted jointly by a small business concern and a research institution in which not less than 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.

The percentage of work is usually measured by both direct and indirect costs; however, proposers should verify how it will be measured with their DoD contracting officer during contract negotiations.

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 STTR Program training related to Fraud, Waste and Abuse is available at: https://www.sbir.gov/tutorials/fraud-waste-abuse/tutorial-1. See Section 4.17 for reporting Fraud, Waste and Abuse.

Funding Agreement

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

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

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

Certified HUBZone Small Business Concern

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

Performance Benchmark Requirements for Phase I

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

Principal Investigator

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

For both Phase I and Phase II, the primary employment of the principal investigator must be with the small business firm or research institution 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 firm or research institution. This precludes full-time employment with another organization. Occasionally, deviations from this requirement may occur, and must be approved in writing by the contracting officer after consultation with the agency SBIR/STTR Program Manager/Coordinator. Further, a small business firm or research institution may replace the principal investigator on an SBIR/STTR Phase I or Phase II award, subject to approval in writing by the contracting officer.

Proprietary Information

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

Research Institution

Any organization located in the United States that is:

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

Research or Research and Development

Any activity that is:

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

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

Research Involving Animal Subjects

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

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

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

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

Research Involving Human Subjects

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

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

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

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

Research Involving Recombinant DNA Molecules

Any recipient performing research involving recombinant DNA molecules and/or organisms and viruses containing recombinant DNA molecules shall comply with the National Institutes of Health Guidelines

for Research Involving Recombinant DNA Molecules, dated January 2011, as amended. The guidelines can be found at: https://osp.od.nih.gov/wp-content/uploads/2016/05/NIH_Guidelines.pdf. Recombinant DNA is defined as (i) molecules that are constructed outside living cells by joining natural or synthetic DNA segments to DNA molecules that can replicate in living cells or (ii) molecules that result from the replication of those described in (i) above.

Service-Disabled Veteran-Owned Small Business (SDVOSB)

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

Small Business Concern (SBC)

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

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

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

Subcontract

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

Subcontractor

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

United States

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

Women-Owned Small Business Concern

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

4.0 PROPOSAL FUNDAMENTALS

4.1 Introduction

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

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

4.2 Proposer Eligibility and Performance Requirements

a. Each proposer must qualify as a small business concern as defined by 13 CFR §701-705 at time of award and certify to this on the Cover Sheet 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 40% of each STTR project must be conducted by the small business concern and a minimum of 30% of the effort performed by the single research institution, as defined in Section 3. The percentage of work is usually measured by both direct and indirect costs.
c. For both Phase I and II, the primary employment of the principal investigator must be with the small business firm or the research institution at the time of award and during the conduct of the proposed effort. At the time of award of a Phase I or Phase II contract, the small business concern must have at least one employee in a management position whose primary employment is with the small business and who is not also employed by the research institution. Primary employment means that more than one half of the principal investigator's time is spent with the small business. Primary employment with a small business concern precludes full-time employment at another organization.
d. For both Phase I and Phase II, all research or research and development work must be performed by the small business concern and its subcontractors in the United States.
e. **Benchmarks**. Proposers with prior SBIR/STTR awards must meet two benchmark requirements for Progress towards Commercialization as determined by the Small Business Administration (SBA) on June 1 each year.

    (1) Phase I to Phase II Transition Rate: For all proposers with greater than 20 Phase I awards over the past five fiscal years excluding the most recent year, the ratio of Phase II awards to Phase I awards must be at least 0.25.

    (2) Commercialization Benchmark: For all proposers with greater than 15 Phase II awards over the last ten fiscal years excluding the last two years, the proposer must have received, to date, an average of at least $100,000 of sales and/or investments per Phase II award received or have received a number of patents resulting from the STTR 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 www.sbir.gov.
- In addition, SBA has posted a Guide to SBIR/STTR Program Eligibility to help small businesses understand program eligibility requirements, determine if they will be eligible at the time of award, and accurately complete necessary certifications.
- The benchmark information on the companies will not be available to the public.
- More detail is available at https://www.sbir.gov/performance-benchmarks.

f. A small business concern must negotiate a written agreement between the small business and the research institution allocating intellectual property rights and rights to carry out follow-on research, development, or commercialization (see Model Agreement for the Allocation of Rights).

4.3 Joint Ventures

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

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

Unless otherwise noted in the participating Component instructions, small businesses that are owned in majority part by multiple venture capital operating companies (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 (sub-awardee, consultant) is providing SETA, A&AS, or similar support to any DoD Component office(s) under: (a) a current award or sub-award; or (b) a past award or sub-award that ended within one calendar year prior to the proposal's submission date.

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

- The name of the DoD Component office receiving the support;
- The prime contract number;
- Identification of proposed team member (sub-awardee, consultant) providing the support; and
- An OCI mitigation plan in accordance with FAR 9.5.

Government Procedures

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

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

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

4.7 Classified Proposals

Classified proposals will not be accepted under the DoD STTR Program. If topics will require classified work during Phase II, the proposing firm must have a facility clearance in order to perform the Phase II work. For more information on facility and personnel clearance procedures and requirements, please

visit the Defense Counterintelligence and Security Agency (DCSA) website at: https://www.dcsa.mil/mc/ctp/fc/.

4.8 Research Involving Human Subjects

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

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

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

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

4.9 Research Involving Animal Subjects

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

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

All Recipients must receive their IACUC's approval as well as secondary or headquarters-level approval by a DoD veterinarian who is trained or experienced in laboratory animal medicine and science. **No**

animal research may be conducted using DoD funding until all the appropriate DoD office(s) grant approval. Submitters proposing research involving human and/or animal use are encouraged to separate these tasks in the technical proposal and cost proposal in order to avoid potential delay of contract award.

4.10 Research Involving Recombinant DNA Molecules

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

4.11 Debriefing/Technical Evaluation Narrative

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

4.12 Pre-Award and Post Award BAA Protests

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

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

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

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

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

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

4.13 Phase I Award Information

All Phase I proposals will be evaluated and judged on a competitive basis in terms of technical capability and technical value. Proposals will be initially screened to determine responsiveness to the topic objective. Proposals passing this initial screening will be technically evaluated by engineers or scientists to determine the most promising technical and scientific approaches. As a common statement of work does not exist, each proposal will be assessed on the merit of the approach in achieving the technical objectives established in the topic. DoD is under no obligation to fund any proposal or any specific

number of proposals in a given topic. It also may elect to fund several or none of the proposed approaches to the same topic.

a. **Number of Phase I Awards**. The number of Phase I awards will be consistent with the Component's RDT&E budget. No Phase I contracts will be awarded until evaluation of all qualified proposals for a specific topic is completed.

b. **Type of Funding Agreement**. Each Phase I proposal selected for award will be funded under negotiated contracts or purchase orders and will include a reasonable fee or profit consistent with normal profit margins provided to profit-making firms for R/R&D work. Firm Fixed Price, Firm-Fixed-Price Level of Effort, Labor Hour, Time & Material, or Cost-Plus-Fixed-Fee type contracts can be negotiated and are at the discretion of the Component Contracting Officer.

c. **Dollar Value**. The Phase I contract value varies among the DoD Components; it is therefore important for proposing firms to review Component-specific instructions regarding award size.

d. **Timing.** Proposing firms will be notified of selection or non-selection status for a Phase I or DP2 award by the DoD Component that originated the topic within 90 days of the closing date for this BAA. Please refer to the Component-specific instructions for details.

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

4.14 Questions about this BAA and BAA Topics

a. **General SBIR/STTR Questions/Information**.

(1) **DSIP Support:**
Email DSIP Support at DoDSBIRSupport@reisystems.com only for assistance with using the DSIP application. Questions regarding DSIP can be emailed to DSIP Support and will be addressed in the order received, during normal operating hours (Monday through Friday, 9:00 a.m. to 5:00 p.m. ET). Please include information on your firm, a proposal number (if applicable), and screenshots of any pertinent errors or issues encountered.

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

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

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

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

- Customer Support Information
- SBIR and STTR Program Opportunities
- Dates for Current and Upcoming Opportunities
- Past SBIR and STTR Program Opportunities

(3) **SBIR/STTR Updates and Notices:**
To be notified of SBIR/STTR opportunities and to receive e-mail updates on the DoD SBIR and STTR Programs, subscribe to the Listserv by selecting "DSIP Listserv" under Quick Links on the DSIP login page.

b. **General Questions about a DoD Component**. Questions pertaining to a particular DoD Component or the Component-specific BAA instructions should be submitted in accordance with the instructions given at the beginning of that Component's topics.

c. **Direct Contact with Topic Authors.** From **April 20, 2022 to May 18, 2022,** this BAA is issued for pre-release with the names of the topic authors and their phone numbers and e-mail addresses. During the pre-release period, proposing firms have an opportunity to contact topic authors by telephone or e-mail to ask technical questions about specific BAA topics. Questions should be limited to specific information related to improving the understanding of a particular topic's requirements. Proposing firms may not ask for advice or guidance on solution approach and you may not submit additional material to the topic author. If information provided during an exchange with the topic author is deemed necessary for proposal preparation, that information will be made available to all parties through Topic Q&A. After this period questions must be asked through Topic Q&A as described below.

d. **Topic Q&A**. Once DoD begins accepting proposals on **May 18, 2022**, no further direct contact between proposers and topic authors is allowed, unless the Topic Author is responding to a question submitted during the pre-release period. However, proposers may submit written questions through Topic Q&A at https://www.dodsbirsttr.mil/submissions/login. In Topic Q&A, all questions and answers are posted electronically for general viewing. Identifying information for the questioner and respondent is not posted.

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

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

The Topic Q&A for this BAA opens on **April 20, 2022** and closes to new questions on **June 1, 2022 at 12:00 PM ET**. Once the BAA closes to proposal submission, no communication of any kind with the topic author or through Topic Q&A regarding your submitted proposal is allowed.

Proposing firms are advised to monitor Topic Q&A during the BAA period for questions and

answers. Proposing firms should also frequently monitor DSIP for updates and amendments to the topics.

4.15 Registrations and Certifications

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

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

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

On April 4, 2022, the DUNS Number will be replaced by the Unique Entity ID (SAM). The Federal Government will use the UEI (SAM) to identify organizations doing business with the Government. The DUNS number will no longer be a valid identifier. If the firm has an entity registration in SAM.gov (even if the registration has expired), a UEI (SAM) has already been assigned. This can be found by signing into SAM.gov and selecting the Entity Management widget in the Workspace or by signing in and searching entity information. **For firms with established Defense SBIR/STTR Innovation Portal (DSIP) accounts, update the firm profile with the UEI (SAM) as soon as possible.**

For new firm registrations, follow instructions during SAM registration on how to obtain a Commercial and Government Entry (CAGE) code and be assigned the UEI (SAM). Once a CAGE code and UEI (SAM) are obtained, update the firm's profile on the DSIP at https://www.dodsbirsttr.mil/submissions/.

In addition to the standard federal and DoD procurement certifications, the SBA STTR Policy Directive requires the collection of certain information from firms at time of award and during the award life cycle.

Each firm must provide this additional information at the time of the Phase I and Phase II award, prior to final payment on the Phase I award, prior to receiving 50% of the total award amount for a Phase II award, and prior to final payment on the Phase II award.

4.16 Promotional Materials

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

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

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

4.18 Fraud and Fraud Reporting

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

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

4.19 State and Other Assistance Available

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

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

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

4.20 Discretionary Technical and Business Assistance (TABA)

DoD has 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.

Guidance on allowable proposal content may vary by Component. A completed proposal submission in DSIP does NOT indicate that each proposal volume has been completed in accordance with the Component-specific instructions. Accordingly, it is the proposing firm's responsibility to consult the Component-specific instructions for detailed guidance, including required proposal documentation and structure, cost and duration limitations, budget structure, TABA allowance and proposal page limits.

DSIP provides a structure for providing the following proposal volumes:

Volume 1: Proposal Cover Sheet
Volume 2: Technical Volume
Volume 3: Cost Volume
Volume 4: Company Commercialization Report (upload of CCR from SBIR.gov to DSIP is required for proposers with prior Federal SBIR or STTR awards)
Volume 5: Supporting Documents

a. Contractor Certification Regarding Provision of Prohibition on Contracting for Certain Telecommunications and Video Surveillance Services or Equipment (Attachment 1)
b. Foreign Ownership or Control Disclosure (Proposers must review Attachment 2: Foreign Ownership or Control Disclosure to determine applicability.)
c. Other supporting documentation (Refer to Component-specific instructions for additional Volume 5 requirements)

Volume 6: Fraud, Waste and Abuse Training

All proposers must complete the following:

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

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

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

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

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

5.2 Marking Proprietary Proposal Information

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

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

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

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

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

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

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

5.3 Phase I Proposal Instructions

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

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

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

b. **Format of Technical Volume (Volume 2)**

(1) **Type of file**: The Technical Volume must be a single Portable Document Format (PDF) file, including graphics. Perform a virus check before uploading the Technical Volume file. If a virus is detected, it may cause rejection of the proposal. **Do not lock or encrypt the uploaded file. Do not include or embed active graphics such as videos, moving pictures, or other similar media in the document.**

(2) **Length**: It is the proposing firm's responsibility to verify that the Technical Volume does not exceed the page limit after upload to DSIP. Please refer to Component-specific instructions for how a technical volume is handled if the stated page count is exceeded. Some Components will reject the entire technical proposal if the proposal exceeds the stated page count.

(3) **Layout**: Number all pages of your proposal consecutively. Those who wish to respond must submit a direct, concise, and informative research or research and development proposal (no type smaller than 10-point on standard 8-1/2" x 11" paper with one-inch margins). The header on each page of the Technical Volume should contain your company name, topic number, and proposal number assigned by the Defense SBIR/STTR Innovation Portal (DSIP) when the Cover Sheet was created. The header may be included in the one-inch margin.

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

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

(1) **Identification and Significance of the Problem or Opportunity.** Define the specific technical problem or opportunity addressed and its importance.

(2) **Phase I Technical Objectives.** Enumerate the specific objectives of the Phase I work, including the questions the research and development effort will try to answer to determine the feasibility of the proposed approach.

(3) **Phase I Statement of Work (including Subcontractors' Efforts)**

a. Provide an explicit, detailed description of the Phase I approach. If a Phase I option is required or allowed by the Component, describe appropriate research activities which would commence at the end of Phase I base period should the Component elect to exercise the option. The Statement of Work should indicate what tasks are planned, how and where the work will be conducted, a schedule of major events, and the final product(s) to be delivered. The Phase I effort should attempt to determine the technical feasibility of the proposed concept. The methods planned to achieve each objective or

task should be discussed explicitly and in detail. This section should be a substantial portion of the Technical Volume section.

b. This BAA may contain topics that have been identified by the Program Manager as research or activities involving Human/Animal Subjects and/or Recombinant DNA. In the event that Phase I performance includes performance of these kinds of research or activities, please identify the applicable protocols and how those protocols will be followed during Phase I. Please note that funds cannot be released or used on any portion of the project involving human/animal subjects or recombinant DNA research or activities until all of the proper approvals have been obtained (see Sections 4.7 - 4.9). **Submitters proposing research involving human and/or animal use are encouraged to separate these tasks in the technical proposal and cost proposal in order to avoid potential delay of contract award.**

(4) **Related Work.** Describe significant activities directly related to the proposed effort, including any conducted by the principal investigator, the proposing firm, consultants, or others. Describe how these activities interface with the proposed project and discuss any planned coordination with outside sources. The technical volume must persuade reviewers of the proposer's awareness of the state-of-the-art in the specific topic. Describe previous work not directly related to the proposed effort but similar. Provide the following:

a. Short description,
b. Client for which work was performed (including individual to be contacted and phone number), and
c. Date of completion.

(5) **Relationship with Future Research or Research and Development**

a. State the anticipated results of the proposed approach if the project is successful.
b. Discuss the significance of the Phase I effort in providing a foundation for Phase II research or research and development effort.
c. Identify the applicable clearances, certifications and approvals required to conduct Phase II testing and outline the plan for ensuring timely completion of said authorizations in support of Phase II research or research and development effort.

(6) **Commercialization Strategy.** Describe in approximately one page your company's strategy for commercializing this technology in DoD, other Federal Agencies, and/or private sector markets. Provide specific information on the market need the technology will address and the size of the market. Also include a schedule showing the quantitative commercialization results from this STTR 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 STTR 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 STTR 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 research institution in the project is required and the institution should be identified and described according to the Cost Breakdown Guidance. A minimum of 40% 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. STTR 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/STTR 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, such as labor, travel, equipment, materials, must be detailed at the same level as prime contractor costs. Provide detailed substantiation of subcontractor costs in your cost proposal. Volume 5, Supporting Documents, may be used if additional space is needed.

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

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

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

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

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

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

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

a. If the proposing firm has prior DoD and/or non-DoD Phase I and/or Phase II SBIR/STTR awards, and **DOES have a new or revised CCR from SBIR.gov to upload to DSIP**, select YES.
   - If the user is the Firm Admin, they can upload the PDF of the CCR from SBIR.gov directly on this page. It will also be updated in the Firm Forms and be associated with all new or in-progress proposals submitted by the firm. If the user is not the Firm Admin, they will receive a message that they do not have access and must contact the Firm Admin to complete this action.
   - **WARNING:** Uploading a new CCR under the Firm Forms section of DSIP or clicking "Save" or "Submit" in Volume 4 of one proposal submission is considered a change for ALL proposals under any open BAAs or CSOs. If a proposing firm has previously certified and submitted any Phase I or Direct to Phase II proposals under ***any*** BAA or CSO ***that is still open***, those proposals will be automatically reopened. Proposing firms will have to recertify and resubmit such proposals. If a proposing firm does not recertify or resubmit such proposals, they will not be considered fully submitted and will not be evaluated.

b. If the proposing firm has prior DoD and/or non-DoD Phase I and/or Phase II SBIR/STTR awards, and **DOES NOT have a new or revised CCR from SBIR.gov to upload to DSIP**, select NO.
   - If a prior CCR was uploaded to the Firm Forms, the proposer will see a file dialog box at the bottom of the page and can view the previously uploaded CCR. This read-only

access allows the proposer to confirm that the CCR has been uploaded by the Firm Admin.

- If no file dialog box is present at the bottom of the page that is an indication that **there is no previously uploaded CCR in the DSIP Firm Forms**. To fulfill the DSIP CCR requirement the Firm Admin must follow steps 1-5 listed above to download a PDF of the CCR from SBIR.gov and upload it to the DSIP Firm Forms to be included with all proposal submissions.

c. If the proposing firm has **NO** prior DoD and/or non-DoD Phase I and/or Phase II SBIR/STTR awards, the upload of the CCR from SBIR.gov is not required and firm will select NO. The CCR section of the proposal will be marked complete.

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

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

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

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

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

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

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

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

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

All proposals must include certifications in Defense Federal Acquisition Regulation Supplement (DFARS) provisions 252.204-7016, 252.204-7017, and clause 252.204-7018, executed by the proposer's authorized company representative. These DFARS provisions and 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

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

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

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

6.0 PHASE I EVALUATION CRITERIA

Proposals will be evaluated based on the criteria outlined below, unless otherwise specified in the Component-specific instructions. Selections will be based on a determination of the overall technical value of each proposal and an evaluation of the cost volume, with the appropriate method of analysis given the contract type to be awarded, in order for selection of the proposal(s) most advantageous 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 proposal 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 BAA or 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/STTR contracts and other contracts of similar size with the Department of Defense (DoD), have an adequate accounting system per General Accepted Accounting Principles (GAAP), Generally Accepted Government Auditing Standards (GAGAS), Federal Acquisition Regulation (FAR) and Cost Accounting Standards (CAS) in place. The accounting system will be audited by the Defense Contract Audit Agency (DCAA). DCAA's requirements and standards are available on their Website at: https://www.dcaa.mil/Guidance/Audit-Process-Overview/ and https://www.dcaa.mil/Checklists-Tools/Pre-award-Accounting-System-Adequacy-Checklist/.

7.7 Phase II Enhancement Policy

To further encourage the transition of STTR 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 STTR funding if the company can match the additional STTR funds with non-STTR 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 establishes 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 established the OSD Transitions SBIR Technology (OTST) Pilot Program. The OTST pilot program is an interim technology maturity phase (Phase II), inserted into the SBIR development.

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

8.0 CONTRACTUAL REQUIREMENTS

8.1 Additional Contract Requirements

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

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

Examples of general provisions:

a. **Standards of Work**. Work performed under the contract must conform to high professional standards.
b. **Inspection**. Work performed under the contract is subject to Government inspection and evaluation at all reasonable times.
c. **Examination of Records**. The Comptroller General (or a fully authorized representative) shall have the right to examine any directly pertinent records of the contractor involving transactions related to this contract.
d. **Default**. The Government may terminate the contract if the contractor fails to perform the work contracted.
e. **Termination for Convenience**. The contract may be terminated at any time by the Government if it deems termination to be in its best interest, in which case the contractor will be compensated for work performed and for reasonable termination costs.
f. **Disputes**. Any dispute concerning the contract which cannot be resolved by agreement shall be decided by the contracting officer with right of appeal.
g. **Contract Work Hours**. The contractor may not require an employee to work more than eight hours a day or forty hours a week unless the employee is compensated accordingly (that is, receives overtime pay).

h. **Equal Opportunity**. The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.
i. **Affirmative Action for Veterans**. The contractor will not discriminate against any employee or applicant for employment because he or she is a disabled veteran.
j. **Affirmative Action for Handicapped**. The contractor will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.
k. **Officials Not to Benefit**. No member of or delegate to Congress shall benefit from the contract.
l. **Covenant Against Contingent Fees**. No person or agency has been employed to solicit or secure the contract upon an understanding for compensation except bona fide employees or commercial agencies maintained by the contractor for the purpose of securing business.
m. **Gratuities**. The contract may be terminated by the Government if any gratuities have been offered to any representative of the Government to secure the contract.
n. **Patent Infringement**. The contractor shall report each notice or claim of patent infringement based on the performance of the contract.
o. **Military Security Requirements**. The contractor shall safeguard any classified information associated with the contracted work in accordance with applicable regulations.
p. **American Made Equipment and Products**. When purchasing equipment or a product under the SBIR funding agreement, purchase only American-made items whenever possible.

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

q. **Unique Identification (UID)**. If your proposal identifies hardware that will be delivered to the government be aware of the possible requirement for unique item identification in accordance with DFARS 252.211-7003.
r. **Disclosure of Information.** In accordance with FAR 252.204-7000, Government review and approval will be required prior to any dissemination or publication, 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 22.2803.
v. **ITAR**. In accordance with DFARS 225.7901-4, Export Control Contract Clauses, the clause found at DFARS 252.225-7048, Export-Controlled Items (June 2013), must be included in all BAAs/solicitations and contracts. Therefore, all awards resulting from this BAA will include DFARS 252.225-7048. Full text of the clause may be found at https://www.govinfo.gov/content/pkg/CFR-2013-title48-vol3/pdf/CFR-2013-title48-vol3-sec252-225-7048.pdf.
w. **Cybersecurity**. Any SBC receiving an SBIR/STTR award is required to provide adequate security on all covered contractor information systems. Specific security requirements and cyber incident reporting requirements are listed in DFARS 252.204.7012. Compliance is mandatory.

x. **Safeguarding Covered Defense Information Controls.** As prescribed in DFARS 252.204-7008, for covered contractor information systems that are not part of an information technology service or system operated on behalf of the Government, the SBC represents that it will implement the security requirements specified by National Institute of Standards and Technology (NIST) Special Publication (SP) 800-171, "Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations".

y. **Limitations on the Use or Disclosure of Third- Party Contractor Reported Cyber Incident Information.** As required in DFARS 252.204-7009, the Contractor must agree that certain conditions apply to any information it receives or creates in the performance of a resulting contract that is information obtained from a third-party's reporting of a cyber incident pursuant to DFARS clause 252.204-7012, Safeguarding Covered Defense Information and Cyber Incident Reporting (or derived from such information obtained under that clause).

z. **Notice of NIST SP 800-171 DoD Assessment Requirements.** As prescribed by DFARS 252.204-7019, in order to be considered for award, the SBC is required to implement NIST SP 800-171. The SBC shall have a current assessment (see 252.204-7020) for each covered contractor information system that is relevant to the offer, contract, task order, or delivery order. The Basic, Medium, and High NIST SP 800-171 DoD Assessments are described in the NIST SP 800-171 DoD Assessment Methodology located at https://www.acq.osd.mil/dpap/pdi/cyber/strategically_assessing_contractor_implementation_of_NIST_SP_800-171.html. In accordance with DFARS 252.204-7020, the SBC shall provide access to its facilities, systems, and personnel necessary for the Government to conduct a Medium or High NIST SP 800-171 DoD Assessment, as described in NIST SP 800-171 DoD Assessment Methodology, linked above. Notification of specific requirements for NIST SP 800-171 DoD assessments and assessment level will be provided as part of the component instructions, topic, or award.

aa. **Contractor Certification Regarding Provision of Prohibition on Contracting for Certain Telecommunications and Video Surveillance Services or Equipment.** In accordance with DFARS Subpart 204.21, DFARS provisions 252.204-7016, 252.204-7017, and clause 252.204-7018 are incorporated into this solicitation. This subpart implements section 1656 of the National Defense Authorization Act for Fiscal Year 2018 (Pub. L. 115-91) and section 889(a)(1)(A) of the National Defense Authorization Act for Fiscal Year 2019 (Pub. L. 115-232). Full text of the provisions and clause and required offeror representations can be found in Attachment 1 of this BAA.

bb. **Disclosure of Ownership or Control by a Foreign Government**. DFARS 252.209-7002, Disclosure of Ownership or Control by a Foreign Government (JUN 2010), is incorporated into this solicitation. In accordance with DFARS 252.209-7002, any SBC submitting a proposal in response to this solicitation is required to disclose, by completing Attachment 2 to this solicitation, Foreign Ownership or Control Disclosure, any interest a foreign government has in the SBC when that interest constitutes control by a foreign government, as defined in DFARS provision 252.209-7002. If the SBC is a subsidiary, it is also required to disclose any reportable interest a foreign government has in any entity that owns or controls the subsidiary, including reportable interest concerning the SBC's immediate parent, intermediate parents, and the ultimate parent.

8.2 Ensuring Adequate COVID-19 Safety Protocols for Federal Contractors

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

Workforce Task Force at: https://www.saferfederalworkforce.gov/contractors/.

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

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

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

United States or its outlying areas means—

(1) The fifty States;

(2) The District of Columbia;

(3) The commonwealths of Puerto Rico and the Northern Mariana Islands;

(4) The territories of American Samoa, Guam, and the United States Virgin Islands; and

(5) The minor outlying islands of Baker Island, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Midway Islands, Navassa Island, Palmyra Atoll, and Wake Atoll.

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

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

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

8.3 Basic Safeguarding of Covered Contractor Information Systems

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

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

(a) Definitions. As used in this clause -

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

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

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

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

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

(b) Safeguarding requirements and procedures.

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

(i) Limit information system access to authorized users, processes acting on behalf of authorized users, or devices (including other information systems).

(ii) Limit information system access to the types of transactions and functions that authorized users are permitted to execute.

(iii) Verify and control/limit connections to and use of external information systems.

(iv) Control information posted or processed on publicly accessible information systems.

(v) Identify information system users, processes acting on behalf of users, or devices.

(vi) Authenticate (or verify) the identities of those users, processes, or devices, as a prerequisite to allowing access to organizational information systems.

(vii) Sanitize or destroy information system media containing Federal Contract Information before disposal or release for reuse.

(viii) Limit physical access to organizational information systems, equipment, and the respective operating environments to authorized individuals.

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

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

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

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

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

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

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

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

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

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

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

8.5 Copyrights

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

8.6 Patents

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

8.7 Technical Data Rights

Rights in technical data, including software, developed under the terms of any contract resulting from proposals submitted in response to this BAA generally remain with the contractor, except that the Government obtains a royalty-free license to use such technical data only for Government purposes during the period commencing with contract award and ending twenty years after completion of the project under which the data were generated. This data should be marked with the restrictive legend specified in DFARS 252.227-7018 Class Deviation 2020-O0007. Upon expiration of the twenty-year restrictive license, the Government has unlimited rights in the STTR data. During the license period, the Government may not release or disclose STTR data to any person other than its support services contractors except: (1) For evaluation purposes; (2) As expressly permitted by the contractor; or (3) A use, release, or disclosure that is necessary for emergency repair or overhaul of items operated by the Government. See DFARS clause 252.227-7018 Class Deviation 2020-O0007 "Rights in Noncommercial Technical Data and Computer Software – Small Business Innovation Research (SBIR) Program." NOTE: Although Class Deviation 2020-O0007 only specifies applicability to SBIR, as required in the Small Business Act [15 USC 638 (p)(2)(B)(v)] and further prescribed by the SBA SBIR/STTR Policy Directive [section 8(b)(2)], this language also applies to STTR.

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

8.8 Invention Reporting

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

8.9 Final Technical Reports - Phase I through Phase III

a. **Content**: A final report is required for each project phase. The reports must contain in detail the project objectives, work performed, results obtained, and estimates of technical feasibility. A completed SF 298, "Report Documentation Page," will be used as the first page of the report. Submission resources are available at https://discover.dtic.mil/submit-documents/. In addition, monthly status and progress reports may be required by the DoD Component.

b. **SF 298 Form "Report Documentation Page" Preparation**:

(1) If desirable, language used by the company in its Phase II proposal to report Phase I progress may also be used in the final report.

(2) For each unclassified report, the company submitting the report should fill in Block 12 (Distribution/Availability Statement) of the SF 298, "Report Documentation Page," with the following statement: "Distribution authorized to U.S. Government only; Proprietary Information, (Date of Determination). Other requests for this document shall be referred to the Component SBIR/STTR Program Office."

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

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

(3) Block 14 (Abstract) of the SF 298, "Report Documentation Page" must include as the first sentence, "Report developed under STTR 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 "STTR 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/STTR)
8725 John J Kingman Road, Suite 0944
Ft. Belvoir, VA 22060-6218

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

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

Special instructions for the submission of CLASSIFIED reports will be defined in the delivery schedule of the contract.DO NOT E-MAIL Classified or controlled unclassified reports, or reports containing STTR Data Rights protected under DFARS 252.227-7018.

ATTACHMENT 1

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

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

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

Name of person authorized to sign: _____

Signature of person authorized: _____

Date: _____

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

DFARS PROVISIONS INCORPORATED IN FULL TEXT:

252.204-7016 Covered Defense Telecommunications Equipment or Services—Representation

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

(End of provision)

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

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

Definitions. As used in this clause—

"Covered defense telecommunications equipment or services" means—

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

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

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

"Covered foreign country" means—

(1) The People's Republic of China; or

(2) The Russian Federation.

"Covered missions" means—

(1) The nuclear deterrence mission of DoD, including with respect to nuclear command, control, and communications, integrated tactical warning and attack assessment, and continuity of Government; or

(2) The homeland defense mission of DoD, including with respect to ballistic missile defense.

"Critical technology" means—

(1) Defense articles or defense services included on the United States Munitions List set forth in the International Traffic in Arms Regulations under subchapter M of chapter I of title 22, Code of Federal Regulations;

(2) Items included on the Commerce Control List set forth in Supplement No. 1 to part 774 of the Export Administration Regulations under subchapter C of chapter VII of title 15, Code of Federal Regulations, and controlled—

(i) Pursuant to multilateral regimes, including for reasons relating to national security, chemical and biological weapons proliferation, nuclear nonproliferation, or missile technology; or

(ii) For reasons relating to regional stability or surreptitious listening;

(3) Specially designed and prepared nuclear equipment, parts and components, materials, software, and technology covered by part 810 of title 10, Code of Federal Regulations (relating to assistance to foreign atomic energy activities);

(4) Nuclear facilities, equipment, and material covered by part 110 of title 10, Code of Federal Regulations (relating to export and import of nuclear equipment and material);

(5) Select agents and toxins covered by part 331 of title 7, Code of Federal Regulations, part 121 of title 9 of such Code, or part 73 of title 42 of such Code; or

(6) Emerging and foundational technologies controlled pursuant to section 1758 of the Export Control Reform Act of 2018 (50 U.S.C. 4817).

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

(b) *Prohibition*. In accordance with section 1656 of the National Defense Authorization Act for Fiscal Year 2018 (Pub. L. 115-91), the contractor shall not provide to the Government any equipment, system, or service to carry out covered missions that uses covered defense

telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system, unless the covered defense telecommunication equipment or services are covered by a waiver described in Defense Federal Acquisition Regulation Supplement 204.2104.

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

(d) *Reporting*.

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

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

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

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

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

(End of clause)

ATTACHMENT 2

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

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

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

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

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

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

(a) Definitions. As used in this provision—

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

(2) "Entity controlled by a foreign government"—

(i) Means—

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

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

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

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

(4) "Proscribed information" means—

(i) Top Secret information;

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

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

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

(v) Sensitive Compartmented Information (SCI).

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

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

Offeror's Point of Contact for Questions about Disclosure
(Name and Phone Number with Country Code, City Code and Area Code, as applicable)

Name and Address of Offeror

Name and Address of Entity Controlled by a Foreign Government

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

(End of provision)

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ARMY
22.B Small Business Technology Transfer (STTR)
PROPOSAL SUBMISSION INSTRUCTIONS

The approved 22.B Broad Agency Announcement (BAA) topics for the Army Small Business Technology Transfer (STTR) Program are listed below. Offerors responding to this BAA must follow all general instructions provided in the Department of Defense (DoD) Program BAA. Specific Army STTR requirements that add to or deviate from the DoD Program BAA instructions provided in the Preface are provided below.

The STTR Program Management Office (PMO), located at the Combat Capabilities Development Command (DEVCOM) Army Research Laboratory (ARL) Army Research Office (ARO), manages the Army's STTR Program. The Army STTR Program aims to stimulate a partnership of ideas and technologies between innovative small business concerns (SBCs) and research institutions (RIs) through Federally-funded research or research and development (R/R&D). To address Army needs and opportunities, the PMO relies on the vision and insight of science and engineering workforce across nine (9) participating Army organizations to put forward topics that are consistent with their mission, as well as command and STTR program goals. More information about the Army STTR Program can be found at https://www.armysbir.army.mil.

See DoD Program Announcement Preface for Technical questions and Topic Author communications. Specific questions pertaining to the Army STTR Program should be submitted to:

Army STTR Program Manager
usarmy.rtp.devcom-arl.mbx.sttr-pmo@army.mil

DEVCOM-ARL-Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709
(919) 549-4200

In addition to the formal announcement period, the Army STTR Program Office will be hosting a virtual Army STTR Industry Day April 26-27, 2022 to further delineate Army requirements and stimulate small business/research institute partnership-building. Please visit: www.armysttr.com for more information.

PHASE I PROPOSAL GUIDELINES

Phase I proposals should address the feasibility of a solution to the topic. The Army anticipates funding two (2) STTR Phase I contracts to small businesses with their research institution partner for each topic. The Army reserves the right to not fund a topic if the proposals received have insufficient merit. Phase I contracts are limited to a maximum of $173,000.00 over a period not to exceed six (6) months. **PLEASE NOTE THAT THE MAXIMUM DOLLAR AMOUNT HAS BEEN INCREASED COMPARED TO PREVIOUS PHASE I's**. Army STTR uses only government employee reviewers in a two-tiered review process unless otherwise noted within the topic write-up. Awards will be made on the basis of technical evaluations using the criteria described in this DoD BAA Preface and availability of Army STTR funds.

The DoD SBIR/STTR Proposal Submission system (https://www.dodsbirsttr.mil/submissions/login) provides instruction and a tutorial for preparation and submission of your proposal. Refer to DoD BAA Preface for detailed instructions on Phase I proposal format. The Company Commercialization Report (CCR) must be uploaded in accordance with the instructions provided in the DoD Program BAA. Information contained in the CCR during will be considered during proposal evaluations.

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The Army requires your entire proposal to be submitted electronically through the DoD-wide SBIR/STTR Proposal Submission Web site (https://www.dodsbirsttr.mil/submissions/login). STTR Proposals consist of six volumes: (1) Proposal Cover Sheet, (2) Technical Volume, (3) Cost Volume, (4) Company Commercialization Report (CCR), (5) Supporting Documents, and (6) Fraud, Waste, and Abuse Training. **Please note that Volume 5 (Supporting Documents: Contractor Certification Regarding Provision of Prohibited Video Surveillance and Telecommunications Services and Equipment and the Foreign Disclosure Addendum) and Volume 6 (Fraud, Waste and Abuse) are now required as noted on the DoD SBIR/STTR website for Phase I proposals.** Proposals not conforming to the terms of this BAA will not be considered. The Army has established a **10-page limitation** for Technical Volumes submitted in response to its topics. This does not include the Proposal Cover Sheets (pages 1 and 2, added electronically by the DoD submission site), the Cost Volume, or the CCR. The Technical Volume includes but is not limited to: technical approach and objectives, key personnel background and qualifications, facility information, the relationship of the proposed work to any prior, current, or pending support of similar proposals or awards, commercialization strategy, references and letters of support, appendices, and all attachments. The Army requires that small businesses complete the Cost Volume form on the DoD Submission site versus submitting it within the body of the uploaded Technical Volume. It is the responsibility of submitters to ensure that the Technical Volume portion of the proposal does not exceed the 10-page limit. Do not include blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume such as descriptions of capability or intent in other sections of the proposal as these will count toward the 10-page limit. **Army STTR Phase I proposals submitted containing a Technical Volume over 10 pages will be deemed NON-COMPLIANT and will not be evaluated. It is the responsibility of the Small Business to ensure that once the proposal is submitted and uploaded into the system that the technical volume .pdf document complies with the 10-page limit.** If you experience problems uploading a proposal, email DSIP Support at DoDSBIRSupport@reisystems.com.

Companies should plan carefully for research involving animal or human subjects, biological agents, etc. as noted in the DoD BAA Preface. The short duration of a Phase I effort may preclude plans including these elements unless coordinated before a contract is awarded.

If the offeror proposes to employ a foreign national, refer to the DoD BAA Preface for definitions and reporting requirements. Please ensure no Privacy Act information is included in this submittal.

If a small business concern is selected for an STTR award, they must negotiate a written agreement between the small business and their selected research institution that allocates intellectual property rights and rights to carry out follow-on research, development, or commercialization (see DoD BAA Preface for more information).

PHASE II PROPOSAL GUIDELINES

All Phase I awardees may apply for a Phase II award for their topic – i.e., no invitation required. Please note that Phase II selections are based, in large part, on the success of the Phase I effort, so it is vital for SBCs to discuss the Phase I project results with their Army Technical Point of Contact (TPOC). Army STTR does not currently offer a Direct-to-Phase II option. Each year the Army STTR Program Office will post Phase II submission dates, 30-day window, on the Army SBIR/STTR web page at https://www.armysbir.army.mil/schedule/. The details on the due date, content, and submission requirements of the Phase II proposal will be provided by the Army STTR PMO via subsequent notification of Phase I awardees. The SBC may submit a Phase II proposal for up to three years after the Phase I selection date, but not more than twice. The Army STTR Program *cannot* accept proposals outside the Phase II

submission dates established. Proposals received by the DoD at any time other than the submission period will not be evaluated.

Phase II proposals will be evaluated for overall merit based upon the criteria in the DoD BAA Preface of this BAA. STTR Phase II proposals have six Volumes: Proposal Cover Sheet, Technical Volume, Cost Volume and Company Commercialization Report, Supporting Documents to include Contractor Certification Regarding Provision of Prohibited Video Surveillance and Telecommunications Services and Equipment and Foreign Disclosure Addendum, Fraud, Waste, and Abuse Training. **Please note that Volume 5 (Supporting Documents) and Volume 6 (Fraud, Waste and Abuse) are now required as noted at the DoD SBIR/STTR website for Phase II proposals.** The Technical Volume has a **20-page limit** including: table of contents, pages intentionally left blank, technical references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes) and any attachments. However, offerors are instructed to NOT leave blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume in others sections of the proposal submission as these will count toward the 20-page limit. ONLY the electronically generated Cover Sheets, Cost Volume and CCR are **excluded** from the 20-page limit. As instructed in the DoD BAA Preface, the CCR is generated by the submission website based on information provided by you through the "Company Commercialization Report" tool. **Army STTR Phase II proposals submitted containing a Technical Volume over 20 pages will be deemed NON-COMPLIANT and will not be evaluated.**

Small businesses submitting a proposal are also required to develop and submit a technology transition and commercialization plan describing feasible approaches for transitioning and/or commercializing the developed technology in their Phase II proposal.

Army Phase II Cost Volumes must contain a budget for the entire 24-month period not to exceed the maximum dollar amount of $1,150,000. **PLEASE NOTE THAT THE MAXIMUM DOLLAR AMOUNT HAS BEEN INCREASED COMPARED TO PREVIOUS PHASE II's**). Costs for each year of effort must be submitted using the Cost Volume format (accessible electronically on the DoD submission site). The total proposed amount should be indicated on the Proposal Cover Sheet as the Proposed Cost. Phase II projects will be evaluated after the base year prior to extending funding for the option year. Phase II proposals are generally structured as follows: the first 12 months (base effort) should be approximately $575,000; the second 12 months of funding should also be approximately $575,000. The entire Phase II effort should not exceed $1,150,000. The Phase II contract structure is at the discretion of the Army's Contracting Officer, and the PMO reserves the option to reduce an annual budget request of greater than $575,000 if program funds are limited.

Any Sequential 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 Army STTR PM in advance.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

In accordance with section 9(q) of the Small Business Act (15 U.S.C. 638(q)), the Army will provide technical assistance services to small businesses engaged in STTR projects through a network of scientists and engineers engaged in a wide range of technologies. The objective of this effort is to increase Army STTR technology transition and commercialization success thereby accelerating the fielding of capabilities to Soldiers and to benefit the nation through stimulated technological innovation, improved manufacturing capability, and increased competition, productivity, and economic growth.

The Army has Technical Assistance Advocates (TAAs) to provide technical assistance to small businesses that have Phase I and Phase II projects with the participating Army organizations within their regions. Firms may request technical assistance from sources other than those provided by the Army and request TABA funding. Details related to TABA are described in the DoD STTR Program BAA. All such requests must be made in accordance with these instructions. It should also be noted that if approved for TABA from an outside source, the firm will not be eligible for the Army's TAA support. TABA may be proposed in the Base and/or Option periods, but the total value may not exceed $6,500 in Phase I and $25,000 per year in Phase II (for a total of $50,000 for two years). All details of the TABA agency and what services they will provide must be listed in the technical proposal under "consultants." **The request for TABA must include details on what qualifies the TABA firm to provide the services that you are requesting, the firm name, a point of contact for the firm (email address and phone number), and a website for the firm. List all services that the firm will provide and why they are uniquely qualified to provide these services.** The award of TABA funds is not automatic and must be approved by the Army STTR Program Manager.

NOTIFICATION SCHEDULE OF PROPOSAL STATUS AND DEBRIEFS

Once the selection process is complete, the Army STTR Program Manager will send an email to the "Corporate Official" listed on the Proposal Coversheet with an attached notification letter indicating selection or non-selection. Small Businesses will receive a notification letter for each proposal they submitted. The notification letter will provide instructions for requesting a proposal debriefing. The Army STTR Program Manager will provide ***written*** debriefings upon request to offerors in accordance with Federal Acquisition Regulation (FAR) Subpart 15.5.

PROTEST PROCEDURES

Refer to the DoD Program Announcement for procedures to protest the Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: usarmy.rtp.devcom-arl.mbx.sttr-pmo@army.mil

DEPARTMENT OF THE ARMY PROPOSAL CHECKLIST

Please review the checklist below to ensure that your proposal meets the Army STTR requirements. You must also meet the general DoD requirements specified in the BAA. **Failure to meet all the requirements may result in your proposal not being evaluated or considered for award**. Do not include this checklist with your proposal.

1. The proposal addresses a Phase I effort (up to **$173,000.00** for up to six-month duration).

2. The proposal is addressing only **ONE** Army BAA topic.

3. The technical content of the proposal includes the items identified in the DoD BAA Preface.

4. STTR Phase I Proposals have six volumes: Proposal Cover Sheet, Technical Volume, Cost Volume, Company Commercialization Report, Supporting Documents, and Fraud, Waste, and Abuse.

5. The Cost Volume has been completed and submitted for Phase I effort. The **total cost should match** the amount on the Proposal Cover Sheet.

6. If applicable, the Bio Hazard Material level has been identified in the Technical Volume.

7. If applicable, include a plan for research involving animal or human subjects, or requiring access to government resources of any kind.

8. The Phase I Proposal describes the "vision" or "end-state" of the research and the most likely strategy or path for transition of the STTR project from research to an operational capability that satisfies one or more Army operational or technical requirement in a new or existing system, larger research program, or as a stand-alone product or service.

9. If applicable, Foreign Nationals are identified in the proposal. Include country of origin, type of visa/work permit under which they are performing, and anticipated level of involvement in the project.

ARMY STTR PROGRAM COORDINATORS (PCs) and Army STTR 22.B Topic Index

Participating Organizations	PC	Phone
DEVCOM-Armaments Center	Benjamin Call	973-724-6275
DEVCOM-Aviation and Missile Center	Dawn Gratz	256-842-8769
DEVCOM-ARL/Army Research Office	Nicole Fox	919-549-4395
DEVCOM-C5ISR Center	Tamarisk Gillespie	
DEVCOM- Chemical Biological Center	Martha Weeks	410-436-5391
CoE-Environmental Research and Development Center (ERDC)	Melonise Wills	703-428-6281
Medical Research and Development Command (MRDC)	Danielle Wilson Amanda Cecil	301-619-3354 301-619-7296
DEVCOM-Soldier Center	Cathy Polito	508-233-5372
DEVCOM-Ground Vehicle Systems Center	George Pappageorge Joseph Delfrate	586-282-4915 586-282-5568

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ARMY STTR 22.B Phase I Topic Index

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A22B-T021	MOF Sponges for Enhanced Soldier Lethality
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A22B-T023	[Topic Removed]
A22B-T024	To develop a portable and automated device: enabling precise and multiplexed detection of metabolites and/or chemicals
A22B-T025	Novel food Ingredient with very high levels of Essential Amino Acids (EAA) (>80% by mass)

VERSION 3

A22B-T001 TITLE: Novel, High-Energy-Density, Lithium-Air Reserve Batteries

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

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with 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 lithium-air reserve batteries for munitions, offering >3× the energy density of current liquid reserve batteries and operating across the military temperature range of -55°C to 125°C.

DESCRIPTION: The Army's new Bottom Attack (BA) munitions for the Close Terrain-Shaping Obstacles (CTSO) program requires reserve batteries with 3-4 times higher specific energy density than that of currently available reserve batteries. Current lithium-metal-based reserve batteries used in munitions, such as those that employ lithium thionyl chloride chemistry, rely on the supply of a liquid electrolyte to the cathode electrode at the time of activation. This design requires storage of the liquid electrolyte separately from the rest of the battery inside a bulky glass ampoule that must be ruptured during the activation process. The extra weight and volume, coupled with the complexity of the glass ampoule, significantly reduces the practical specific energy density of these batteries.

Gas-activated batteries have the advantage eliminating liquid in the activation process. Lithium-air batteries have the highest theoretical energy density of all lithium metal batteries at 3,860 mA/g[1], based on the weight of lithium. A primary reserve Li-air battery has the potential of outperforming all existing commercial liquid reserve batteries in terms of energy density, activation times, and simplicity of the activation mechanism. However, some critical barriers to the practical implementation of Li-air batteries remain. Among the challenges are sluggish oxygen reduction reaction (ORR) kinetics[2], the deactivation of the porous cathode electrode by discharge products[3], electrolyte decomposition[3], lithium metal corrosion by air contaminants (e.g. H2O, N2, and CO2) and the liquid electrolyte, and slow mass transfer rates[4]. All these challenges significantly limit the practically achievable energy density and rate capacity of Li-air batteries. This topic seeks solutions to overcome these limitations to enable the design and demonstration of a primary reserve Li-air battery that is more energy dense than existing liquid reserve battery technologies, that can perform across a temperature range of -55°C to 125°C, and that has a shelf life of 20 years or more. The developed lithium-air reserve batteries must be capable of being hardened for gun-firing setback accelerations of up to 70,000 Gs.

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PHASE I: Model the proposed solutions to determine their potential to address the challenges of developing high-energy-density lithium-air reserve batteries for munitions applications, and select candidate technologies for phase I experimentation. Technologies that yield successful experimental data are to be demonstrated through proof-of-concept assemblies under appropriate discharge conditions. A conceptual design concept is to be delivered.

PHASE II: The innovative solutions selected during phase I are to be optimized and implemented in battery prototypes to be designed, fabricated, and tested during phase II. These prototypes will be tested to demonstrate performance and energy density. Prototypes will include single cells and multiple cell battery packs. The offeror will work with the Army to define the most relevant discharge profiles and environmental testing conditions. The prototypes must demonstrate higher energy density than and comparable rate capacity to currently available liquid reserve batteries. A detailed cost analysis and a technology transition plan to scale up and commercialize the technology must also be prepared.

PHASE III DUAL USE APPLICATIONS: Phase III will primarily entail refinement of the designs developed during phase II in preparation for a pre-production prototype. The effort will be coordinated with stakeholders during all phases, which will facilitate requirements definition and transition of the technology. Strategic partnerships will be developed to further the commercialization potential of the technology.

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8. J. Read , K. Mutolo, M. Ervin, W. Behl, J. Wolfenstine, A. Driedger and D. Foster, "Oxygen transport properties of organic electrolytes and performance of lithium/oxygen battery," Journal of the Electrochemical Society, vol. 150, no. 10, pp. A1351-A1356, 2003.

KEYWORDS: Lithium-air, batteries, energy density

VERSION 3

A22B-T002 TITLE: Verification, Validation, Assurance, and Trust of Machine Learning Models and Data for Safety-Critical Applications in Armaments Systems

RT&L FOCUS AREA(S): Artificial Intelligence/Machine Learning, Cybersecurity

TECHNOLOGY AREA(S): Weapons, Information Systems

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OBJECTIVE: To establish fundamental methodologies to verify and validate data sources and AI/ML models that require high assurance in safety-critical functions of armaments systems.

DESCRIPTION: Significant advances have been achieved in the field of machine learning (ML), spurring proliferation of the technology in the public and private sectors. This topic seeks to develop these technologies to achieve battlefield overmatch, intelligent analysis of combat information, and real-time decision-making to more rapidly achieve mission goals.

To achieve this mission capability, numerous fundamental complexities and challenges must be overcome to assure the developed technologies will operate within their operational and mission bounds safely and reliably. Some of these challenges include the following:

• Inability to view the model decision process
• Inability to obtain training data or information after model development;
• Lack of validated certification processes for models;
• Inability to understand existing training (transfer learning);
• Inability to fully capture the environmental noise and inputs that may influence decisions and actions.

Ultimately, to field products the Army must demonstrate they are safe, suitable, and supportable through the materiel release process as defined in AR-770-3. This project seeks to lay the groundwork for how ML based technologies will be qualified, particularly for Armaments Center applications, in which lethality capabilities require high-assurance and safety-critical qualifications. These technologies could utilize computer vision, signal processing, natural language, and regression, but other applications may be possible.

PHASE I: Phase I will be the research and development of fundamental metrics and measures that can be used in the certification and qualification of training data sets and models, both combined and separate. Armaments Center must clearly understand the provenance, characteristics, and limitations of training data sets, the capabilities of models, how the two may

be adapted or augmented to meet potential needs, and the potential risks associated with armaments system integration. Research to identify means of measurement of data sets and models will establish risk indicators for stakeholders and evaluators. Phase I will culminate in delivery of a detailed report outlining the proposed metrics and measures and the value of each to evaluating and mitigating risks associated with employing data sets or models in armaments systems, enabling end product qualification with items deemed safe, suitable, and supportable for materiel release to the field.

PHASE II: Develop a process to effectively measure training data sets and models in accordance with previously derived key metrics and measures. Products of phase two would be process and procedures that align with current guidance and justify any deviations that may be required due to the unique nature of the technologies under study. This process must include the means and methods of evaluating the metrics and measures identified in phase I across different data types (images, tabular data, time series data) to address the concerns and uniqueness of safety-critical functions in the armament system's applications and complex operating environments. In addition to following existing precepts for materiel release, develop risk reduction and evaluation techniques for situations in which no detailed requirements have been established earlier in the lifecycle (S&T, R&D phases) to aid in the development and design of products for assurance. Phase II will culminate with a documented process and procedures showcased in pilot demonstration.

PHASE III DUAL USE APPLICATIONS: A fundamental product or process that can be leveraged to assess training data sets and models developed by and for Armaments Center prior to integration and formal testing with armaments systems. Training data sets to be assessed may include images, video, time series, and tabular data, depending on the application and the technology leveraged. The solution will allow Armaments Center to evaluate training data sets and model suitability for intended applications early in the lifecycle to accommodate any necessary corrective action, to provide a means to collect and document the key metrics and measures, and to communicate risks and concerns to assurance stakeholders. Ultimately the use of this product will enable materiel release stakeholders to clearly understand the risks and limitations of the data and associated models developed. The end product will help shape and inform the assurance model for AI/ML-enabled armaments systems critical to delivering lethality overmatch through enhanced speed and accuracy while meeting crucial standards for safety.

REFERENCES:

1. E. Schmidt, R. Work, et.al., "Final Report: National Security Commission on Artificial Intelligence, Chapter 7 Establishing Justified Confidence in AI Systems" 2021.
2. Department of the Army, "Army Regulation 770-3, Type Classification and Materiel Release," July 2021
3. Department of Defense, "MIL-STD-882E, Department of Defense Standard Practice System Safety," May 2012
4. Safety Critical Systems Club, Data Safety Initiative Working Group, "Data Safety Guidance," SCSC-127F, February 2021.

KEYWORDS: Artificial intelligence, machine learning, trust, assurance, test, evaluation, verification, validation, data

VERSION 3

A22B-T003 TITLE: Integration of Innovative, Safe Methods of Low-G Activation of Munitions

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

TECHNOLOGY AREA(S): Weapons

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OBJECTIVE: Miniaturized, gun-hardened devices to be incorporated in reserve batteries and initiation trains addressing high-G loading and vibration during transportation and flight for shoulder-fired munitions, terrain shaping munitions, missiles, and rockets.

DESCRIPTION: In recent years, highly reliable inertial igniters have been successfully developed for use in gun-fired munitions and mortars that differentiate prescribed all-fire events from accidental events such as drops on hard surfaces and vibration during transportation. Such inertial igniters detect prescribed firing acceleration and differentiate it from accidental events by ensuring that minimum prescribed firing setback acceleration magnitude and duration have been experienced by the munition before activation. Such inertial igniters are employed to activate reserve batteries and initiation trains in gun-fired munitions, in which the projectile is subjected to high setback accelerations ranging from 1000 Gs to several thousand Gs with durations from several milliseconds to fifteen milliseconds. Reliable inertial igniters, however, do not currently exist for applications such as shoulder-fired munitions, terrain shaping munitions, missiles, and rockets, in which the firing setback accelerations are in tens of Gs, with durations as long as 100 milliseconds. Current technology mostly employs onboard power sources such as primary batteries or other power sources to power sensors such as accelerometers to detect a firing event and differentiate it from accidental events via onboard microprocessors. Onboard primary batteries introduce issues related to shelf life, safety, and reliability. As a result, eliminating onboard power sources is a highly desirable aim. To integrate the inertial activation devices into the reserve batteries is likewise very desirable. The primary objective of this STTR project is the development of novel methods to design and integrate inertial initiation devices into reserve batteries and initiation trains that can be miniaturized to prevent unwanted activation for low-G and long duration setback acceleration applications such as shoulder-fired munitions, terrain shaped munitions, missiles, and rockets, particularly small and low power reserve batteries. The proposed concepts must eliminate the need for onboard power sources and sensory and processing devices for firing event detection. The proposed concepts must be capable of being readily integrated into reserve batteries. The proposed innovative inertial initiator concepts must be capable of being produced at relatively low cost and must provide reliability on the order of 99.9% with a 95% confidence level. It must also enable a shelf life of over 20 years. The

proposed innovative inertial initiator concepts must be capable of being designed for activation at as low as 10-20 G shock loading magnitudes with 100-150 millisecond duration, while being capable of withstanding up to 5,000 G (preferably higher) accidental shock loading with 1 millisecond (preferably longer) duration. Scalability of the proposed innovative inertial initiators to various reserve battery sizes is highly desirable. The designs selected to proceed to phase II need to have a 20 year shelf-life, operation across the entire military temperature range (-55C to 125C), and the ability to withstand accidental shock loading up to 20,000 Gs with 1 millisecond duration.

PHASE I: Design novel inertia-based miniature initiator concepts for reserve batteries and initiation trains for applications such as shoulder-fired munitions, terrain shaping munitions, missiles, and rockets, which are subjected to relatively low G but long duration setback accelerations but must be protected from high-G but short duration accidental accelerations. Develop analytical models of the dynamics of the inertial mechanisms of the proposed initiator concepts for determining the feasibility of each developed concept and simulate its performance under various firing and accidental drops conditions and for optimal selection of their various design parameters.

PHASE II: For the selected reserve batteries, develop prototypes of the best igniter concepts developed during phase I, and perform laboratory tests demonstrating their capabilities. Prepare plans for phase III of the project, including identification of the demonstrator round, prototype design, integration, and test plans (progressing from air gun testing to live-fire testing), and design for manufacturing.

PHASE III DUAL USE APPLICATIONS: The prototype technology will be demonstrated initially for PM-CCS, PdD Combat Armaments and Protection Systems to showcase successful non-electrical initiation capability. The proposer, along with the Armaments Center proponents, will engage with JPEO A&A and PEO M&S, and their prime contractors, to integrate the non-electrical initiation system into a broader range of munitions.

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KEYWORDS: Activation mechanisms, passive, miniaturize

VERSION 3

A22B-T004 TITLE: Multi-Phase Blast Munition

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

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with 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: To develop and demonstrate the next-generation of multi-phase blast munitions by taking advantage of the synergistic integration of high-explosives and reactive materials to provide battlefield superiority through increased lethality.

DESCRIPTION: The US Army is developing new munitions that require more space for electronics, sensors, and rocket motors in order to increase range and accuracy. As a result, these munitions have less room for payload and lethal mechanisms while still requiring the same performance or in some cases, increased performance. There are several Long Range Precision Fires (LRPF) projects on-going that require significantly longer range munitions, particularly in the 155mm size (XM1113 & XM1155). These munitions will have notably smaller payload volumes and therefore decreased lethality unless new warhead technologies are implemented in these systems.

The Army is interested in developing the next-generation of blast munitions that will provide overmatch capabilities on the battlefield, in line with Army Modernization Priorities. The introduction of metals into explosive formulations constitutes the basis of thermobaric munitions and provides the baseline for blast performance. The addition of aluminum or other metals to high explosives (HEs) enables in increase in the overall detonation temperatures, provides an improvement of Gurney energy output and significantly enhances the overall blast performance compared to HEs alone. Based on the type of munition, further improvement of performance can be obtained by the incorporation of reactive materials (RM) in the surrounding casings of HE charges. The benefits of this type of configuration are numerous, and include an ease of incorporation of these RM liners into existing systems, along with the ability to maintain munition design specifications while improving performance. Since this approach does not require the requalification of HEs, the replacement of inert casing materials with RM liners offers an easier path to transition the technology into fielded systems. Another benefit of this approach is the ability to produce blast performance attributes beyond simple metallized explosives. While the metal content of HE formulations is limited, an RM liner can easily supply a larger mass of the metal additive, thus enhancing blast performance.

Further changes in the integration of both HE and RM within a munition has led to a variety of novel, high-energy blast explosive configurations. Although these innovative combinations of HEs and RMs provide enhanced blast effects, scaling effects still need to be demonstrated. Independent of configuration, the performance of blast munitions is currently limited by the incomplete combustion of the metal additives, either within the HE formulations or as part of RM liners. Beyond variation of HE-RM configurations, the next level of lethality will rely upon the intimate understanding of the kinetic and thermodynamic interactions between high explosive energetic releases and RM combustion events. Accordingly, understanding the relationship between HE detonation pressure and temperature on the ignition and propagation attributes of RMs holds the potential to increase the efficiency of metal and metal-based formulations.

This topic leverages Army's on-going Advanced Warheads Technology (AWT) and Advanced Propulsion & Explosives (APEX) projects.

PHASE I: Develop correlations between coupled HE and RM performance attributes through experimental testing of RM formulations of interest, provided to the Army for quantification of energy release and overall blast performance.

PHASE II: Further develop and optimize the HE-RM synergistic interactions established in Phase I using thermodynamic analysis to achieve the optimal combinations of energy release properties. Scale up the manufacturing process and produce prototypes in at least three (3) configurations of interest to the Army and deliver five (5) prototypes from each configuration to the Army. Conduct field tests to demonstrate performance.

PHASE III DUAL USE APPLICATIONS: Transition the developed materials and related technology to a major manufacturer for incorporation of this technology into next-generation munitions for the Long Range Precision Fires (LRPF), Next Generation Combat Vehicle (NGCV), & Air and Missile Defense (AMD) Cross Functional Teams (CFTs). To further exploit the benefits of the developed technology, form partnerships with other manufacturers for applications within civilian sectors, such as the oil and construction industries. This technology can also be leveraged for mining applications and applications related to underwater blasting and demolition, breaking log jams, breaking ice jams, initiating avalanches, timber or tree cutting, the perforation of arctic sea-ice or permafrost, glacier blasting, ice breaking, etc.

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5. DoD Joint Enhance Munitions Technology Program (JEMTP)

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KEYWORDS: High explosive, reactive materials, multi-phase blast, combustion efficiency, blast munitions, detonation pressure, detonation temperature

VERSION 3

A22B-T005 TITLE: Metal Injection Molding for Improved Tungsten Fragmentation Warheads

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

TECHNOLOGY AREA(S): Weapons, Materials

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OBJECTIVE: Investigate and demonstrate tungsten medium caliber fragmentation warheads made with Metal Injection Molding (MIM) for improved performance and reduced cost.

DESCRIPTION: Tungsten is being used to improve the lethality of warheads due to its higher density. Because it is difficult to machine, tungsten powder is being pressed and sintered into preformed fragments, and then cast into warheads using a resin or metal matrix. There are many steps and there is significant labor involved, resulting in much higher costs for the increase in performance.

Injection molding is one of the lowest cost manufacturing processes due to the very high throughput and consistency. Metal injection molding utilizes the same process to injection mold metal powders with a resin binder into small complex parts which can then be debinded to remove the resin and sintered into a solid metal part. These steps are largely automated in batch or conveyor processes. It is most cost effective for making small, complex, difficult to machine parts with high cost materials in large quantities. MIM could be utilized to make tungsten medium caliber warheads with internal features to optimize fragmentation for increased performance at a lower cost than other methods.

One technical challenge is the possible need for a pusher plate to contain the explosive reaction as the warhead expands, to optimize the transfer of the energy into the fragments instead of between them. Forming the fragment body with the pusher plate into a monolithic structure could provide an additional cost and performance improvement.

PHASE I: During Phase I, MIM tungsten samples will be procured to perform feasibility testing. Testing will determine if MIM tungsten has the physical properties to properly fragment, if a pusher plate is required to achieve the desired performance, or if MIM tungsten is inappropriate for this application. Test results and further material analysis of the MIM tungsten will drive initial design work for a MIM tungsten warhead to be fabricated in Phase II.

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Based on test results, material evaluation, Picatinny's ability to load warheads, and upcoming programs which may be leveraged, a warhead will be selected for MIM tungsten prototyping (most likely 40mm grenade, 30mm autocannon, or smaller).

Also during Phase I, existing DOTC contractors will be prepared to support Phase II of the effort. Work on forming the fragmentation body with the pusher plate may start if DOTC work orders are prepared in time.

PHASE II: During phase II, the contractor will fabricate warhead prototypes in accordance with government specifications. The government will load and perform static detonation testing to evaluate performance. The government will optimize designs for a full-up round. In parallel, the contractor will investigate forming the fragmentation body with the pusher plate.

PHASE III DUAL USE APPLICATIONS: During Phase III, contractors will fabricate optimized warhead prototypes. The government will load and perform static detonation testing to confirm performance improvements. The government will then integrate the warheads into full up rounds for live fire testing. Work on forming the fragmentation body with the pusher plate may continue in this phase.

A business study will be performed to evaluate the cost and performance enhancements of transitioning the technology.

REFERENCES:

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2. A Mathematical Model of Penetration of Chunky Projectiles in a Gelatin Tissue Simulant, Larry M Sturdivan, ARCSL-TR-78055; https://apps.dtic.mil/sti/pdfs/ADA063525.pdf
3. Metal Injection Molding of Tungsten Heavy Alloys: SBIR Phase I, Gary M Allen, MTL TR 91-37; https://apps.dtic.mil/sti/pdfs/ADA242742.pdf
4. Enhanced Fragmentation Modeling, Peter Rottinger; https://apps.dtic.mil/sti/pdfs/ADA504428.pdf

KEYWORDS: Tungsten, Fragment, Warhead, Medium Caliber, Metal Injection Molding, MIM

VERSION 3

A22B-T006 TITLE: Limited-view/sparse-angle computed tomography software for efficient CT reconstruction

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

TECHNOLOGY AREA(S): Sensors

OBJECTIVE: Limited-view/sparse-angle CT software reducing time/dose required for 3D reconstruction compared to the filtered back projection. Reconstruction quality within industry standards & compatibility with image parameters for X-radiography & neutron radiography.

DESCRIPTION: The Armaments Center's Radiography Laboratory is used to determine in a nondestructive way a product's actual internal construction and composition as compared to the specification with which its construction parameters were set. The results of this nondestructive evaluation are then used to confirm a product's quality and integrity (safety, lethality, ruggedness and survivability), and to verify claims of operational limits and prepare assets for reliable field operations.

Computed Tomography (CT) is a computational method in nondestructive evaluation that produces a 3D reconstruction from a series of 2D images. To produce a CT, the item under inspection is placed between an X-ray source and detector. The object (or in some cases the source-detector pair) is rotated for a series of image acquisitions at varying angles. The collected images are supplied to software that uses one of several mathematical methods to convert the 2D images into a 3D reconstruction. In the context of nondestructive testing, X-rays and neutrons are most commonly used in the context of industrial manufacturing.

Filtered back projection (FBP) is the most common method for CT reconstruction. This method produces accurate 3D reconstructions using minimal computing power at the cost of increased projections. In medical imaging, the Hounsfield scale is used to measure a material's opacity to X-ray radiation, where a higher value indicates more opacity. Muscle tissue has a Hounsfield unit (HU) value of 10-40 HU, whereas steel has a value of 20,000 HU. An FBP CT of industrial manufactured parts could require from several hundred to thousands of projections, necessitating acquisition times on the order of tens of minutes (usually 15-45 minutes.). For this reason, CT is restricted to R&D environments and is only used as a last resort in production processes. CT data provides complete knowledge of the position of relevant indications within a manufactured part. In the medical field, faster acquisition times are desired to reduce the dose delivered to a patient while industry is driven not by dose but by acquisition times while maintaining stringent requirements for contrast and resolution. Limited-view CT promises a reduced overall time by minimizing X-ray time at the cost of modestly increasing computing time. Current advances in CT algorithms make such a reconstruction method possible. The literature indicates limited view CT is a developing method that has successfully been applied case by case.

Certain items possess density gradients that make them inaccessible to X-rays, demanding interrogation by neutrons. Limited-view CT can be particularly helpful in neutron radiography, where acquisition time per image can be considerably longer than X-rays. In addition to our current x-ray CT capability, our laboratory is on schedule to gain an in-house neutron

radiography capability in a few years, and this installation will most likely evolve into a neutron radiography CT capability. Since no off-the-shelf software package allows for reliable, limited-view CT reconstruction, this project aims to produce the first such package for use with items relevant to the Army and apply it to both X-ray CT and neutron radiography CT.

PHASE I: Develop the mathematical and software methods for limited-view/sparse-angle CT. The possibility of a vast reduction in image acquisition requirements while maintaining sufficient image quality should be theoretically established.

PHASE II: Develop and demonstrate prototype limited-view/sparse-angle CT software that successfully reconstructs an item of sufficient complexity while meeting quality and acquisition objectives.

PHASE III DUAL USE APPLICATIONS: The US Army can use this system for faster X-ray CTs and more robust neutron radiography CTs. Industry could use this system to increase speed of nondestructive evaluation, increasing total production. This system could also be used in the medical field for high-fidelity CTs of patients while delivering minimal X-ray doses.

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KEYWORDS: Nondestructive Evaluation (NDE); Computed Tomography (CT); Limited-View/Sparse-Angle CT; X-Ray; Neutron Radiography (NR); CT Reconstruction

VERSION 3

A22B-T007 TITLE: Chip-scale directed energy with single-mode laser beam combining

RT&L FOCUS AREA(S): Microelectronics, Directed Energy

TECHNOLOGY AREA(S): Electronics, Weapons

OBJECTIVE: To create chip-scale directed energy microsystems that perform beam combining of single mode lasers with high beam quality and high brightness output.

DESCRIPTION: Edge-emitting laser diodes bars have reached power levels of kilowatts with only centimeter width and several millimeter lengths [1, 2]. However, vertical cavity surface emitting lasers (VCSELs) hold potential for higher beam quality and higher brightness. Wall-plug efficiencies for both regimes exceed 50% - a level needed to power scale systems to directed energy levels for miniaturization and thermal management considerations. How one can coherently beam combine diode lasers has been a long-standing Holy Grail for direct diode kilowatt systems for decades, starting full bore in the late 1990s [2]. Some success has been achieved by use of Talbot cavities to coherently combine edge emitting arrays [2, 3] as well as VCSEL arrays [4, 5]. However, to create high beam quality outputs, the individual emitters must be single mode (transverse single-lobed spatial profile), which requires a small cross-sectional area. VCSELs have been developed using oxide apertures to control the spatial mode; however, they also cause significant heating, limiting the performance and even becoming unreliable and detrimental below 3 micron diameters. Vertical cavity lasers are sought to overcome this bottleneck by removing this oxide barrier, the thermal insulator inherent to the poor high power performance [6]. In addition, monolithic beam combining cavities are sought to fully miniaturize coherent beam combining and produce high brightness. Alternative approaches that couple in-plane lasers that can be beam combined, either spectrally (called wavelength beam combining) or coherently could be relevant here – depending on the coupling efficiency and thermal management considerations. Particular concerns are related to thermo-optic refractive index effects causing loss of coherence across the chip. Regardless, chip-scale directed energy systems should be pursued toward higher brightness, higher power levels for next generation DOD systems. The key considerations include low coupling loss of the individual lasers to the chip (diode or fiber lasers can be considered), thermal management related to heat concentration on the chip or adjoining it, and the means of beam combining to attain a high beam quality output. The preferable approach is to explore having the lasers and the beam combining all on one chip. The coupling between the lasers and the beam combining part of the system is likely a key part of the desired investigation. Both the minimization of loss going from the laser to combining section and the way light is coupled to the other lasers will likely need intensive study. This will need explained and depends on the proposed architecture.

PHASE I: Pursue chip-scale directed energy beam combining techniques using high efficiency diode or fiber lasers (exceeding 50% wall-plug efficiency each with 0.9-2.1 micron wavelengths that are oxide-free (at least near the active region) to enable high power operation, with high reliability. Design coherent beam combining architecture for either vertical cavity arrays or in-plane laser beam combining. Use of monolithic cavities or chip-scale solutions should be pursued both to demonstrate minimal footprint and show a path toward combining larger

numbers of lasers. Additional design considerations should be investigated for the incorporation of effective liquid cooling of arrays to pursue maximum power achievable.

Brightness levels of 1000 MW/cm2*sr should be shown to be feasible along with power scaling to > 100 W/cm2 – without coherent combining, but to show thermal heat dissipation design considerations. A demonstration of coherent combining of arrays at multi-Watt levels (uncooled peak power) from 10 or more individual lasers that shows promise to proceed to phase II. Specifically, based upon phase I results, commercialization potential for arrays with increased brightness and high beam quality should be assessed with a particular eye toward fiber laser pump diodes and free-space laser communications – along with the eventual goal of higher power level directed energy applications. (If edge coupling to the chip is used, approaches that minimize size, weight, and power are most highly desired, i.e. toward fully monolithic chip-scale systems).

PHASE II: Continue implementation of beam combining designs. Pursue 100 Watt peak power, uncooled coherently combined arrays and designs for higher power, cooled arrays. Brightness levels of 1000 MW/cm2*sr should be demonstrated that achieve combining efficiencies of 80% or more for the chip-scale architecture.

Optimization of the arrays and studies on minimal spacing between individual lasers for the nominal power target level and within the beam combining architecture should continue along with needed studies to explore power scaling with larger arrays. Demonstration of chip-scale systems that achieve > 100 W peak power with designs that can scale to over a KW. An assessment of cooling for the array to achieve continuous wave operation should be made toward phase III demonstrations. Eventually, cooled arrays of > 100 W/cm2 average power are desired.

PHASE III DUAL USE APPLICATIONS: Pursue further optimization of array cooling and power scaling with refined chip designs. In addition, multi-stage architectures should be pursued to combine lower power arrays to achieve kW power level output. Monolithic cavities should be pursued for at least the first stage of combining with secondary combining by either external cavities or secondary monolithic cavities. Interfacing of the arrays with fiber lasers for effective pumping to multi-kW levels are sought for development. Other consideration to utilize techniques to create lower power arrays (still multi-Watt) for LIDAR, free-space laser communications, and beam scanning and surveillance LIDAR should be made. Particular consideration for phased arrays should be considered for beam steering and adaptive optical beam control to mitigate atmospheric turbulence to achieve maximum power on target.

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KEYWORDS: directed energy, integrated photonics, laser diode, coherent beam combining, beam forming

VERSION 3

A22B-T008 TITLE: Rapid Optimization and Trade Space Framework for Adapting Aero-Structures

RT&L FOCUS AREA(S): Autonomy

TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Design, develop, and demonstrate a rapid aero-structural assessment framework for finding the optimal three dimensional solution of the design trades associated with adaptation, material performance, mass, and energy cost.

DESCRIPTION: Army air vehicles are designed as a compromise among the optimal configurations for the various expected missions in which they will perform. Most air vehicles cannot structurally adapt to various mission segments, unlike biological analogs, such as insects or birds [Reich; Lentink; Rosen]. Ideally, platforms could adapt to achieve the optimal configuration for each segment of the mission, e.g. configurations in which the vehicle has high maneuverability and endurance, and is collapsible/foldable for storage. Fluid dynamics simulations and experiments demonstrate that vehicle shape changes enable improvements in aerodynamic performance; however, these efforts typically do not consider structural complexity, cost, and material stiffness/strength with the associated trades [Faber; Vocke; Vale].

The goal is to create an assessment framework for platform adaptation that incorporates the given structural and aerodynamic conditions for an Army relevant problem. An example mission could be a small UAS that is capable of deploying from a collapsed configuration, dashing, and then loitering on station all the while adapting itself to perform optimally in each segment. The tool is expected to inform the required material properties of the morphing structure, for example: specific stiffness, strength, and activation energies. The work will also need to include consideration of the fluid structure interaction (FSI) [Barcelos; Gursul], which typically requires large amounts of computational power and is not viable for optimization without the use of novel uncoupling schemes [Scholten; White]. An effort will need to be made to reduce the computational time by use of similar parallelization or uncoupling schemes to explore the design space and optimize on a complex three dimensional structure. The framework will need to show that it can assess a FSI problem and return the best solution and trades with an aerodynamic and structural accuracy of at least 90% compared to other computational methods. Use of unlicensed or free-license software by the framework is desirable as it adds to the potential parallelization by not requiring multiple licenses to be purchased and maintained.

The framework will need to focus on the assessment of adaptation in terms of the potential benefit to mission performance. Instead of static boundary conditions representing one state, the framework would need to accept two or more potential mission states (e.g. dashing, loitering, etc.) for which an internally consistent best structural solution can be found. Finally, the mission performance improvement would need to be weighed against the design trades associated with the weight and energy required for adaptation. The framework would likely determine the requirements of stimulus sensitive materials [Mabe; Jayasankar] and actuation across various Army relevant vehicle size scales and applications. At a minimum, the framework should be demonstrated against three different Army use cases and compared with a baseline representing a

non-adapting configuration that is a compromise of the optimal configurations for each mission or mission segment.

If successful, this effort would enable new tools for the Future Vertical Lift Army modernization priority by computing design trades and solutions for penetration through congested environments via extended maneuverability and range with respect to existing platforms.

PHASE I: Design, develop, and validate an assessment framework that demonstrates the ability to rapidly simulate the design space of and perform trades on performance, mass, and other characteristics associated with a relevant Army aero-structure and mission. As an example, teams might consider a Class 1-2 UAS capable of adapting shape from a stowed configuration to perform a mission at low altitude within a congested environment. It is expected that teams will consult with the government in order to determine an appropriately bounded problem. Individual simulations should handle relatively large deformations associated with low-mass solutions. The framework should utilize computational techniques which reduce the typical computational time (100-1000x) associated with three dimensional coupled fluid structure interactions, such as parallelization. The goal of phase 1 is to demonstrate an ability to interrogate the trade space associated with bounds on a FSI problem to find the optimal design. The simulation should have an accuracy compared to slower analyses of at least 90%.

Further, define the complete proof-of-concept optimization and trade space framework that will be developed in Phase 2, including a technically viable path for including potential adaptations. Adaptation technologies include stimulus sensitive materials, actuators, etc., which are internally consistent within the structure for different mission segments (dash, maneuver, endurance, etc.) but provide increased aerodynamic performance, for example, by modifying camber or span to increase lift. Typically there will be a point in design where mission segments need to be sufficiently numerous or different in order for adaptation to be viable, which should be computable in Phase 2.

PHASE II: Design, develop, and validate an assessment framework that demonstrates the ability to rapidly simulate the design space of and perform trades on performance, mass, and energy associated with structural adaptation cost. In addition to the accuracy requirements of the Phase 1 effort, the framework should be able to identify which potential structural adaptations are viable for given mission requirements defined as structural and aerodynamic bounds. Assessment across mission requirements will need to be consistent internally for structural performance computation. The framework should also address user competency and likelihood of accurate solution generation.

PHASE III DUAL USE APPLICATIONS: Currently, the Army relies on researcher experience to experimentally assess vehicle designs and determine the viability of the concept. Maturity of the rapid optimization and trade space framework will allow Army engineers to determine the trade space associated with various basic science technologies developed in academia, industry, and research institutions. A vehicle that is able to adapt itself can respond optimally to Soldier needs; this tool will be able to accept mission requirements and provide technical trades and solutions. For example, a mission space may require a UAS to be Soldier- or air vehicle-borne, penetrate a congested space, and then loiter on station for an extended time. The end state of the

framework would provide a tool for rapid assessment of the technology required to construct a vehicle that is fully collapsible, is able to shorten its planform to maneuver through forests or trees undetected, and then lengthen its planform to loiter at extended duration.

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KEYWORDS: Unmanned aerial system, UAS, fluid structure interaction, optimization, morphing vehicle, adaptive structure

VERSION 3

A22B-T009 TITLE: Solid Oxide Fuel Cell CPOX Reforming of Biogas

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

TECHNOLOGY AREA(S): Materials

OBJECTIVE: Demonstrate Catalytic Partial Oxidation of time varying gaseous hydrocarbon fuels.

DESCRIPTION: To meet the Army's energy sustainability strategy goals, power sources that can utilize alternative fuels are needed. The goal is to improve our use of energy assets by optimizing use of available energy resources. Solid Oxide Fuel Cells (SOFC) have the potential to provide this power from a wide variety of fuels including complex hydrocarbons, which are generally not amenable for use with other fuel cell technologies. However, current SOFC systems are optimized for a single fuel and are generally not fuel flexible. A small scale, 1kW fuel cell operating on, or augmented with, bio-generated gas would provide additional capability and reduced supply chain dependence. Critical to development of a fieldable power system is a robust catalytic partial oxidation (CPOX) fuel processor capable of converting biogas to solid oxide fuel cell reactants (hydrogen and carbon monoxide) without additional process water. The fuel processor must be capable of operating over wide ranges of bio-gas composition with operating conditions being optimized on the fly will demonstrate on of the critical technologies to enable fuel flexibility.

PHASE I: Design, construct, and evaluate component and subscale CPOX assemblies using time varying gaseous fuels to include methane, propane, and biogas. These results should support the potential to develop a system capable of less than 30 minute start times with varying hydrocarbon fuels. Provide a detailed conceptual design of a CPOX assembly capable for providing syngas for a 1-3 kW power system, with a start-up time less than 20 minutes a volume below 150 cm3/kW, a weight less than 1 kg/kW, cyclic durability in excess of 100 cycles, and a design capable of withstanding MIL-SPEC-810 vibration levels. based upon the results generated in this effort.

PHASE II: In phase II, based on the results from the successful phase I program, design, construct, and evaluate a full scale brass-board CPOX system capable for providing syngas for a 1-3kW SOFC system using time varying gaseous fuels from 100% methane, propane, and biogas. CPOX should be capable of start-up within 15 minutes, have a volume below 100 cm3/kW and a weight less than 0.5 kg/kW, cyclic durability in excess of 2000 cycles, and a design capable of withstanding MIL-SPEC-810 vibration levels.

PHASE III DUAL USE APPLICATIONS: Robust SOFC power systems with dynamic fuel flexibility will significantly impact both military and commercial applications, accelerating product development, particularly for lightweight portable power devices and domestic use.. Because the market and the number of devices in the commercial sector is much larger than the military market, widespread usage of this technology will drive down the cost of devices for the military. Demonstrate achievements from the STTR effort to show applicability to field conditions and compatibility with biogas. Likely sources of funding if the phase III program if

successful include: CERDEC, PEO Soldier and PEO Combat Support and Combat Service Support Product Manager Mobile Electric Power Systems.

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KEYWORDS: SOFC, CPOX, fuel flexibility, multifuel

VERSION 3

A22B-T010 TITLE: Agile Machine Learning in Dynamic Environments for Complex Event Processing

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

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop a system to detect and classify complex events that can be quickly retrained for different operating environments using sparse training data by leveraging human domain expertise.

DESCRIPTION: Effective network command, control, communications and intelligence in MDO environments requires situational understanding across multiple domains in order to achieve overmatch against the adversary. In the fight against a peer adversary, it is anticipated that such overmatch will require short decision cycles in the order of minutes or less. To this end, fully autonomous solutions are needed to ingest sensor data and contextual information across the battlespace to provide actionable recommendations to the decision maker. Today, automated solutions for target detection and classification are beginning to appear to be possible across the cyber and various physical (land, air, sea, space) domains. However, intelligence analysts would still be needed to interpret these warnings and indicators to correlate the observed movements of various entities across domains into coordinated adversarial tactics, techniques, and procedures (TTPs). Such coordination represents a sequence of atomic activities across fairly large scales of time and space and broadly speaking fall under the guise of complex events in the data science literature [1]. For instance, the amalgamation of many coordinated atomic loitering and movement activities of vehicles and dismounts can represent a single red force reconnaissance complex event. It is desirable for automated systems to report as many true complex events as possible while limiting the number of unique false events reported per an extended interval of time, e.g., hours.
Deep learning methods have successfully classified simple activities that span short time intervals and are localized such as sports and daily activities [2-3]. However, deep learning has yet to provide satisfactory solutions for complex event processing [4]. Furthermore, the rapidly changing and unpredictable MDO environment means that limited data will be available for training, and thus, it is expected that a purely end-to-end deep learning solution would be inadequate. Recently, it has been demonstrated that human domain expertise can be combined with deep learning to recognize complex events [5] and that neuro-symbolic machine learning can adapt data-driven machine learning to recognize atomic concepts without explicit labels using limited data with only the complex events labeled [6-7]. While these results are promising, the complex event processing methods have yet to be developed and evaluated for recognition of existing and emerging TTPs in the MDO setting.

The goal of this topic is to advance and demonstrate the state of complex event processing systems to enable reliable classification over a large set of possible TTPs that span over various domains. To this end the performer will need (1) define a set of relevant complex events that can capture the richness and variability of possible workflows for each event, (2) collect data for such complex events across multiple domains in a variety of operational environments (e.g., weather conditions, operational tempos, etc.), (3) develop complex event processing solutions

that incorporate both domain expertise and data-driven learning, and (4) demonstrate classification performance over the complex event processing solution. For the purposes of feasibility, it is expected that the data collection will fully leverage synthetic data generation technologies for at least phases I and II.

PHASE I: Define at least three complex events that entail data collected from one domain. Each complex event must entail at least three atomic activities separated in time by the order of minutes and in space such that the field of view of a single sensor is unable to detect the event. The data collection should represent at least two different operating environments and contain background atomic activities that are not correlated to any of the three complex events. The complex event classification systems should be trained over large amounts of data for one operating condition, and then adapted for the second operating condition using a significantly smaller fraction of training data. Overall, the complex event classification system should exhibit a probability of detection of at least 0.9 with a false report rate of one per hour. Furthermore, the probability of correct classification should exceed 0.9 for the full trained operating condition while still achieving a probability of correct classification of 0.8 for the adapted operating condition.

PHASE II: Define at least ten complex events that entail data collected from two or more domains. Each complex event must entail at least ten atomic activities and at least one complex event must exhibit a timespan of one hour. Furthermore, five of the complex events must be separated in space such that more than three spatially disparate sensors are required to detect these events. The data collection should represent at least three different operating environments and contain background atomic activities that are not correlated to any of the three complex events, but much of the background activities must be correlated to normal civilian activities such as commuting to work, running errands, etc. The complex event classification systems should be trained over large amounts of data for one operating condition, and then adapted for the two other operating condition using a significantly smaller fraction of training data. Overall, the complex event classification system should exhibit a probability of detection of at least 0.9 with a false report rate of one per hour. Furthermore, the probability of correct classification should exceed 0.9 for the fully trained operating condition while still achieving a probability of correct classification of 0.8 for the adapted operating conditions.

PHASE III DUAL USE APPLICATIONS: The complex event processing system should be able to allow domain experts to quickly define adversarial TTPs across any domain and the system should be able to train over modest amounts of labeled data. Such technology should benefit the civilian sector by enabling law enforcement to detect and classify emerging complex events by foreign and domestic terrorist groups using open source signals collected over social media as well as monitoring attacks of various infrastructure systems in the cyber domain.

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KEYWORDS: artificial intelligence, machine learning, complex event processing, situational understanding, classification, detection

VERSION 3

A22B-T011 TITLE: High-Temperature, Low-Voltage Operation Avalanche Photodetectors (APD) in the Extended Short Wavelength Bands

RT&L FOCUS AREA(S): Quantum Sciences

TECHNOLOGY AREA(S): Electronics

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with 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 high-sensitivity at near-room-temperature avalanche photodetector (APD) that operates at low voltage with high gain in the extended short-wave infrared (e-SWIR) spectrum range of 2 to 2.5 µm.

DESCRIPTION: Photodetectors with high sensitivity operating in high-temperature, low-voltage regime in the e-SWIR spectrum range of ~ 2 to 2.5 µm are in high demand [1,2]. A number of approaches have been explored in the recent years in pursue of this goal, but the current performance metrics do not yet meet the stringent requirements for the desired applications. The Army is seeking innovative approaches in next-generation e-SWIR detector technology to significantly improve sensitivity and response time. These innovations include, but are not limited to, novel structures to achieve low-voltage operation and low-dark current APDs covering e-SWIR band for image sensing and communication systems with small size, weight, power and cost (SWaP-C) requirements.

A range of APD technologies have been developed in the past and even achieved single photon sensitivity, which explains why the APD is preferred for many applications. However, there are still many application constraints, such as cost, power consumption, reliability, robustness of operating environment and response time. Silicon APD based photoreceivers have state-of-the-art noise-equivalent-power of 40 fW/rt(Hz) with a bandwidth of 140 MHz and proven performance in various applications. However, at wavelengths beyond 1.1 µm, silicon becomes transparent to infrared light. Commercially available III-V APDs (e.g. InGaAs APDs) at 1.55 µm applicable for fiber communications [3-4] cannot be used in applications beyond 1.7 µm. Standard APDs with spectral responsivity to 2 µm and beyond show increased dark current and excess noise factor, which limit the gain and hence the signal-to-noise ratio (SNR) of the detection system [5]. In addition, many of these standard technologies (e.g. HgCdTe APDs) are not viable for many field applications due to their need for cryogenic cooling, resulting in high SWaP-C.

Furthermore, conventional APDs apply a variable reverse-bias voltage across the device junction to create a variable avalanche gain during APD operation, which in turn optimizes the sensitivity of the receiver. However, to achieve satisfactory levels of avalanche gain, many APDs require high reverse-bias voltages in the 40V to 60V range, and some require voltages exceeding 80V [6]. In addition, the APD avalanche gain depends on temperature and varies with the manufacturing process. Thus, for typical systems in which the APD must operate at constant gain, the high-voltage bias must vary to compensate for the temperature effects. To achieve constant gain in a typical APD supply, the temperature coefficient must be maintained at approximately +0.2%/°C, which corresponds to 100mV/°C. The latter makes the device energy consumption inefficient and incompatible with current CMOS IC technology supply voltages, requiring additional high bias circuit in the read-out.

It is highly desirable to design a next-generation APD for e-SWIR photoreceivers to overcome the deficiencies of the standard APD available today. Novel APD solutions are desired that simultaneously enable low-voltage (e.g. <20V) APD operations, reduce dark current, and exhibit low excess noise factor to achieve high gain and enhanced SNR at or near room temperature. Novel APDs technologies focused on structure design, providing high bandwidth, high gain and high quantum efficiency, are sought rather than based on material composition changes.

PHASE I: Develop a novel APD device structure with material(s) system enabling detection in extended-SWIR spectral range (2-2.5 µm). Theoretically model and simulate APD design, operating at e-SWIR wavelength that is scalable from single element to arrays, e.g. VGA format and beyond. Design, model and simulate essential electrical and optical characteristics for an APD device that meets the performance requirements for low-voltage operation, low excess noise and low dark-current at or near room temperature. A maximum gain is needed at low biasing voltage (e.g. <20V), with low dark current density of a few nA/cm2 at unity gain at or near room temperature. Deliver the simulation and design results.

PHASE II: Fabricate, evaluate and optimize a prototype of single element APD as well as an APD array of 4 x 4 elements or larger. Demonstrate low-voltage biased APD operation on single element devices. Demonstrate spectral cut-off wavelengths at e-SWIR wavelength bands as high as 2.5 µm. Explore option(s) for readout integration and processing e-SWIR APD. Demonstrate functionality and mechanical integrity over the military temperature range and background-limited infrared photo-response against calibrated illumination. A proof of concept FPA is desirable, but not required.

PHASE III DUAL USE APPLICATIONS: Demonstrate APD array integrated into a system for field testing. APD arrays with extended sensitivity to the e-SWIR range are desirable for identifying, tracking, and targeting hostile forces and communicating covertly in applications such as micro air vehicle (MAV) sensors, laser target tracking, laser radar, missile tracking, persistent surveillance and 3D imaging, satellite imaging and interceptors. The detector arrays are also expected to enable measurement and characterization of transient phenomena that have an e-SWIR spectral content, such as a missile signature, flashes, or measuring and characterizing unknown emission signatures in the battlefield. In addition, the commercialization of this technology is expected to provide low cost, high performance imagers for potential uses in variety of commercial applications including automobile, security and surveillance, medical

imaging, machine vision, agriculture, scientific imaging including astronomy, mapping, weather monitoring, as well as border patrol and various homeland security applications.

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KEYWORDS: Avalanche Photodiode, APD, multi-color, detectors, extended SWIR, e-SWIR, bias voltage, noise factor, ROIC, sensors, FPA, multispectral sensor; LADAR; High Bandwidth; Dark current, Laser Radar, Imaging, bio-sensing

VERSION 3

A22B-T012 TITLE: High-Fidelity Design Tools for Electromagnetic Scattering Over Hypersonic Vehicles

RT&L FOCUS AREA(S): Hypersonics

TECHNOLOGY AREA(S): Weapons

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with 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: To develop new mathematical constructs and high-fidelity design tools to predict time-accurate electromagnetic signatures of morphing hypersonic vehicles.

DESCRIPTION: The Army is interested in designing next-generation hypersonic flight vehicles with enhanced system speed, reach, and lethality addressing Army's and DoD's Priorities in Long Range Precision Fires and Hypersonics. Revolutionary systems must meet new tactical requirements for performance, reach, and lethality, while simultaneously mitigating the strong electromagnetic signatures emitted. New concepts will include the ability of controlling hypersonic vehicle performance and maneuverability based on morphing structures in external and internal aerothermodynamics by time-varying the angle of attack (AOA). The presence of an AOA results in significant differences of the surface temperatures as well as in emissions of electromagnetic characteristics in intensity and spectral band. Historically, computational fluid dynamics has played a central role in the design and development of hypersonic vehicles, largely due to the prohibitive cost associated with testing facilities. However, existing simulation approaches are limited in its ability to predict hypersonic aerothermodynamics and its interactions solving complex fluid, thermal, kinetic, and structural problems using tightly-coupled approaches. Hypersonic modeling under realistic flight conditions is complicated by the nonlinearity and multiphysics nature present that acts across a wide range of scales [1-2]. Variations in atmospheric conditions, chemical kinetics, vibrational excitation, ablation products, and gas-surface interactions further complicate the high enthalpy plasma system [3]. The Army is therefore seeking high-fidelity design approaches to predict the flight environment of a hypersonic vehicle, along with gas-flow chemistry, shock induced heating, and material-response, including thermoacoustics transport, and full-spectrum EM propagation capabilities. Solutions will include novel capabilities for modeling time-varying morphing structures coupled with aerothermochemistry and electromagnetic wave propagation. Electromagnetic frequency ranges of interest include X-band, Ka-band, and also IR/RF. In solving the system of PDEs, the solution must also include accurate physics-based closures for processes including turbulent shear stress and heat transfer fluxes, particle laden flows, and chemical kinetics for any unresolved physics. This research will lead to new solutions to PDEs with faster and greater

accuracy. The new tools should be able to handle realistic glide body, missile geometries, and scramjet propulsion systems for sustained powered flight in the Mach 6 to 20 range. Tools must have the ability to be deployed in traditional/emerging high performance computing architectures (CPU GPU) efficiently and demonstrate improved scalability over the state-of-the-art. In-situ visualization and data extraction techniques must be available to provide end users the ability to seamlessly navigate the sea of data encountered in real-time analysis.

PHASE I: Develop 3D high-fidelity modeling concepts to predict aero-thermal effects and EM signatures that include both RF/IR signature responses for morphing vehicles and adaptive structures and demonstrate benefits over low fidelity approaches. High fidelity approaches for reacting turbulence and fluid structure interaction should be based on LES and finite rate chemical kinetics. The company should identify strengths/weaknesses associated with alternative solutions, methods, and new concepts. Demonstrate theoretical credibility of proposed computational and include EM experimental validation targets. Computational vetting and demonstration of concepts to be conducted using canonical blunt-nose single or double cone hypersonic shapes and beyond is suitable in this phase.

PHASE II: During Phase-II, the framework developed in Phase-I will be extended and validated to support hypersonic morphing vehicles for potential applications in air-breathing missiles, boost-glide missiles, and high-maneuver interceptors with EM signature analysis. Tools should demonstrate ability to model complex aerothermochemistry, thermoacoustics, shock induced heating, structural material response, and broad spectrum EM propagations (e.g., X-band, K-band, IR./RF), using high-fidelity LES approaches. The tools will capture in detail non-equilibrium processes including boundary layer transition to turbulence, onset of material ablation, finite-rate non-equilibrium chemistry, and gas-surface interactions responsible for surface deformation. It shall consider material dielectric properties including RF permittivity, absorptance, reflectance and thermal conductivity. Demonstrate time-accurate predictions based on tightly-coupled fluid structure interaction for time-varying AOA in morphing internal and external hypersonic vehicles. Complete model, executable code, and deploy on state-of-the-art high performance computing systems with demonstrable performance on existing or emerging computing architectures.

Demonstrate model validation by comparison with reference DNS databases, EM experimentation in the open literature, or data from the Army or DoD laboratories. The high-fidelity model should demonstrate at least 10% improved accuracy in capturing transients over existing approaches based on RANS or empirical correlations. The complete software package shall be available to ARL during all phases of the project to conduct independent assessment and vetting of the developed tools. Coordinate development efforts with the government, and potential prime-contractor partners, to ensure product relevance and compatibility with missile defense projects and government modeling and simulation systems. The developed complete computational tool sets along with user guide(s) at the end of Phase-II shall be delivered to ARL for government use on HPC platforms to conduct mission projects.

PHASE III DUAL USE APPLICATIONS: Collaborate with simulation model developer(s) and/or user(s) on integration of product(s) into a missile defense application. Optimize toolset to accommodate new advances in the technology of tracking and prediction of glide body or cruise

missile flight. Transition the technology to an appropriate government or defense contractor for integration and testing. Integrate and validate the functional signature tools into a real-world missile defense application.

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KEYWORDS: Hypersonics, aerothermochemistry, morphing systems, computational fluid dynamics

VERSION 3

A22B-T013 TITLE: Mapping Strain in Composite Materials using Terahertz Metamaterials

RT&L FOCUS AREA(S): Microelectronics

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Design and demonstrate a methodology to detect and map regions of incipient failure in opaque composite materials using terahertz metamaterial laminates whose polarimetric response is sensitive to local strain.

DESCRIPTION: Military platforms are increasingly composed of composite materials because they are lighter and less expensive than metals, but their failure is more difficult to predict or detect. It is often the case that regions of high strain go undetected before catastrophic failure, so a means to detect these incipient failures is of critical importance. Recently, a promising solution to this challenge has been proposed [1,2]: metamaterial laminates with a strain-dependent polarimetric response [3,4] may be adhered onto or embedded within a composite, and their polarimetric response may be spectroscopically probed in transmission or reflection geometries. Spatially mapping the polarimetric signature of the metamaterial laminate will reveal the local strain fields within the composite, which will be permanently recorded if the metamaterials break under sufficient stress. Indeed, metamaterial arrays or layers of metamaterial laminates may be designed with different threshold stress responses, so that the amount of strain historically experienced by the composite may be recovered and spatially mapped, thus revealing regions of incipient failure. For other applications which require dynamic monitoring of evolving composite strain fields in real time, self-healing deformable metamaterials are of interest because they can record current levels of strain while reversibly returning to an unstrained signature when the stress is released. Metamaterials operating within the terahertz spectral region (0.1-3 THz) provide a nearly optimal compromise of spatial resolution and material penetration depth in a manner that depends on the unique properties of the composite host. Application of these terahertz metamaterials for non-destructive testing could become a transformative approach to maintenance that will enable longer operating times for systems beyond the current conservative maintenance schedules, increase operational readiness, and at the same time increase safety and confidence.

PHASE I: Design and quantitatively assess the synergistic electromagnetic and mechanical performance of a terahertz metamaterial laminates adhered onto or embedded within an opaque composite host, whose polarimetric response is sensitive to the local strain and may be mapped in reflection (preferable) or transmission geometries. Of interest are two types of metamaterials, those with permanently severable break junctions for quantitatively recovering the amount of strain experienced historically, and those that are reversibly deformable for quantitatively recovering the amount of strain currently experienced by the composite. The objective is to demonstrate the feasibility of the concept through a detailed design of both the polarimetric metamaterial laminates and the instrument that will rapidly map the locally-sensed strain fields between 0.1 - 5%. The design must include a quantitative estimate of the achievable spatial resolution (must be less than 5 mm) and strain sensitivity (within 10% of actual strain) for a variety of opaque host materials of practical interest for military platforms.

PHASE II: Construct, demonstrate, and deliver the sensor design and exemplar composites containing strain-dependent terahertz metamaterial laminates designed in Phase I. Opaque hosts must be at least 1000 square centimeters in size, and the strain mapping, preferably in a reflection geometry, must be accomplished in less than an hour. The spatial resolution (must be less than 5 mm) and strain sensitivity (within 10% of actual strain) must be demonstrated and quantitatively assessed as a function of at least three opaque host materials in order to ascertain the universality of the technique. Of particular interest is the mapping of strain field extrema, both for historical strain fields using break junction metamaterials and for current strain fields using reversibly deformable metamaterials, spanning the range between 0.1 - 5% for metamaterial laminates adhered onto or embedded within composite material hosts of specific military interest.

PHASE III DUAL USE APPLICATIONS: These metamaterials will enable the development of a laminate that can be added to any composite material to provide a fast, low cost, high resolution non-destructive test capability using a compact hand-held sensor. It will find military application via industrial fabrication capability applied to most military vehicle and aircraft programs of record. Adoption by industry will be stimulated by the advantages for commercial vehicles, aircraft, and composite structures. This technology will significantly reduce operating cost, life-cycle costs, and accident costs.

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KEYWORDS: Strain mapping, metamaterial, terahertz, composite material

VERSION 3

A22B-T014 TITLE: Terahertz Radar-on-Chip

RT&L FOCUS AREA(S): Autonomy

TECHNOLOGY AREA(S): Electronics

OBJECTIVE: To develop low cost radar-on-chip operating at the terahertz frequencies with millimeter range resolution and low power consumption based on integrated circuit technologies.

DESCRIPTION: The terahertz part of the electromagnetic spectrum from 0.3 to 1 THz has unique advantages for radar applications, including large bandwidths for improving range resolution and small antenna apertures [1]. It will enable new radar systems for autonomous navigation, security surveillance and screening, biometric vital sign detection, human-machine interfaces, and much more. Prototype THz radar systems mostly using GaAs Schottky diode technology have shown impressive results. However, they are bulky and expensive, and mostly limited to laboratory demonstrations.

The aggressive scaling of CMOS integrated circuit (IC) technology driven by Moore's Law has resulted in miniaturization of computational devices. On the analog side, the transistor cutoff frequency fmax has increased steadily to ~350 GHz for 45 nm CMOS nodes [2][3]. However, further scaled nodes (< 45 nm) has not seen more improvement because of increased gate and wiring resistances. In the meantime, SiGe HBT technology has emerged as a viable solution in the THz band with commercial SiGe HBT technology achieving 500 GHz fmax, and 700-GHz fmax for the next technology node. SiGe HBT technology is enabling fundamentally operated circuits above 300 GHz. Furthermore, the speed of SiGe HBT devices is projected to continue to improve with transistor scaling. Theoretical analysis of the performance limits of SiGe HBTs indicates that their operating frequencies should reach 1 THz and beyond.

On the system side, these advances have enabled the commercialization of various millimeter-wave systems such as automotive radars. Building on low power RF-CMOS technology, low cost single-chip collision avoidance radars at 77 GHz have become widely available [4]. Besides offering high range resolution, they also include multiple transmitters and receivers in a single-chip form factor that can be electronically configured into coherent beam forming mode for long range detection or MIMO (multiple-input, multiple-output) radar mode for enhanced angular resolution.

Based on the above developments, the use of silicon based IC technologies for single-chip THz radars at frequencies greater than 300 GHz is also promising and feasible [5]. The large bandwidth available at the THz frequencies will provide range resolution down to millimeter range that would be impossible to achieve with microwave and millimeter-wave radar systems, and potentially enable new applications such as high-precision secure perimeter tracking and remote gesture recognition [6]. However, past research has shown that systems operating at the THz frequencies cannot be a simple scaling of classic RF design techniques to the higher frequencies because the new operating frequencies are close to or higher than the device fmax. Novel circuit architectures will be required to overcome the device limitations. This STTR topic will explore innovative circuit design techniques in order to enable THz radar-on-chip.

PHASE I: Identify IC technology nodes with device characteristics suitable for terahertz frequency operation. The technologies being considered could be silicon-based (CMOS or SiGe), III-V based (GaN or InP), or heterogeneous integration of different technologies. Perform device characterization and modeling of the IC technology nodes. Develop radar system parameters and perform trade study between system size, architecture, operating frequency, antenna structure, range, power consumption, etc. Develop overall system-level models based on optimized parameters selected from the trade study. Design initial circuits implement against the identified technology nodes and develop initial antenna design for the radar system. The radar system should contain 1 transmitter and 1 receiver, and has the following targeted system parameters: >300 GHz, 2% instantaneous bandwidth, 0 dbm TX power, 15 dB RX noise figure, -70 dBc/Hz phase noise at 1 MHz offset. Phase I study should determine the feasibility of developing a THz radar-on-chip.

PHASE II: Perform detailed circuit design and IC fabrication against the foundry technology nodes chosen in Phase I. The targeted system parameters should include the following: >300 GHz, 10% instantaneous bandwidth, 3 transmitters (5 dBm TX power each) and 4 receivers (10 dB RX noise figure) in a single chip, -90 dBc/Hz phase noise at 1 MHz offset. Explore use of the spread spectrum modulation code waveforms in addition to convention frequency-modulated continuous wave (FMCW). The detection range should be >100m (or maximum achievable range within the power and noise constraints of the overall system) and range resolution ~1 mm. The IC design should include option to allow multiple chips to operate in parallel and synchronously to improve detection range and angle resolution. Fabricate the ICs through a multi-project wafers service within the STTR budget constraint. Construct a prototype radar system based on the ICs and demonstrate its performance.

PHASE III DUAL USE APPLICATIONS: It is expected that THz radar-on-chip will enable a wide range of radar applications including autonomous navigation, security surveillance and screening, biometric vital sign detection, human-machine interfaces, and much more. Low cost of terahertz radar-on-chip ICs will be a key enabler for these applications.

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VERSION 3

KEYWORDS: Radar, sub-millimeter wave, terahertz, integrated circuits, CMOS, SiGe, GaN, InP, MIMO, autonomous navigation, human-machine interface

VERSION 3

A22B-T015 TITLE: Canine VO2Max Measurement System

RT&L FOCUS AREA(S): Biotechnology

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: Develop a canine respiratory mask system capable of reliably measuring VO2Max in Military Working Dogs in treadmill-based exercise studies.

DESCRIPTION: Military Working Dogs (MWDs) have proven to be a vital component in the execution of warfighter missions. The optimization of an MWD's ability to perform at very high levels for long durations and to process the operational environment under high levels of stress and distraction will significantly improve their operational effectiveness and recovery. Aerobic potency is a critical component of overall performance and is improved through canine conditioning. Improved aerobic potency leads to enhanced cardiovascular and respiratory capacity to help increase work capacity and overall performance. Measurement of VO2Max is a non-invasive way to measure fitness and cardiovascular health and track improvements over time. Currently there are no reliable canine systems that capable of measuring VO2Max in Military Working Dogs. The goal of this topic is to develop a canine VO2Max measurement system addressing the following requirements:

1. Provides a complete seal so reliable measurements can be made
2. Able to be used in MWDs in treadmill-based exercise studies
3. End users able to use during routine conduction of fitness evaluations

Research conducted under this topic must comply with Federal and Department of Defense Regulations, and Public Law (in particular, Animal Welfare Act 4 and amendments) regarding the treatment of dogs.

PHASE I: Design an appropriate canine respiratory mask system capable of reliably measuring VO2Max that will meet the requirements outlined above. Threshold and objective quantitative health requirements including physiological, anatomical and behavioral will be defined after consulting with both military and commercial sources. Provide a detailed description of the operation of the system and mechanism of air sampling to support reliable measurements from a complete seal. Identify components and/or develop technical specifications for components that, when integrated, will meet the performance goals. Conduct necessary calculations on the design and performance of the components to demonstrate the feasibility and practicality of the proposed Canine VO2Max Measurement System. Demonstrate a prototype system or primary components of a prototype system at TRL 3+.

PHASE II: Optimize and construct working prototypes at TRL 4-5 as designed in Phase I to meet or exceed stated objectives. Conduct laboratory tests to validate all specifications. Conduct field tests if appropriate. Develop final product specification documents that include a list of all system components and their requirements and instructions for deployment and stowage. In addition, an investigation of potential alternative applications should be conducted in conjunction with a market assessment.

PHASE III DUAL USE APPLICATIONS: Any materials and technology developed under this project could be incorporated for use in other applications for MWDs. Proposed system could be introduced into the civilian marketplace for use in canine conditioning studies and other research. The system would also be applicable to federal, state and local law enforcement agencies that utilize working dogs.

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KEYWORDS: Military Working Dog, Canine Conditioning, Canine Physiology, Canine VO2Max

VERSION 3

A22B-T016 TITLE: Explainable AI for Complex Decision Making for Command and Control in MDO

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

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop Explainable AI (XAI) middle layer to adequately explain and develop novel AIs for complex reasoning for Command and Control (C2) decision aids for Multi-Domain Operation (MDO) wargaming.

DESCRIPTION: Artificial intelligence (AI) is fundamental to realizing the full potential of Multi-Domain Operations (MDO) in the future joint force (TRADOC TP 525-3-1, 2018). The U.S. Army must develop and leverage AI solutions to account for the complexity and scale of dynamic MDO against a variety of adversarial threats. AI-enabled systems can create and exploit potential windows of superiority through deliberate planning, convergence, and synchronization of effects (MCoE, 2021). However, AI-enabled systems resemble black boxes that mysteriously convert incoming data to predicted outcomes. The need for explainable AI (XAI) is especially critical for military domain analysts and command staff decision makers who must rely on the AI-generated recommendations for neutralizing emerging kinetic and non-kinetic threats. AI system-produced learning models and resulting predictions must be both understandable and appropriately trusted by the human decision makers using the system. Outcomes of the system should resonate with decision makers' own expertise and intuitions (tacit knowledge) as well as integrate and enhance the cognitive and psychological factors that contribute to theories of complex adaptive decision-making and interdisciplinary approaches to complex reasoning.

An XAI middle layer opens the black box by communicating the internal representations, processes, predictions, and surprises to human decision makers in an understandable and trust-building manner supporting effective human-AI collaborative decision-making. The process to increase the explainability of complex decision-making often involves directly or implicitly enumerating all key possible outcomes that come as a consequence of a particular choice. In the past, this enumeration step often involved speculation and extrapolation built upon a combination of historical pattern analysis and human experience. The decision-maker's level of understanding of the predictions was in part determined by the information presented, and upon the resonance or dissonance of that information with the decision-maker's own experiences and intuitions. Today, both simulation science and data science have augmented the outcome prediction step. Although the use of mathematical and statistical predictors based upon a combination of first-principle modeling and data-driven science is now ubiquitous and has often replaced human intuition as the generator of possible future outcomes, how the decision-maker engages with these analytical processes has not changed—it remains predicated on understanding the complex decision. As AI-enabled systems and tools move to the forefront of options used by today's decision-makers to create data-driven outcome predictions, it is important to develop novel XAI approaches.

The XAI middle layer will interface with a variety of U.S. Army AI applications to enable fully interactive analysis, exploration, and development of the AI algorithms through multimodal

interfaces to the tacit knowledge, decision, and action spaces characteristic of C2 battlespace platforms. The XAI middle layer will generate new decision-making representations on available visualization ecologies or augment existing battlespace representations with additional XAI information. Development of novel interactive visualization and advanced interrogation approaches to XAI interfaces will play an important role in enabling overall understanding and development of the AI reasoning towards explainability.

PHASE I: Develop a conceptual design for a XAI middle layer utilizing the following: inputs about game states, AI sensing, and AI actionable choices for one or more AI-predicted future states, and an initial capability to integrate with associated 2D/3D C2 display representations (e.g. Battlespace Visualization and Interaction, BVI). The conceptualization should combine the above elements into a workflow for use in a human-AI team decision-making context with simplified geospatial battlespace capabilities, so that the human understands how the AI's assumptions and predictions drive its decision suggestions, and so that the AI can leverage human choice behavior and tacit reasoning to learn to produce better predictions in complex decision-making. Proposers are encouraged to build on top of DARPA XAI outcomes, leveraging previous DoD investment in that program (https://xaitk.org, https://onlinelibrary.wiley.com/toc/26895595/2021/2/4). Deliverables include a report or presentation demonstrating the conceptual design and a path forward for Phase II.

PHASE II: Develop and demonstrate a proof-of-concept prototype system based on the preliminary design from Phase 1. The prototype should display the AI models' perceived current states and anticipated future states of friendly and hostile units, and demonstrate a moderate-depth (2 to 4 sequential choices) decision tree for simplified MDO scenarios for complex decision-making for one or more of the following: game theory, meta-reasoning, and deception. Proposers are encouraged to use ARL's AI testbeds and their associated 2D and 3D resources (https://github.com/USArmyResearchLab/ARL_Battlespace is an ARL wargaming AI testbed that is transitioning to a new testbed Simple Yeho, a 1024x1024 3D grid environment and API for an NGCV scenario with multiple layers for foliage, roads, and visibility, and their associated uncertainties, that is being developed under ARL's Human Autonomy Teaming ERP), to develop the XAI middle layer and demonstrate integration with the underlying AI and AI development. Examples of AI predictions and AI-guided choice behaviors will be provided for XAI development. Developers who choose to base on ARL's API will be provided access to use and modify the AI code from the testbed to generate their own simulations and predictions. Performance metrics will be based on a series of progressively harder problems in terms of the effective depth of the decision guidance (e.g. in terms of progressively increasing the number of factors displayed, the depth of sequentially dependent choices explained, progressively increasing uncertainty in the state observation, and how these relate to human+AI team performance against an AI opponent in a wargame across a variety of mission scenarios), depth of integration with the development of novel AI for complex reasoning, and 3rd party user feedback on the XAI performance (e.g. as measured via NASA TLX).

PHASE III DUAL USE APPLICATIONS: Expected outcome is a software product for an XAI middle layer, deployable for a variety of human-AI collaborative complex decision making applications. The path for transition is to mature the prototype developed in Phase 2 by delivering phased incremental improvement until a fully operational XAI middle layer capability

is achieved. Work with the government and industry partners to demonstrate the system to user groups in an operational setting. The overall scale goal should address tactical as well as C2. Incorporation of user feedback into the system is important. A real-world implementation analysis should be conducted to establish a process for integrating the prototype XAI middle layer into a program of record. For example, results should demonstrate translation of the XAI from the ARL AI testbed's grid space to real-world wargaming maps (e.g. One World Terrain), including different terrain and/or environment types, for displaying alternative Courses of Action (COAs). Results should also extend the depth of the decision-making to include multiple factors or units (e.g. 3 or more unit action combinations) and/or sequential choices (5 or more) or domains (3 or more, one of which should include cyber deception). The new XAI middle layer technology will support Mission Command Battle Lab - Mission Command CDID's Tacit Reasoning AI development task, in coordination with ARL Futures Division Advancing Concepts Office. It will also support efforts to assess and place Soldiers who are technically fluent and adaptive (e.g. ARI's T-SAVVY program).

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KEYWORDS: Mission command, command and control, decision making, explainable AI, wargaming, course of action, game theory, deception

VERSION 3

A22B-T017 TITLE: Thermal Lensing-Free Chalcogenide Windows

RT&L FOCUS AREA(S): Directed Energy

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: Design chalcogenide window with a thermo-optic coefficient dn/dT = 0 and a low absorption coefficient at wavelengths near λ=1.064 μm, while remaining optically transparent in the MWIR and LWIR regions.

DESCRIPTION: Recently, chalcogenide optics have been developed with thermo-optic coefficients dn/dT near zero in the mid-wave infrared (MWIR) and long-wave infrared (LWIR) regions [Gleason], where n is the optical index of refraction and T is temperature. Currently, no such materials have been developed that accomplish this in the 1030 nm to 1070 nm, which covers Yb:YAG to Nd:YAG fiber lasers. We believe that the development of such a glass will have no thermal lensing at these wavelengths and thus, a higher damage threshold than chalcogenides currently available. Such optics will have to maintain a low absorption coefficient at 1 micron as well as good optical imaging quality like those chalcogenides currently on the market.

The primary goal of this STTR is to develop methods for manufacturing chalcogenide glasses with optimal thermo-optical properties that can perform in harsh environments. The glass should have a temperature coefficient of refractive index dn/dT = 0 and low absorption coefficient around 1.064 μm (1030-1070 nm), and optical transparency and high transmission in the MWIR and LWIR spectral regions while maintaining good optical imaging quality. The glass should be capable of handling high optical power densities without damage and should not degrade with exposure to light, humidity, etc. Fabrication techniques needed to realize the proposed chalcogenide designs should be clearly defined in the Phase I effort and an optical window manufactured. Such structures should be scalable for optics with a diameter up to 4 inches. It is expected that any such designs will require multiple glass compositions to be manufactured to fine tune to the appropriate composition.

Key findings in Gleason et al. indicate that “trends in refractive index and dn/dT were found to be related to the atomic structure present within the glassy network, as opposed to the atomic percentage of any individual constituent.” Because of this additional degree of freedom, chalcogenide optics can be fabricated based on “compositional design” allowing for on demand

glass properties including the thermal – optical response as well as mechanical properties for environmental robustness. Such optics are useful for commercial applications that transmit over the MWIR and LWIR spectral regions. The chalcogenide optics will provide uninterrupted, enhanced force protection and day/night situational awareness. Military applications for this technology include laser safety devices for Mounted/Dismounted Ground System thermal sensors, and for thermal imaging systems on manned aircraft, unmanned aerial vehicles, and unattended ground sensors.

PHASE I: Fabricate a chalcogenide glass that has a temperature coefficient of refractive index dn/dT = 0 around 1.064 μm and zero or negative dn/dT in the range 1030-1070 nm. The glass must have transmission greater than 63.5%, in the MWIR and LWIR spectral regions and a low absorption coefficient, less than 0.05/cm, around 1.064 μm. It must also maintain good optical imaging quality in the MWIR and LWIR spectral regions: 3-5 μm and 7-10 μm (ideally up to 14 μm), respectively. Such glass should be capable of handling optical power densities up to 1 MW/cm2 in the range 1030-1070 nm without out damage, enabled by the low absorption coefficient and dn/dT of zero. The glass should be stable over time and not degrade or experience a change of properties with exposure to light, humidity, etc. [Frantz] Environmental specifications include an operating temperature of -40°C to +71°C, storage temperature and temperature shock from -51°C to +71°C, and an operating/storage humidity of -40°C to +71°C and 95% relative humidity (RH). It should be noted that designing such an optic will likely require the fabrication of multiple glass compositions to approach the desired material. The deliverables shall include a detailed design, fabrication plan, and multiple 1-inch diameter optical windows (coupons) with measurement results of the refractive index, absorption coefficient, thermal properties, transmittance and reflection spectra spanning the full spectral range (400 nm through 14 μm), and dn/dT measurements. Coupons should be scalable to 4 inches in diameter. Designs that meet all of the specs, especially the damage threshold and transmission, but not the temperature coefficient of refractive index of zero, will be considered.

PHASE II: Fabricate a chalcogenide glass, which meets all the phase 1 requirements, with an improved (higher) damage threshold targeting 10 MW/cm2 by focusing on other parameters (i.e. homogeneity enhancement, precision annealing profiles, reduction of absorption coefficient through different compositions or other methods) that may increase the damage threshold. The absorption coefficient and other parameters should meet phase 1 requirements. Damage testing will be conducted at the U.S. Army Research Laboratory with a 200 μm to 900 μm laser beam spot size. The expected deliverables are a write-up of the results of the fabrication study varying other parameters (and their effect on the various properties) and at least four one-inch chalcogenide windows with the improved damage threshold that meet the specs of phase 2. Such windows should be scalable to four inches in Phase 3. Additionally, potential commercial and military transition partners for a Phase 3 effort shall be identified.

PHASE III DUAL USE APPLICATIONS: Chalcogenides such as these can be used in systems which use thermal systems. Potential commercial applications include thermal security cameras for use in Homeland Security applications (perimeter security at airports, coastal ports, nuclear power installations), UAV sensors, as well as satellite sensors. The possibility to incorporate these structures into current sensors could also be explored, for the potential use in both ground vehicles and aircrafts. Additionally, selenide-based chalcogenide glasses are already widely

employed in the athermal imaging systems, especially in the low-cost IR system of auto navigation. [Lin] Finally, such optics may be used to increase the thermal stability of SWIR cameras.

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KEYWORDS: high power, continuous wave, chalcogenide, 1 micron, optics, infrared, visible, high transmission, MWIR (mid wave infrared), LWIR (long wave infrared), absorption coefficient

VERSION 3

A22B-T018 TITLE: Optical Management of Digital Sensor Data using Cryogenic Photonics

RT&L FOCUS AREA(S): Control and Communications, Microelectronics, Network Command

TECHNOLOGY AREA(S): Electronics, Information Systems, Materials, 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: Effort seeks to examine and utilize photonic components available today for application in cryogenic environments of high performance infrared sensor arrays.

DESCRIPTION: Data rate demands of high performance Army imaging sensors have historically increased exponentially and are expected to continue doing so. Infrared sensors are being tasked with performing multiple functions simultaneously and at ever increasing pixel counts. Higher frame rates allow for additional applications but come with the cost of increased power usage. Army sensors today currently rely on electrical outputs for data transmission of scene imagery information to downstream electronics. Electrical output lines can only output so much data per channel, and thus the number of output lines have increased dramatically creating additional power consumption. An alternative solution to an impending data management bottleneck is conversion of digital read-out integrated circuit (ROIC) output signals to an optical data stream harnessing commercially matured photonic components. An optical output link ensures that future high performance imaging data rate demands can be easily met and is scalable to match sensor application demands. Additionally, optical data outputs enable flexible system design, are not susceptible to EMI interference, and exhibit excellent energy efficiency.

Optical signal processing has been adopted by datacom and telecom industries to provide enormous data rates with superior energy efficiency to electrical transmission. Modulation and transceiver components have matured significantly but the photonic components that are offered commercially today are typically designed for room temperature application and their performance at the cryogenic temperatures required for the highest performance infrared sensors is undocumented. Furthermore, foundry offerings vary in terms of the types of photonic modulators available, whether components are custom or incorporated into the foundry Process Design Kits (PDKs), their compatibility with mixed signal design elements, and their degree of integration. In order to overcome the engineering challenge of harnessing photonic components, there is a need to document the performance and integration level being offered today so that future programs can reduce the technical risk of converting to optical outputs.

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The barrier to making the switch from electronics to photonic interconnects has yet to be overcome. Programs of record for infrared focal plane array (IRFPA) sensors often elect to settle for smaller evolutionary improvements in cryogenic electronic communications, instead of the leap-ahead capabilities available with high-speed, low energy cryogenic photonic links. IRFPA sensor development programs need compelling evidence to fully motivate the transition to this new technology. This project aims to inform Army sensor programs of the most suitable approach for incorporating these optical components. By testing pathways today, we can determine the readiness level of the various foundry offerings moving forward. In addition to a comprehensive study of available offerings, this work will also demonstrate the most suitable optical output link in a laboratory setting using appropriate transmission protocols. This demonstration will be performed at cryogenic temperature and will have a satisfactorily low bit-error rate.

PHASE I: In Phase I performers will evaluate potentially feasible schemes to implement optical modulation in a cryogenic environment. In addition to evaluation, performers will begin preliminary work in acquiring hardware and software required for conversion of digital data to optical output link. All solutions must be compatible with current and future read-out integrated circuit technology, including necessary interface transmission protocols, practical signal modulation driving, and compact floorplan of integration. Solution must be suitable for use alongside sensor read-outs used in relevant Army programs. With the goal of maximizing system integration, team will preliminarily assess and design elements based upon viable foundry offerings or epilayer vendor procurement. Evaluation and design in Phase I should not be limited to a single source but should cover the commercial landscape to include all reasonably feasible solutions that can provide error-free performance. Bit error-rates must be lower than 1E-10 with the goal of being equal to or lower than 1E-12. In all cases, energy per bit and total system energy costs should be minimized and data transmission solution scheme must be able to reach modulation efficiency of less than 600 fJ per bit. By the end of Phase I, performers are expected to have comprehensively presented solutions to meet program expectations, began component design, clearly presented on the level of integration and energy usage analysis, provided a detailed test characterization plan, and initiated dialogue with foundry and/or material vendor business departments for acquiring components in Phase II.

PHASE II: In Phase II, performers will acquire necessary photonic components from commercial foundries and begin systematic performance testing of various modulation schemes at cryogenic temperatures. Test temperatures must be relevant to high performance infrared sensor arrays. Coupling, insertion, and chip-to-chip losses will be documented alongside component power consumption to better understand system energy budget. On-off keying and tunability at cryogenic temperatures will be fully reported. A comprehensive performance and energy report detailing component results from different foundries will also include realistic configuration analysis of integrating alongside existing ROIC technologies. Development and integration of photonic components should be as monolithic as possible. Following presentation of performance and integration report for all explored foundry and scheme solutions, a single optical modulation scheme will be selected for laboratory demonstration at cryogenic temperature to include bit error rate testing. Demonstration effort should replicate infrared camera system as much as possible.

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PHASE III DUAL USE APPLICATIONS: This project is expected to significantly mature the engineering and integration challenges of converting digital sensor data to optical data transmission outputs. The findings of this effort will inform future high performance sensor programs on best practices to lower technology risk and give Army sensor programs confidence to implement this revolutionary change to sensor data management moving forward. This project naturally pairs with the highest data demanding sensors with broad applications in surveillance, wide field-of-view sensors, fast-event detection, targeting, and tracking. Near term transition pathways include airborne sensor packages with targeting and tracking requirements, such as Apache and Future Vertical Lift, which would benefit from being operated at higher frame rates than are currently possible. Superior energy efficiency of optical data outputs will also lower dewar cooler assembly energy budget, thus increasing system lifecycle, and appeal to sensor programs with moderate data rates and volume units, such as PM GS and PM TS sensors.

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VERSION 3

KEYWORDS: Sensors, Photonics, Optical Modulators, Digital Read-outs, Cryogenic, Data Transmission

VERSION 3

A22B-T019 TITLE: Synthetic Platform for Device-Agnostic Quantum Dot IR Photodectors

RT&L FOCUS AREA(S): Quantum Sciences, Microelectronics

TECHNOLOGY AREA(S): Electronics, Materials, 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 'synthetic platform' and design rules to produce device-agnostic semiconductor nanocrystal (quantum dot/QD) absorbers for infrared sensors.

DESCRIPTION: Current infrared (IR) sensors typically use epitaxial semiconductors or microbolometers as optoelectronic absorbers. Epitaxial semiconductor sensors achieve high speed and sensitivity, but are expensive and typically operate at cryogenic temperatures. Microbolometer cameras may operate uncooled, but operate only in the long-very long wave IR (LWIR-VLWIR) range with limited sensitivity and speed.

Quantum dots are already widely employed for photonic applications such as LEDs. Using QDs as IR absorbers requires control of the optoelectronic properties (e.g. charge transfer) of QD assemblies, which remain poorly understood [1-7]. Current approaches to QD-based sensors require developing QD materials in parallel with a sensor 'scaffold' (e.g. readout integrated circuit/ROIC). Only recently have advances in electronics and materials enabled a commercial IR sensor featuring a QD absorber [7,8].

Improved understanding and control of optoelectronic properties of QD assemblies would allow QDs to be optimized to a chosen sensor design, without the need to develop sensor scaffolds and QD absorbers in parallel. Such 'device-agnostic' QDs would be compatible with the variety of QD image sensor designs (e.g. photoconductive, photovoltaic, bulk or low dimensional absorbers…) already in development.

This STTR targets 'leap-ahead' innovation to mature QD IR absorber technology as an alternative to microbolometers or epitaxial semiconductors. QD-based IR sensors could enable low-cost, high-speed, lightweight uncooled infrared detectors across the short- to long-wave infrared (SWIR-LWIR) regions. Additionally, QD absorbers could enable uncooled mid-wave IR (MWIR) cameras, a current technology gap [2-5,9,10]. The advantages of QD-based IR detectors compared to current technologies (e.g. microbolometers or epitaxial semiconductors) are a result of quantum confinement phenomena in QDs and simple processing.

VERSION 3

Due to quantum confinement effects, QD absorbers may bypass performance-limiting thermal noise issues encountered in bulk semiconductors and operate with little/no cooling. Wavelengths including SWIR-LWIR can be achieved by controlling QD size and composition. As photodetectors, QD devices are capable of high sensitivity and high response speeds compared to microbolometer-based systems [1-5,8].

QDs are prepared in simple liquid suspensions, which may be painted, printed, dropped or spun onto a sensor scaffold such as a ROIC. This processing enables rapid, low-cost synthesis of large volumes of QDs (>1m2 absorber/day for <$1K materials) [3,4,7,8].

A successful synthetic platform for applying QD absorbers in IR cameras will result in improved sensor performance and stability, lower costs and faster development times compared to current technologies. This will require:
- identification and understanding of the phenomena determining the final properties of QD-based absorbers,
- accurate screening methods to characterize the relevant properties of as-synthesized QDs,
- model(s) capable of predicting sensor/absorber performance from QD screening results, and
- synthetic protocols and processes to control the QD properties that determine final sensor performance.

The product of this STTR will be a platform to produce QDs designed and optimized based on specifications for a given image sensor. QDs would be compatible with the variety of QD infrared image sensor designs already in development. Further, a single sensor design could be optimized for various wavelengths by choosing the appropriate QD to apply to the basic scaffold.

PHASE I: Determine the feasibility of synthesizing device-agnostic QDs for IR absorption. The Phase I deliverable is a report. In the Phase I report the performer should:
A) Identify class(es) of QDs of interest (e.g. II-VI, III-V, perovskite…) and relevant QD properties for investigation (e.g. size distribution, surface chemistry, photoluminescence…). Identify synthetic approach(es) for QDs of interest. Identify existing methods and/or propose testing methods to measure the QD properties of interest.
B) Identify potential uncooled QD absorber sensor formats of interest and relevant sensor performance metrics for prediction/evaluation (e.g. detectivity, responsivity, stability, quantum efficiency…). Identify existing and/or propose test device(s) to characterize sensor performance metrics. For identified metrics, determine ranges of performance that would be competitive with current industry-standard technologies and allow comparison between QD devices and current uncooled technologies.
C) Propose a systematic approach to develop and demonstrate relations between properties identified in A) and performance metrics identified in B).

PHASE II: Execute systematic investigations into QD properties and sensor performance outlined in Phase I report. Validate QD characterization methods identified in Phase I. Synthesize and characterize QDs with variable properties of interest (as identified in Phase I). Verify synthetic control of QD properties of interest.

Fabricate and validate test device(s) for sensor characterization identified in Phase I. Apply synthesized QDs to test devices and identify correlations and/or causal relationships between QD properties and final sensor performance.

Based on experimental results, identify the primary QD properties governing final sensor performance. Construct predictive model(s) for relating QD synthesis/QD properties to sensor performance.

Successful Phase II results will clarify basic design rules for QD-absorbers and devices. Phase II deliverables should include design rule(s)/model(s) for predicting and optimizing at least one sensor metric to match or exceed the 'industry competitive' range identified in Phase I. Other successful outcomes could include demonstrating design-optimization models for multiple metrics in one sensor design, or one metric in multiple sensor designs. Rules/Models should be accompanied by a 'library' of synthetic protocols to control the relevant QD properties.

PHASE III DUAL USE APPLICATIONS: The ultimate product of the proposed STTR will be a synthetic platform comprising design rules for QD-based absorbers and a set of synthetic protocols for implementing said design rules. Recent and ongoing developments in sensor scaffolds for QDs have demonstrated and continue to optimize multiple sensor designs. A device-agnostic synthetic platform for QDs, as envisioned here, will enable broad application of QD-based sensors tailored to specific missions. Combining the appropriate sensor scaffold with the optimal QDs accesses a broad design envelope to provide interchangeable 'plug-and-play' IR sensors with optimized wavelength, resolution and size, weight, power and cost (SWaP-C) parameters.

Potential applications for QD-based IR imagers include wearable sensors with comparable or better SWaP-C than current microbolometers and improved speed and sensitivity. Such sensors are ideal for the Army Integrated Visual Augmentation System (IVAS), for example. Small drones and autonomous vehicles operating in degraded visual environments would also benefit from the low cost and tailorable performance of QD imagers.

Current applications for QD absorbers are based on the designs of conventional IR cameras. Another 'leap-ahead' enabled by determining design rules for QD-absorber fabrication is commercialization of novel camera designs using large-scale detectors and/or novel geometries (e.g. curved, flexible sensors) not possible with current technologies.

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KEYWORDS: Quantum Dot, Nanocrystal, Infrared Detector, Infrared Absorber, Long Wavelength Infrared (LWIR), Uncooled, Sensor, Low-dimensional materials

VERSION 3

A22B-T020 TITLE: Multi-Domain Operations Logistics Reduction through Integrated Phosphine Sensors within Materiel Storage Containers

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

TECHNOLOGY AREA(S): Sensors, 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: To vastly improve logistics in Multi-Domain Operations (MDO) through a low-cost phosphine sensor which can be integrated onto existing storage containers housing Red Phosphorus (RP)-related materiel.

DESCRIPTION: MDO in contested EW (electronic warfare) environments require technologies and weapon systems capable of delivering payloads on target and on time. EM (electromagnetic) attenuating aerosols play a crucial role in protecting the Warfighter MDO by decreasing or modifying electromagnetic signatures detectable by various sensors, seekers, trackers, targeting and optical enhancement devices, and the human eye. RP remains the highest performing fielded visible obscurant, capable of generating the highest-yielding aerosol on a volume and weight basis. Leveraging the exceptional performance of RP is critical when considering payload and load-out constrained systems, such as a rocket warheads. While efforts are underway to modify RP to be less reactive to water, stockpile material is still subject to degradation resulting in the release of highly toxic phosphine gas within the storage containers of RP munitions (Pepelko 2004). Of particular interest, the PA150 (NSN: 8140-01-451-7538) / PA154 (NSN: 8140–01–380–5857) / PA157 (NSN: 8140–01–354–0766) could be outfitted with these sensors. Existing commercially-available sensors are very expensive and not easily integrated onto munition containers, their use would require “breaking the seal” of storage containers, thereby potentially exposing those involved to the toxic phosphine (Brabec 2019). The goal of this program would be a sensor that would not break the seal of either the inner or outer packs of the container. State-of-the-art sensor technologies are frequently based upon electrochemical or semiconductor sensing media that can directly interact with an analyte, has been p- or n-modified, or has been functionalized by an inorganic or organic moiety capable of direct analyte interaction. Several state-of the-art approaches include: monolayer materials, such as Al2C (Rahimi 2021), self-assembled monolayers (Xia 2013); reduced graphene oxide (Furue 2017), nitrogenated graphene (Yar 2019) which can provide significant signal response enabled by very thin monolayers while providing very high surface areas for analyte interaction; nanoporous and nanostructured silicon (Ozdemir 2010), providing both high surface areas due to nanoporosity and the ability to tune conduction through charge carrier modification or nanostructure growth; and, organic sensing

media functionalized with specific moieties (Kim 2020). Sensors based upon these sensing media may function by measuring changes in conductivity induced by variations in charge carriers (electron and hole) when analytes sorb or desorb from the surface, or cause displacement of previously adsorbed species, such as oxygen. Although considered state-of-the-art, these approaches require direct contact of the sensing media and their electronic circuits with the analyte of interest, such as phosphine. Using these sensor technologies with munitions could create significant hazards in the presence of corrosive environments, causing corrosion of circuits and potentially leading to local heating, sparking, or other unintended initiation sources for phosphine, di-phosphine, or the payload. This topic seeks to develop technologies able to monitor phosphine concentrations within munition containers while eliminating any potential for unintended ignition of gases generated by degradative processes, or munition payloads. This low-cost sensor could be fitted upon all existing storage containers to provide an immediate and reliable on-demand read-out of phosphine concentration relative to action level, vastly improving logistics in MDOs.

PHASE I: Develop and fabricate a sensor that incorporates all necessary components to function, including both the non-electronic (interior), interface, sensor components (breadboard scale), self-calibration and zeroing, and reliably measures low-level concentrations of phosphine 0.01 ppm ± 0.02 ppm (an order of magnitude below the OSHA TWA) and high-level concentrations of phosphine to 100 ppm (± 2 ppm). Successful proposals will include any assumptions, along with the expected sensitivity and specificity of the proposed approach. While phosphine is the only pnictogen hydride anticipated to be present as a degradation byproduct, proposed solutions should indicate if the approach will show sensitivity toward phosphine over other pnictogen hydrides. Proposed designs should avoid the use of microheaters that could contribute to unintended ignition. This sensor shall be integrated onto existing munition containers with little to no modification to said containers. At most, two adjacent small sampling holes would be permitted, provided they do not compromise the form, fit or function of the container. Offeror shall coordinate their proposed integration locations and design with the technical points of contact to ensure proper form, fit and function is retained. All components and technological approaches shall be selected in a way to ensure a minimum 15-year uninterrupted service life, and the device shall be serviceable to extend the service life by an additional 15 years, assuming intermittent on-demand usage. Sensor shall incorporate features to maintain calibration, prevent signal drift as a function of time or phosphine saturation. Design approach shall incorporate features to prevent fouling or saturation by other substances, and reliably function when the phosphine saturation limit is reached. Paper study to ensure capability of being miniaturized and cost no more than $15 per unit, assuming 10,000 units of production. Given the low cost of simple circuitry (e.g. dollar store calculators) it is assumed that the cost of the integrated sensor should not exceed the specified per-unit cost at production quantities. Approaches exist to potentially lower manufacturing costs (Prajesh 2015), however awareness of Ph II requirements should be taken to ensure the prototype, once miniaturized, will meet environment/vibrational requirements (ruggedness), as well as any industry and regulatory standards for sensors of toxic materials. Efforts should be made to ensure recovery, reusability, and refurbishment of sensors. Presumed components and parts list, along with shelf and use lifespans shall be provided as a deliverable to Phase I.

PHASE II: Miniaturize according to Ph I paper study. Demonstrate the required per-unit cost can be achieved by direct in-house fabrication or through partnerships with commercial electronics fabricators. Must meet all ruggedness (cold and hot conditioning, logistic vibration, drop testing) parameters for the munitions containing RP (MIL-STD-810H, others) while installed on an operationally relevant container. Budget should include all components necessary to meet the requirements, including operationally relevant containers. All production hardware required to produce 10,000 units per year, such as dies, molds, etc., shall be produced and made available during Ph II. All molds, dies, tooling, software, and components shall be a Phase II deliverable. All enclosures and components shall withstand storage and field conditions for a minimum of 30 years. Any seals (e.g. elastomers) incorporated into the design shall withstand storage and field conditions without leakage or other failure for a minimum of 30 years or a minimum of 15 years if the seals are serviceable. Sensor shall retain full functionality and meet all performance requirements for a minimum of 30 years. All energy sources shall provide enough power for full operation for a minimum of 30 years, or shall provide enough power for full operation for a minimum of 15 years and shall be serviceable to extend the service life by an additional 15 years. Full technical data package describing the production unit, components, sourcing, repair protocols, and replacement parts shall be a Phase II deliverable.

PHASE III DUAL USE APPLICATIONS: Produce no less than 10,000 units and in integrate into existing RP munition storage containers. Lotting will be in accordance with MIL-STD-1168.

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KEYWORDS: RP, Phosphine, Detection, Spectroscopy, MOPP, Obscurant

VERSION 3

A22B-T021 TITLE: MOF Sponges for Enhanced Soldier Lethality

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

TECHNOLOGY AREA(S): Chem Bio Defense

OBJECTIVE: The Army seeks innovative solutions for engineering metal-organic frameworks into composite sponges and foams for use in personal protective equipment (PPE).

DESCRIPTION: This topic seeks to develop MOF-polymer composites in the form of sponges and foams for enhanced personal protection equipment (PPE). MOFs offer enhanced protection against chemical warfare agents (CWAs)1-3 and toxic industrial chemicals (TICs)4-6. Sponges and foams can be useful for small footprint filters when used with a mask, ballistic protection if integrated into a helmet, and/or small scale portable decontamination of contaminated areas. In For each of these areas, a combined MOF-sponge composite can lead to enhancements in comparison to currently fielded equipment for improved Soldier Lethality.

MOF sponges (and/or foams) will be developed using available techniques that incorporate high mass loadings of MOF (threshold of 50 wt%, objective above 80 wt%). A variety of techniques can be used to make composites resulting in structures such as high internal phase emulsions (polyHIPE) and aerogels.7-9 Composites may be fabricated from pre-existing sponges/foams, with in situ growth of the MOF onto the polymer, or by making the sponge/foam with pre-synthesized MOF.

The resulting composite sponges/foams should be mechanically robust, with MOFs adhered to the surface without shedding and the overall structure free-standing. The foams will be compressible and not fully rigid. Composites should withstand/hold up against most common solvents without dissolving.

MOFs will be accessible within the sponge/foam composites as assessed by nitrogen porosimetry and chemical activity. Composites will be evaluated for toxic vapor uptake and reactivity, including vapor threats (e.g., ammonia, chlorine, DMMP) and chemical warfare agents/simulants (e.g., DMNP, DFP, GB, GD, HD).

PHASE I: Demonstrate the ability to make sponges/foams with multiple MOFs, including HKUST-1, UiO-66-NH2, and MOF-808, at loadings exceeding 50 wt%. MOFs will be accessible to toxic chemicals. Demonstrate the ability to control loading of MOF. The composite will be free-standing and compressible without shedding MOF particles. Composites will be fabricated and delivered to CBC in approximately 3” x 3” x 1” swatches.

PHASE II: Optimize composite sponge/foam with respect to mechanical and chemical properties. Understand additional potential benefits of technology, including ballistic/shock protection. Understand the effects of environmental conditions and contaminants on the composite. Scale the process to make commercial-type sponges. Tune processing techniques to understand trade-offs associated with flexibility, hardness, MOF content, MOF shedding,

chemical performance, etc. Collect data on composite activity (toxic gas adsorption, breakthrough, permeation, and/or reactivity).

PHASE III DUAL USE APPLICATIONS: Collaborate with industry partners to develop technologies, to include novel filter designs, decontamination sponges/wipes, air storage devices, and more.

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KEYWORDS: Chemical warfare agent, toxic industrial chemical, filtration, protection, metal-organic framework, MOF, foam, sponge, decontamination

VERSION 3

A22B-T022 TITLE: A Novel Pre-Compression Kolsky Tension Bar Technique for Brittle Materials

RT&L FOCUS AREA(S): Hypersonics

TECHNOLOGY AREA(S): Materials, Weapons

OBJECTIVE: Develop an innovative Kolsky tension bar system to characterize the dynamic tensile behavior of brittle materials at high strain rates.

DESCRIPTION: Tension-induced dynamic fragmentation is often observed on the back side of the penetration/perforation targets as a result of stress wave reflection from the free surface. Tensile/spall damage generated during the fragmentation process significantly compromises the penetration resistance of the target material, which leads to reduced protection capability. This unique challenge is further exacerbated by the lack of a reliable dynamic tensile characterization system for brittle materials. Over the past several decades, some efforts have been made to develop a Kolsky bar-based dynamic tensile testing technique using the ideas of spall tension [1,2], split tension [3,4], and direct tension [5,6]. A common draw back of all these techniques is that the specimens rarely reach the state of stress equilibrium or constant strain-rate deformation at the time of fracture due to extremely small tensile failure strain for most of the brittle materials.

The goal of this topic is to develop a Kolsky tension bar system capable of extending the tensile strain of brittle specimens during dynamic tests through the implementation of a pre-compression mechanism. This idea leverages the relatively large compressive failure strain for brittle materials to effectively provide additional time for the tensile specimens to achieve dynamic stress equilibrium and constant strain-rate deformation. The proposed new Kolsky tension bar technique needs to provide a wide range of adjustable pre-compressive stresses to accommodate different types of brittle materials (high-strength concrete, armor glass/ceramics, composites, etc.) for the Army's applications.

PHASE I: Demonstrate the design concept for the new Kolsky tension bar system, and the unique mechanism of applying/controlling the static pre-compressive stress to tensile specimens. Develop a reliable specimen attachment technique to ensure 1. rigid, steady specimen/bar connection, and 2. smooth and continuous transition from compressive to tensile loading conditions. Demonstrate the feasibility of tailoring the dynamic loading wave to achieve stress equilibrium and constant strain rate deformation for the test specimen. Deliver a report documenting the research and development efforts along with a detailed description of the proposed prototype Kolsky tension bar. Phase I focuses on the conceptual design of the prototype. Only the most effective and promising design that addresses all the aforementioned requirements will be given consideration for a Phase II award.

PHASE II: Manufacture a prototype of the Kolsky tension bar system proposed in Phase I. Demonstrate the pre-compression mechanism at several designated stress levels, and the loading wave tailoring capability aimed at achieving desired dynamic stress equilibrium and constant strain rate deformation. Demonstrate the specimen attachment technique that is capable of

handling the rapid transition from compression to tension. Phase II will also require live demonstration tests using the prototype system. The materials of choice are fiber-reinforced and non-reinforced high-strength concrete, or other brittle material with limited tensile strain capacity and clear applications for the Army. These materials are chosen due to their extremely low tensile failure strength (and strain) compared to other brittle materials.

Reporting and documentation: (1) the CAD drawings, operation manual, and safety guideline for the prototype system; (2) the verification procedure that demonstrates the experimental results meet the desired testing conditions. In addition to the reporting and documentation, Phase II also requires delivery of a well-tuned, fully functioning pre-compression Kolsky tension bar system.

PHASE III DUAL USE APPLICATIONS: The development of a pre-compression Kolsky tension bar system benefits a broad range of military applications such as vehicular/body armor design, testing of high-strength/ultra-high-strength concrete for impact and blast protection, development of composite gun barrel for light-weight gun system, etc. This new technique also has potential to satisfy the needs of academic research on dynamic tensile behavior of other emerging brittle materials, and clear applications for the Army through the various materials R&D efforts in support of several modernization priorities through the CFTs.

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KEYWORDS: split Hopkinson bar, brittle material, Kolsky tension, dynamic tensile behavior

VERSION 3

A22B-T023 [Topic Removed]

VERSION 3

A22B-T024 TITLE: To develop a portable and automated device: enabling precise and multiplexed detection of metabolites and/or chemicals

RT&L FOCUS AREA(S): Biotechnology

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: To develop a portable, automated, and easy to use in vitro diagnostic (IVD) device for rapid detection of metabolites and/or chemicals from minimally invasive biomatrices.

DESCRIPTION: Metabolite fingerprints are used to discover biomarkers of diseases by providing comprehensive information on the physiological state. These typical end products of biofunctions are used to comprehend the upstream molecular perturbations and can inform the disease dynamics. The metabolites detection is facilitated by methods including capillary electrophoresis mass spectrometry (MS), nuclear magnetic resonance MS, liquid chromatography (LC) and gas chromatography (GC) MS. In recent years, FDA has approved multiple MS based in vitro diagnostic (IVD) tools for newborn screening, tacrolimus detection (LC-MS/MS platform) and microbial identification (MALDI-TOF based detection). There are several laboratory-developed tests available to monitor drug abuse or pain, quantify steroids or vitamin D and its derivatives (Cheng et al. 2017). Emerging studies converge on establishing metabolites for the elucidation of biochemical pathways to improve diagnosis and therapeutic capabilities, enhancing Military readiness. Studies have identified metabolic/inflammation pathways and biomarkers for Alzheimer's disease, Parkinson's disease, and PTSD (Melon et al. 2019; Dean et al. 2019; Kinney et al. 2018, Lian et al. 2019). For instance, patients suffering from PTSD are typically susceptible to the disturbances in somatic pathology in inflammation, metabolic syndrome, and mitochondrial dysfunction. These metabolites, such as Global Arginine Bioavailability Ratio and lactate/citrate, outperformed the combined individual components (Dean et al. 2019), emphasizing the need for a targeted multiplexing capability to detect the metabolite profile. Current instrumentation for metabolite detection is expensive and rely on complicated upstream handling of large biological samples. The above criteria raises a challenge to deploy such systems in austere conditions and bed side clinics. Although there are some portable and field-rugged mass spectrometers available commercially, they lack end-to-end analytical methods or clinical accuracy. Integrated microfluidic devices for sample preparation, separation and/or introduction are emerging in the field of bioanalysis, requiring further exploration. The efforts are in development of point-of-care (PoC) tests, with the ideal version for this test being an independent and self-sustainable operation allowing a non-trained operator to load samples into the instrument and obtain informative results with minimal user intervention. Fully integrated device as one system will significantly advance PoC decisions. This topic seeks to develop a portable, automated, rapid, easy to use device for sample testing that is effective for the detection and screening of targeted metabolites to determine any user-defined clinical landmark(s) or distinguish the disease states (e.g. identify healthy cohorts from diseases cohorts or vice versa). Improving the mass analyzers in a portable format along with chromatography and/or electrophoresis have the potential to revolutionize biomedical science and would offer benefits in multiplexing. The targeted molecules could be related to metabolism (e.g. shortchain fatty acids, amino acids, lipid, phenolic/indolic compounds) and/or hormones/precursors (e.g. GABA, dopamine, serotonin). The proposed technology can use blood

or other non-invasive biological fluids (urine, saliva and sweat). It should have a low footprint and an enabled multiplexing capability to be used onsite, bedside, or at minimally supervised clinics. This device will raise the possibility of: identifying the metabolomics differences associated with PTSD; contribute to personalized biomarker-based monitoring; and treating underlying pathophysiology in PTSD.

PHASE I: Provide experimental evidence indicating the potential for this assay to be applied effectively using either existing, modified, or novel field-rugged mass spectrometry systems. Use of human or animal subjects is not intended or expected, in order to establish/achieve the necessary proof-of-concept in Phase I. At the end of this phase, a working prototype of the assay(s) should be completed with some demonstration of feasibility, integration, and/or operation of the prototype. In addition, descriptions of data analysis and interpretations concept and concerns should be outlined. Phase I should also include the detailed development of Phase II testing plan.

PHASE II: During this phase, the integrated system should undergo testing. Here, we will develop suitable initial small molecule compound libraries and demonstrate the end-to-end analytical method, sufficient to indicate the operations in the final device. Accuracy, reliability, and usability should be assessed. Capabilities that are sought herein should preferably encompass an end-to-end method to include low (or minimally) invasive biospecimen collection and an automated assay followed by simple sample analysis. This testing should be controlled and rigorous. The preferred method shall be in an easy-to-use format, not too technically demanding, and require instrumentation with minimal analytics. To note, solicited capability excludes any antibody-based enzyme-linked immunosorbent assay (ELISA) or primer-based polymerized chain reaction (PCR) method. Statistical power should be adequate to document initial efficacy and feasibility of the assay. This phase should also demonstrate evidence of commercial viability of the tool. Accompanying the application should be standard protocols and procedures for its use and integration into ongoing programs.

PHASE III DUAL USE APPLICATIONS: Phase III efforts should include a focus on technology transition, preferably commercialization of STTR research and development. The product developed is intended to be suitable for use and potential procurement by all of the Services. Realization of a dual-use technology applicable to both the military and civilian use is preferred. Therefore, the successful transition path of the technology is expected to include close engagement with military medical acquisition program managers (USAMMDA) during product commercialization to ensure appropriate product applicability for military field deployment. During this phase, expand the compound library and range of analytical methods for testing and evaluation of the operation and effectiveness of utilizing an integrated system. Accuracy, reliability, and usability should be assessed. This testing should be controlled and rigorous. Statistical power should be adequate to document initial efficacy and feasibility of the assay. This phase should also demonstrate evidence of commercial viability of the tool. Accompanying the application should be standard protocols and procedures for its use and integration into ongoing programs.

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KEYWORDS: Mass spectrometry, liquid chromatography, gas chromatography, multiplex assay, portable device, small molecules, metabolomics, metabolites, chemicals, biomarker, in vitro diagnostics tool

VERSION 3

A22B-T025 TITLE: Novel food Ingredient with very high levels of Essential Amino Acids (EAA) (>80% by mass)

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

TECHNOLOGY AREA(S): Human Systems

OBJECTIVE: Develop novel food ingredient with >80% content by mass essential amino acids in proportions similar to whey protein, which is rapidly bioavailable, flavorless, and shelf stable for incorporation into rations.

DESCRIPTION: Essential amino acids (EAAs) must be obtained through dietary protein and are the limiting factor for muscle protein synthesis in the body. During combat operations, warfighters engage in sustained physical activity with few opportunities to eat which can lead to negative energy and protein balances. This is a common occurrence in austere environments, such as the arctic, where the average daily energy expenditure is 6000 kcal, with potential energy deficits exceeding 40% of what is required for energy balance. To sustain metabolism during negative protein balance, the warfighter's skeletal muscle is catabolized leading to losses in lean body mass. This makes the warfighter less effective at accomplishing their mission and overmatching the enemy. In scenarios where energy deficit is unavoidable, strategies to support performance and improve recovery should focus on providing the highest quality nutrition provision that mitigates detrimental effects and aids in warfighter recovery.

Unfortunately, most food proteins do not contain high levels of EAA. "Gold standard" proteins (whey, casein, egg) contain only 40-50% EAA by mass, and are difficult to incorporate into combat rations in high levels. Direct fortification of combat rations with free amino acids has been unsuccessful due to the bitterness of free amino acids. In addition, free amino acids tend to react with other compounds in the food to produce non-nutritive off flavors and colors. These irreversible reactions (e.g., Maillard browning), reduce amino acid content and bioavailability of EAA within the food. Organoleptic quality of combat rations is of the utmost importance so that Soldiers will be motivated to consume the rations even when stressed. Maintaining the formulated nutritional profile across storage and deployment is imperative to support performance and recovery.

This topic seeks a novel food ingredient that can be a "blank canvas" for ration developers to create the next generation of compact, tasty and nutritious combat rations. The ideal ingredient would have greater than 80% content of EAA, neutral flavor, provide essential amino acids in proportions similar to whey protein, release EAA into the blood stream at a rate which approaches that of consuming free crystalline amino acids, be stable/maintain protein quality over storage at high temperatures, not react with reducing sugars in the food, and be easy to incorporate into a wide variety of combat rations ranging from bars to complete entrees.

PHASE I: Depending on the nature of the technology proposed, phase I deliverables may consist of a technical report, and/or proof of concept experiments, and/or the preparation of a small sample (5-500g) of the novel ingredient for evaluation by Army scientists. Successful offerors will demonstrate the technology is feasible, and scalable past benchtop level.

Any ingredient samples provided must be food safe and contain only GRAS/Food grade materials. Offerors should plan to address the food safety concerns inherent in producing food ingredients (e.g., microbiological quality, allergenicity, quality control/GMP) with a view to obtaining GRAS status for the novel food ingredient. Offerers should plan to address the Army's concerns with both the organoleptic and nutritional stability of the ingredient during deployment in combat rations. Combat rations are tested for stability using accelerated storage studies of 1 month at 120*F, 6 months at 100*F, and 3 years at 80*F.

Offerors should compare their ingredient to gold standard protein sources and propose appropriate analytical strategies for verifying and validating the quality and suitability of the ingredient for combat rations.

PHASE II: Phase II will involve scale up and deployment of the technology used to create the novel ingredient, with a target of supplying between 2-20kg of food safe, ready to use powdered ingredient for evaluation by DEVCOM SC food technologists by the end of phase II.

Successful offerors will demonstrate the capability to scale up the technology to low-rate initial production, and a technology path towards the production of the food ingredient in larger amounts (1-100 tons/year) suitable for supply to DoD combat ration suppliers.

Offerors will conduct the activities needed to support applying for GRAS status of the ingredient in Phase II, which will support transition to Phase III.

Offerors will demonstrate successful execution of the analytical strategies proposed in phase I, for verifying and validating the quality and suitability of the ingredient for combat rations, including stability under accelerated storage test conditions.

In lieu of human/animal trials (all cases to be conducted in compliance with IACUC or IRB-approved protocols, and with the coordination and approval of the COR), offerors may demonstrate the bioaccessibility of the ingredient by appropriate chemical analysis procedures.

Offerors may demonstrate their food ingredient being used in a variety of food formulations, with a special interest in products besides bars/beverages, e.g. retorted entrées or baked goods. Ideally the product could be incorporated in significant amounts into combat rations with both high (retort entrée's) and low water activities (baked goods, bars).

PHASE III DUAL USE APPLICATIONS: The end state for this project is the creation of a novel food ingredient with very high essential amino acid content, that can be used to create shelf stable combat rations with greater levels of high-quality protein/EAA while being more compact and palatable than existing rations.

After successful verification/validation studies by Army scientists, the most likely pathway for transition is judged to be supply of the raw ingredient to 3rd party manufacturers of combat rations. Ration suppliers could be asked to make combat rations which will be specified to

contain the ingredients that meet performance specifications for EAA content, or to contain protein quality levels which can be achieved using the technology of this STTR.

Outside of the military market, it is anticipated that there would be interest in this ingredient by the food/nutrition industry because an ingredient with a very high EAA content could be used to valorize low quality cheaper protein sources by converting them to high quality complete proteins. Alternatively, the ingredient could be used to create sports nutrition products that sustain muscle growth/recovery by supplying EAA.

REFERENCES:

1. Nutrient Composition of Rations for Short-Term, High-Intensity Combat Operations. National Academies Press. (https://www.nap.edu/catalog/11325/nutrient-composition-of-rations-for-short-term-high-intensity-combat-operations)
2. AR40-25 Nutrition and Menu Standards for Human Performance Optimization (https://armypubs.army.mil/epubs/DR_pubs/DR_a/pdf/web/AR40-25_WEB_Final.pdf)
3. Essential Amino Acids and Protein Synthesis: Insights into Maximizing the Muscle and Whole-Body Response to Feeding. Nutrients. 2020 Dec 2;12(12):3717. doi: 10.3390/nu12123717. PMID: 33276485; (https://pubmed.ncbi.nlm.nih.gov/33276485/)
4. The Skeletal Muscle Anabolic Response to Plant- versus Animal-Based Protein Consumption. J Nutr. 2015 Sep;145(9):1981-91. doi: 10.3945/jn.114.204305. Epub 2015 Jul 29. PMID: 26224750. (https://pubmed.ncbi.nlm.nih.gov/26224750/)

KEYWORDS: Essential Amino Acid, Combat Ration, Protein, Food Technology, Combat Feeding, Muscle

AIR FORCE
22.B SMALL BUSINESS TECHNOLOGY TRANSFER (STTR) Phase I
PROPOSAL PREPARATION INSTRUCTIONS
AMENDMENT 1
13 May 2022

This Amendment hereby makes the following revisions:

1. Topic SF22B-T006 is hereby revised.

All other solicitation terms and provisions remain unchanged as a result of this Amendment.

AIR FORCE
22.B SMALL BUSINESS TECHNOLOGY TRANSFER (STTR) Phase I
PROPOSAL PREPARATION INSTRUCTIONS

Air Force (AF) Phase I proposal submission instructions are intended to clarify the Department of Defense (DoD) Broad Agency Announcement (BAA) as it applies to the topics solicited herein. **Firms must ensure proposals meet all requirements of the 22.B STTR BAA posted on the DoD SBIR/STTR Innovation Portal (DSIP) at the proposal submission deadline date/time.**

Complete proposals **must** be prepared and submitted via https://www.dodsbirsttr.mil/submissions/ (DSIP) on or before the date published in the DoD 22.B STTR BAA. Offerors are responsible for ensuring proposals comply with the requirements in the most current version of this instruction at the proposal submission deadline date/time.

Please ensure all e-mail addresses listed in the proposal are current and accurate. The AF is not responsible for ensuring notifications are received by firms changing mailing address/e-mail address/company points of contact after proposal submission without proper notification to the AF. **If changes occur to the company mail or email addresses or points of contact after proposal submission, the information must be provided to the AF SBIR/STTR One Help Desk.** The message shall include the subject line, "22.B Address Change".

Points of Contact:

- General information related to the AF SBIR/STTR program and proposal preparation instructions, contact the AF SBIR/STTR One Help Desk at usaf.team@afsbirsttr.us.
- Questions regarding the DSIP electronic submission system, contact the DoD SBIR/STTR Help Desk at dodsbirsupport@reisystems.com.
- For technical questions about the topics during the pre-announcement and open period, please reference the DoD 22.B STTR BAA.
- Air Force SBIR/STTR BAA Contracting Officers (CO):
    - Mr. Daniel Brewer, Daniel.Brewer.13@us.af.mil

General information related to the AF Small Business Program can be found at the AF Small Business website, http://www.airforcesmallbiz.af.mil/. The site contains information related to contracting opportunities within the AF, as well as business information and upcoming outreach events. Other informative sites include those for the Small Business Administration (SBA), www.sba.gov, and the Procurement Technical Assistance Centers (PTACs), http://www.aptacus.us.org. These centers provideGovernment contracting assistance and guidance to small businesses, generally at no cost.

CHART 1: Air Force 22.B STTR Phase I Information at a Glance

Topic Number	Performance Period	Max STTR Funding	Technical Volume Contents
AF22B-T001	9 months	$150,000	White Paper NTE 20 Pages

PHASE I PROPOSAL SUBMISSION

DoD 22.B STTR BAA, https://www.dodsbirsttr.mil/submissions/login, includes all program requirements. Phase I efforts should address the feasibility of a solution to the selected topic's requirements. See Chart 1 (AF-1) for proposal dollar values, periods of performance, and technical volume content.

Limitations on Length of Proposal

The Phase I Technical Volume page limits identified in Chart 1 do not include the Cover Sheet, Cost Volume, Cost Volume Itemized Listing (a-j). The Technical Volume must be no smaller than 10-point on standard 8-1/2" x 11" paper with one-inch margins. Only the Technical Volume and any enclosures or attachments count toward the page limit. In the interest of equity, pages/slides in excess of the stated limits will not be reviewed. The documents required for upload into Volume 5, "Other", do not count toward the specified limits.

Phase I Proposal Format

Proposal Cover Sheet: If selected for funding, the proposal's technical abstract and discussion of anticipated benefits will be publicly released. Therefore, do not include proprietary information in these sections.

Technical Volume: The Technical Volume should include all graphics and attachments but should not include the Cover Sheet, which is completed separately. Phase I technical volume (uploaded in Volume 2) shall contain the required elements found in Chart 1. Make sure all graphics are distinguishable in black and white.

Key Personnel: Identify in the Technical Volume all key personnel who will be involved in this project; include information on directly related education, experience, and citizenship.

- A technical resume of the Principal Investigator, including a list of publications, if any, must be included.
- Concise technical resumes for subcontractors and consultants, if any, are also useful.
- Identify all U.S. permanent residents to be involved in the project as direct employees, subcontractors, or consultants.
- Identify all non-U.S. citizens expected to be involved in the project as direct employees, subcontractors, or consultants. For all non-U.S. citizens, in addition to technical resumes, please provide countries of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project, as appropriate. Additional information may be requested during negotiations in order to verify the foreign citizen's eligibility to participate on a contract issued as a result of this announcement.

Phase I Work Plan Outline

NOTE: The AF uses the Phase I Work Plan Outline in lieu of a Statement of Work (SOW). DO NOT include proprietary information in the Work Plan Outline. This will necessitate a request for revision and may delay contract award, if selected.

In the Work Plan section, start with a Work Plan Outline in the following format:

1) Scope: List the major requirements and specifications of the effort.

2) Task Outline: Provide a brief outline of the work to be accomplished over the span of the Phase I effort.
3) Milestone Schedule
4) Deliverables
    a. Kickoff meeting within 30 days of contract start
    b. Progress reports
    c. Technical review within 6 months
    d. Final report with SF 298

Cost Volume: Cost information should be provided by completing the Cost Volume in DSIP and including the Cost Volume Itemized Listing specified below. The Cost Volume detail must be adequate to enable Air Force personnel to determine the purpose, necessity and reasonability of each cost element. Provide sufficient information (a-i below) regarding funds use if an award is received. The DSIP Cost Volume and Itemized Cost Volume Information will not count against the specified page limit. The itemized listing may be submitted in Volume 5 under the "Other" dropdown option.

a. **Special Tooling/Test Equipment and Material**: The inclusion of equipment and materials will be carefully reviewed relative to need and appropriateness to the work proposed. Special tooling and test equipment purchases must, in the opinion of the CO, be advantageous to the Government and relate directly to the effort. It may include such items as innovative instrumentation and/or automatic test equipment.

b. **Direct Cost Materials**: Justify costs for materials, parts, and supplies with an itemized list containing types, quantities, prices and where appropriate, purpose.

c. **Other Direct Costs**: This category includes, but it not limited to, specialized services such as machining, milling, special testing or analysis, and costs incurred in temporarily using specialized equipment. Proposals including leased hardware must include an adequate lease vs. purchase justification.

d. **Direct Labor**: Identify key personnel by name, if possible, or by labor category if not. Direct labor hours, labor overhead and/or fringe benefits, and actual hourly rates for each individual are also necessary.

e. **Travel**: Travel costs must relate to project needs. Break out travel costs by trip, number of travelers, airfare, per diem, lodging, etc. The number of trips required, as well as the destination and purpose of each, should be reflected. Recommend budgeting at least one trip to the Air Force location managing the contract.

f. **Subcontracts**: Involvement of a research institution in the project is required. Involvement of other subcontractors or consultants may also be desired. Describe in detail the tasks to be performed in the Technical Volume and include information in the Cost Volume for the research institution and any other subcontractors/consultants. The proposing SBC must perform a minimum of 40% of the Phase I R/R&D and the research institution must perform a minimum of 30%. Work allocation is measured by direct and indirect costs AFTER REMOVAL OF THE SBC's PROPOSED PROFIT. This work allocation requirement is codified in statute; therefore, the Government CO cannot waive it. STTR efforts may include subcontracts with Federal Laboratories and Federally Funded Research and

Development Centers (FFRDCs). NOTE: Not all Federal Laboratories or FFRDCs qualify as research institutions.

Support subcontract costs with copies of executed agreements. The supporting agreement documents must adequately describe the work to be performed. At a minimum, each planned subcontractor's information must include a SOW with a corresponding detailed cost proposal.

g. **Consultants**: Provide a separate agreement letter for each consultant. The letter should briefly state what service or assistance will be provided, the number of hours required, and hourly or daily rate.

h. **DD Form 2345**: For proposals submitted under export-controlled topics, either by International Traffic in Arms or Export Administration Regulations (ITAR/EAR), a copy of 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 United States/Canada Joint Certification Program website, http://www.dla.mil/HQ/InformationOperations/Offers/Products/LogisticsApplications/JCP/DD2345Instructions.aspx. The DD Form 2345 must be approved prior to award if proposal is selected for negotiations and funding.

NOTE: Restrictive notices notwithstanding, proposals may be handled for administrative purposes only, by support contractors TEC Solutions, Inc., APEX, Oasis Systems, Riverside Research, Peerless Technologies, HPC-COM, Mile Two, Wright Brothers Institute, and MacB (an Alion Company). In addition, only Government employees and technical personnel from Federally Funded Research and Development Centers (FFRDCs) MITRE and Aerospace Corporations working under contract to provide technical support to AF Life Cycle Management Center and Space and Missiles Centers may evaluate proposals. All support contractors are bound by appropriate non-disclosure agreements. Please contact one of the Contracting Officer identified on A-1 with any concerns.

i. **Cost Sharing**: Cost share is not accepted as part of Phase I proposals.

Company Commercialization Report (CCR) (Volume 4)
Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR Program BAA for full details on this requirement. Information contained in the CCR will not be considered by the Air Force during proposal evaluations.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

The Air Force does not participate in the Discretionary Technical and Business Assistance (TABA) Program. Proposals in response to Air Force topics should not include TABA.

PHASE I PROPOSAL SUBMISSION CHECKLIST

Firms shall register in the System for Award Management (SAM), https://www.sam.gov, to be eligible for proposal acceptance. Follow instructions therein to obtain a Commercial and Government Entity (CAGE) code and Dunn and Bradstreet (DUNS) number. Firms shall also verify "Purpose of Registration" is set to "I want to be able to bid on federal contracts or other procurement opportunities. I also want to be able to apply for grants, loans, and other financial assistance programs", NOT "I only want to apply for federal assistance opportunities like grants, loans, and other financial assistance

programs." Firms registered to compete for federal assistance opportunities only at the time of proposal submission will not be considered for award. Addresses must be consistent between the proposal and SAM at award. Previously registered firms are advised to access SAM to ensure all company data is current before proposal submission and, if selected, award.

1) The Air Force Phase I proposal shall follow the topic-specific information in Chart 1.

2) It is mandatory complete proposal submission -- DoD Proposal Cover Sheet, Technical Volume with any appendices, Cost Volume, Itemized Cost Volume Information, Company Commercialization Report, and Fraud, Waste and Abuse Certificate of Training Completion -- be executed electronically through DSIP.

Please note the FWA Training shall be completed prior to proposal submission. When training is complete and certified, DSIP will indicate completion of the Volume 6 requirement. The proposal cannot be submitted until the training is complete. The AF recommends completing submission early, as site traffic is heavy prior to solicitation close, causing system lag. **Do not wait until the last minute.** The AF will not be responsible for proposals not completely submitted prior to the deadline due to system inaccessibility unless advised by DoD.

AIR FORCE PROPOSAL EVALUATIONS

The AF will utilize the Phase I proposal evaluation criteria in the DoD 22.B STTR BAA with the factors in descending order of importance.

The AF will utilize Phase II evaluation criteria in the DoD 22.B STTR BAA with the factors in descending order of importance.

Proposal Status and Feedback

The Principal Investigator (PI) and Corporate Official (CO) indicated on the Proposal Cover Sheet will be notified by e-mail regarding proposal selection or non-selection. Small businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the Proposal Number and Topic Number referenced.

Feedback will not be provided for Phase I proposals determined Not Selectable.

IMPORTANT: Proposals submitted to the AF are received and evaluated by different organizations, handled topic by topic. Each organization operates within its own schedule for proposal evaluation and selection**.** Updates and notification timeframes will vary. If contacted regarding a proposal submission, it is not necessary to request information regarding additional submissions. Separate notifications are provided for each proposal.

It is anticipated all the proposals will be evaluated and selections finalized within approximately 90 calendar days of solicitation close. Please refrain from contacting the BAA COs for proposal status before that time.

Refer to the DoD STTR Program BAA for procedures to protest the Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: Air Force SBIR/STTR BAA Contracting Officer Daniel Brewer, Daniel.Brewer.13@us.af.mil.

AIR FORCE SUBMISSION OF FINAL REPORTS

All final reports will be submitted to the awarding AF organization in accordance with the purchase order or contract. Companies will not submit Final Reports directly to the Defense Technical Information Center (DTIC).

PHASE II PROPOSAL SUBMISSIONS

AF organizations may request Phase II proposals while technical performance is on-going. This decision will be based on the contractor's technical progress, as determined by an AF TPOC's review using the DoD 22.B STTR BAA Phase I review criteria. All Phase I awardees will be provided an opportunity to submit a Phase II proposal unless the Phase I purchase order has been terminated for default or due to non-performance by the Phase I company.

Phase II is the demonstration of the technology found feasible in Phase I. Only Phase I awardees are eligible to submit a Phase II proposal. All Phase I awardees will be sent a notification with the Phase II proposal submittal date and detailed Phase II proposal preparation instructions. If the physical or email addresses or firm points of contact have changed since submission of the Phase I proposal, correct information shall be sent to the AF SBIR/STTR One Help Desk as instructed on A-1. Phase II dollar values, performance periods, and proposal content will be specified in the Phase II request for proposal.

NOTE: AF primarily awards Phase I and II contracts as Firm Fixed Price. However, awardees are strongly urged to work toward a Defense Contract Audit Agency (DCAA) approved accounting system. If the company intends to continue work with the DoD, an approved accounting system will allow for competition in a broader array of acquisition opportunities. Please address questions to the Phase II CO, if selected for award.

All proposals must be submitted electronically via DSIP by the date indicated in the Phase II request for proposal. Note: Only ONE Phase II proposal may be submitted for each Phase I award.

AIR FORCE STTR PROGRAM MANAGEMENT IMPROVEMENTS

The AF reserves the right to modify the Phase II submission requirements. Should the requirements change, all Phase I awardees will be notified. The Air Force also reserves the right to change any administrative procedures at any time to improve management of the AF STTR Program.

AIR FORCE 22.B STTR Phase I Topic Index

AF22B-T001	Co Orbital Threat Prediction and Assessment
AF22B-T002	Improved Integrated Circuit based Electricity to Radio Frequency Conversion Efficiency Development for Space based Applications
AF22B-T003	Variable Emissivity Thermal Control Capability Development for Space based Applications
AF22B-T004	Collaboration of Humans and Autonomy Research Teaming Testbed (CHART2)
AF22B-T005	Complex Emitter Behavioral Analysis Using Machine Learning
AF22B-T006	Self-Regulating Heaters for Satellites

AF NUMBER: AF22B-T001

TITLE: Co Orbital Threat Prediction and Assessment

TECH FOCUS AREAS: Network Command, Control and Communications; Artificial Intelligence/Machine Learning

TECHNOLOGY AREAS: Space Platform; Battlespace

OBJECTIVE: Develop methods for anticipating adversary spacecraft Courses of Action (CoAs) that differentiate between threat types; address finite burn, continuous thrust, and impulsive maneuvers; and encompass three body dynamics for beyond GEO objects.

DESCRIPTION: Battlespace awareness within the space domain is a critical foundation for planning appropriate courses of action, responding to threats, protecting vulnerable assets, and preparing contingency plans. The ability to maintain flexible deterrent options in various situations relies upon maintaining an accurate picture of (1) what is happening now, and (2) what could happen in the future. Because the set of future possibilities is infinite, it is important to broadly characterize these possibilities, and to best understand those which require a response or present the greatest threats to our assets and affect the service they provide. Classifying threats' possible actions, the object's subsequent trajectory, and what threats it can pose from along that trajectory are critical to maintaining object custody and awareness.

PHASE I: Identify potential solutions that enables prediction and characterization of co-orbital threats, and effectively manage the large set of future possibilities. Evaluate the solutions' feasibility and tractability for use in an operational environment. Compare performance and computation time for the investigated solutions. Proposed solutions should address finite burn, continuous thrust, and impulsive maneuvers, differentiate between kinetic and non-kinetic threats, and address three body dynamics for beyond GEO objects.

PHASE II: Develop prototype software that enables prediction and characterization of co-orbitals threats and manages the large number of future possibilities in a manner that is digestible and actionable for the user. Generate simulated threat trajectories and observations for threats in all orbital regimes with both continuous and impulsive thrust maneuvers. Demonstrate prototype capabilities by processing the simulated data. Display predicted courses of action and Indications and Warnings (I&W) in a prototype user interface with basic data visualization. GFE is not anticipated.

PHASE III DUAL USE APPLICATIONS: Develop prototype software that enables prediction and characterization of co-orbitals threats and manages the large number of future possibilities in a manner that is digestible and actionable for the user. Generate simulated threat trajectories and observations for threats in all orbital regimes with both continuous and impulsive thrust maneuvers. Demonstrate prototype capabilities by processing the simulated data. Display predicted courses of action and Indications and Warnings (I&W) in a prototype user interface with basic data visualization. GFE is not anticipated.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are

advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR HelpDesk: usaf.team@afsbirsttr.us

REFERENCES: [1] The Aerospace Corporation, "Space Threat Assessment 2021," 2021. [2] S. M. Brown, "Knowledge Acquisition for Adversary Course of Action Prediction Models," AAAI Technical Report FS-02-05, 2002. [3] E. J. Santos, D. Li, E. E. Santos and J. Korah, "Temporal Bayesian Knowledge Bases - Reasoning About Uncertainty with Temporal Constraints," Expert Systems with Applications, vol. 39, no. 17, pp. 12905-12917, 2012.

KEYWORDS: Indications and Warning; Orbit Determination; Data Science; Course of Action Prediction; Threat Identification; Threat Characterization SS Radio Occultation; LEO; Hypersonics

AF NUMBER: AF22B-T002

TITLE: Improved Integrated Circuit based Electricity to Radio Frequency Conversion Efficiency Development for Space based Applications

TECH FOCUS AREAS: Microelectronics; Directed Energy; 5G

TECHNOLOGY AREAS: Electronics; Space Platform; Materials; Information Systems; Air Platform; Battlespace

OBJECTIVE: The research team selected for this STTR award will be tasked with developing robust, compact, low cost, and easy to manufacture Radio Frequency Integrated Circuits (RFICs) that can efficiently convert a steady supply of electrical energy into a stable high power RF signal for power beaming applications. Robustness will be measured as the extent the RFICs developed by the STTR awardee can operate a high temperatures, at low temperatures, are tolerant of large temperature swings, can tolerate the hostile conditions found in an orbital environment, and the extent the RFICs developed are resistant to degradation as a function of operation time. Compactness well be measured as a function of how many RFICs can be established on a fixed panel given a specific mass and volume limit. Low cost and easy to manufacture will be measured as the extent the RFICs developed by the STTR awardee can be made with low cost materials and are amenable to being manufactured using standard high throughput integrated circuit (IC) production techniques. High efficiency will be assessed as the extent the RFICs developed by the STTR awardee can exceed the performance of state of the art mass produced RFICs; specifically, the DC-to-RF conversion efficiency of the RFICs developed should be greater than 40% when, either acting independently or in concert with a collection of RFICS, broadcasting at least 200W of RF power. High power RF broadcast stability will be measured as a function of the maximum RF power a RFIC can output, the extent a single or array of RFICs can provide a constant RF signal with a specific waveform, and the duration a RFIC can continuously output RF energy.

DESCRIPTION: This STTR call seeks to combine the academic prowess of a university and the commercial expertise of a small business to develop new Radio Frequency Integrated Circuit (RFIC) design paradigms to efficiently generate Radio Frequency (RF) energy for space based power beaming applications. Solid state RF devices are sought as it has been shown that they can be compact, lightweight, and extreme temperature tolerant components that can be designed to generate large amounts of RF power when reasonable amounts of voltage or electric current is applied. To support efforts to develop space based power beaming capabilities, the RFICs developed by this STTR will need to be suitable for deployment on space platforms, capable of producing stable waveforms, can be used to create a high power signal, require limited voltage to operate, have long operational lifetimes, are easy to integrate into existing space systems, and can be mass produced at low cost. Proposals sought in this STTR will detail how their planned work will create RFICs that will outperform current state of the art RFICs by utilizing new designs, address challenges with creating a space systems, and enable successful designs to be manufactured easily. Of particular interest will be discussions on how the new RFICs the proposers plan to develop can be used to create high power RF beams with desired waveforms given the limited amount of electrical power available to be expended on spacecraft, how the proposed designs will mitigate undesired energy losses, why the proposed designs are anticipated to be robust enough to be used on a long duration space mission, and why it anticipated that the proposed RFIC design the proposers plan to develop will easy to manufacture.

PHASE I: By the conclusion of their Phase I effort, the STTR awardee will be expected to have completed a laboratory demonstration that proves their RFIC design can generate an RF signal with a reasonable electrical power to RF power conversion efficiency.

PHASE II: By the conclusion of a Phase II effort, the STTR awardee will be expected to have prepared RFICs, working either independently or in collectively, capable of generating a stable RF signal. This RF signal should have a desirable RF waveform and be emitted at a strength greater than 200W.

PHASE III DUAL USE APPLICATIONS: By the conclusions of a Phase III effort, approaches to package promising RFICs developed by this STTR will have been discovered that will enable these RFICs to be easily integrated into electronic systems. Additionally, ways to mass produce promising RFICs developed by this STTR will also have been identified.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR HelpDesk: usaf.team@afsbirsttr.us

REFERENCES: References Sato, D. et al., “Thermal Design of Photovoltaic/Microwave Conversion Hybrid Panel for Space Solar Power System”, IEEE Journal of Photovoltaics, 7, 1, 2017, pp. 374-382; Jaffe, P. et al., “Sandwich module prototype progress for space solar power”, Acta Astronautica, 94, 2014, pp. 662–671; Jaffe P. et al., "Energy Conversion and Transmission Modules for Space Solar Power," in Proceedings of the IEEE, 101, 6, 2013, pp. 1424-1437; H. Ikeda et al. "Power conversion efficiency in DC-to-RF MOS-FET high power inverter operating at 2.5 MHz," 1991., IEEE International Symposium on Circuits and Systems, 1991, pp. 3035-3038 vol.5.

KEYWORDS: RF; RFIC; Radio Frequency Integrated Circuit; DC to RF; power beaming; directed energy; RF generation; space; spacecraft; satellite

AF NUMBER: AF22B-T003

TITLE: Variable Emissivity Thermal Control Capability Development for Space based Applications

TECH FOCUS AREAS: Quantum Sciences

TECHNOLOGY AREAS: Space Platform; Materials

OBJECTIVE: The goal of this STTR is to create a variable emissivity thermal control device or coating that can adopt at least two states that differ in emissivity by at least 0.5 and can either adopt either a very low emissivity state, specifically a state with less than 0.1 emissivity, or a very high emissivity state, specifically a state with an emissivity greater than 0.9, that is robust enough to tolerate extended use on an orbital platform. The emissivity change of this device should be triggered either by input from an external user or by a change in temperature. User input triggered variable emissivity devices should have low Size, Weight, and Power (SWAP) requirements and be easy to use and integrate existing systems. Temperature triggered variable emissivity coatings or devices should adopt a high emissivity state the system it is thermally regulating is hot and a low emissivity state when this system is cold.

DESCRIPTION: Keeping an orbital asset at an optimal operating temperature can be extremely challenging as orbiting spacecraft experience large temperature swings as the extent it is illuminated by the Sun changes as it enters and leaves eclipse, the difficulty in getting hardware into space, the limited amount of volume available on spacecraft, the limited amount of power available on spacecraft, and the restriction that any heat that is released from a spacecraft must leave radiatively as spacecraft operate in a vacuum. To alleviate thermal control challenges, this STTR seek to combine the academic expertise of universities and the product development expertise of small businesses to develop space tolerant variable emissivity devices or coatings that can radiatively release heat from a spacecraft when it becomes too hot and curtail the heat released from a spacecraft when it is too cold. As a technology to support spacecraft operations, the variable emissivity technology sought by this STTR should provide good thermal control, have low Size, Weight, And Power (SWAP) requirements, be robust enough to tolerate the hostile conditions found in orbit, is easy to use, and is simple to incorporate into existing spacecraft designs. The degree of thermal control the technology can provided will be assessed by the maximum emissivity the technology can establish, the minimum emissivity the technology can establish, the total change in emissivity the technology can provide, and the extent the technology can establish the optimal emissivity when the spacecraft is at different temperatures. Overall SWAP will be considered as the amount of mass, volume, and power needed to install and operate the system. Robustness will be assessed as the extent the device or coating can tolerate temperature cycling and endure extended exposure to high energy photons and charged particles found in space. Ease of use will be measured by how difficult it is to get the variable emissivity technology to adopt the desired emissivity and how few reasonably probable ways the variable emissivity technology can fail can be identified. Finally, amenability to integration into existing spacecraft designs will be assessed by extent the form of the variable emissivity technology developed by this STTR can be tailored to accommodate different spacecraft architectures. The proposals sought for this STTR will present an innovative new approach to create a variable emissivity device thermal control device or detail a convincing plan to improve the performance of approaches explored in the past. If an innovative new approach is proposed, it would be useful if the proposer articulated why this new approach is promising. If the proposed approach utilizes some form of reversible electroplating, it would be useful if the proposers provided discussion on how they plan to overcome limitations with the low IR transparency of electrical conductors. If the proposed approach utilizes oxidation changes or charge migration, it would be useful if the proposers discuss why their approach is still anticipated to function when exposed to the charged particle and radiation

environment found in space. If the proposed approach utilizes a phase change, it would be useful if the proposers articulate why they believe their proposed approach will tolerate repeated cycling between a high and low emissivity configuration. With any approach presented, it is important for the proposers to detail why they believe their proposed approach will be able to provide the desired thermal control and why they believe their proposed approach will be suitable for extended use on an orbital asset.

PHASE I: Complete a laboratory demonstration of a variable emissivity device that can adopt a high emissivity state when hot and a low emissivity state when cold.

PHASE II: Prepare a robust variable emissivity thermal device or coating that can provide at least 0.5 emissivity change, can adopt an emissivity state above 0.8 or below 0.2, and is packaged in such a way that it can be deployed to space where its performance while on orbit can be assessed.

PHASE III DUAL USE APPLICATIONS:

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR HelpDesk: usaf.team@afsbirsttr.us

REFERENCES: Wu, X et al., “Passive Smart Thermal Control Coatings Incorporating CaF2/VO2 Core−Shell Microsphere Structures”, Nano Lett. 2021, 21, pp. 3908-3914; Athanasopoulos, N. et al., “Variable emissivity through multilayer patterned surfaces for passive thermal control: preliminary thermal design of a nano-satellite”, 48th International Conference on Environmental Systems, 8-12 July 2018, Albuquerque, New Mexico; Vlassov, V. V. et al., “Analysis of Concept Feasibility and Results of Numerical Simulation of a Two-Stage Space RadiatorWith Variable Emissivity Coating”, Heat Transfer Engineering 2017, 38, 10, pp. 963-974; Vlassov, V.V. et al., “New Concept of Space Radiator with Variable Emittance”, J. of the Braz. Soc. Of Mech. Sci. & Eng. 2010, 32, 4, pp. 400-408; Darrin, A.G. et al., "Variable emissivity through MEMS technology," ITHERM 2000. The Seventh Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems (Cat. No.00CH37069), 2000, pp. 264-270

KEYWORDS: Variable emissivity; thermal control; reversible electroplating; phase change; electrochromic; smart windows; functional paint; space; spacecraft

AF NUMBER: AF22B-T004

TITLE: Collaboration of Humans and Autonomy Research Teaming Testbed (CHART2)

TECH FOCUS AREAS: Network Command, Control and Communications; Autonomy

TECHNOLOGY AREAS: Ground Sea; Space Platform; Information Systems; Air Platform

OBJECTIVE: The objective of this topic is to develop a mid-fidelity stand-alone testbed for critical research on human-autonomy teaming concepts that uses command and control (C2) tasks relevant to Joint All Domain Command and Control (JADC2) missions (air, land, sea, cyber, and space). Ultimately, use of a mid-fidelity research testbed that enables quick turn research will inform design guidelines and interface components, minimizing long lead time and costly modifications to high-fidelity systems currently used to investigate and validate human-autonomy teaming for military operations.

DESCRIPTION: 711 HPW/RHWC 6.2 human-autonomy research has relied on a mix of low-fidelity software, mid-fidelity testbeds, and high-fidelity systems (example of the latter is the Intelligent Multi-UxV Planner with Adaptive Collaborative/Control Technologies [IMPACT]). [1] Although low-fidelity testing yields quick answers to interface concepts agnostic of mission requirements, testbeds provide a quick way to examine concepts within a representative mission environment without the lead time and software costs involved to modify a fully operational system such as IMPACT. A mid-fidelity testbed will be an essential research tool for evaluating new human-autonomy teaming solutions, given that more and more systems will include some form of intelligent aiding due to advancements in artificial intelligence that change the role and tasking of human operators. The “Collaboration of Humans and Autonomy Research Teaming Testbed” (CHART2) product of this effort will be a critical component for evaluating the effectiveness of candidate control and display technologies in providing support to human and autonomy JADC2 team members, in that current testbeds are inadequate. For example, a mid-fidelity testbed, Adaptive Levels of Autonomy (ALOA; SBIR product from the early 2000s [2]) has supported over a decade of experiments investigating system performance related to levels of automation that are, however, limited in their ability to support teaming with the human operator. There are newer teaming test environments that demonstrate modularity in human-autonomy teaming structures, generate scenarios for observing human interaction, and facilitate the measurement and analysis of responses. [3] However, these mid-fidelity testbeds, as well as the high-fidelity IMPACT system, are inadequate to enable quick-turn research investigating human-autonomy teaming that involves asset allocation/transfer, task allocation/sharing, and varying communication structures. Nor do they support tasks that are representative of those envisioned for future complex JADC2 missions. They are also not designed to simulate or support a range of robust and highly capable types of autonomy (e.g., that support vehicle operations, C2, and/or decision support tools for mission related tasks). Lastly, their autonomy components are less able to work as a teammate to the human operator in flexible communication and interaction structures, how and when humans and autonomous teammates update and share information or collaborate in a task, involving a variety of data streams in support of completing JADC2 relevant mission tasks. Thus, a stand-alone mid-fidelity testbed featuring simulated and/or real autonomy components is needed that supports research examining a variety of human-autonomy teaming/communication structures. This testbed should support representative JADC2 tasks, meaning missions that include task completion with UxV (Unmanned Vehicles), as well as at least satellite and cyber effects to collaboratively address tasks within the simulated environment. A variety of test protocols should also be supported by which the experimenter can specify which domain(s) are available for task completion, as well as which teaming protocols are in effect, how communication

structures are configured, and the available candidate display/control interfaces for any given trial/mission. Moreover, the testbed needs to be modular to enable the experimenter to configure a variety of multi-domain scenarios such that tasks/their order/mission events/difficulty level, as well as the autonomy's capability/reliability/transparency can be specified across multiple experimental trials. Ideally, the tasks, although representative of envisioned JADC2 tasks, should be easily trained to enable a wide range of test participants (college students to DoD subject matter experts). With respect to completion of specific JADC2 related tasks/missions, the testbed should be designed such that the human-autonomy teaming can be dynamic and context dependent. The testbed should support assessment of team collaboration on task completion, in order to determine what teaming structures and station interfaces best support mutual visibility and directability across human-autonomy members, as well as enhance task performance, completion of mission objectives, and the human's situation awareness and appropriate trust in the autonomy. [4,5] Specifically, the CHART2 testbed should enable timely evaluation of the effectiveness of candidate controls and displays in establishing and updating working agreements that define each human-autonomy team member's responsibilities for completing JADC2 task related functions, as well as coordinate courses of action, communicate pertinent information, track task completion/system status, and support shared situation awareness. [6] The results from research using a human-autonomy teaming focused mid-fidelity CHART2 testbed in DoD laboratories will mature solutions and accelerate follow-on validation research in high-fidelity systems (e.g., IMPACT), as well as inform C2 interface requirements and decision support aids needed for eventual JADC2 military applications. For example, multiple quick turn experiments using the CHART2 testbed can narrow down specific symbology and needed level of detail on the autonomy's processing to effectively apply multiple domains for task completion. The product's mission context and tasks also have the potential to be reconfigured for human-autonomy teaming applications appropriate for multiple civilian and commercial domains (e.g. Air Traffic Control, Emergency Response coordination), as well as basic research to examine factors influencing human-autonomy teaming on task performance (e.g., human's personality/experience level/workload and autonomy support's timeliness, transparency, etc.).

PHASE I: Phase I will primarily focus on a) exploring the human autonomy teaming research space to determine what teaming concepts and interfaces will be supported and configurable in the testbed, b) identifying JADC2 tasks to represent within the testbed and relevant team performance metrics with easily exportable formatted data, and c) describing the proposed hardware/software developmental approach for implementing the testbed to best support a variety of teaming related experimental designs. For the latter, relevant features for experimenter control include, but are the limited to, selection of: available domains, number and types of tasks to be completed and resulting workload level, teaming structure (number of teammates, responsibility of teammates, etc.), features of controls and displays by which the human-autonomy team members interact, capability/transparency/reliability of the autonomy, and objective and subjective participant data to record and analyze.

PHASE II: Develop and demonstrate a prototype testbed with the human-autonomy teaming concepts and JADC2 representative tasks identified in Phase I. This demonstrative testing should focus specifically on: 1. The choices for manipulated teaming structures. 2. Validated measures collectable using the testbed and their exportability 3. How the solution can be sustainable and scalable to the needs of researchers. Other specific DoD or governmental customers who express interest in using the product should also be identified.

PHASE III DUAL USE APPLICATIONS: The software development practices employed against this topic will inform research testbed designs for a variety of human and autonomy teaming applications,

both commercial and government. Additionally, with modifications, the testbed could be reconfigured to support research examining human-autonomy teaming in support of related civilian applications.

REFERENCES: [1] Draper, M., Rowe, A., Douglass, S., Calhoun, G., Spriggs, S., Kingston, D., ... & Reeder, J. (2018). Realizing autonomy via intelligent hybrid control: Adaptable autonomy for achieving UxV RSTA team decision superiority (also known as Intelligent Multi-UxV Planner with Adaptive Collaborative/Control Technologies (IMPACT)) (AFRL-RH-WP-TR-2018-0005). Wright-Patterson Air Force Base United States: Air Force Research Laboratory. [2] Johnson, R., Leen, M., & Goldberg, D. (2007). Testing adaptive levels of automation (ALOA) for UAV supervisory control (Technical Report AFRL-HE-WP-TR-2007-0068), Air Force Research Laboratory. [3] O'Neill, T., McNeese, N., Barron, A., & Schelble, B. (2020). Human–autonomy teaming: A review and analysis of the empirical literature. Human Factors, 0018720820960865. [4] Calhoun, G., Bartik, J., Ruff, H., Behymer, K., & Frost, E. (2021). Enabling human-autonomy teaming with multi-unmanned vehicle control interfaces. Human-Intelligent Systems Integration (Special Issue on "Human-Autonomy Teaming in Military Contexts"), 3, 155-174. 1-20. https://doi.org/10.1007/s42454-020-00020-0 [5] O'neill, O. (2002). Autonomy and trust in bioethics. Cambridge University Press. [6] Calhoun, G., Bartik, J., Ruff, H., Behymer, K., & Frost, E. (2021). Enabling human-autonomy teaming with multi-unmanned vehicle control interfaces. Human-Intelligent Systems Integration (Special Issue on "Human-Autonomy Teaming in Military Contexts"), 3, 155-174. 1-20. https://doi.org/10.1007/s42454-020-00020-0

KEYWORDS: Human Autonomy Teaming; Teaming; Testbed; Test console; Tasks; Automation; Human AI teaming; Human Agent Teaming

AF NUMBER: AF22B-T005

TITLE: Complex Emitter Behavioral Analysis Using Machine Learning

TECH FOCUS AREAS: Autonomy; Artificial Intelligence/Machine Learning

TECHNOLOGY AREAS: Sensors

OBJECTIVE: Given sequences of observations of unknown radar waveforms, develop behavioral models to enable inference of radar intent and threat level, and to enable prediction of future behaviors. These models should generalize to arbitrary emitters without a priori knowledge.

DESCRIPTION: The proliferation of low cost, high performance computing hardware has enabled the development of increasingly complex radar systems. The agility and modularity of these new threats force electronic support (ES) systems to operate against a much wider threat parameter space where it is impossible to capture every radar system variant in a mission data file (MDF). Numerous techniques have been proposed to address the recognition of known agile multifunction radar systems [1] [2] [3] [4], and many methods for recognizing unknown observations have been proposed in the machine learning literature [5]. However, very few publications consider making useful inferences against unknown radar systems [6] [7]. An accurate understanding of the threat landscape is important when selecting and optimizing an electronic countermeasure response. Therefore, handling unknown signals remains an urgent challenge for ES systems. If no MDF match for an observed signal is found, the observation is labeled as an unknown. Given a sequence of these observations over time, a range of useful inferences could be made, including the radar's intent (e.g. search vs. track) and threat level to the ES host platform. The main objective of this effort is to use statistical modeling and machine learning techniques to construct behavioral models for these unknown radar waveforms to track and predict behaviors over time. Developing such models requires consideration of several questions. What features are needed to construct effective behavior models? Traditional pulse descriptor words (PDWs) containing pulse time of arrival, frequency, pulse width, and amplitude have historically provided enough information for single pulse characterization and emitter identification. However, given the increased complexity of agile multifunction radars, it might be necessary to consider additional features at different timescales. How can we best apply tools from statistics and machine learning to form behavior models? As this effort considers unknown waveforms with no a priori (MDF) knowledge, such a model should be generalizable to a wide range of potential threats. Once a behavior model has been fit to a sequence of observations, how can these behaviors be associated with varying levels of threat? For instance, the behavior model might indicate that the radar is deploying tracking modes. Based on this knowledge, and considering other factors such as inferred distance to the threat, the ES system should infer an appropriate threat level. Given a time history of behaviors, can the model be used to predict future behaviors? Predictive inference could reduce the reaction time of electronic warfare systems, reducing the time required to select and deploy electronic countermeasures. The contractor will develop and evaluate a software prototype of the proposed modeling technique. The software prototype will need to be written to interface with the government-owned Advanced Research Concepts for Electronic Measures (ARCEM) test and evaluation framework to enable the government to conduct in-house verification testing. ARCEM provides the technical pipeline – technology maturation and staging – between AFRL and the 350th Spectrum Warfare Wing, which can be utilized for spiral transition of promising technologies. The government will provide data for the contractor to use in evaluating the developed behavior models, and will provide interface control documents for the ARCEM architecture. No other government materials, equipment, or facilities are required to successfully address this topic.

PHASE I: Conduct a study to evaluate the feasibility of the proposed solution (referencing (1) – (4) above). Phase I should document the proposed approach to behavior modeling, complete with a discussion of the assumptions made, limitations of the selected modeling approach, and a plan to demonstrate the model effectiveness given government furnished data with proposed performance metrics. The government will provide interface control documents for the ARCEM architecture to enable the contractor to plan their phase II implementation accordingly.

PHASE II: Develop and demonstrate prototype determined to be the most feasible solution during the Phase I study using government furnished data. Deliver ARCEM-compliant prototype source code and final report detailing the theory, implementation, and quantitative performance of the prototype.

PHASE III DUAL USE APPLICATIONS: The emitter agnostic behavior modeling described in this topic supports the vision of cognitive electronic warfare by enabling the host platform to make useful inferences about unknown emissions and formulate appropriate responses. Commercial applications include spectrum sharing and dynamic spectrum access, where predicting the behavior of primary users could enable a secondary user to rapidly maneuver to mitigate interference to primary users.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR HelpDesk: usaf.team@afsbirsttr.us

REFERENCES: R. Wiley, ELINT: The Interception and Analysis of Radar Signals, Artech House, 2006.;

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Z.-M. Liu and P. S. Yu, "Classification, Denoising, and Deinterleaving of Pulse Streams With Recurrent Neural Networks," IEEE Transactions on Aerospace and Electronic Systems, 2019.;

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A. Wang and V. Krishnamurthy, "Signal Interpretation of Multifunction Radars; Modeling and Statistical Signal Processing With Stochastic Context Free Grammar," IEEE Transactions on Signal Processing, 2008.;

V. Krishnamurthy, K. Pattanayak, S. Gogineni, B. Kang and M. Rangaswamy,; Adversarial Radar Inference; Inverse Tracking, Identifying Cognition, and Designing Smart Interference,; IEEE Transactions on Aerospace and Electronic Systems, 2021.

KEYWORDS: Software defined radar; Cognitive electronic warfare; Radar intent inference; Behavior modeling; Probability and statistics; Machine learning

AF NUMBER: AF22B-T006

TITLE: Self-Regulating Heaters for Satellites

TECH FOCUS AREAS: Autonomy

TECHNOLOGY AREAS: Space Platform

OBJECTIVE: Develop and commercialize self-regulating (positive temperature coefficient, PTC) heaters for use on satellites in any earth orbit.

DESCRIPTION: Self-regulating heaters are heaters with a designed-in temperature setpoint that exists as a property of the resistor material. They are 'smart' heaters, automatically and independently warming each region of the heater circuit to the designed setpoint without a temperature sensor. The electrical resistance of the heater material jumps substantially at the setpoint, inhibiting electric flow and production of heat above the setpoint temperature. Self-regulating heaters are in use in the petrochemical and automotive industries for pipe freeze protection and seat warmers. The space industry needs self-regulating heaters for propellant system heaters where allowable temperature ranges are tight and thermal environments vary in both time and space. Conventional solutions to propellant system thermal control are resource intensive, requiring much engineering design and touch labor as well as much hardware and burdening the flight computer to control the circuits. Self-regulating heaters reduce all of these resource demands. Self-regulating heaters can also provide similar benefits for other satellite heaters such as those for batteries, mechanisms, and antennas. Existing self-regulating heaters are not suited for space applications for several reasons: 1) the form factor is too large and inflexible: existing self-regulating heaters are a stiff cable while satellite self-regulating heaters must be a thin-film heater such as adhesively-applied polyimide heaters commonly used on satellites. Additionally, these heaters must be suitable to install on two orthogonal bend axes: a 1/8" bend radius and a 3" bend radius, 2) existing self-regulating heaters provide their resistance transition via a melt expansion process to break the percolating path; this means that existing self-regulating heaters cannot be exposed to temperatures greater than their setpoint temperature, 3) Existing self-regulating heaters are not designed to handle the space environment; specifically: vacuum, ionizing radiation, and wide thermal cycles. This topic solicits proposals to develop and commercialize self-regulating heaters for space applications that address these aforementioned insufficiencies of existing self-regulating heaters. Additionally, the materials design must be capable of tuning during manufacturing of the material for setpoint temperatures between -5 and 20 C. A 30:1 (threshold) and 100:1 (objective) turndown ratio between the electrical resistances above and below the setpoint temperature must be achieved. The technology must be capable of yielding designs operating with any voltage between 12 and 100 VDC, and must be capable of producing designs yielding 1 to 10 W/in2 heat flux at the fully ON condition. Capable to withstand exposure to environments in all of the following orbits: 5 years in low earth orbit (LEO), 10 years in middle earth orbit (MEO), or 15 years in geosynchronous earth orbit (GEO) including vacuum, ionizing radiation, and thermal cycling. Radiation environments should assume the technology receives 40 mils of spacecraft Aluminum shielding (threshold) or no additional shielding (objective); radiation shields incorporated in the heater will be considered but radiation-hardened heater materials are strongly preferred. Thermal cycles between -5 and 40 C, with LEO 60k cycles, MEO 15k cycles, and GEO 6k cycles. Also survive up to 10 thermal cycles from -40 to 70 C. The material should always remain a solid. The manufacturing process should be scalable, e.g. screen printing techniques; the installation process should minimize touch labor. Proposers must demonstrate a strong intent and capability to commercialize the technology. Proposers are strongly encouraged to form teams with manufacturing partners and systems integrators for technology transition.

PHASE I: Build and test the performance of hardware. Demonstrate by analysis and/or test the feasibility of the concept to meet all requirements.

PHASE II: Further develop manufacturability of hardware. Test environmental capability of the hardware. The culmination of the Phase II effort shall include the hardware delivery of 10 functional, tested self-regulating heaters demonstrating a variety of sizes and mounting configurations.

PHASE III DUAL USE APPLICATIONS: Design, build, deliver, and support an experiment to allow the USSF to demonstrate the technology in a combined effects environment.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR HelpDesk: usaf.team@afsbirsttr.us

REFERENCES: 1. Gilmore, D. G., Spacecraft Thermal Control Handbook Volume I: Fundamental Technologies, 2nd Ed, The Aerospace Press, El Segundo, CA, 2002; 2. Wertz, J.R., Larson, W.J., Space Mission Analysis and Design, Microcosm Inc. Hawthorne, CA, 10th Ed, 2008; 3. Fortescue, P., Stark, J., Swinerd, G., Spacecraft Systems Engineering, 3rd Ed., John Wiley and Sons, West Sussex, England, 2003.

KEYWORDS: Resilience; Directed Energy Threat; DE threat; hardware

CHEMICAL AND BIOLOGICAL DEFENSE PROGRAM
FY22.B Small Business Technology Transfer (STTR)
Proposal Submission Instructions

The approved FY22.B topic included in the Chemical and Biological Defense (CBD) Small Business Technology Transfer (STTR) Program is provided in this document. Offerors responding to this Announcement must follow all general instructions provided in the Department of Defense (DoD) Program Announcement. Specific CBD STTR requirements that add to or deviate from the DoD Program Announcement instructions are provided below.

Please read the entire DoD Announcement and these CBD STTR instructions carefully prior to submitting your proposal. Also go to https://www.sbir.gov/about/about-sbir#sbir-policy-directive to read the SBIR/STTR Policy Directive issued by the U. S. Small Business Administration (SBA).

INTRODUCTION

In response to Congressional interest in the readiness and effectiveness of U.S. Nuclear, Biological and Chemical (NBC) warfare defenses, Title XVII of the National Defense Authorization Act for Fiscal Year 1994 (Public Law 103-160) requires the Department of Defense (DoD) to consolidate management and oversight of the Chemical and Biological Defense (CBD) Program into a single office – Office of the Assistant Secretary of Defense for Nuclear, Chemical and Biological Defense Programs. The Joint Science and Technology Office for Chemical and Biological Defense (JSTO-CBD), located at the Defense Threat Reduction Agency (DTRA), provides the management for the Science and Technology component of the Chemical and Biological Defense Program. Technologies developed under the Small Business Technology Transfer (STTR) Program have the potential to transition to the Joint Program Executive Office for Chemical Biological Radiological and Nuclear Defense (JPEO-CBRND) if the appropriate level of technology maturity is demonstrated. The JSTO-CBD Science & Technology programs and initiatives improve defensive capabilities against Chemical and Biological Weapons of Mass Destruction. The STTR portion of the CBD Program is managed by the JSTO-CBD.

The mission of the Chemical and Biological Defense Program is to ensure that the U.S. Military has the capability to operate effectively and decisively in the face of chemical or biological warfare threats at home or abroad. Numerous factors continually influence the program and its technology development priorities. Improved defensive capabilities are essential in order to mitigate the overall impact of chemical and biological threats. The U.S. military requires the finest state-of-the-art equipment and instrumentation available to permit our warfighters to 'detect to warn' and avoid contamination, if possible – and to be able to sustain operations in a potentially contaminated environment. Further information is available at the Office of the Assistant Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs homepage at https://www.acq.osd.mil/ncbdp/cbd/

The overall objective of the CBD STTR Program is to improve the transition or transfer of innovative Chem-Bio technologies to the end user – the warfighter – in addition to commercializing technologies within the private sector for mutual benefit. The CBD STTR

Program targets those technology efforts that maximize a strong defensive posture in a biological or chemical environment using passive and active means as deterrents. These technologies include chemical and biological detection for both point and stand-off capabilities; individual and collective protection; hazard mitigation (decontamination); medical pre-treatments (e.g., vaccine development and delivery); medical therapeutics (chemical countermeasures and biological countermeasures); medical diagnostics; Digital Battlespace Management (aka information systems technology) to include but not limited to modeling and simulation (e.g., meteorological dispersion), disease surveillance, data fusion, and health & human effects to include wearable technologies.

Proposals not conforming to the terms of this Announcement will not be considered. CBD STTR reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality as determined by CBD STTR will be funded. CBD STTR reserves the right to withdraw from negotiations at any time prior to contract award. The Government may withdraw from negotiations at any time for any reason to include matters of national security (foreign persons, foreign influence or ownership, or other related issues).

Use of Foreign Nationals (also known as Foreign Persons), Green Card Holders, and Dual Citizens

See the "Foreign Nationals" section of the DoD STTR Program Announcement for the definition of a Foreign National (also known as Foreign Persons).

ALL offerors proposing to use foreign nationals, green-card holders, or dual citizens, MUST disclose this information regardless of whether the topic is subject to export control restrictions. Identify any foreign nationals or individuals holding dual citizenship expected to be involved on this project as a direct employee, subcontractor, or consultant. For these individuals, please specify their 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 the project. You may be asked to provide additional information during contract negotiations in order to verify the foreign citizen's eligibility to participate on a STTR 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)).

Proposers responding to a topic in this BAA must follow all general instructions provided in the Department of Defense (DoD) STTR Program BAA. The Chemical and Biological Defense STTR Program requirements in addition to or deviating from the DoD Program BAA are provided in the instructions below.

Specific questions pertaining to the administration of the Chemical and Biological Defense STTR Program and these proposal preparation instructions should be directed to: Mr. Larry Pollack, Chemical and Biological Defense STTR Program Manager, JSTO-CBD, at lawrence.p.pollack2.civ@mail.mil or dtra.belvoir.rd.mbx.jsto-cbd-chem-bio-defense-sbir@mail.mil

PHASE I PROPOSAL GUIDELINES

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD STTR Program BAA.

Technical Volume (Volume 2)

The technical volume is not to exceed 20-pages and must follow the formatting requirements provided in the DoD STTR Program BAA. No other information included in the other proposal volumes counts against the 20-page Proposal Technical Volume page limit. Pages provided in excess of this length will not be evaluated or considered for review. The proposal must not contain any type smaller than 10-point font size (except as legend on reduced drawings, but not tables).

Your entire proposal submission must be submitted electronically through the Defense SBIR/STTR Innovation Portal (DSIP) located at: https://www.dodsbirsttr.mil

A hardcopy is NOT required and will not be accepted by the Chemical and Biological Defense STTR Program. Hand or electronic signature on the proposal is NOT required.

Any questions pertaining to the DoD SBIR/STTR submission system should be directed to DSIP Support: DoDSBIRSupport@reisystems.com

NEW: The maximum dollar amount for a Phase I proof-of-concept/feasibility study is $183,000 for a period of performance of up to six (6) months. **The CBD STTR Program will not accept Phase I proposals which exceed $183,000 for the Phase I effort**. The total STTR funding amount available for Phase II activities from a resulting Phase II contract is not to exceed $1,200,000.

Selection of Phase I proposals will be based upon the three evaluation criteria discussed in this Program Announcement. The CBD STTR 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. All STTR contract awards, both Phase I and Phase II, are subject to availability of funding.

Companies should plan carefully for any research involving animal or human subjects, chemical agents, biological agents, etc. The brief Period of Performance available for a Phase I project precludes plans that include these elements, as all DoD requirements and necessary approvals associated with animal and/or human use must be strictly adhered to, and require considerable coordination and significant time for final protocol approvals. See below for further information regarding all research that will include research involving human subjects and/or animal use.

Proposals not conforming to the terms of this Announcement, and any unsolicited proposals, will not be considered. All awards are subject to the availability of funding and successful completion of contract negotiations. The Chemical and Biological Defense Program is not responsible for any funds expended by the proposer prior to contract award.

Cost Volume (Volume 3)

The Phase I Base amount must not exceed $183,000. Total Base cost for Phase I must be clearly identified on the Proposal Cover Sheet (Volume 1) and in Volume 3.

Company Commercialization Report (CCR) (Volume 4)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD STTR Program BAA for full details on this requirement. Information contained in the CCR will not be considered by the Chemical and Biological Defense Program during proposal evaluations.

Supporting Documents (Volume 5)

Offerors are welcome to provide Supporting Documents in this section, but these documents will not be considered by the Chemical and Biological Defense Program during proposal evaluations.

DIRECT TO PHASE II PROPOSAL GUIDELINES

The Chemical and Biological Defense STTR Program is not currently participating in any Direct to Phase II topics.

PHASE II PROPOSAL GUIDELINES

Phase II proposals may only be submitted by Phase I awardees.

Phase II is the demonstration of the technology that was found feasible in Phase I. Phase I awardees may submit a Phase II proposal without invitation; however, it is strongly encouraged that a Phase II proposal not be submitted until sufficient Phase I progress can be evaluated and assessed based on results of the Phase I proof-of-concept/feasibility study. Therefore, it is suggested that a Phase II proposal be submitted no sooner than five months from date of Phase I contract award. **All Phase II proposal submissions must be submitted electronically through the Defense SBIR/STTR Innovation Portal system at: https://www.dodsbirsttr.mil**

At the proposal submission website, Phase II proposals MUST be submitted to '**CBD** STTR' regardless of which DoD contracting office negotiated and awarded the Phase I contract. Additional instructions regarding the Phase II proposal submission process including submission key dates will be provided to Phase I awardees after the Phase I contract is awarded; additional information may also be found at http://www.cbdsbir.net to include Phase II proposal submission cycle deadlines established by the CBD SBIR/STTR Program Manager.

The Phase II proposal must include a concise summary of the Phase I project including the specific technical problem or opportunity addressed and its importance, the objective of the Phase I project, the type of research conducted, findings or results of this research, and technical feasibility of the proposed technology. Due to limited funding, the CBD STTR program reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

All proposers are required to develop and submit a commercialization plan describing feasible approaches for marketing and manufacturing the developed technology. Proposers are required to submit a budget for the entire 24-month Phase II Period of Performance. During contract

negotiation, the Contracting Officer may require a Cost Volume for a base year and an option year; thus, proposers are advised to be aware of this possibility. These costs must be submitted using the Cost Volume format (accessible electronically on the DoD SBIR/STTR submission site). The total proposed amount should be indicated on the Proposal Cover Sheet as the Proposed Cost. At the Contracting Officer's discretion, Phase II projects may be evaluated for technical progress prior to the end of the base year, prior to extending funding for the option (second) year.

The CBD STTR Program is committed to minimizing the funding gap between Phase I and Phase II activities. The CBD STTR Program typically funds a cost plus fixed fee Phase II award, but may award a firm fixed price contract at the discretion of the Contracting Officer.

It is recommended that Phase II awardees have a Defense Contract Audit Agency (DCAA) approved accounting system. If you do not have a DCAA approved accounting system, this could delay/prevent a Phase II contract award. Visit https://www.dcaa.mil/Customers/Small-Business for more information on DCAA approved accounting systems.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)
At this time, the CBD STTR Program is not participating in the Technical and Business Assistance (TABA) Program.

EVALUATION AND SELECTION
All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD STTR Program BAA.

Proposing firms will be notified of selection or non-selection status for a Phase I award within 90 days of the closing date of the BAA. Notification will be provided via e-mail to the small business offeror – specifically to the Corporate Official (Business Point of Contact) and the Principal Investigator, as listed on the Cover Page (Volume I) of the proposal.

Upon written request via e-mail sent to dtra.belvoir.rd.mbx.jsto-cbd-chem-bio-defense-sbir@mail.mil and within 30-days of non-selection, debriefing statements will be provided by the CBD STTR Program Office. The debriefing statement will be provided only via reply e-mail to the Corporate Official and the Principal Investigator, as listed on the Cover Page (Volume I) of the proposal.

Refer to the DoD STTR Program BAA for procedures to protest the Announcement.
As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: Mr. Larry Pollack, Chemical and Biological Defense (CBD) STTR Program Manager, Joint Science and Technology Office for Chemical and Biological Defense (JSTO-CBD), lawrence.p.pollack2.civ@mail.mil

ADDITIONAL INFORMATION

Fraud, Waste and Abuse

All offerors must complete the fraud, waste, and abuse training (Volume 6) that is located on the Defense SBIR/STTR Innovation Portal (DSIP) (https://www.dodsbirsttr.mil). Please follow guidance provided on DSIP to complete the required training prior to submitting proposals.

To Report Fraud, Waste, or Abuse, Please Contact:
DoD Inspector General (IG) Fraud, Waste & Abuse
Hotline: (800) 424-9098
hotline@dodig.mil

Additional information on Fraud, Waste and Abuse may be found in the DoD Instructions of this Announcement.

CBD STTR Projects Requiring Animal and Human Subjects

Companies should plan carefully for any research involving human subjects and/or animal use in addition to the use of any chemical or biological warfare agents, and use of any agents associated with "Dual Use Research of Concern (DURC)". The brief Phase I Period of Performance precludes plans requiring the use of many of these materials as well as animal and/or human subjects prior to obtaining all necessary DoD approvals.

Animal Use: If the proposed research involves the use of animal, the research cannot begin until the U.S. Army Medical Research and Development Command, Office of Research Protections (USAMRDC ORP), Animal Care and Use Review Office (ACURO) provides written authorization that the research may proceed. Offerors are required to: a) justify and b) include detailed information on the use of animals, and c) include the location(s) of where the animal work is to be performed.

The DTRA Research Oversight Board (ROB), in coordination with the appropriate CBD STTR POC, will provide ongoing oversight throughout the duration of the effort to ensure proper approvals are in place.

The DTRA ROB and USAMRDC ACURO conduct site visits as part of its responsibility for compliance oversight. Offerors and subcontractors must comply with all applicable research involving animal use protections requirements. Accurate and complete study records must be maintained and made available to representatives of the DTRA ROB and USAMRDC ORP ACURO. Non-compliance with these terms and conditions may result in withholding of funds and/or the termination of the award. Further information may be required if the proposal is successful. Modifications to the already approved protocols require approval by the ACURO prior to implementation.

Protection of Human Subjects: Research under CBD STTR awards involving the use of human subjects, to include the use of human biospecimens (human anatomical substances)* and/or human data, shall not be proposed for any Phase I Period of Performance.

If the research proposed during the Phase II Period of Performance includes research involving human subjects, to include the use of human anatomical substances and/or human data, the research cannot begin until the USAMRDC Human Research Protection Office (HRPO) provides written authorization that the research may proceed. HRPO authorization is required for any offeror and subcontractors that will use funds from this award to conduct research involving human subjects, human anatomical substances, and/or human data. Offerors are required to: a) justify and b) outline the use, and c) include the source of the human subjects, human biospecimens and/or human data involved in the research.

The DTRA Research Oversight Board (ROB), in coordination with the appropriate CBD STTR POC, will provide ongoing oversight throughout the duration of the effort to ensure proper approvals are in place.

*This prohibition does not apply to research under this award that solely uses only one or both of the following types of human biospecimens to accomplish its aims: (1) established/exiting *commercially* available human cell lines; (2) established/existing patient-derived xenograft (PDX) models.

The DTRA ROB and USAMRDC ORP HRPO conduct site visits as part of its responsibility for compliance oversight. Prime and subcontractors must comply with all applicable human research protections requirements. Accurate and complete study records must be maintained and made available to representatives of the DTRA ROB and USAMRDC ORP HRPO. Non-compliance with these terms and conditions may result in withholding of funds and/or the termination of the award. Further information may be required if the proposal is successful.

CBD STTR FY22.B Topic Index

TOPIC #: CBD22B-T001

TITLE: Millimeter Wave Imaging with High-Electron-Mobility Transistors (HEMT) or Schottky Diode Rectifiers

RT&L FOCUS AREA(S): Warfighting Requirements (GWR)
TECHNOLOGY AREA(S): Chemical/Bio Defense, Materials/Processes

OBJECTIVE: Develop a low-cost millimeter wave imager based on High-electron-mobility transistors and Schottky diode rectifiers. The goal is to develop an advanced composite detector that can be assembled into compact arrays for low cost and high sensitivity W-band imaging applications.

DESCRIPTION: Millimeter wave imaging has been shown to be a useful tool in the detection of potential threats to military personnel. Examples include the use of millimeter wave imaging for chemical/biological detection, person-borne improvised explosive device detection, land-mine detection, and unmanned aerial system (UAS) detection. W-band (75 GHz to 110 GHz) imagers have proven to be particularly useful to the military for the detection of threats. A low-cost solution to imaging in the millimeter wave region has the potential to provide significant benefits to numerous programs within the DoD. High-electron-mobility transistors (HEMTs) and Schottky Diodes have been identified two technologies with potential for addressing the needs of the Chemical and Biological Defense (CBD) Program.

High-electron-mobility transistors (HEMTs) are able to operate at higher frequencies than ordinary transistors. The high sheet concentration of free electrons in HEMTs can support plasma wave propagation between the source and drain, even at frequencies well above the free-electron transit-time cutoff for the device. Since the two-dimensional electron gas in HEMTs can create a direct current (DC) term in the drain-source voltage in response to an applied alternating current (AC) voltage, the HEMT can function as a detector in the gigahertz (GHz) region. HEMT based detectors typically operate at room temperature in the overdamped plasma wave regime where rectification occurs when the in-coming GHz radiation, coupled to the source and gate electrodes, modulates both the carrier density and drift velocity, causing a non-linearity and inducing a plasma wave that propagates through the channel. A DC component is formed with the magnitude of the DC component being proportional to the intensity of the incoming radiation. The resulting DC component can be measured at the drain contact either in a short circuit (photoconductive mode) or in an open circuit (photovoltaic mode) configuration. This detection mechanism depends on the HEMTs transconductance along with asymmetric feeding of the source and drain into the channel. The asymmetric feeding requires that the source and drain electrodes possess different geometries or the channel itself is intrinsically asymmetric.

Schottky Diode based devices can be utilized for the development of room temperature millimeter wave sensors. CMOS technology can be used as a platform for the fabrication of the millimeter wave devices, enabling reliable, cost-effective and circuits-friendly solutions. GaAs and GaN-based structures have been successfully used for sensor development. These materials successfully served for the fabrication of nanodiodes for millimeter wave detection. Schottky Diodes are reliable and have fast response times. In its simplest form, a Schottky barrier diode

(SDB) consists of a metal film on a lightly doped semiconductor forming a Schottky contact at metal-semiconductor interface with potential barrier and rectifying electrical characteristics. Typically, the Schottky barrier is lower than the energy bandgap of the semiconductor and has a lower forward bias drop and thus can detect and rectify small signal levels in the GHz range.

A W-Band imager running at video rate (24 frames/sec or better) should be able to detect objects at a distance of at least 15 meters and possess a noise equivalent temperature difference (NETD) of 3 degrees Kelvin or less. The imager should be able to detect targets with a resolution of 10 cm or better at a distance of 15 meters.

PHASE I: Develop and test a single pixel detector operating in the W-Band using either a High-electron-mobility transistors (HEMT), a Schottky Diode Rectifier, or a combination of the two technologies. Demonstrate the system can detect a NETD of 3 degrees or less. Develop a design of an imager operating in the W-Band that can detect an object to at least a distance of 15 meters with a resolution of 10 cm or better with a NETD of 3 degrees K or less. The detector should be able to operate at video rate (24 frames/sec or better).

PHASE II: Construct and demonstrate a working prototype W-Band imaging system using the design developed in Phase I. Demonstrate video rate imaging of threats from a distance of 15 meters or better. Deliver the working prototype to the government for further testing.

PHASE III: Further research and development during Phase III efforts will be directed toward refining the final deployable equipment and procedures. Design modifications based on results from tests conducted during Phase III will be incorporated into the system. Manufacturability specific to Chemical and Biological Defense Program Concept of Operations (CONOPS) and end-user requirements will be examined.

PHASE III DUAL USE APPLICATIONS: The development of a low-cost solution to imaging in the millimeter wave region has the potential to provide significant benefits to numerous programs to include chemical sensing in the commercial markets.

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KEY WORDS: High-electron-mobility transistor (HEMT), Schottky Diode Rectifiers, millimeter wave imaging, W-Band imager, plasma wave, room temperature, transconductance

DHA 2022.B Small Business Technology Transfer (STTR)
Proposal Submission Instructions

INTRODUCTION

The Defense Health Agency (DHA) STTR 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 STTR Program should be addressed according to the DoD STTR Program BAA. For technical questions about a topic during the pre-release period, contact the Topic Author(s) listed for each topic in the BAA. To obtain answers to technical questions during the formal BAA period, visit https://www.dodsbirsttr.mil/submissions/login.

The DHA Program participates in up to three DoD SBIR BAAs each year. Proposals not conforming to the terms of this BAA will not be considered.

Proposers responding to a topic in this BAA must follow all general instructions provided in the Department of Defense (DoD) STTR Program BAA. DHA requirements in addition to or deviating from the DoD Program BAA are provided in the instructions below.

Specific questions pertaining to the administration of the DHA STTR Program and these proposal preparation instructions should be directed to:

DHA STTR Program Management Office (PMO)
Email - usarmy.detrick.medcom-usamrmc.mbx.dhpsbir@mail.mil
Phone - (301) 619-7296

PHASE I PROPOSAL GUIDELINES

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD STTR Program BAA.

Technical Volume (Volume 2)

The technical volume is not to exceed **20** pages and must follow the formatting requirements provided in the DoD STTR Program BAA. Do not duplicate the electronically-generated Cover Sheet or put information normally associated with the Technical Volume in other sections of the proposal as these will count toward the 20-page limit.

Only the electronically-generated Cover Sheet and Cost Volume are excluded from the 20-page limit. Technical Volumes that exceed the 20-page limit will be reviewed only to the last word on the 20th page. Information beyond the 20th page will not be reviewed or considered in evaluating the offeror's proposal. To the extent that mandatory technical content is not contained in the first 20 pages of the proposal, the evaluator may deem the proposal as non-responsive and score it accordingly.

Content of the Technical Volume

The Technical Volume has a 20-page limit including: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes) and any other attachments. Refer to the instructions provided in the DoD STTR Program BAA for full details on content of the technical volume.

Cost Volume (Volume 3)
The Phase I Base amount must not exceed **$250,000**. Costs for the Base must be separated and clearly identified on the Proposal Cover Sheet (Volume 1) and in Volume 3.

Company Commercialization Report (CCR) (Volume 4)
Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD STTR Program BAA for full details on this requirement. Information contained in the CCR **will** be considered by DHA during proposal evaluations.

Supporting Documents (Volume 5)
DHA STTR will accept a Volume Five (Supporting Documents) as required under the DoD STTR Program BAA.

Fraud, Waste and Abuse Training Certification (Volume 6)
DoD requires Volume 6 for submission. Please refer to the Phase I Proposal section of the DoD SBIR/STTR Program BAA for details.

PHASE II PROPOSAL GUIDELINES
Phase II proposals may only be submitted by Phase I awardees. Phase II is the demonstration of the technology found feasible in Phase I. All DHA STTR 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 STTR 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 STTR electronic proposal submission system (https://www.dodsbirsttr.mil/submissions/login). This site contains step-by-step instructions for the preparation and submission of the Proposal Cover Sheets, the Company Commercialization Report, the Cost Volume, the Technical Volume, Supporting Documents, and Fraud, Waste, and Abuse certificate.

The DHA STTR Program will evaluate and select Phase II proposals using the evaluation criteria in the DoD STTR Program BAA. Due to limited funding, the DHA STTR Program reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

Small businesses submitting a proposal are required to develop and submit a Commercialization Strategy describing feasible approaches for transitioning and/or commercializing the developed technology in their Phase II proposal. This plan should be included in the Technical Volume.

The Cost Volume must contain a budget for the entire 24-month Phase II period not to exceed the maximum dollar amount of $1,100,000. These costs must be submitted using the Cost Volume format (accessible electronically on the DoD submission site), and should be presented side-by-side on a single Cost Volume Sheet.

DHA STTR Phase II Proposals have six Volumes: Proposal Cover Sheets, Technical Volume, Cost Volume, Company Commercialization Report, Supporting Documents, and Fraud, Waste, and Abuse. The Technical Volume has a **40-page** limit including: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of

work and resumes) and any attachments. Do not include blank pages, duplicate the electronically-generated Cover Sheets or put information normally associated with the Technical Volume in other sections of the proposal as these will count toward the 40-page limit.

Technical Volumes that exceed the 40-page limit will be reviewed only to the last word on the 40th page. Information beyond the 40th page will not be reviewed or considered in evaluating the offeror's proposal. To the extent that mandatory technical content is not contained in the first 40 pages of the proposal, the evaluator may deem the proposal as non-responsive and score it accordingly.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

The DHA SBIR Program does not participate in the Technical and Business Assistance (formally the Discretionary Technical Assistance Program). Contractors should not submit proposals that include Technical and Business Assistance.

The DHA SBIR Program has a Technical Assistance Advocate (TAA) who provides technical and commercialization assistance to small businesses that have Phase I and Phase II projects.

EVALUATION AND SELECTION

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD STTR Program BAA.

Proposing firms will be notified via email to the Corporate Official of selection or non-selection status for a Phase I award within 90 days of the closing date of the BAA.

Refer to the DoD STTR Program BAA for procedures to protest the Announcement.
As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to:

Ms. Samantha Connors
SBIR/STTR Chief, Contracts Branch 8
Contracting Officer
U.S. Army Medical Research Acquisition Activity
Phone: (301)-619-6979
Email: Samantha.l.connors.civ@mail.mil

AWARD AND CONTRACT INFORMATION

Phase I awards will total up to $250,000 for a 6 month effort. Phase I contract awards will be awarded as Purchase Orders indicating the Technical Point of Contact. Phase II awards will be a Firm Fixed contract with the Contracting Officer Representative and other contracting staff identified.

ADDITIONAL INFORMATION

RESEARCH INVOLVING HUMAN SUBJECTS, HUMAN SPECIMENS/DATA, OR ANIMAL RESEARCH

The DHA STTR Program highly discourages offerors from proposing to conduct Human Subjects, Human Specimens/Data, or Animal Research during Phase I due to the significant lead time required to prepare regulatory documentation and secure approval, which could substantially delay the performance of the Phase I award. While technical evaluations will not be negatively impacted, Phase I projects requiring Institutional Review Board approval may delay the start time of the Phase I award. If necessary

regulatory approvals are not obtained within two months of notification of selection, the decision to award may be terminated.

Offerors are expressly forbidden to use, or subcontract for the use of, laboratory animals in any manner without the express written approval of the US Army Medical Research and Development Command (USAMRDC) Animal Care and Use Review Office (ACURO). Written authorization to begin research under the applicable protocol(s) proposed for this award will be issued in the form of an approval letter from the USAMRDC ACURO to the recipient. Modifications to previously approved protocols require re-approval by ACURO prior to implementation.

Research under this award involving the use of human subjects, to include the use of human anatomical substances or human data, shall not begin until the USAMRDC's Office of Research Protections (ORP) provides formal authorization. Written approval to begin a research protocol will be issued from the USAMRDC ORP, under separate notification to the recipient. Written approval from the USAMRDC ORP is required for any sub-recipient using funds from this award to conduct research involving human subjects. If the Offeror intends to submit research funded by this award to the US Food and Drug Administration, Offerors should propose a regulatory strategy for review.

Non-compliance with any provision may result in withholding of funds and or termination of the award.

WAIVERS

In rare situations, the DHA STTR Program allows for a waiver to be incorporated allowing federal facility usage for testing/evaluation. A waiver will only be permitted when it has been determined that no applicable U.S. facility has the ability or expertise to perform the specified work. The DHA STTR Program has the right of refusal. If approved, the DHA STTR Program will assist in establishing the waiver for approval. If approved, the proposer will subcontract directly with the federal facility and not a third party representative.

END

DHA STTR 22.B Topic Index

DHA22B-001 TITLE: Integrated Blast Acquisition Test Surrogate

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

TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: Develop an anatomically accurate low cost blast surrogate to test and evaluate current and next-generation personal protective equipment (PPE).

DESCRIPTION: Injury to brain, lungs and neurosensory systems from blast related trauma has been a critical problem for Warfighter brain health and performance (e.g. traumatic brain injury, hearing loss, lung injury) since World War I. Although, the current personal protective equipment is designed to provide limited protection against shrapnel and projectiles from explosive events and low caliber ammunition, there is substantial injury risk stemming from the blast overpressure exposure; consequently, technologies that provide protection against blast are highly desirable.

Emerging blast threats and increased mobility requirements for future wars require acquisition of lightweight next-generation PPE, which require test and evaluation for efficacy. Testing systems that provide material based protection/prevention require surrogate platforms to rapidly test and evaluate these systems. Current blast surrogate technologies such as blast test device (BTD) or other surrogate systems either provide limited surface pressure measurements or cost-prohibitive non- surface measurements, which can potentially be used to estimate the extent and magnitude of lung injury. Head surrogates such as the Hybrid III are designed for automotive testing, with biomechanical considerations unsuited for blast protection, and other surrogate systems that measure restricted surface head pressures exist, but are cost-prohibitive. Other head surrogates can measure intracranial pressure, but these systems do not account for neurosensory systems, are not anatomically accurate, and are not integrated into a torso model (Robert et al., 2007). None of these systems are validated applying biological biomechanics to represent an anatomically accurate system. Overall, there are no anatomically integrated blast test acquisition surrogates (iBATS) that are validated with accurate surrogate head, lung and sensory systems. In addition, there are no adequate technologies and test protocols to reduce the risk of Warfighters' injuries during combat and training operations in overpressure environments (Pratt NJ., 2017; Review of Department of Defense Test Protocols for Combat Helmets, 2014). Assessing different types of PPE in live animal models is not always practically possible against each threat, weapons system and scenario that produces blast overpressure. Thus, a validated surrogate system such as iBATS is required to acquire PPE with demonstrated effectiveness for emerging blast threats, and to estimate the risk in training and combat environments. The iBATS system should be low cost (<$5K), re-usable, modular, integrated for head, neck, torso and neurosensory systems, anatomically accurate, and portable. The system should ideally withstand and record static pressures as high as 70 psi in a bare (no PPE) configuration and should be biomechanically validated from biological testing (but not required in Phase I). In the later phases, this system should record pressures and transmit the data wirelessly. Overall, this topic desires to develop an iBATS system for PPE acquisition and risk assessment against current and future blast threats.

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 at head, torso and neurosensory system. This will be achieved by subjecting the prototypes to dynamic loading of blast overpressure exposure at different pressures (e.g. 5–25 psi in steps of 5psi). Offerors may discuss the testing requirements with the POC for the topic. At the end of the phase, a working prototype/device should demonstrate the feasibility/application of the system for repeatability of blast testing at 5–25 psi static pressures. In addition, provide a road-map or experimental plan to test the efficacy of the system at static pressures as high as 70 psi in bare configuration and 130 psi with PPE. In

addition, provide a Phase II roadmap for modular system and manufacturing process for a maximum cost of $5,000 for the whole unit. No biomechanical validation is required in this phase.

PHASE II: Phase I prototype with an iterative process should be converted into a modular prototype to withstand higher pressures- up to 70 psi without PPE and 130 psi in static pressure with PPE at least for 3 consecutive tests (total 6 tests). Offerors may coordinate with WRAIR for blast testing and utilize their biomechanical expertise for pre-clinical testing. Replaceable modular systems for each of the organs in head, torso and neurosensory systems should be developed for iBATS system from Phase I prototype. The system modular should be fully validated against the biological biomechanical characterizations that are being developed at WRAIR. Ideally, data recorded should be wirelessly transmitted for risk analysis. At the end of this phase, a fully developed modular prototype should be validated that can withstand 70 psi bare configuration and should be ready for commercialization plan. A roadmap should be presented for surrogate data to analyze with a software package for injury risk.

PHASE III DUAL USE APPLICATIONS: The prototypes developed should provide operational viability in the blast conditions in which Warfighters' blast-induced performance deficits have been documented in training (e.g. breaching) and can be anticipated in various austere operational environments. 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. A software package should be fully integrated to quickly analyze and produce the injury risk of various organ systems. Plans for large-scale production, licensing and process for rapid deployment of devices without compromising the performance standards of the product are sought through the funding from government sources and/or private organizations.

REFERENCES:

1. Roberts JC, Merkle AC, Biermann PJ, Ward EE, Carkhuff BG, Cain RP, O'Connor JV. Computational and experimental models of the human torso for non-penetrating ballistic impact. J Biomech. 2007; 40(1):125-36.
2. Prat NJ, Daban JL, Voiglio EJ, Rongieras F. Wound ballistics and blast injuries. J Visc Surg. 154:S9- S12. (2017)
3. Review of Department of Defense Test Protocols for Combat Helmets, Washington (DC): National Academies Press (US), ISBN-13: 978-0-309-29866-7, (2014).

KEYWORDS: blast, surrogate, head, torso, sensory, integrated, modular

Defense Threat Reduction Agency
STTR 22.B Small Business Technology Transfer (STTR)
Proposal Submission Instructions

1.0 INTRODUCTION

The Defense Threat Reduction Agency (DTRA) mission is to enable the DoD, the U.S. Government, and International Partners to counter and deter Weapons of Mass Destruction (WMD) Chemical Biological, Radiological, Nuclear, and Improvised Threat Networks. The DTRA STTR program is consistent with the purpose of the Federal SBIR/STTR Program, i.e., to stimulate a partnership of ideas and technologies between innovative small business concerns and Research Institutions through Federal-funded research or research and development (R/R&D).

The approved FY22.B topic solicited for the Defense Threat Reduction Agency (DTRA) Small Business Technology Transfer (STTR) Program is included in these instructions followed by the full topic description. Offerors responding to this Broad Agency Announcement (BAA) must follow all general instructions provided in the related Department of Defense Program BAA and submit proposals by the date and time listed in the DoD Program BAA. Specific DTRA requirements that add to or deviate from the DoD Program BAA instructions are provided below with references to the appropriate section of the DoD document.

The DTRA Small Business Technology Transfer (STTR) Program is implemented, administered, and managed by the DTRA SBIR/STTR Program Office. Specific questions pertaining to the administration of the DTRA STTR Program and these proposal preparation instructions should be submitted to:

Mr. Mark D Flohr
DTRA SBIR/STTR Program Manager
Mark.D.Flohr.civ@mail.mil
Tel: (571) 616-6066

Defense Threat Reduction Agency
8725 John J. Kingman Road
Stop 6201
Ft. Belvoir, VA 22060-6201

For technical questions about specific topic requirements during the pre-release period, contact the DTRA Technical Point of Contact (TPOC) for that specific topic. To obtain answers to technical questions during the formal BAA open period visit: https://www.dodsbirsttr.mil/submissions/login. For questions regarding the Defense SBIR/STTR Innovation Portal, contact DSIP Support at dodsbirsupport@reisystems.com.

Proposals not conforming to the terms of this announcement will not be considered. DTRA reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality as determined by DTRA will be funded. DTRA reserves the right to withdraw from negotiations at any time prior to contract award. The Government may withdraw from negotiations at any time for any reason to include matters of national security (foreign persons, foreign influence or ownership, inability to clear the firm or personnel for security clearances, or other related issues). Please read the entire DoD announcement and DTRA instructions carefully prior to submitting your proposal as there have been significant updates to the requirements.

The SBIR/STTR Policy Directive is available at:
https://www.sbir.gov/sites/default/files/SBIRSTTR_Policy_Directive_2019.pdf.

2.0 SMALL BUSINESS ELIGIBILITY REQUIREMENTS

2.1 The Offeror

Each offeror must qualify as a small business at time of award per the Small Business Administration (SBA) regulations at 13 CFR 121.701-121.705 and certify to this in the Cover Sheet section of the proposal. Those small businesses selected for award will also be required to submit a Funding Agreement Certification document provided by contracts prior to award.

2.2 SBA Company Registry

Per the 2019 SBIR-STTR Policy Directive, all STTR applicants are required to register their firm at SBA's Company Registry prior to submitting a proposal. Upon registering, each firm will receive a unique control ID to be used for submissions at any of the eleven (11) participating agencies in the program. For more information, please visit the SBA's Firm Registration Page: https://www.sbir.gov/user/login/.

2.3 Use of Foreign Nationals, Green Card Holders and Dual Citizens

See the "Foreign Nationals" section of the DoD SBIR Broad Agency Announcement for the definition of a Foreign National (also known as Foreign Persons).

ALL offerors proposing to use foreign nationals, green-card holders, or dual citizens, MUST disclose this information regardless of whether the topic is subject to export control restrictions. Offers must identify any foreign nationals or individuals holding dual citizenship expected to be involved on this project as a direct employee, subcontractor, or consultant. For those 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. You may be asked to provide additional information during negotiations in order to verify the foreign citizen's eligibility to participate on a STTR contract. Supplemental information provided in response to this paragraph will be protected in accordance with the Privacy Act (5 U.S.C. 552a), if applicable, and the Freedom of Information Act (5 U.S.C. 552(b)(6)).

Proposals submitted to export control-restricted topics and/or those with foreign nationals, dual citizens or green card holders listed will be subject to security review during the contract negotiation process (if selected for award). DTRA reserves the right to vet all uncleared individuals involved in the project, regardless of citizenship, who will have access to Controlled Unclassified Information (CUI) such as export-controlled information. If the security review disqualifies a person from participating in the proposed work, the contractor may propose a suitable replacement. In the event a proposed person is found ineligible by the government to perform proposed work, the contracting officer will advise the offeror of any disqualifications but may not disclose the underlying rationale. In the event a firm is found ineligible to perform proposed work, the contracting officer will advise the offeror of any disqualifications but may not disclose the underlying rationale.

3.0 PHASE I PROPOSAL GUIDELINES

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD STTR Program BAA.

3.1 Technical Volume (Volume 2)

The Phase I technical volume is not to exceed 20 pages in length and must follow the formatting requirements provided in the DoD STTR Program BAA. Any pages in the technical volume over the 20 pages will not be considered in the proposal evaluations.

3.2 Content of the Technical Volume

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

(a) Identification and Significance of the Problem or Opportunity.
Define the specific technical problem or opportunity addressed and its importance.

(b) 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.

(c) Phase I Statement of Work (including Subcontractors' Efforts).

(1) Provide an explicit, detailed description of the Phase I approach. 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.

(2) 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 as indicated in the DoD BAA. **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.**

(d) 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:

(1) Short description,
(2) Client for which work was performed (including individual to be contacted and phone number), and
(3) Date of completion.

(e) Relationship with Future Research or Research and Development.

(1) State the anticipated results of the proposed approach if the project is successful.

(2) Discuss the significance of the Phase I effort in providing a foundation for Phase II research or research and development effort.

(3) 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

(f) 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 STTR project that your company expects to achieve.

(g) 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.

(h) 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 (e.g., copy of valid passport, visa, work permit, etc.) 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)).

(i) 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.

(j) Subcontractors/Consultants. Involvement of a university or other subcontractors or

consultants in the project may be appropriate. If such involvement is intended, it should be identified and described to the same level of detail as the prime contractor costs. A minimum of two- thirds of the research and/or analytical work in Phase I, as measured by direct and indirect costs, must be conducted by the proposing firm, unless otherwise approved in writing by the Contracting Officer. SBIR efforts may include subcontracts with Federal Laboratories and Federally Funded Research and Development Centers (FFRDCs). A waiver is no longer required for the use of federal laboratories and FFRDCs; however, proposer must certify their use of such facilities on the Cover Sheet of the proposal.

(k) 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 . Refer to the instructions provided in the DoD STTR BAA for this requirement. *Note: If this does not apply, state in the proposal "No prior, current, or pending support for proposed work."*

3.3 Cost Volume (Volume 3)

The Phase I Base amount must not exceed $167,500.00. DTRA provides an MSExcel workbook for the Cost Volume as a template for proposal use. The Cost Volume template is available in the DSIP portal.

Important: when completing the cost volume, enough information should be provided to allow the agency to understand how you plan to use the requested funds if a contract is awarded. Itemized costs of any subcontract or consultant should be provided to the same level as for the prime small business. If an unsanitized version of costs cannot be provided with the proposal, the Government may request it during negotations, if selected. Refer to the instruction provided in the DoD STTR Program BAA for additional details on the content of the Cost Volume.

Note: Cost for travel funds must be justified and related to the needs of the project. DTRA does not include any fee on travel costs, so proposal should exclude fee on any travel costs proposed.

For more information about cost proposals and accounting standards, see https://www.dcaa.mil/Guidance/Audit- Process-Overview/

3.4 Company Commercialization Report (CCR) (Volume 4)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD STTR Program BAA for full details on this requirement. Information contained in the CCR will not be considered by DTRA during proposal evaluations.

3.5 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).

(a) All proposers are REQUIRED to submit the following documents to Volume 5:
   1. Contractor Certification Regarding Provision of Prohibition on Contracting for Certain Telecommunications and Video Surveillance Services or Equipment (BAA

Attachment 1) (REQUIRED)
2. Foreign Ownership or Control Disclosure (BAA Attachment 2) (Proposers must review Attachment 2: Foreign Ownership or Control Disclosure to determine applicability)

(b) Any of the following documents may be included in Volume 5 if applicable to the proposal.
1. Letters of Support
2. Additional Cost Information
3. Funding Agreement Certification
4. Technical Data Rights (Assertions)
5. Lifecycle Certification
6. Allocation of Rights

4.0 DIRECT TO PHASE II PROPOSAL GUIDELINES

The Defense Threat Reduction Agency does not participate in the Direct to Phase II Program.

5.0 PHASE II PROPOSAL GUIDELINES

Small business concerns awarded a Phase I contract are permitted to submit a Phase II proposal for evaluation and potential award selection. The Phase II proposals are best submitted no later than (NLT) 30 days AFTER the end of the 7 month Phase I period of performance.

All STTR Phase II awards made on topics from solicitations prior to FY13 will be conducted in accordance with the procedures specified in those solicitations.

DTRA is not responsible for any money expended by the proposer prior to contract award.

DTRA has established a **40-page limitation** for the Technical Volume submitted in response to its topics. This does not include the Proposal Cover Sheets (pages 1 and 2, added electronically by the DoD submission site), or the Cost Volume, or the Company Commercialization Report. The Technical Volume includes, but is not limited to: table of contents, pages left blank, references and letters of support, appendices, key personnel biographical information, and all attachments.

Further details on the due date, content, and submission requirements of the Phase II proposal will be provided either in the Phase I award or by subsequent notification.

Phase II Proposal Instructions

Each Phase II proposal must be submitted through the Defense SBIR/STTR Innovation Portal by the deadline as specified in the Phase II Proposal Guidelines, or in the Phase I award or subsequent notification. **The format should be similar to Phase I proposal except the Phase II Technical Proposal is limited to 40 pages.** Each proposal submission must contain a Proposal Cover Sheet, Technical Volume, Cost Volume, a Company Commercialization Report (see the appropriate section of the BAA Announcement) and Volume 5. The Commercialization Strategy Volume should be more specific than was required for Phase I.

As indicated in the DoD STTR Program BAA, the CCR is generated by the submission website based on information provided by you through the “Company Commercialization Report” tool.

Commercialization Strategy

See the appropriate section DoD STTR 22.B BAA.

Phase II Evaluation Criteria

Phase II proposals will be reviewed for overall merit based upon the criteria specified in this Broad Agency Announcement and will be similar to the Phase I process.

Public Release of Award Information

If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released via the Internet. Therefore, do not include proprietary or classified information in these sections. For examples of past publicly released DoD SBIR/STTR Phase I and II awards, visit https://www.dodsbirsttr.mil/submissions/login.

6.0 DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

In accordance with the Small Business Act (15 U.S.C. 632), DTRA will authorize the recipient of a Phase I or Phase II SBIR/STTR award to purchase Discretionary Technical & Business Assistance services, such as access to a network of scientists and engineers engaged in a wide range of technologies, or access to technical and business literature available through on-line data bases, for the purpose of assisting such concerns as:

- making better technical decisions concerning such projects;
- solving technical problems which arise during the conduct of such projects;
- minimizing technical risks associated with such projects; and
- developing/commercializing new commercial products/processes resulting from such projects.
- Meeting cyber security requirements.

If you are proposing use of Discretionary Technical and Business Assistance (TABA), you must provide a cost breakdown in the Cost Volume under "Other Direct Costs (ODCs)" and provide a one-page description of the vendor you will use and the Technical and Business Assistance you will receive. For the Phase I project, the amount for TABA may not exceed $6,500 per award. For the Phase II project, the TABA amount may be less than, equal to, but not more than $50,000 per project. The description should be included in Volume 5 of the proposal.

Approval of technical and business assistance is not guaranteed and is subject to review of the contracting officer.

For Discretionary Technical and Business Assistance, small business concerns may propose one or more vendors. Additionally, business-related services aimed at improving the commercialization success of a small business concern may be obtained from an entity, such as a public or private organization or an agency or other entity established or funded by a State that facilitates or accelerates the commercialization of technologies or assists in the creation and growth of private enterprises that are commercializing technology.

7.0 EVALUATION AND SELECTION

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD STTR Program BAA.

7.1 DTRA Evaluation Authority. DTRA has a single Evaluation Authority (EA) for all proposals received under this solicitation. The EA either selects or rejects Phase I and Phase II proposals based upon the results of the review and evaluation process plus other considerations including limitation of funds, and investment balance across all the DTRA topics in the solicitation. To provide this balance, a lower rated proposal in one topic could be selected over a higher rated proposal in a different topic. DTRA reserves the right to select all, some, or none of the proposals in a particular topic.

7.2 Notifications. Following the EA decision, the DTRA SBIR/STTR office will release notification e-mails of selection or non-selection status for a Phase I award within 90 days of the closing date of the BAA. E-mails will be sent to the addresses provided for the Principal Investigator and Corporate Official. Offerors may request a debriefing of the evaluation of their not selected proposal and should submit this request via email to: dtra.belvoir.RD.mbx.sbir@mail.mil and include "STTR 22.B / Topic XX Debriefing Request" in the subject line. Debriefings are provided to help improve the offeror's potential response to future solicitations. Debriefings do not represent an opportunity to revise or rebut the EA decision.

For selected offers, DTRA will initiate contracting actions which, if successfully completed, will result in contract award. DTRA Phase I awards are issued as fixed-price purchase orders with a maximum period of performance of seven-months. DTRA may complete Phase I awards without additional negotiations by the contracting officer or without opportunity for revision for proposals that are reasonable and complete.

7.3 DTRA Support Contractors Select DTRA-employed support contractors may have access to contractor information, technical data or computer software that may be marked as proprietary or otherwise marked with restrictive legends. Each DTRA support contractor performs under a contract that contains organizational conflict of interest provisions and/or includes contractual requirements for nondisclosure of proprietary contractor information or data/software marked with restrictive legends. These contractors require access while providing DTRA such support as advisory and assistance services, contract specialist support, and support of the Defense Threat Reduction Information Analysis Center (DTRIAC). The contractor, by submitting a proposal or entering into this contract, is deemed to have consented to the disclosure of its information to DTRA's support contractors.

The following are, at present, the prime contractors anticipated to access such documentation: Broadleaf Inc (contract specialist support), Kent, Campa and Kate, Inc. (contract closeout support), ARServices (Program Management Advisory and Assistance Services--A&AS), Systems Planning and Analysis, Inc. (Subject Matter Expertise A&AS), Polaris Consulting (Small Business Program Support), Seventh Sense Consulting, LLC (Acquisition Support), Kapili Services, LLC and TekSynap (DTRIAC) and Savantage Solutions (Accounting and Financial Systems Support). This list is not all inclusive (e.g., subcontractors) and is subject to change.

7.4 Protests. Refer to the DoD STTR Program BAA for procedures to protest the Announcement.

As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to:

Service of Protest (Sept 2006)

(a) Protests, as defined in section 33.101 of the Federal Acquisition Regulation, that are filed directly with an agency, and copies of any protests that are filed with the Government Accountability Office (GAO), shall be served on the Contracting Officer (addressed to Mr. Herbert Thompson, Contracting Officer, as follows) by obtaining written and dated acknowledgment of receipt from (if mailed letter) Defense Threat Reduction Agency, ATTN: AL-ACQ (Mr. Herbert Thompson), 1680 Texas Street, Kirtland AFB, NM 87117. If Federal Express is used for the transmittal, the appropriate address is: Defense Threat Reduction Agency, ATTN: AL-ACQ (Mr. Herbert Thompson), 8151 Griffin Avenue SE, Building 20414, Kirtland AFB, NM 87117-5669

(b) The copy of any protest shall be received in the office designated above within one day of filing a protest with the GAO.

8.0 AWARD AND CONTRACT INFORMATION

DTRA plans on Phase I projects for a seven (7) month period of performance with six months devoted to the research and the final month for the final report. The award size of the Phase I contract is no more than $167,500.00 not withstanding a maximum of $6,500.00 for Discretionary Technical and Business Allowance (TABA). The award size of a Phase II contract is no more than $1,100,00.00 not withstanding a maximum of $50,000.00 for Discretionary Technical and Business Allowance (TABA).

9.0 ADDITIONAL INFORMATION

9.1 Export Control Restrictions

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.

The technology within some DTRA topics is restricted under export control regulations including the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR). ITAR controls the export and import of listed defense-related material, technical data and services that provide the United States with a critical military advantage. EAR controls military, dual-use and commercial items not listed on the United States Munitions List or any other export control lists. EAR regulates export-controlled items based on user, country, and purpose. **The offeror must ensure that their firm complies with all applicable export control regulations.**

NOTE: Export control compliance statements found in these 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.

9.2 Cyber Security

Any Small Business Concern receiving an STTR 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.

9.3 Feedback

In an effort to encourage participation in, and improve the overall STTR award process, offerors may submit feedback on the STTR solicitation and award process to: dtra.belvoir.RD.mbx.sbir@mail.mil for consideration for future STTR BAAs.

END

DTRA STTR 22.B Topic Index

DTRA22B-001 TITLE: Distributed Source Testing in Multiple Test Beds

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

TECHNOLOGY AREA(S): Battlespace; Nuclear; Sensors

OBJECTIVE: DTRA seeks to develop a capability that will allow for the creation of a radiological fallout area for test and evaluation, while minimizing radiation dose to radiation worker

DESCRIPTION: To improve the warfighters ability to operate in radiological contamination environments, DTRA is developing improved tools to rapidly identify and map radiological hazards. Without access to actual radiation fallout areas from nuclear detonations, DTRA needs to create spatially-distributed radiation area to assess sensor systems and associated analytical tools.

Requirements for this development are as follows:

- The resulting contamination field must span at least a 30m x 50m area
- The total amount of radiological gamma activity should total approximately 1 curie
- Capability should be able to be used multiple times
- Capability should allow for creation of different fallout patterns and distributions
- Within environmental and regulatory guideline
- Minimize radiation dose to personnel using developed solutions

PHASE I: Phase I will consist of a conceptual design, to include risk reduction, of a prototype system that will meet the performance goals described in the Description section. Consideration should be given to literature search, analysis, and modeling to demonstrate applicability of the proposed capability. Preliminary fabrication can be performed to obtain engineering data for analysis. The Phase I deliverable is a final report detailing the work performed in Phase 1, analysis of the results, the conceptual design, and application to Phase II development.

PHASE II: Phase II will construct and test a prototype system. The Phase II deliverable will be a final report that includes test results and technical drawing of the prototype system.

PHASE III DUAL USE APPLICATIONS: Phase III will mature the prototype and provide a system for U.S. government use and independent evaluation.

REFERENCES:

1. G.F. Knoll, Radiation Detection and Measurement – 4th edition (Chapter 7), John Wiley & Sons, 2010.

KEYWORDS: Distributed Source, Fallout, Radiation Hazard

VERSION 3

Missile Defense Agency (MDA)
22.B Small Business Technology Transfer (STTR)
Proposal Submission Instructions

INTRODUCTION

The Missile Defense Agency's (MDA) mission is to develop and deploy a layered Missile Defense System (MDS) to defend the United States, its deployed forces, allies, and friends from missile attacks in all phases of flight.

The MDA Small Business Technology Transfer (STTR) Program is implemented, administered, and managed by the MDA SBIR/Small Business Technology Transfer (STTR) Program Management Office (PMO), located within the Innovation, Science, & Technology (DV) directorate.

Offerors responding to a topic in this Broad Agency Announcement (BAA) must follow all general instructions provided in the Department of Defense (DoD) STTR Program BAA. MDA requirements in addition to or deviating from the DoD Program BAA are provided in the instructions below.

Specific questions pertaining to the administration of the MDA STTR Program and these proposal preparation instructions should be directed to:

Missile Defense Agency
SBIR/STTR Program Management Office
MDA/DVR
Bldg. 5224, Martin Road
Redstone Arsenal, AL 35898

Email: sbirsttr@mda.mil
Phone: 256-955-2020

Proposals not conforming to the terms of this announcement may not be considered. MDA reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality as determined by MDA will be funded. MDA reserves the right to withdraw from negotiations at any time prior to contract award. The Government may withdraw from negotiations at any time for any reason to include matters of national security (foreign persons, foreign influence or ownership, inability to clear the firm or personnel for security clearances, or other related issues).

Please read the entire DoD Announcement and MDA instructions carefully prior to submitting your proposal. Please go to https://www.sbir.gov/about#policy-directive to read the SBIR/STTR Policy Directive issued by the Small Business Administration.

PHASE I PROPOSAL GUIDELINES

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Offerors are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD STTR Program BAA.

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DSIP (available at https://www.dodsbirsttr.mil) will lead you through the preparation and submission of your proposal. Read the front section of the DoD announcement for detailed instructions on proposal format and program requirements. Proposals not conforming to the terms of this announcement may not be considered.

MDA's objective for Phase I is to determine the merit and technical feasibility of the concept. The contract period of performance for Phase I is six (6) months.

Proposal Cover Sheet (Volume 1)
On DSIP at https://www.dodsbirsttr.mil/submissions, prepare the Proposal Cover Sheet.

Technical Volume (Volume 2)
The technical volume is not to exceed 15 pages and must follow the formatting requirements provided in the DoD STTR Program BAA. Any pages submitted beyond the 15-page limit will not be evaluated.

Content of the Technical Volume
For technical volume format guidance, please refer to the "Format of Technical Volume" section within the DoD STTR 22.B BAA

If including a letter(s) of support and/or Technical and Business Assistance (TABA) request, it must be included as part of Volume 5 and will not count towards the 15-page Technical Volume (Volume 2) limit. Any technical data/information that should be in the Technical Volume (Volume 2) but is contained in other Volumes will not be considered.

Cost Volume (Volume 3)
The Phase I Base amount must not exceed $150,000 or not to exceed $155,000 if TABA is included. MDA does not utilize the Phase I Option as part of the STTR 22.B Phase I BAA.

Company Commercialization Report (CCR) (Volume 4)
Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD STTR Program BAA for full details on this requirement. Information contained in the CCR will not be considered by MDA during proposal evaluations.

Supporting Documents (Volume 5)
MDA will only accept the following four documents as part of Volume 5:
1. Contractor Certification Regarding Provision of Prohibited Video Surveillance and Telecommunications Services and Equipment (Required).
2. Foreign Ownership or Control Disclosure (Offerors must review Attachment 2 in the DoD STTR Program BAA to determine applicability.)
3. Request for TABA using the MDA Phase I TABA form (optional).
4. Letters of support (optional).

If including a request for TABA, the MDA Phase I TABA Form MUST be completed and uploaded using the "Other" category within Volume 5 of DSIP.

If including letters of support, they MUST be uploaded using the "Letters of Support" category within Volume 5 of DSIP. A qualified letter of support is from a relevant commercial or Government Agency procuring organization(s) working with MDA, articulating their pull for the technology (i.e., what MDS

need(s) the technology supports and why it is important to fund it), and possible commitment to provide additional funding and/or insert the technology in their acquisition/sustainment program. Letters of support shall not be contingent upon award of a subcontract.

Any documentation other than the Prohibited Video Surveillance and Telecommunications Services and Equipment form, Foreign Ownership or Control Disclosure, letter(s) of support, or requests for TABA included as part of Volume 5 WILL NOT be considered.

DIRECT TO PHASE II PROPOSAL GUIDELINES

MDA is not accepting Direct to Phase II proposals for the 22.B STTR BAA.

PHASE II PROPOSAL GUIDELINES

Phase II proposals may only be submitted by Phase I awardees. Details on the due date, format, content, and submission requirements of the Phase II proposal will be provided by the MDA SBIR/STTR Program Management Office during the fourth month of the Phase I period of performance.

MDA will evaluate and select Phase II proposals using the Phase II evaluation criteria listed in the DoD Program announcement. While funding must be based upon the results of work performed under a Phase I award and the scientific and technical merit, feasibility and commercial potential of the Phase II proposal, Phase I final reports will not be reviewed as part of the Phase II evaluation process. The Phase II proposal should include a concise summary of the Phase I effort including the specific technical problem or opportunity addressed and its importance, the objective of the Phase I effort, the type of research conducted, findings or results of this research, and technical feasibility of the proposed technology. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

All Phase II awardees must have a Defense Contract Audit Agency (DCAA) approved accounting system. It is strongly urged that an approved accounting system be in place prior to the MDA Phase II award timeframe. If you do not have a DCAA approved accounting system, this will delay/prevent Phase II contract award. Please visit https://www.dcaa.mil/Customers/Small-Business for more information on obtaining a DCAA approved accounting system.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

The SBIR/STTR Policy Directive allows agencies to enter into agreements with suppliers to provide technical assistance to SBIR and STTR awardees, which may include access to a network of scientists and engineers engaged in a wide range of technologies or access to technical and business literature available through online data bases.

All requests for TABA must be completed using the MDA SBIR/STTR Phase I TABA Form and included as a part of Volume 5 of the proposal package. MDA will not accept requests for TABA that do not utilize the MDA SBIR/STTR Phase I TABA Form or are not provided as part of Volume 5 of the Phase I proposal package.

A STTR firm may acquire the technical assistance services described above on its own. Firms must request this authority from MDA and demonstrate in its STTR proposal that the individual or entity selected can provide the specific technical services needed. In addition, costs must be included in the cost volume of the offeror's proposal. The TABA provider may not be the requesting firm, an affiliate of the requesting firm, an investor of the requesting firm, or a subcontractor or consultant of the requesting firm

otherwise required as part of the paid portion of the research effort (e.g. research partner or research institution).

If the awardee supports the need for this requirement sufficiently as determined by the Government, MDA will permit the awardee to acquire such technical assistance, in an amount up to $5,000 per year. This will be an allowable cost on the STTR award. The per year amount will be in addition to the award and is not subject to any burden, profit or fee by the offeror. The per-year amount is based on the original contract period of performance and does not apply to period of performance extensions. Requests for TABA funding outside of the base period of performance (6 months) for Phase I proposal submission will not be considered.

The purpose of this technical assistance is to assist STTR awardees in:

1. Making better technical decisions on STTR projects;
2. Solving technical problems that arise during STTR projects;
3. Minimizing technical risks associated with STTR projects; and
4. Developing and commercializing new commercial products and processes resulting from such projects including intellectual property protections.

The MDA Phase I TABA form can be accessed here: (https://www.mda.mil/global/documents/pdf/SBIR_STTR_PHI_TABA_Form.pdf) and must be included as part of Volume 5 using the "Other" category.

EVALUATION AND SELECTION

All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD STTR Program BAA. Selections will be based on best value to the Government considering the evaluation criteria listed in the DoD STTR Program BAA which are listed in descending order of importance.

MDA reserves the right to award none, one, or more than one contract under any topic. MDA is not responsible for any money expended by the offeror before award of any contract. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality as determined by MDA will be funded.

Please note that potential benefit to the MDS will be considered throughout all the evaluation criteria and in the best value trade-off analysis. When combined, the stated evaluation criteria are significantly more important than cost or price.

It cannot be assumed that reviewers are acquainted with the firm or key individuals or any referenced experiments. Technical reviewers will base their conclusions only on information contained in the proposal. Relevant supporting data such as journal articles, literature, including Government publications, etc., should be listed in the proposal and will count toward the applicable page limit.

AWARD AND CONTRACT INFORMATION

The MDA Contracting Office will distribute selection and non-selection email notices to all firms who submit an MDA STTR proposal. Proposing firms will be notified of selection or non-selection status for a Phase I award within 90 days of the closing date of the BAA. The email will be distributed to the "Corporate Official" and "Principal Investigator" listed on the proposal coversheet and will originate from the sbirsttr@mda.mil email address. MDA cannot be responsible for notification to a company that provides incorrect information or changes such information after proposal submission.

MDA will provide written feedback to unsuccessful offerors regarding their proposals upon request. Requests for feedback must be submitted in writing to the MDA SBIR/STTR PMO within 30 calendar days of non-selection notification. Non-selection notifications will provide instructions for requesting proposal feedback. Only firms that receive a non-selection notification are eligible for written feedback. Refer to the DoD STTR Program BAA for procedures to protest the Announcement.

As further prescribed in the Federal Acquisition Regulation (FAR) 33.106(b), FAR 52.233-3, protests after award should be submitted to Tina Barnhill via email: sbirsttr@mda.mil.

The Missile Defense Agency will issue all contract awards. The cognizant Government Contracting Officer is the only Government official authorized to enter into any binding agreement or contract on behalf of the Government.

Offeror Small Business Eligibility Requirements

Each offeror must qualify as a small business at time of award per the Small Business Administration's (SBA) regulations at 13 CFR 121.701-121.705 and certify to this in the Cover Sheet section of the proposal. Small businesses that are selected for award will also be required to submit a Funding Agreement Certification document and be registered in the Supplier Performance Risk System https://www.sprs.csd.disa.mil/ prior to award.

Ownership Eligibility

Prior to award, MDA may request business/corporate documentation to assess ownership eligibility as related to the requirements of SBIR/STTR Program Eligibility. These documents include, but may not be limited to, the Business License; Articles of Incorporation or Organization; By-Laws/Operating Agreement; Stock Certificates (Voting Stock); Board Meeting Minutes for the previous year; and a list of all board members and officers. If requested by MDA, the contractor shall provide all necessary documentation for evaluation prior to STTR award. Failure to submit the requested documentation in a timely manner as indicated by MDA may result in the offeror's ineligibility for further consideration for award.

Performance Benchmark Requirements for Phase I Eligibility

MDA does not accept proposals from firms that are currently ineligible for Phase I awards as a result of failing to meet the benchmark rates at the last assessment. Additional information on Benchmark Requirements can be found in the DoD SBIR/STTR Program BAA.

References to Hardware, Computer Software, or Technical Data

In accordance with the SBIR/STTR Policy Directive, the work within the SBIR/STTR contracts are to conduct feasibility-related experimental or theoretical Research/Research and Development (R/R&D) related to described agency requirements. The purpose for Phase I is to determine the scientific and technical merit and feasibility of the proposed effort.

It is not intended for any formal end-item contract delivery and ownership by the Government of your hardware, computer software, or technical data. As a result, your technical proposal should not contain any reference to the term "Deliverables" when referring to your hardware, computer software, or technical data. Instead use the term: "Products for Government Testing, Evaluation, Demonstration, and/or possible destructive testing."

The standard (if applicable) formal deliverables for a Phase I are the:
A001: Report of Invention(s), Contractor, and/or Subcontractor(s)//Patent Application for Invention
A002: Status Report//Phase I Bi-monthly Status Report
A003: Contract Summary Report//Phase I Final Report
A004: Certification of Compliance// STTR Funding Agreement Certification - Life Cycle Certification
A005: Computer Software Product//Product Description
A006: Technical Report - Study Services//Prototype Design and Operation Document

FAR 52.203-5 Covenant Against Contingent Fees
As prescribed in FAR 3.404, the following FAR 52.203-5 clause shall be included in all contracts awarded under this BAA:

(a) The Contractor warrants that no person or agency has been employed or retained to solicit or obtain this contract upon an agreement or understanding for a contingent fee, except a bona fide employee or agency. For breach or violation of this warranty, the Government shall have the right to annul this contract without liability or to deduct from the contract price or consideration, or otherwise recover, the full amount of the contingent fee.

(b) Bona fide agency, as used in this clause, means an established commercial or selling agency, maintained by a contractor for the purpose of securing business, that neither exerts nor proposes to exert improper influence to solicit or obtain Government contracts nor holds itself out as being able to obtain any Government contract or contracts through improper influence.

"Bona fide employee," as used in this clause, means a person, employed by a contractor and subject to the contractor's supervision and control as to time, place, and manner of performance, who neither exerts nor proposes to exert improper influence to solicit or obtain Government contracts nor holds out as being able to obtain any Government contract or contracts through improper influence.

"Contingent fee," as used in this clause, means any commission, percentage, brokerage, or other fee that is contingent upon the success that a person or concern has in securing a Government contract.

"Improper influence," as used in this clause, means any influence that induces or tends to induce a Government employee or officer to give consideration or to act regarding a Government contract on any basis other than the merits of the matter.

ADDITIONAL INFORMATION

Federally Funded Research and Development Centers (FFRDCs) and Support Contractors
Only Government personnel with active non-disclosure agreements will evaluate proposals. Non-Government technical consultants (consultants) to the Government may review and provide support in proposal evaluations during source selection. Consultants may have access to the offeror's proposals, may be utilized to review proposals, and may provide comments and recommendations to the Government's decision makers. Consultants will not establish final assessments of risk and will not rate or rank offerors' proposals. They are also expressly prohibited from competing for MDA STTR awards in the STTR topics they review and/or on which they provide comments to the Government.

All consultants are required to comply with procurement integrity laws. Consultants will not have access to proposals or pages of proposals that are properly labeled by the offerors as "Government Only."

Pursuant to FAR 9.505-4, the MDA contracts with these organizations include a clause which requires them to (1) protect the offerors' information from unauthorized use or disclosure for as long as it remains proprietary and (2) refrain from using the information for any purpose other than that for which it was furnished. In addition, MDA requires the employees of those support contractors that provide technical analysis to the SBIR/STTR Program to execute non-disclosure agreements. These agreements will remain on file with the MDA SBIR/STTR PMO.

Non-Government consultants will be authorized access to only those portions of the proposal data and discussions that are necessary to enable them to perform their respective duties. In accomplishing their duties related to the source selection process, employees of the aforementioned organizations may require access to proprietary information contained in the offerors' proposals.

SBA Company Registry

Per the SBIR/STTR Policy Directive, all applicants are required to register their firm at SBA's Company Registry prior to submitting a proposal. Upon registering, each firm will receive a unique control Identification number to be used for submissions at any of the eleven (11) participating agencies in the SBIR or STTR program. For more information, please visit the SBA's Firm Registration Page: http://www.sbir.gov/registration.

Organizational Conflicts of Interest (OCI)

The basic OCI rules for Contractors that support development and oversight of STTR topics are covered in FAR 9.5 as follows (the Offeror is responsible for compliance):

(1) The Contractor's objectivity and judgment are not biased because of its present or planned interests which relate to work under this contract;

(2) The Contractor does not obtain unfair competitive advantage by virtue of its access to non-public information regarding the Government's program plans and actual or anticipated resources; and

(3) The Contractor does not obtain unfair competitive advantage by virtue of its access to proprietary information belonging to others.

All applicable rules under the FAR Section 9.5 apply.

If you, or another employee in your company, developed or assisted in the development of any STTR requirement or topic, please be advised that your company may have an OCI. Your company could be precluded from an award under this Broad Agency Announcement (BAA) if your proposal contains anything directly relating to the development of the requirement or topic. Before submitting your proposal, please examine any potential OCI issues that may exist with your company to include subcontractors and understand that if any exist, your company may be required to submit an acceptable OCI mitigation plan prior to award.

In addition, FAR 3.101-1 states that Government business shall be conducted in a manner above reproach and, except as authorized by statute or regulation, with complete impartiality and with preferential treatment for none. The general rule is to avoid strictly any conflict of interest or even the appearance of a conflict of interest in Government-contractor relationships. An appearance of impropriety may arise where an offeror may have gained an unfair competitive advantage through its hiring of, or association with, a former Government official if there are facts indicating the former Government official, through

their former Government employment, had access to non-public, competitively useful information. (See *Health Net Fed. Svcs*, B-401652.3; *Obsidian Solutions Group*, LLC, B-417134, 417134.2). The existence of an unfair competitive advantage may result in an offeror being disqualified and this restriction cannot be waived.

It is MDA policy to ensure all appropriate measures are taken to resolve OCI's arising under FAR 9.5 and unfair competitive advantages arising under FAR 3.101-1 to prevent the existence of conflicting roles that might bias a contractor's judgment and deprive MDA of objective advice or assistance, and to prevent contractors from gaining an unfair competitive advantage.

Use of Foreign Nationals (also known as Foreign Persons), Green Card Holders, and Dual Citizens

See the "Foreign Nationals" section of the DoD STTR Program announcement for the definition of a Foreign National (also known as Foreign Persons).

ALL offerors proposing to use foreign nationals, green card holders, or dual citizens, MUST disclose this information regardless of whether the topic is subject to export control restrictions. Identify any foreign nationals or individuals holding dual citizenship expected to be involved on this project as a direct employee, **subcontractor, or consultant.** For these individuals, please specify their country of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project. You may be asked to provide additional information during negotiations in order to verify the foreign citizen's eligibility to participate on a STTR contract. Supplemental information provided in response to this paragraph will be protected in accordance with the Privacy Act (5 U.S.C. 552a), if applicable, and the Freedom of Information Act (5 U.S.C. 552(b)(6)).

Proposals submitted to export control-restricted topics and/or those with foreign nationals, dual citizens, or green card holders listed will be subject to security review during the contract negotiation process (if selected for award). MDA reserves the right to vet all un-cleared individuals involved in the project, regardless of citizenship, who will have access to Controlled Unclassified Information (CUI) such as export controlled information. If the security review disqualifies a person from participating in the proposed work, the contractor may propose a suitable replacement. In the event a proposed person and/or firm is found ineligible by the Government to perform proposed work, the contracting officer will advise the offeror of any disqualifications but is not required to disclose the underlying rationale.

Export Control Restrictions

The technology within most MDA topics is restricted under export control regulations including the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR). ITAR controls the export and import of listed defense-related material, technical data and services that provide the United States with a critical military advantage. EAR controls military, dual-use and commercial items not listed on the United States Munitions List or any other export control lists. EAR regulates export controlled items based on user, country, and purpose. The offeror must ensure that their firm complies with all applicable export control regulations. Please refer to the following URLs for additional information: https://www.pmddtc.state.gov/ and https://www.bis.doc.gov/index.php/regulations/export-administration-regulations-ear.

Most MDA STTR topics are subject to ITAR and/or EAR. If the topic write-up indicates that the topic is subject to ITAR and/or EAR, your company may be required to submit a Technology Control Plan (TCP) during the contracting negotiation process.

Flow-Down of Clauses to Subcontractors

The clauses to which the prime contractor and subcontractors are required to comply include, but are not limited to the following clauses: MDA clause H-08 (Public Release of Information), DFARS 252.204-7000 (Disclosure of Information), DFARS clause 252.204-7012 (Safeguarding Covered Defense Information and Cyber Incident Reporting), and DFARS clause 252.204-7020 (NIST SP 800-171 DoD Assessment Requirements). Your proposal submission confirms that any proposed subcontract is in accordance to the clauses cited above and any other clauses identified by MDA in any resulting contract. All proposed universities will need to provide written acceptance of the Flow-Down Clauses in both SBIR and STTR proposals.

MDA Clause H-08 Public Release of Information (Publication Approval)

MDA Clause H-08 pertaining to the public release of information is incorporated into all MDA STTR contracts and subcontracts without exception. Any information relative to the work performed by the contractor under MDA STTR contracts must be submitted to MDA for review and approval prior to its release to the public. This mandatory clause also includes the subcontractor who shall provide their submission through the prime contractor for MDA's review for approval.

a. In addition to the requirements of National Industrial Security Program Operations Manual (DoD 5220.22-M), all foreign and domestic contractors and their subcontractors are required to comply with the following:

1) Any official MDA information/materials that a contractor/subcontractor intends to release to the public that pertains to any work under performance of this contract, the Missile Defense Agency (MDA) will perform a prepublication review prior to authorizing any release of information/materials.

2) At a minimum, these information/materials may be technical papers, presentations, articles for publication, key messages, talking points, speeches, and social media or digital media, such as press releases, photographs, fact sheets, advertising, posters, videos, etc.

b. Subcontractor public information/materials must be submitted for approval through the prime contractor to MDA.

c. Upon request to the MDA Procuring Contracting Officer (PCO), contractors shall be provided the "Request for Industry Media Engagement" form (or any superseding MDA form).

d. At least 45 calendar days prior to the desired release date, the contractor must submit the required form and information/materials to be reviewed for public release to MDAPressOperations@mda.mil, and simultaneously provide courtesy copy to the appropriate PCO.

e. All information/materials submitted for MDA review must be an exact copy of the intended item(s) to be released, must be of high quality and are free of tracked changes and/or comments. Photographs must have captions, and videos must have the intended narration included. All items must be marked with the applicable month, day, and year.

f. No documents or media shall be publically released by the Contractor without MDA Public Release approval.

g. Once information has been cleared for public release, it resides in the public domain and must always be used in its originally cleared context and format. Information previously cleared for public release but containing new, modified or further developed information must be re-submitted.

Rights in Noncommercial Technical Data and Computer Software – SBIR Program (DFARs 252.227-7018)
Use this link for full description of Data Rights:
https://www.acquisition.gov/dfars/part-252-solicitation-provisions-and-contract-clauses#DFARS-252.227-7018

Fraud, Waste, and Abuse
All offerors must complete the fraud, waste, and abuse training (Volume 6) that is located on DSIP (https://www.dodsbirsttr.mil). Please follow guidance provided on DSIP to complete the required training.

To Report Fraud, Waste, or Abuse, Please Contact:
MDA Fraud, Waste & Abuse
Hotline: (256) 313-9699
MDAHotline@mda.mil

DoD Inspector General (IG) Fraud, Waste & Abuse
Hotline: (800) 424-9098
hotline@dodig.mil

Additional information on Fraud, Waste and Abuse may be found in the DoD Instructions of this announcement.

Proposal Submission
All proposals MUST be submitted online using DSIP (https://www.dodsbirsttr.mil). Any questions pertaining to DSIP should be directed to DSIP Support: DoDSBIRSupport@reisystems.com.

It is recommended that potential offerors email topic authors to schedule a time for topic discussion during the pre-release period.

Classified Proposals
Classified proposals **ARE NOT** accepted under the MDA STTR Program. The inclusion of classified data in an unclassified proposal MAY BE grounds for the Agency to determine the proposal as non-responsive resulting in the proposal not being evaluated. Contractors currently working under a classified MDA STTR contract must use the security classification guidance provided under that contract to verify new STTR proposals are unclassified prior to submission. Phase I contracts are not typically awarded for classified work. However, in some instances, work being performed on Phase II contracts will require

security clearances. If a Phase II contract will require classified work, the offeror must have a facility clearance and appropriate personnel clearances in order to perform the classified work. For more information on facility and personnel clearance procedures and requirements, please visit the Defense Counterintelligence and Security Agency Web site at: https://www.dcsa.mil.

Use of Acronyms

Acronyms should be spelled out the first time they are used within the technical volume (Volume 2), the technical abstract, and the anticipated benefits/potential commercial applications of the research or development sections. This will help avoid confusion when proposals are evaluated by technical reviewers.

Communication

All communication from the MDA SBIR/STTR PMO will originate from the sbirsttr@mda.mil email address. Please white-list this address in your company's spam filters to ensure timely receipt of communications from our office.

Proposal titles, abstracts, anticipated benefits, and keywords of proposals that are selected for contract award will undergo an MDA Policy and Security Review. Proposal titles, abstracts, anticipated benefits, and keywords are subject to revision and/or redaction by MDA. Final approved versions of proposal titles, abstracts, anticipated benefits, and keywords may appear on DSIP and/or the SBA's SBIR/STTR award site (https://www.sbir.gov/sbirsearch/award/all).

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VERSION 3

MDA STTR 22.B Topic Index

Approved for Public Release (topics)
22-MDA-11065 (7 Feb 22)

VERSION 3

MDA22-T001 TITLE: Paratemporal Simulation with Uncertainty Quantification

OUSD (R&E) MODERNIZATION PRIORITY: Cybersecurity; Network Command, Control and Communications; Artificial Intelligence/Machine Learning; General Warfighting Requirements

TECHNOLOGY AREA(S): Weapons; Information Systems; Battlespace

OBJECTIVE: Creation of a Modeling and Simulation (M&S) development and execution environment which significantly decreases the time to execute statistically significant batches of stochastic simulation runs for the purpose of estimating scenario output/outcome distributions while improving our knowledge of the outcome distributions.

DESCRIPTION: This topic seeks the development of a paratemporal M&S architecture that must not only execute efficiently, but it must be scalable and should not introduce any significant burden on developers of the simulations and the underlying algorithmic models. Commonly, to estimate the distribution of scenario outputs/outcomes of a stochastic simulation, we would execute the simulation repeatedly with different random seeds until there were sufficient runs to estimate the distributions of the results to an acceptable level of confidence.

In "cloning", "5-D" or "paratemporal" simulation, a simulation is run until a stochastic decision point is reached, at which point the current simulation states and probabilities of branching are saved. The simulation is then executed for one possible branching until another branching point is reached. The process is then repeated until the execution end-point is reached. The simulation is then restarted at a saved state (cloned) and an alternative branch is taken. In this way, the simulation need not be completely rerun for additional executions and the probabilities and distributions of each path execution can be calculated. This is also extremely parallelizable for great efficiency in execution on multiple processors. For an academic "toy" example, assume a simulation that starts at execution time t=0 at state s=0. After one second of computational time (t=1) a random model is reached which either adds 1 to the state, or 0 resulting in states of either s=1, or s=0. This repeats until instantaneously after t=4, at which point there are a total of 16 possible branching routes with the final states being (4, 3, 3, 2, 3, 2, 2, 1, 3, 2, 2, 1, 2, 1, 1, 0), with probabilities calculated with stored probabilities at each branch.

Starting from the beginning but intentionally choosing outcomes to step through each possible branching route would require 64 seconds of computational time and gives complete knowledge of the distribution of results. In this "toy" example, a statistically significant number of executions (>20 runs/>80 s of execution time) actually requires more resources while providing less knowledge of the output distribution.

Using "paratemporal" simulation that reuses results up to new branch points, all 16 possible branching routes can be executed in 14 s. A more sophisticated paratemporal execution that recognizes and reuses tree branches from common states could reduce this execution time further to 7 s. However, simple paratemporal simulation suffers from a scalability issue. Paratemporal simulations with a small number of branchings (e.g. missile intercept draws) and necessitated segment state saves have been demonstrated. However, a simple implementation of paratemporal simulation does not scale as the number of branches increases (e.g. numerous detection vs. noise draws in sensor simulations).
To tackle this scalability issue, it is desirable to develop more sophisticated paratemporal simulation techniques that take advantage of uncertainty quantification methods to increase the scalability while still providing improved, albeit imperfect, knowledge of scenario outcome/output distributions. For example,

it may be possible to combine segments of similar draws (such as the sensor detections) into super segments to minimize state saves and select branch/branch family executions to maximize knowledge of outcome distributions.
Any solution will almost certainly require a communication from an algorithmic model using a random draw to the simulation engine/execution manager to inform it of the branching point, provide the branch probabilities, and store state information. It is critical that the developed solution minimize the complexity of developing the M&S software implementing this model to the simulation engine interface. The developed architecture must not only execute efficiently, but it must be scalable and should not introduce any significant burden on developers of the simulations and the underlying algorithmic models.

PHASE I: Develop a proof-of-concept of the algorithms, tools, software and analyses that demonstrate potential for achieving the topic objectives:
- Stochastic batch speed-up (via speed test comparisons vs. traditional)
- Increased knowledge and confidence in scenario outcome/output distributions (via test & analysis comparing resulting distributions and confidence intervals with traditional methods, including marginal gain with more executions)
- Scalability as number of random draws increases (via demonstration & analysis with increasingly complex stochastic models/simulation/scenarios)
- Minimized development and maintenance workload for models and simulation infrastructure using the developed capability (via demonstration and analysis of required software tasks)

PHASE II: Develop a full prototype capability demonstrating initial capabilities per topic objectives with the intent in testing the capability for experimentation in government M&S labs. This should include prototype level user and design documentation. Development should facilitate cyber security approval for loading the prototype software on government computer systems through cyber aware design decisions and development of cyber security artifacts.

PHASE III DUAL USE APPLICATIONS: Develop operational capability for use in government simulations, including user and design documentation. Maintain and improve capabilities based on Phase II and Phase III use experience. Continue to support cyber assurance.

REFERENCES:

1. 1) S. B. Yoginath, M. Alam and K. S. Perumalla, "Energy Conservation Through Cloned Execution Of Simulations," 2019 Winter Simulation Conference (WSC), 2019, pp. 2572-2582, https://ieeexplore.ieee.org/document/9004821
2. 2) Xiaosong Li, Wentong Cai, and Stephen J. Turner. 2017. Cloning Agent-Based Simulation. ACM Trans. Model. Comput. Simul. 27, 2, Article 15 (July 2017), 24 pages. DOI: https://doi.org/10.1145/3013529
3. 3) C. Lammers, J. Steinman, M. Valinski, K. Roth. “Five-Dimensional Simulation for Advanced Decision Making,” SPIE—Enabling Technologies for Simulation Science XIII, Paper SPIE 7348-16.

KEYWORDS: Models; Simulation; M&S; Simulation Engines; Stochastic Models; Random Models; Uncertainty; Probability; Statistics; Simulation Cloning; Cloned Execution; 5-D Simulation; Five-Dimensional Simulation; Paratemporal Simulation; Simulation States

VERSION 3

MDA22-T002 TITLE: Recommendation Technology for Digital Engineering Artifacts

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

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop innovative recommendation algorithms applicable to digital data engineering artifacts and tools that could be used by system engineers for the Missile Defense System (MDS) Systems of Systems (SoS) to support identification and classification of authoritative sources of truth (ASoT) throughout system development life cycles.

DESCRIPTION: This topic seeks new and innovative technologies for applying a user-personalized content recommendation engine for collaborative filtering based on the user's reviews and comments, sentiment analysis, and ratings for artifacts and tools throughout the Systems Engineering (SE) V process applied to new artifacts and tools. Existing recommendation engines (e.g. crowdsourcing techniques) were developed for large scale commercial applications that draw upon millions of users with billions of inquiries on common topics to establish preferred relationships. Government engineers would number in the hundreds, and would make tens of thousands of inquiries on specialized technical engineering, data, and Modeling and Simulation (M&S) artifacts, many unique to the Government. These artifacts generally would be associated with Model Based Systems Engineering (MBSE) artifacts providing significant direct correlation data. However, preferred relationships will change as systems progress through their development cycles and include additional artifacts and data such as engineering analysis, test data, M&S data, RAM data, production and fielding data.
Often, products and data are developed at each level of the V-model, then passed on to the next level in a stove piped fashion and are not treated as a strategic asset that exists across the entire lifecycle. Thus, these products are usually not reusable or extensible for other aspects of engineering. Additionally, knowledge learned throughout this process is difficult to capture and reinsert into the next round of activities by the people that are developing and using the next round of artifacts and tools.
With the complexity of the MDS increasing and the amount of data exponentially increasing, faster and smarter engineering techniques and tools that are based on collaborative development of pipelines that work in automatic ways while enabling a user content recommendation engine are desired. In addition, technologies that allow one to query across all the collected and metadata tagged engineering data sets are also desired. Lastly, technologies that enhance the quality and effectiveness of the MDS, shorten integration time enabling the government to gain efficiencies reducing schedules, and produce more lethal weapon systems are also of interest.

PHASE I: Design and develop improved solutions, methods, and concepts for applying user-personalized content recommendation engines and crowdsourcing in systems engineering to create and rate sources of truth and knowledge across the MDS SoS. The solutions should capture the key areas where new development is needed, suggest appropriate methods and technologies to minimize the time intensive processes, and incorporate new technologies researched during design development. Define the architecture and data structures for the MDS M&S enterprise.

PHASE II: Complete a detailed prototype design user-personalized content recommendation engine and a crowd sourced environment incorporating government performance requirements. The contractor should coordinate with the government during prototype design and development to ensure that the delivered

products will be relevant to ongoing and planned missile defense projects. This prototype design will be used to form the development and implementation of a mature, full-scale capability in Phase III.

PHASE III DUAL USE APPLICATIONS: Scale-up the capability from the prototype utilizing the new hardware and/or software technologies developed in Phase II into a mature, fieldable capability. Work with missile defense integrators to integrate the technology for a missile defense system level engineering environment.

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2. 2) https://www.af.mil/Portals/1/documents/7/Take_the_Red_Pill-Digital_Acquisition.pdf
3. 3) https://ieeexplore.ieee.org/document/8601282

KEYWORDS: Digital Engineering; MBSE; Data Science; Machine Learning; System of Systems; data strategy; content recommendation engine; crowd source

VERSION 3

MDA22-T003 TITLE: Surrogate Models to Accelerate High-Fidelity Physics Based Simulation

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

TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Creation of a simulation emulator that accelerates execution time by orders of magnitude and includes uncertainty quantification without requiring large amounts of training data.

DESCRIPTION: End-to-end simulations have significantly improved the ability to massively parallelize simulations in cloud based HPC environments. However, cloud based environments can be expensive and can be infeasible to acquire the number of resources needed in an acceptable time span. Creating simulation emulators is a popular approach to speeding up simulation execution; however, traditional methods, such as data driven models or traditional machine learning models, have several limitations including requiring large amounts of data, limited accuracy, narrow applicability, and uncharacterized uncertainty.
Recent advances in physics-informed machine learning (PIML) and reduced order modeling have demonstrated incredible promise at accelerating traditional simulators (sometimes up to 1,000x faster) while sacrificing minimal amounts of fidelity. Replacing these bottlenecks enables the ability to scale these simulations to collect sufficient data in resource-constrained environments.
This topic seeks to further develop and utilize these advances in surrogate modeling to accelerate a specific bottleneck in simulation execution (such as debris or EO-IR scene generation) using a limited amount of data. This acceleration of simulation will remove barriers to real-time and faster-than-real-time execution and enable rapid testing and prototyping. The surrogate model will characterize its uncertainty and explicitly define its bounds of applicability. Beyond demonstration of a specific use case, the approach will be generalizable to other simulation components.

PHASE I: Develop proof-of-concept algorithms, tools, software and analyses that demonstrate a potential for achieving the topic objectives:
- Identify candidate physics models at unclassified level
- Develop evaluation metrics for comparison to existing model baseline
- Incorporate physics based simulation execution time enhancements
- Provide increased knowledge and confidence in surrogate models derived from high fidelity physics based data and simulations
- Demonstrate understanding of uncertainty and bounds of applicability for surrogate models

PHASE II: Develop a full prototype capability demonstrating initial capabilities per topic objectives (per Phase I) with the intent of testing the capability for experimentation in government Modeling and Simulation labs using government provided physics models. This should include prototype level user and design documentation. Development should facilitate cyber security approval for loading the prototype software on government computer systems through cyber aware design decisions and development of cyber security artifacts.

PHASE III DUAL USE APPLICATIONS: Develop operational capability for use in government simulations, including user and design documentation. Maintain and improve capabilities based on Phase I and Phase II use experience. Continue to support cyber assurance.

REFERENCES:

1. 1) Kasim, M., Watson-Parris, D., Deaconu, L., Oliver, S., Hatfield, P., Froula, D. & Vinko, S. (2020). Up to two billion times acceleration of scientific simulations with deep neural architecture search. In APS Division of Plasma Physics Meeting Abstracts (Vol. 2020, pp. BO05-001)
2. 2) Kadupitiya, J. C. S., Sun, F., Fox, G., & Jadhao, V. (2020). Machine learning surrogates for molecular dynamics simulations of soft materials. Journal of Computational Science, 42, 101107
3. 3) Moseley, B., Markham, A., & Nissen-Meyer, T. (2021). Finite Basis Physics-Informed Neural Networks (FBPINNs): a scalable domain decomposition approach for solving differential equations. arXiv preprint arXiv:2107.07871

KEYWORDS: Surrogate Models; Hybrid Models; Data Driven Models; Physics Based Models; physics-informed machine learning; machine learning; reduced order modeling

VERSION 3

MDA22-T004 TITLE: Deep Reinforcement Learning (DRL) Enabled Warfighter Assistant

OUSD (R&E) MODERNIZATION PRIORITY: Network Command, Control and Communications; Autonomy; Artificial Intelligence/Machine Learning; General Warfighting Requirements

TECHNOLOGY AREA(S): Weapons; Sensors; Information Systems; Human Systems; Battlespace

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

OBJECTIVE: Create explainability tools and methods to be applied to machine learning (ML) agents capable of assisting warfighters in training and operational scenarios.

DESCRIPTION: With the growing complexity of the world, the warfighter's decision space has become enormous. While there are existing techniques, tactics, and procedures defined by an engagement doctrine, it is infeasible for a human to predict and respond to the entire set of intricate strategies an adversary might present. Recent advances in DRL have been able to create powerful agents capable of making decisions under uncertain and complicated scenarios, but the reasoning behind the DRL suggestions is often opaque. Humans must remain in the loop during operations due to the high-consequence nature of the environment and they must also have confidence that the DRL recommendation is trustworthy. Therefore, in addition to developing these ML capabilities, there is a need to also transition them into assistive tools for humans. This topic seeks to (1) develop explainable reasoning behind DRL generated recommendations and (2) integrate them into intuitive and interpretable tools capable of assisting analysts and decision makers. This would allow for increased adoption and trust of ML based solutions and enhanced warfighter effectiveness in assessing current status of forces, threats, and response options. Courses of action can be recommended using a DRL trained agent and explained with assistive tools.

PHASE I: Develop proof-of-concept algorithms, tools, software and analyses that demonstrate potential for achieving the topic objectives:
- Identify notional simulation and scenario for DRL
- Develop explainability features and increase transparency of DRL agent decision making
- Explain factors influencing DRL based suggestions and actions
- Develop concepts for explainability and trust tool integration into analyst and/or warfighter interfaces

PHASE II: Develop a full prototype capability demonstrating initial capabilities per topic objectives (per Phase I) with the intent of testing the capability for experimentation in government Modeling and Simulation labs using government provided DRL framework. This should include prototype level user and design documentation. Development should facilitate cyber security approval for loading the prototype software on government computer systems through cyber aware design decisions and development of cyber security artifacts.

PHASE III DUAL USE APPLICATIONS: Develop operational capability for use in government simulations, including user and design documentation. Maintain and improve capabilities based on Phase I and Phase II use experience. Continue to support cyber assurance.

REFERENCES:

4. https://deepmind.com/research/case-studies/alphago-the-story-so-far
5. https://www.darpa.mil/news-events/2020-08-07 Advanced algorithms to fly simulated F-16 dogfights against each other, Air Force pilot in online finale

KEYWORDS: Deep Reinforcement Learning; Data Driven Models; machine learning; agent based models; decision making; decision aids; recommendation engines; operator assistants

VERSION 3

MDA22-T005 TITLE: Improved Hypersonic Jet Interaction Modeling with Propulsion Exhaust Chemistry

OUSD (R&E) MODERNIZATION PRIORITY: Hypersonics

TECHNOLOGY AREA(S): Weapons

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

OBJECTIVE: Develop improved tools to model hypersonic jet interaction that account for reactive chemistry of propulsive plumes.

DESCRIPTION: Future hypersonic interceptors may require lateral divert thrusters for maneuverability. Plumes from these thrusters can create jet interaction effects when they interact with the hypersonic flow field. These interactions are very complex and are impacted by a number of factors including vehicle geometry, velocity, altitude, etc. Jet interaction can be modeled through existing computational fluid dynamics (CFD) codes, but challenges arrive in the tradeoffs between fidelity and required computing power. In particular this topic seeks improved modeling tools that can assess chemistry of the plume, its reactions with the air, and its potential effects on interceptor instrumentation.
Models should be capable of assessing jet interaction of plumes from both liquid propellants, such as hydrazine based bipropellants, and solid propellants, such as ammonium perchlorate based composite propellants. Tool development should focus on improving fidelity, while retaining reasonable computing power requirements to allow for sufficient quantities of simulations to support trade studies typical in aerospace system developments. Tools should be capable of performance for a wide range of vehicle geometries, velocities, and altitudes.

PHASE I: Conduct modeling and simulation that provides proof of concept for the proposed tools for use with either solid or liquid propellant chemistries in hypersonic flows. The government will provide a generic interceptor geometry that can be used.

PHASE II: Optimize the simulation tools and demonstrate effectiveness for both solid and liquid propellant plumes. Validate tools with hypersonic wind tunnel testing for at least 1 reactive plume chemistry.

PHASE III DUAL USE APPLICATIONS: Commercialize modeling tool and provide it to hypersonic interceptor system integrators.

REFERENCES:

1. U.S. Missile Defense Agency. August 6, 2021. Missile Defense System. Retrieved from http://www.mda.mil/index.html
2. George P. Sutton. 2010. "Rocket Propulsion Elements." 8th edition, John Wiley & Sons Inc.

3. Praharaj, S. C., Roger, R.P., Chan, S. C., and Brooks, W. B. “CFD Computations to Scale Jet Interaction Effects from Tunnel to Flight”. AIAA Paper 97-0406, January 1997
4. Hsieh, T. and Wardlaw, A. B. Jr., “Numerical Simulation of Cross Jets in Hypersonic Flow Over a Biconic Body,” AIAA Paper 94-0165, Jan 1994.
5. Robinson, Michael A., “Application of CFD to BMDO JI Risk Mitigation: External Burning,” AIAA Paper No. 99-0803, 37th Aerospace Sciences Meeting and Exhibit, Reno, NV, Jan. 1999.

KEYWORDS: Jet Interaction; Plumes; Computational Fluid Dynamics; Hypersonics; rocket propulsion

VERSION 3

MDA22-T006 TITLE: Femtosecond Direct Diode Laser System (fsDDLS) Enabling Hypersonic Drag Reduction

OUSD (R&E) MODERNIZATION PRIORITY: Microelectronics; Hypersonics; Directed Energy

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

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

OBJECTIVE: Develop high performance, low Size, Weight, and Power (SWaP) fsDDLS capable of generating and sustaining filaments/plasma channels in the atmosphere ahead of a vehicle in hypersonic flight to reduce drag, heating, and displace shock.

DESCRIPTION: This topic seeks the development of fsDDLS with SWaP appropriate for practical on board flight application and with sufficient energy deposition capability to effect drag reduction on a hypersonic vehicle via Laser filamentation. A fsDDLS has the potential to provide high (>70%) electrical-to-optical power conversion efficiency (PCE) in a relatively simple compact package vs. more complex Lasers (Fiber Lasers, Solid State Lasers, Gas Lasers, Diode Pumped Alkali Lasers, etc.). Two common approaches for achieving short pulse widths (taken as Full Width at Half Maximum (FWHM)) with laser diodes include gain switching, i.e. modulating the optical gain by switching the pump current, and mode locking. Mode-locked laser diodes can be external-cavity devices or monolithic devices and mode locking can be active, passive or a combination thereof. Ultimately, to achieve higher optical output power any design would involve some form of stacking or compact arrangement of individual diodes, with provision made for integrated cooling and temperature control. To achieve adequate optical output beam quality one would also expect a creative approach to combine, condition, and collimate output from the diode array. Approaches that rely on a fiber output would need to take into account pulse dispersion and other effects that might impact output quality. The end goal is a laser module with external access for power, control electronics, and thermal management (i.e. some means of controlled heat exchange that will not impact surrounding avionics and flight package), as well as an optical output port that could be configured for a specific application in Phase III that would involve generating optical filaments or plasma channels in the atmosphere.

Femtosecond-laser plasmas form when atoms or molecules are ionized by high intensity laser pulses with widths on the order of tens to hundreds of femtoseconds (fs). The weak plasma is created via multiphoton ionization, where electrons absorb multiple photons to overcome the ionization potential of an atom or molecule. Filaments form when sufficient radiation is applied to cause self-focusing (Kerr effect) along the beam path. The filament is sustained by balancing self-focusing (Kerr effect) and defocusing (Kerr saturation) along the path to create a weak plasma channel in the transmission medium. If a filament is created in a hypersonic flow, additional energy can be deposited in the channel to displace gas and disrupt shockwaves in the hypersonic flow. In theory, a channel created by a vehicle mounted fsDDLS in hypersonic flight could reduce drag, heating, and displace shockwaves in a manner similar to an aero-

spike. Laser aero-spikes have been studied in the past; however, in that case energy was concentrated at a point in the flow ahead of the target; whereas, a vehicle mounted fsDDLS could create a reduced density channel extending tens of meters (or more) ahead of the vehicle.
Performance goals for system include: operation at a central wavelength of ~800 nm, with pulse duration around 50 fs to 200 fs, peak pulse power above 15 GigaWatts (GW), pulse energy greater than 5 millijoules, and average output power greater than 5 Watts, assuming a pulse repetition rate of 1 kHz. For demonstration purposes, a laser module that is roughly 50mm x 100mm x 25mm or smaller, with mass under 3 kg desired. In a hypersonic flight application, a fully developed module would need to be able to survive dynamic environments encountered by avionics and electronics carried in hypersonic flight and natural and manmade radiation environments that might be encountered at high altitude in a worst case scenario.

PHASE I: Develop preliminary system design(s) with anticipated performance. Perform modeling, simulation and analysis (MS&A) and/or limited bench level testing to demonstrate the concept and an understanding of the technology. The proof of concept demonstration may be subscale and used in conjunction with MS&A results to verify scaling laws and feasibility.

PHASE II: Complete a critical design and demonstrate the use of the technology in a table top/brass board prototype. Evaluate the effectiveness of the technology. Perform MS&A and characterization testing within the financial and schedule constraints of the program to show the level of performance achieved. If brass board achieved, government can provide independent test and characterization. Develop a plan for Phase III product design, fabrication, test and characterization.

PHASE III DUAL USE APPLICATIONS: Incorporate lessons-learned from the Phase II prototype into a product design and fabricate/assemble a test unit. Work with government and/or government contractor to demonstrate product's performance improvement as compared to the state of the art. Work with government and/or government contractor to fully qualify the product for the intended application(s). Assist government and/or government contractor in integrating this product into a demonstrator system and assist with test and characterization.

REFERENCES:

1. S. Zeng, et.al, "Photonic integrated circuit based beam combining for future direct diode laser systems," Conference on Lasers and Electro-Optics, OSA Technical Digest (OSA, 2020), paper SF1O.6. https://www.osapublishing.org/abstract.cfm?URI=CLEO_SI-2020-SF1O.6
2. Benjamin Döpke, et.al, Self-optimizing femtosecond semiconductor laser, Opt. Express (23)8, 9711-9716 (2015).
3. Martin Hofmann, Mode-locked Diode Lasers from Microscopic Analysis to Femtosecond Pulses, Final Report, Grant No. FA9550-14-1-0137, 02/28/2018. (Search term: AFRL-AFOSR-UK-TR-2018-0027).
4. Zhu, Y., "Hybridly Integrated Diode Lasers for Emerging Applications: Design, Fabrication, and Characterization" (2019). All Dissertations. 2510. https://tigerprints.clemson.edu/all_dissertations/2510
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VERSION 3

KEYWORDS: Direct Diode Laser System; DDLS; Femtosecond Semiconductor Laser; Femtosecond Direct Diode Laser; Femtosecond Diode Laser; Laser Filamentation; Laser Aero-Spike

VERSION 3

MDA22-T007 TITLE: Quantum-Computing-Aided Materials Research and Development

OUSD (R&E) MODERNIZATION PRIORITY: Quantum Sciences

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 the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: This topic seeks to demonstrate the use of quantum computing-based modeling and simulation to design and develop lightweight structural materials.

DESCRIPTION: The government has interest in developing quantum computing-based software to design new lightweight materials that surpass the strength to weight ratios of existing materials such as titanium and carbon/epoxy-based composites. Lightweight structures can provide benefit to missile systems through volume and mass reduction, allowing for increased interceptor range and decreased booster size.

Quantum computers have the potential to exponentially outperform classical computers for certain problems, due to their use of qubits (rather than 0/1 bits) to store information, and to the property of quantum entanglement between bits. While reliable large-scale quantum computing remains some years away, many different organizations are currently making major progress. Quantum computing could be very effective for engineering new materials; recent interest from industry has resulted in early development of quantum methods that simulate the molecular interactions and material properties of the near-infinite number of possible material recipes with the goal to down-select based on desired material properties [1].

Design and simulation of the materials for this topic should ultimately be accomplished through quantum computing methods. Proposers may choose to focus on different lightweight structure types, such as metals or composites. The ultimate goal should be design of a completely new material. For example, consider high-entropy alloys which consist of 5 or more different elements [2]. Utilizing traditional computing to assess all the different combinations would be impractical, but quantum computing methods could more efficiently find an optimal composition for structural applications. Desired material properties include long-term stability at ambient conditions and retention of high strength to weight properties at elevated temperatures.

PHASE I: Phase I should include a feasibility study investigating the use of a quantum software simulation capability that would enable engineering of materials. The software should involve a simulation of quantum interactions between atoms and the resulting properties.

PHASE II: Phase II should include an investigation into the availability of quantum computing hardware that is able to support the software simulation capability developed in Phase I. Phase II should also

include engineering of a candidate lightweight structural material that can be analyzed using the notional software from the Phase I. Fabrication of the engineered material is desired but not required.

PHASE III DUAL USE APPLICATIONS: Phase III should combine the efforts of Phase I and Phase II to realize the engineered candidate material in physical form. Testing should be performed on the material to determine the accuracy of quantum software simulation predictions.

REFERENCES:

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2. E. P. George, D. Raabe, and R. O. Ritchie "High-entropy alloys," Nature Reviews Materials, 2019.

KEYWORDS: Quantum Computing; Engineered materials; Lightweight Structures; Modeling and Simulation; Combinatorics

VERSION 3

MDA22-T008 TITLE: Diode-pumped Alkali Laser Key Energetics Parameters Measurement and Assessment

OUSD (R&E) MODERNIZATION PRIORITY: Directed Energy

TECHNOLOGY AREA(S): Ground Sea; Weapons; Space Platforms; Air Platform

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

OBJECTIVE: Design and conduct an experiment to measure and assess the electron energy distribution of the gain medium of a high-power diode-pumped alkali (rubidium) laser (DPAL) with high-pressure helium.

DESCRIPTION: As DPAL systems scale up in power, they form a plasma that reduces the optical to optical efficiency, resulting in increased gas heating, poor size, weight, and power, and possible negative impacts to beam quality. An experimental understanding of the electron number density and the electron energy distribution function (EEDF) is needed for model validation to assess scaling potential. However, EEDF parameters involved in the lasing interactions have only been calculated, not directly measured. As the EEDF varies based on the environment, its measurement has proved difficult for parameter spaces of interest. This topic seeks methods for direct measurement of the EEDF that will enable the DPAL systems under development to scale to operationally relevant powers. The measurements are required to be made under a variety of buffer gas pressures, laser intensities, and rubidium densities. Techniques of interest for measuring these key parameters include but are not limited to Thomson Scattering, Stark Broadening, and microwave interferometry.

PHASE I: Design an experiment to obtain measurements of EEDF (ion density). Phase I includes completing and delivering a methodology and design to measure the EEDF under relevant pump laser intensities, buffer gas pressures, and rubidium densities. Produce a cost estimate and schedule to carry out such an experiment. Identify long-lead items which must be procured. Work with the Government and independent evaluators designated by the Government to identify areas of improvement for the design to provide more relevant data.

PHASE II: Complete the EEDF measurements experiment and deliver the data to the Government. Phase II includes updating the design of the Phase I experiment based on Government feedback. Procure equipment necessary for the experiment. Assemble experimental apparatus as required. Conduct experiments to collect data to measure the electron number density and the electron energy distribution function (EEDF). The measurement shall be made under a variety of buffer gas pressures, laser intensities and rubidium densities that will be decided together with the Government. Collect and analyze the data and deliver to the Government. Work with the Government and independent evaluators designated by the Government to identify areas of improvement for the experimental design and procedure to provide more relevant data. Implement changes based on feedback.

Approved for Public Release (topics)
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PHASE III DUAL USE APPLICATIONS: The goal of this phase is to transfer the information and knowledge gained in Phase II to the DoD Diode Pumped Alkali Laser community, to include any industry partner that is involved in scaling the DPAL to weapon system power levels. This effort may include incorporating the information into a DPAL model.

REFERENCES:

1. O. Zatsarinny, et al.," Electron collisions with Cesium atoms – benchmark calculations and applications to an electron-pumped excimer," Plasma Sources, Science, and Technology, 23 #3, pp 1-7, (2014)
2. Hai P. Le and Jean-Luc Cambier, "Conservative algorithms for non-Maxwellian plasma kinetics," Phys. Plasmas, 24, 122105 (2017)
3. M. S. Dimitrijevic and S. Sahal-Brechot, "Stark Broadening of Neutral Potassium Lines," J. Quant. Spectrosc. Radiat. Transfer Vol. 38, No. 1, pp 37-45, (1985)
4. V. M. Donnelly, "Plasma electron temperatures and electron energy distributions measured by trace rare gases optical emission spectroscopy", J. Phys. D: Appl. Phys. 37 R217, (2004)
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KEYWORDS: DPAL; Diode-pumped Alkali Laser; Electron Energy Distribution Function; Ion Density

VERSION 3

MDA22-T009 TITLE: Enhancement of Non-Kinetic Capabilities for Ballistic Missile Defense

OUSD (R&E) MODERNIZATION PRIORITY: Space; Directed Energy

TECHNOLOGY AREA(S): Weapons; Sensors; Space Platforms

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

OBJECTIVE: This topic seeks innovative technologies to apply and defeat incoming ballistic missiles to provide the capability and capacity to outpace the threat.

DESCRIPTION: Ballistic missile defense concepts and capabilities in all phases of the threat flight are desired. Of particular interest are non-kinetic solutions such as directed energy capabilities. The Government is interested in Directed Energy System concepts with weapon, sensor and fire control component technologies and Test and Evaluation. Directed Energy Component technologies desired include, but are not limited to, ion sources, radio frequency quadrupoles (RFQ), drift tube LINACS, Charge Couple Cavities, beam sensing and beam steering, magnetic optics, and neutralizers. Innovative solutions for neutral beam ion sources, radiofrequency quadrapole (RFQ), and other required linear accelerator components are desired. Innovative solutions for magnetic optics, beam steering and beam sensing, neutralizers, and detectors are also desired. Facilities for integration of these component technologies are desired.

PHASE I: Develop and conduct proof-of-principle concept studies, simulations and/or demonstrations of neutral beam techniques, algorithms, component technologies and development of component technologies.

PHASE II: Phase II will provide for integration and test of component technologies. Update/develop studies, algorithms and component technologies and techniques based on Phase I results and demonstrate technology in a laboratory environment. Demonstrate component technologies meet the component requirements to support integration into an effective concept.

PHASE III DUAL USE APPLICATIONS: Phase III will provide transition to project or program for future system. Integrate components, techniques and algorithms into missile defense systems and demonstrate the improved overall updated capability. Pursue partnerships with DoD system integrators. Dual use applications include missile defense and high energy physics basic research.

REFERENCES:

1. Toole, Michael T and Willis, Jay C, “Paper Session 1-A – Neutral Particle Beam Overview” (1990), The Space Congress Proceedings, 16.
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KEYWORDS: Ion sources; radiofrequency quadrapole; drift tube LINAC; Charged Couple Cavities; magnetic optics; beam sensing; beam steering; neutralizer; detectors

VERSION 3

MDA22-T010 TITLE: Additive Manufacturing of Advanced Metallics

OUSD (R&E) MODERNIZATION PRIORITY: Space; Hypersonics

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 the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Demonstrate additive manufacturing of metallic materials for hypersonic flight systems.

DESCRIPTION: This topic seeks innovative additive manufacturing processes to produce metallic components that increase both availability and reliability of metallic materials for use in hypersonic flight vehicles. The extreme operational environment that hypersonic flight vehicles experience requires structural components that are capable of withstanding high temperatures and loads. Development of material and manufacturing technology for advanced metallic components is applicable for the development of hypersonic flight systems to include both threat test targets and missile defense systems, with the intent of overcoming the current availability and manufacturing deficiencies for producing aerospace grade materials of specific alloys that have high strength and high temperature resiliency. Evaluation criteria for proposed material solutions include thermal expansion, thermal conductivity, specific heat, and strength assessments that show performance equivalent to or exceeding that of current material solutions that use traditional manufacturing approaches such as casting or forging. These materials should show the ability to perform in structural and thermal conditions representative of operation in the hypersonic flight environment. The Inconel family of alloys is the performance baseline for proposed high temperature high strength materials. Proposed material solutions should provide consistent and quality components that can survive in high temperature environments. Additionally, additive manufacturing approaches will show enhanced performance and a decrease in manufacturing costs by enabling near net shape fabrication and reducing production timelines.

PHASE I: Demonstrate the technical feasibility of the proposed materials approach. Provide technical demonstration that material solutions are viable in hypersonic environments via material properties and analysis. Develop test plans to demonstrate manufacturing design parameters and ground testing of components. Develop manufacturing and quality approach for full-scale sized components.

PHASE II: Actively demonstrate the innovative material approach by manufacturing subscale coupons of materials for laboratory and ground testing. Evaluate material performance in hypersonic relevant environments via analysis and testing. Conduct manufacturing assessments to determine statistical parameters of quality and repeatability. Provide the Government with preliminary cost and schedule projections of material components compared to the current state-of-the-art.

PHASE III DUAL USE APPLICATIONS: Demonstrate use of full-scale components in hypersonic environments. Develop full-scale manufacturing capabilities providing data on quality and reliability of components. Provide full-scale cost assessments for production.

REFERENCES:

1. Materials and structures for hypersonic vehicles Darrel R. Tenney, W. Barry Lisagor, and Sidney C. Dixon Journal of Aircraft 1989 26:11, 953-970
2. Byron Blakey-Milner, Paul Gradl, Glen Snedden, Michael Brooks, Jean Pitot, Elena Lopez, Martin Leary, Filippo Berto, Anton du Plessis, Metal additive manufacturing in aerospace: A review,
3. Materials & Design, Volume 209, 2021, 110008, ISSN 0264-1275, https://doi.org/10.1016/j.matdes.2021.110008.

KEYWORDS: Additive Manufacturing; Advanced Materials; Advanced Metallics; Hypersonics

VERSION 3

MDA22-T011 TITLE: Hypersonic Seeker Window Attachment for Hypersonic Flight Systems

OUSD (R&E) MODERNIZATION PRIORITY: Hypersonics

TECHNOLOGY AREA(S): Sensors; Materials

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

OBJECTIVE: Demonstrate innovative infrared (IR) and radio frequency (RF) window materials and integrated antenna technology for hypersonic flight systems.

DESCRIPTION: The Government is seeking innovative solutions to enable hypersonic missile systems with seeker capabilities. Advanced windows are generally only available in small quantities and manufactured by traditional processes in laboratories. The Government would like to establish an additive manufacturing method to produce window materials that are reliable, consistent, and optimized to perform in hypersonic environments.

Materials will need to demonstrate that RF and/or IR signals can be transmitted through the materials while in high temperature ranges expected for hypersonic applications (>500-1,000°C). In addition, load testing at elevated temperatures is required to analyze thermal gradient effects on the material. Window materials will need to interface and attach to hot structural hypersonic aeroshell materials including but not limited to carbon composites.

The Government is interested in utilizing state of the art additive manufacturing technology to design and manufacture window materials. Additive manufacturing is highly desired to allow near net shape manufacturing of components to reduce manufacturing time and to lower costs. Additive manufacturing also allows for material customization and optimization for specific applications to enhance performance. The goals of this development effort center on (1) leveraging new materials and technology to produce RF and/or IR seeker windows that survive the hypersonic environment while interfacing with aeroshell materials and (2) implementing an additive manufacturing approach that provides cost and schedule advantages over existing technologies. Material production should be automated to provide consistent and quality components that can survive in extreme hypersonic thermal and structural environments while maintaining optical efficiency.

PHASE I: Demonstrate the technical feasibility of the proposed material approach. Provide technical demonstration that material solution(s) are viable in hypersonic environments via material properties and analysis. Develop test plans to demonstrate manufacturing design parameters and thermo-structural and optical ground testing of window and attachment components. Develop manufacturing and quality approach for full-scale components.

PHASE II: Actively demonstrate the innovative material approach by manufacturing subscale coupons of window and attachment materials for laboratory and ground testing. Evaluate material performance in hypersonic relevant environments via analysis and testing. Conduct manufacturing assessments to determine statistical parameters of quality and repeatability. Provide the Government with preliminary cost and schedule projections of material components compared to the current state-of-the-art.

PHASE III DUAL USE APPLICATIONS: Demonstrate use of full-scale components in hypersonic environments. Develop full-scale manufacturing capabilities providing data on quality and reliability of components. Provide full-scale cost assessments for production.

REFERENCES:

1. Chan, C. B. and Singh, N. “Calculation of refractive index around a hypersonic vehicle with infrared sensors.” Proceedings IEEE Southeastcon'92, April 1992, pp. 562-565. https://doi.org/10.1109/SECON.1992.202416.
2. Krell, A.; Baur, G. M. and Dahne, C. “Transparent sintered sub-µm Al2O3 with IR transmissivity equal to sapphire.” International Society for Optics and Photonics, Window and Dome technologies VIII, Vol. 5078, September 2003, pp. 199-207. https://doi.org/10.1117/12.485770.

KEYWORDS: Seeker Window; Sensors; Hypersonic; High Temperature; Additive Manufacturing; Advanced Materials

VERSION 3

MDA22-T012 TITLE: Structural Insulators for Hypersonic Flight Systems

OUSD (R&E) MODERNIZATION PRIORITY: Hypersonics

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 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: Mature manufacturing of insulation materials that can survive in high temperature environments.

DESCRIPTION: Advanced insulation methods are sought for the design of hypersonic systems to manage and reduce the amount of heat transferred from the aeroshell to sensitive internal electronic equipment (flight computer, batteries, etc.). The Government desires insulating materials that can reduce heat transfer to internal components in addition to supporting structural loading of the surrounding aeroshell.

Hypersonic structural insulation materials need to be able to operate nominally when saturated at temperatures in the range of 1,000-1,500°C, maintaining structural and thermal performance integrity. Use of additively manufactured components is an additional requirement to allow for manufacturing cost savings and customized shapes that can interface with complex surfaces.
Proposed material solutions must meet a combination of characteristics for use in Government hypersonic applications to include (1) survivability in high temperature environments (1,000-1,500°C), (2) superior heat transfer characteristics, (3) compressive, tensile, and shear loading capabilities, (4) use of additive manufacturing processes, and (5) repeatable manufacturing methods to allow reliable material properties.

PHASE I: Demonstrate the technical feasibility of the proposed materials approach.
Provide technical demonstration that material solutions are viable in hypersonic environments via material properties and analysis. Develop test plans to demonstrate manufacturing design parameters and ground testing of components. Develop manufacturing and quality approach for full-scale sized components.

PHASE II: Actively demonstrate the innovative material approach by manufacturing subscale components for laboratory and ground testing. Evaluate material performance in hypersonic relevant environments via analysis and testing. Conduct manufacturing assessments to determine statistical parameters of quality and repeatability.

PHASE III DUAL USE APPLICATIONS: Demonstrate use of full-scale components in hypersonic environments. Develop full-scale manufacturing capabilities providing data on quality and reliability of components. Provide full-scale cost assessments for production.

REFERENCES:

1. David Glass. "Ceramic Matrix Composite (CMC) Thermal Protection Systems (TPS) and Hot Structures for Hypersonic Vehicles," AIAA 2008-2682. 15th AIAA International Space Planes and Hypersonic Systems and Technologies Conference. April 2008. https://ntrs.nasa.gov/api/citations/20080017096/downloads/20080017096.pdf
2. Venkatapathy, Ethiraj. “Modern Advances in Ablative TPS.” International Planetary Probe Workshop, 2013. https://ntrs.nasa.gov/citations/20140000871

KEYWORDS: Advanced Materials; Additive Manufacturing; Thermal Protection; Hypersonic; Structural Insulators

VERSION 3

MDA22-T013 TITLE: Low Cost Carbon-Carbon Development for Hypersonic Flight Systems

OUSD (R&E) MODERNIZATION PRIORITY: Hypersonics

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 the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop automated low cost Carbon-Carbon material production methods to provide consistent and quality components that can survive in extreme hypersonic thermal and structural environments.

DESCRIPTION: This topic seeks mature manufacturing processes of low-cost Carbon-Carbon materials for use in government hypersonic flight systems. The Government is looking for material solutions for Carbon-Carbon that can reduce manufacturing time while maintaining component quality. Government hypersonic applications desire Carbon-Carbon solutions that can obtain a density that is consistent and reliable throughout the material component. Emphasis is placed on innovative rapid densification methods, automated weaving techniques, and/or additive manufacturing processes that can enable the significant reduction in manufacturing time. Additional structural requirements will be communicated upon award.

PHASE I: Demonstrate the technical feasibility of the proposed materials approach. Provide technical demonstration that scaled material solutions are viable in hypersonic environments. Develop test plans to demonstrate automated manufacturing parameters and thermo-structural ground testing of subscale components. Develop manufacturing and quality approach for full-scale components. Subscale Carbon-Carbon technology development for Phase I expands to prove manufacturing at a full-scale during the Phase II effort, with sizing requirements provided upon Phase II award.

PHASE II: Actively demonstrate material approach by manufacturing subscale coupons of innovative material(s) for laboratory and ground testing. Evaluate material performance in hypersonic relevant environments via analysis and testing. Conduct manufacturing assessments to determine statistical parameters of quality and repeatability. Provide the Government with preliminary cost and schedule projections of material components compared to the current state-of-the-art. Evaluate material performance in hypersonic relevant environments via analysis and testing. Conduct manufacturing assessments to determine statistical parameters of quality and repeatability.

PHASE III DUAL USE APPLICATIONS: Demonstrate use of full-scale components in hypersonic environments. Develop full-scale manufacturing capabilities providing data on quality and reliability of components. Provide full-scale cost assessments for production.

REFERENCES:

1. Muhammed, F., Lavaggi, T., Advani, S. et al. Influence of material and process parameters on microstructure evolution during the fabrication of carbon–carbon composites: a review. J Mater Sci 56, 17877–17914 (2021). https://doi.org/10.1007/s10853-021-06401-3
2. Reveles, N.D., R.S. Miskovish, and E.L. Blades. “A Closely Integrated Fluid/Solid Framework with Chemistry for Hypersonic Ablating Vehicles.” National Space and Missile Symposium, Chantilly, VA. Jun 2015.

KEYWORDS: Hypersonics; Advanced Manufacturing; Advanced Materials; Carbon-Carbon

Office of the Undersecretary of Defense, Research and Engineering (OUSD(R&E))
Basic Research Office (BRO)
22.B Small Business Technology Transfer (STTR)
Proposal Submission Instructions

INTRODUCTION

The Office of the Undersecretary of Defense, Research and Engineering (OUSD(R&E)) Basic Research Office (BRO) STTR Program aims to facilitate the transition of basic research to applied research by collaborations between academic researchers and small businesses, as well as 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 (R&D) results. The BRO STTR program focuses on exploiting scientific discoveries from the DoD Basic Research Programs and providing a mechanism to further scientific development, maturation, and commercialization. **High-risk with potential for high-reward approaches are sought in addressing the scientific challenges described in the topics below**. These approaches should be stimulated by early research in academia supported by DoD basic research programs.

Proposers responding to a topic in this BAA must follow all general instructions provided in the Department of Defense (DoD) 22.B STTR Program BAA. OSD BRO requirements in addition to or deviating from the DoD Program BAA are provided in the instructions below.

Specific questions pertaining to the administration of the OSD BRO STTR Program and these proposal preparation instructions should be directed to: Dr. Jennifer Becker, Jennifer.j.becker.civ@army.mil.

PHASE I PROPOSAL GUIDELINES

The Defense SBIR/STTR Innovation Portal (DSIP) is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Detailed instructions regarding registration and proposal submission via DSIP are provided in the DoD STTR Program BAA.

Phase I is to determine, to the extent possible, the scientific, technical, and commercial merit and feasibility of ideas submitted under the STTR Program. Proposals should concentrate on research or R&D that 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. **Phase I proposals should clearly articulate the basic research advances that will be exploited. Phase I proposals should also include a tentative plan for Phase II. Evaluation of the Phase I proposal will include an assessment of not only the feasibility studies planned for Phase I, but the overall approach and product proposed at the end of Phase II.** The BRO anticipates funding up to two (2) STTR Phase I contracts to small businesses with their research institution partner for each topic. The BRO reserves the right to not fund a topic if the proposals received have insufficient merit.

The Phase I Base amount must not exceed $150,000 over a period of exactly 6 months and the Phase I Option amount must not exceed $100,000, with a period of performance of exactly 6 additional months.

Technical Volume (Volume 2)

The technical volume is not to exceed 15 pages and must follow the formatting requirements provided in the DoD STTR Program BAA. Technical volumes exceeding 15 pages will be deemed non-compliant and will not be evaluated**.**

Content of the Technical Volume
In addition to the Phase I proposal content specified in DoD STTR BAA, this program requires a narrative description on how early research in academic labs will be transitioned to the small business via this opportunity. In addition, the Phase I Technical Proposal must also include a preliminary Phase II Plan specifying the overall vision, approach, and potential product proposed at the end of Phase II. This must all be included within the 15-page limit for the technical volume.

Include, within the 15-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. Option tasks should be those tasks that would enable rapid transition from the Phase I feasibility effort into the Phase II prototype effort.

The Technical Volume includes, but is not limited to: table of contents, pages left blank, references and letters of support, appendices, key personnel biographical information, and all attachments. It is the responsibility of submitters to ensure that the Technical Volume portion of the proposal does not exceed the 15-page limit. Do not include blank pages, duplicate the electronically generated cover pages or put information normally associated with the Technical Volume such as descriptions of capability or intent in other sections of the proposal as these will count toward the 15-page limit. **BRO STTR Phase I proposals submitted containing a Technical Volume over 15 pages will be deemed NON-COMPLIANT and will not be evaluated. It is the responsibility of the Small Business to ensure that once the proposal is submitted and uploaded into the system that the technical volume .pdf document complies with the 15-page limit.**

Cost Volume (Volume 3)
The Phase I Base amount must not exceed $150,000 over a period of exactly 6 months and the Phase I Option amount must not exceed $100,000 with a period of performance of exactly 6 months. Costs for the Base and Option must be separated and clearly identified on the Proposal Cover Sheet (Volume 1) and in Volume 3.

Company Commercialization Report (CCR) (Volume 4)
Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD STTR Program BAA for full details on this requirement. Information contained in the CCR will not be considered by OSD BRO during proposal evaluations.

Supporting Documents (Volume 5)
BRO will only accept Supporting Documents required by the DoD STTR Program BAA:
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)

PHASE II PROPOSAL GUIDELINES
Phase II proposals may only be submitted by Phase I awardees. All Phase I awardees are eligible to submit a Phase II proposal. Please note that Phase II selections are based, in large part, on the success of the Phase I effort, so it is vital for small business concerns to discuss the Phase I project results with their BRO Technical Point of Contact (TPOC). The 30-day window to submit a Phase II proposal will commence at the end of the Phase I Base Period. The details on the due date, content, and submission

requirements of the Phase II proposal will be provided to Phase I awardees by the BRO STTR PMO via subsequent notification. This will be the only opportunity to submit a Phase II proposal for the BRO topics. The BRO STTR Program *cannot* accept proposals outside the Phase II submission dates established. Proposals received by the DoD at any time other than the submission period will not be evaluated.

Phase II proposals are expected to be structured as follows: a 10-12 month base period not to exceed $850,000; a 10-12 month option period not to exceed $850,000. The entire Phase II effort should not exceed $1,700,000.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)
Technical and Business Assistance is not offered for the OSD BRO topics.

EVALUATION AND SELECTION
All proposals will be evaluated in accordance with the evaluation criteria listed in the DoD STTR Program BAA. The criteria will be in descending order of importance with technical merit, soundness, and innovation of the proposed approach being the most important, followed by qualifications of key personnel, and then followed by the commercialization potential. **Evaluation of the Phase I proposal will include an assessment of not only the feasibility studies planned for Phase I but the overall approach and product proposed at the end of Phase II.** Due to limited funding, the BRO reserves the right to limit awards under any topic. Awards will be made on the basis of technical evaluations using the criteria described in the DoD STTR Program BAA and availability of BRO STTR funds.

Only Government personnel will evaluate proposals with the exception of personnel from Strategic Analysis, Inc who will provide programmatic and administrative assistance for all topics.

Proposing firms will be notified of selection or non-selection status for a Phase I award within 90 days of the closing date of the BAA. Email notifications of selection or non-selection will be sent to the point-of-contact listed as the Corporate Official on the proposal Cover Sheet. Consequently, the e-mail address on the proposal Cover Sheet must be correct.

Requests for a debrief must be made within 30 calendar days of select/non-select notification 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 30 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.

Refer to the DoD STTR Program BAA for procedures to protest the Announcement.
As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: usarmy.rtp.aro.mail.sttr-pmo@mail.mil

AWARD AND CONTRACT INFORMATION
The Phase I Base amount must not exceed $150,000 over a period of exactly 6 months and the Phase I Option amount must not exceed $100,000, with a period of performance of exactly 6 additional months.

ADDITIONAL INFORMATION
Companies should plan carefully for research involving animal or human subjects, biological agents, etc. (Reference details provided in the DoD STTR Program BAA). The short duration of a Phase I effort may preclude plans including these elements unless coordinated before a contract is awarded.

If the offeror proposes to employ a foreign national, refer to the DoD STTR Program BAA for definitions and reporting requirements. Please ensure no Privacy Act information is included in this submittal.

If a small business concern is selected for an STTR award, they must negotiate a written agreement between the small business and their selected research institution that allocates intellectual property rights and rights to carry out follow-on research, development, or commercialization (See Model Agreement for the Allocation of Rights).

END

OSD-BRO STTR 22.B Phase I Topic Index

OSD22B-001 TITLE: Scalable Production of Engineered Designer Proteins Containing Multiple Distinct Non-canonical Amino Acids

OUSD (R&E) MODERNIZATION PRIORITY: Biotechnology

TECHNOLOGY AREA(S): Materials

OBJECTIVE: Develop cellular or cell-free synthetic processes from genomically recoded organisms to achieve robust, reliable and cost-effective production of engineered proteins containing multiple distinct non-canonical amino acids that are scalable to manufacturing-relevant levels.

DESCRIPTION: Biological systems are capable of synthesizing long sequence-defined protein biopolymers with extremely high efficiency and accuracy by employing templates to provide sequence information. The precisely defined sequence of the amino acid building blocks directs the folding and assembly of these proteins into higher-order structures capable of a variety of advanced functions evolved to solve biological challenges such as catalysis, sensing and signal transduction. These higher-ordered natural protein structures also display diverse material properties spanning highly flexible and extensible to extremely tough and fracture resistant. However, natural protein biopolymers are assembled using a limited library of only 20 amino acid monomer building blocks. In contrast, synthetic polymers boast a vast array of monomer building blocks with functionality and properties not accessible to natural proteins. Yet, chemical routes to the synthesis of long-chain polymers with control over monomer sequence have remained elusive. Co-opting the genetic code and the natural translation machinery to accept non-biological monomers is an attractive approach to access the diverse functionality afforded by non-biological chemical monomers while maintaining the precision polymer sequence control provided by biology [1,2]. This approach has the potential to develop novel hybrid biological-abiological polymers with functionalities not accessible either in natural biological systems or via traditional chemical synthesis.

To enable the translation machinery to incorporate monomer building blocks beyond the 20 canonical amino acids, researchers have been exploring expansion of the genetic code through reassignment of degenerate codons to direct the incorporation of non-canonical amino acids [3,4,5]. Using genomically recoded organisms in which one or more codons were reassigned to a non-canonical amino acid, researchers have demonstrated the incorporation of a variety of non-canonical amino acids at a single site within a protein. Building upon these results, researchers have recently demonstrated the incorporation of multiple instances of a single non-canonical amino acid within a protein [6,7] as well as the incorporation of up to three distinct non-canonical amino acids into the same protein [8]. While these results demonstrate the promise of genomic recoding to access complex hybrid biological-abiological polymers with novel functionalities, the efficiency of incorporation of multiple non-canonical amino acids is currently very low, requiring highly sensitive techniques for detection of the targeted engineered protein product.

The objective of this topic is to develop cellular or cell-free biotechnology processes from genomically recoded organisms that support efficient and accurate incorporation of multiple distinct non-canonical amino acids into engineered proteins. Designed processes must consider scaling of protein production to manufacturing-relevant levels for protein-based materials (i.e., exceeding protein production levels that would be relevant for a protein-based therapeutic).

PHASE I: Build on recent advances to design methods for cellular or cell-free synthetic processes from genomically recoded organisms to efficiently and accurately incorporate two (2) distinct non-canonical amino acids in an engineered protein at lab-relevant scales. Design a framework to be implemented in

Phase II that will enable increased production levels of proteins containing multiple non-canonical amino acids by at least a factor of 10 relative to the current state-of-the-art.

PHASE II: Further develop approaches from Phase I to increase the number of multiple distinct non-canonical amino acids incorporated into engineered proteins to three (3) or more. Implement the framework designed in Phase I and demonstrate increased production levels of proteins containing multiple instances of a single non-canonical amino acid and/or proteins containing two or more distinct non-canonical amino acids by at least a factor of 10 relative to the current state-of-the-art.

PHASE III DUAL USE APPLICATIONS: Phase 3 efforts will optimize and develop approaches to incorporate >3 distinct non-canonical amino acids and scale production of hybrid biological-abiological protein polymers to manufacturing-relevant levels for protein-based materials. A variety of dual-use applications would benefit from an efficient production pipeline for engineered hybrid biological-abiological protein polymers, including synthetic enzymes for catalysis, scaffolds for molecular encoding and data storage, nanoelectronics, and self-healing materials.

REFERENCES:

1. Kofman, C. et al. Engineering molecular translation systems. Cell Systems 12, 593-607 (2021);
2. Shapiro, D.M. et al. Protein nanowires with tunable functionality and programmable self-assembly using sequence-controlled synthesis. Nat Commun 13, 829 (2022).
3. Ostrov, N. et al. Design, synthesis, and testing toward a 57-codon genome. Science 353, 819-822 (2016).
4. Sanders, J. et al. New opportunities for genetic code expansion in synthetic yeast. Curr Opin Biotechnol 75, 102691 (2022).
5. Tang, H. et al. Recent Technologies for Genetic Code Expansion and their Implications on Synthetic Biology Applications. J Mol Biol 167382 (2021).
6. Amiram, M. et al. Evolution of translation machinery in recoded bacteria enables multi-site incorporation of nonstandard amino acids. Nat Biotechnol 33, 1272–1279 (2015).
7. Martin, R.W. et al. Cell-free protein synthesis from genomically recoded bacteria enables multisite incorporation of noncanonical amino acids. Nat Commun 9, 1203 (2018).
8. Robertson, W., et al. Sense codon reassignment enables viral resistance and encoded polymer synthesis. Science 372, 1057-1062 (2021).

KEYWORDS: Protein engineering; non-canonical amino acids; genomically recoded organisms; genetic code expansion; sequence-defined polymers; biotechnology

OSD22B-002 TITLE: Intelligent Multi-Laser System for Metal Additive Manufacturing

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

TECHNOLOGY AREA(S): Materials; Information Systems

OBJECTIVE: To significantly accelerate the laser metal powder bed additive manufacturing (LPBAM) process and improve the microstructural quality of LPBAM parts by developing a scalable, intelligent multi-laser based system. In this AM system, some of the lasers query the powder bed quality prior to melting it, while other lasers use that information to intelligently process the powder bed, yet other lasers monitor and control the solidification rates for microstructural control and part quality.

DESCRIPTION: In spite of the significant advantages of the AM process to enable a broader design envelope, there are still significant technological challenges that limit the full utilization of AM. Some of these challenges include, but are not limited to: the slow production rates requiring several hours or days to build parts; post-processing treatments and machining to optimize the build; defects and residual stresses to meet dimensional tolerances. Depending on the materials, AM lacks process stability that can produce consistent, defect-free parts on a first fabrication.

At the root of all these challenges are three physical limitations: the small size of the laser processing volume (typically a 50-micron diameter by 50-micron tall cylinder), the wide powder size distribution, and finally the fast heating and cooling rates. The first two limitations contribute to a large point-to-point static variability of the powder bed physical properties (process mass, absorptivity, heat capacity, thermal conductivity, and density), while the last limitation adds dynamic variability to the powder bed from spatter, splatter and powder denudation effects. Another limitation of current AM systems is that they typically process the powder bed with a single laser leading to large thermal gradients across parts and the associated large residual stresses.

Intelligent multi-laser control and processing can enable unique processing regimes that could alleviate or even eliminate those challenges. For example, in one of many possible conceptions to this topic, a system could be scalable by modules. Each module could include three lasers, the process monitoring sensors and one intelligent controller. One of the lasers, moving at constant speed, would preheat the powder with constant power (without melting it) to produce a unique thermal pattern that would be captured by an intelligent controller. The second laser in the module, moving closely behind the first and operated by the same intelligent controller, could melt-process the powder to a precise final temperature based on the previous thermal history at and around that location. Finally, the third laser, moving closely behind the second, could control the cooling rate while the intelligent controller captures the thermal profile that could be used for processing the next tracks or layers.

In a different intelligent multi-laser conception, each laser could remain stationary while processing a single point on the powder bed. The thermal processing of each point could have three phases. First, the lasers could query the powder by preheating it with constant power for a precise amount of time (without melting) while an intelligent controller captures the unique thermal profile at and around each point. Next, based on the information gained, the same intelligent controller could melt-process the powder to a precise final temperature and let it cool following a precise cooling rate all the while capturing the thermal profiles for later use. Finally, after the processing phase, all the lasers could intelligently shift to new positions and the process would repeat.

The above are just two possible approaches out of many others that address the requirements of this topic. Any innovative approach that is scalable and that integrates multiple lasers (or multiple laser beams) with process monitoring sensors via an intelligent controller to probe the powder bed prior to processing it

with the goal of making AM parts faster and with better microstructure will be considered for funding. The proposal author should clearly indicate which research advances the university partner will contribute to the project and how the small business plans to incorporate them into the AM system.

PHASE I: During the Phase I effort, the contractor will conduct a feasibility study of their proposed scalable, intelligent multi-laser AM system for metal powder bed fusion that includes validation tests that are consistent with a Phase I STTR budget by addressing only the most critical items of their approach and/or making simple coupons. By the end of the Phase I effort the PI will develop a detailed design of the AM system that includes at a minimum: 1- The approach for querying the powder bed and the anticipated information and resolution (spatial and temporal) to be gained from the approach; 2- The intelligent processing approach to be used (machine learning, deep neural networks, neuromorphic processing or others) including the input query parameters and the output laser system control parameters and time constants; 3- The intelligent processor training approach which could include: material process modeling and simulation tools; training coupons and auxiliary data, such as mechanical tests result, x-ray tomography and micrographic analysis for training and ground truth data generation. The contractor will continue building the scalable, intelligent multi-laser during the Option phase by acquiring system components and refining the design of the system based on the validation test results.

PHASE II: Complete the scalable, intelligent multi-laser AM system by developing the control software and GUI. Perform full system validation tests after completing all the training exercises of the intelligent component of the system. For the full system validation, identify a challenge part between the performer and the Navy/DoD team. Fabricate two challenge parts, one for destructive microstructural analysis and another for mechanical testing. The success criteria consists in making the challenge parts in a shorter amount of time (consequence of having a multi-laser system); with less defects and distortions (consequence of probing the powder bed prior to processing it); and with better control of the microstructure and mechanical performance (consequence of the intelligent process control) than the same parts made by other state of the art AM platform but without multi-lasers, powder bed probing and Intelligent control.

PHASE III DUAL USE APPLICATIONS: Military and Commercial sectors that could benefit from this AM system include: aerospace, shipping, space, transportation, rail, automobile and medical. Applications include almost all technology areas such as: engine parts, structural parts, mechanical or electrical parts, medical prosthetics, and tooth implants. The contractor shall support the Navy/DoD to help transitioning the system to a DoD facility in support of various programs. The contractor should also identify potential commercialization opportunities

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KEYWORDS: Metal Additive Manufacturing; Artificial Intelligence; AI; Machine Learning; Neural Networks; Laser Based Powder Bed Fusion; Process Monitoring Sensors; Lasers

OSD22B-003 TITLE: Monolithic CMOS Integration of SiGeSn High Performance Optoelectronic Devices

OUSD (R&E) MODERNIZATION PRIORITY: Microelectronics; Network Command, Control and Communications; General Warfighting Requirements (GWR)

TECHNOLOGY AREA(S): Sensors; Electronics; Chem Bio Defense; Space Platforms; Materials; Information Systems

OBJECTIVE: Develop a SiGeSn monolithic integration technology with CMOS for optoelectronic devices operating in the wavelength range between 2.0 and 5.0 micrometers.

DESCRIPTION: Group-IV alloys SiGeSn (silicon germanium tin) have many unique electrical and optical properties such as a wide infrared spectrum coverage up to 12 micrometers, direct bandgap optical transition, and large feasibility of bandgap engineering by independently tuning the incorporation of Si, Ge, and Sn. One appealing feature of the material is its low growth temperature that enables it to be monolithically integrated with CMOS circuits. Therefore the success of the material development would open possibilities for DoD to address the challenges for future infrared imaging and integrated photonics. Significant progress for SiGeSn material development has been made in the last a few years, which includes high quality material growth with more than 20% Sn, prototype GeSn photodetector covering the whole SWIR range, and lasers operating up to 180 K with broad wavelength coverage (2-3 micrometer). This success is largely due to the use of low cost commercially available $SnCl_4$ precursor and the industry standard group-IV epitaxy reactors widely adopted by IC fabs and foundries. This unique material development mode fits well with the general philosophy of Si-photonics to utilize the well-established microelectronics infrastructure to simultaneously obtain devices with high performance and low cost. However, almost all current SiGeSn material development is based on wafer scale thin film growth. The challenge of the large lattice mismatch between Si and GeSn is often addressed by first growing a thick buffer with multiple layers which normally have high dislocation density and could limit the final device performance. Although all envisioned devices are expected to monolithically integrate SiGeSn with CMOS, there is very little or no research regarding how this integration should be implemented. An effective integration strategy would play a critical role for the transition of SiGeSn from material development to building useful devices. One possible solution for the integration is to utilize a selective area growth technique: aspect ratio trapping (ART). The rationale to pursue ART growth of GeSn and SiGeSn comes with a variety of benefits, but other approaches may also be relevant. We are seeking a paradigm shift in the growth of GeSn which could solve the challenge of material development and future integration with CMOS.

PHASE I: Establish the integration strategy, demonstrate the feasibility of specific growth techniques or approaches of SiGeSn with sizes down to sub-micron, and clearly show a path to scale up to wafer level and integrate with CMOS.

PHASE II: Based on the developed technique, extensively study the material property and conduct a comparison with the thin film material in the context of device applications such as detectors and emitters; develop advanced structures for optoelectronic devices operating in the wavelength range between 2.0 and 5.0 micrometers; fabricate and characterize devices; and show significant improved device performance.

PHASE III DUAL USE APPLICATIONS: The technology would enable both military and commercial customers to build integrated RF photonics chips for future Radar signal processing unit and wireless communication network, as well as the large size, low cost, uncooled, low power, and digital format

infrared imaging sensors used for soldiers and future Smart phones, home security cameras, and automobile night vision for enhanced driving safety.

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KEYWORDS: SiGeSn; GeSn; CVD; emitters; detectors; Group IV photonics; silicon photonics; optoelectronic devices; monolithic integration; infrared imaging

OSD22B-004 TITLE: Ultra-Pure Atomic Wafer Fusion for Ultra-Wide Bandgap, Ultra-High Power, High Thermal Conductivity Power Switches

OUSD (R&E) MODERNIZATION PRIORITY: Microelectronics; Network Command, Control and Communications; General Warfighting Requirements

TECHNOLOGY AREA(S): Ground Sea; Electronics; Materials

OBJECTIVE: Develop a high purity, ultra-high vacuum surface activated bonded wafer fusion (UHV-SAB) tool for heterogeneous integration of dissimilar materials for electronic materials integration and thermal management solutions. The target of the topic is to demonstrate a wafer fusion system that is able to bond wafers using an in-vacuo low damage surface preparation process (i.e., atomic surface activation step) in order to produce a high density of dangling bonds prior to wafer fusion in a high purity, high vacuum (i.e., free of interfacial species) environment [1].

DESCRIPTION: Future Navy ships and other DoD assets will require high power converters for systems such as Air and Missile Defense Radar (AMDR) and propulsion on DDG-51 size ship platforms. High voltage, high efficiency power switches are required to achieve enhanced Size, Weight, and Power enhancements, and doing so affordably (SWaP-C). Ga2O3 has six crystalline phases that have been researched for more than eight decades [3]. The monoclinic phase of Ga2O3 (β-Ga2O3) is the only thermodynamically stable phase with an UWBG of (4.85 eV) and high critical field (Ec = 6-8 MV/cm), resulting in a nearly ten-fold higher Baliga FOM than that of 4H-SiC (BFOM of Ga2O3 = 3444, BFOM of 4H-SiC = 300) [4]. Recent major advances in Ga¬2O3 melt-growth techniques have resulted in commercial substrate technology, which as of late 2018 has progressed to the 6” (150-mm) wafer scale. This critical milestone in semiconductor technology, combined with its attractive electronic properties, have positioned Ga2O3 to offer savings in both energy and cost in high-power, high-temperature electronic device applications.

The goal of this capability is to improve the efficiency of thermal transport across heterogeneous interfaces because of the promotion of newly-discovered phonon modes observed at the interface of high quality epitaxial materials [2]. To extend this concept to dissimilar materials such as GaN, Ga2O3, and diamond, an advanced wafer bonding capability must be developed. For example, the Ultra-Wide Bandgap (UWBG) semiconductor Gallium Oxide (Ga2O3) semiconductor has an extraordinarily high critical electric field breakdown strength but suffers from low thermal conductivity. To achieve a superior thermal solution, fusion or bonding of Ga2O3 to a high thermal conductivity substrate such as Silicon Carbide (SiC) or diamond may present the Navy/DoD with an aggressive approach to very high performance power electronics. In another example, Wide Bandgap (WBG) Gallium Nitride High Electron Mobility Transistors (GaN HEMTs) technology suffers thermally and presents a trade-off between millimeter wave output power and reliability. Fusion of GaN HEMTs to diamond substrates for example could boost thermal performance tremendously by eliminating interface layers that cause an increase in thermal barrier resistance (TBR.) Such a breakthrough would improve millimeter wave output power without sacrificing reliability.

Wafer bonding also permits two or more optically-dissimilar materials to be smoothly interfaced over long distances with low optical losses. This new hybrid material enables previously unattainable optical properties. For example, the silicon waveguides used for photonic integrated circuits lack the intrinsic electro-optic and nonlinear properties required for amplification or high-fidelity modulation. Wafer-bonding an active material such as LiNbO3 or InGaAs to the silicon waveguide layer allows state-of-the-art optical functionality compatible with CMOS based semiconductor fabrication. Also, wafer-bonding permits the placement of materials with very different refractive indices in close proximity. This enables

birefringent phase-matching, dispersion engineering, and ultra-high mode intensities for efficient nonlinear frequency mixing.

The leading approach to wafer bonding presently uses direct wafer bonding which requires annealing at elevated temperatures to develop a strong interface bond. This approach does not address bonding of materials with dissimilar coefficient of thermal expansion such as between Ga2O3 and diamond or GaN and diamond. State of the art (SOA) in-situ surface bond activation via plasma bonding or sputter cleaning leave undesirable damage to the surface which does not produce an atomically sharp bonding interface. Other SOA bonding approaches add monolayers of metal to assist in bonding the dissimilar surfaces; this is not desirable either since the bonding interlayer could result in an electrically conductive interface. Deposition of dielectrics is not desirable because it increases TBR. Instead, an in-vacuo subtractive clean is desirable to activate covalent bonds and induce direct bonding of the dissimilar materials at the atomic level. Upon bringing the two wafers into contact at room temperature, strongly covalently bonded surfaces with minimal thickness of amorphous damage layers are required. In-vacuo outgassing annealing or low power plasma cleaning of the wafers prior to bonding pair may be required. UWBG Ga2O3 semiconductor material has a high Baliga power figure of merit (FOM) needed for high voltage, high efficiency power switches; however, previously states, Ga2O3 material has a poor thermal conductivity. One goal of the effort is to wafer bond Ga2O3 wafers to a high thermal conductivity SiC wafer with a low damage and low electrical resistance wafer bond interface. The objective, then, is to develop a system for low surface damage, ultra-high vacuum, room temperature atomic surface-activated wafer bonding of WBG and UWBG semiconductor wafers.

The proposed surface-activated bonded (SAB) system should strive to achieve the following desired characteristics
• Sample size 2” to 6” diameter, 0.1 to 5 mm thick
• Vacuum Level > 1x10-7 Torr
• In-vacuo surface preparation approach to ensure ultra-low damage, ultra-clean and sharp bonded interface. Such approaches could include various plasma sources and fast atom beams.
• Bonding pressure up to 3000 Newtons
• Annealing temperature up to 1000°C
• Vacuum load lock for insertion of wafers into main vacuum chamber
• In-situ monitoring capability including residual gas analyzer (RGA)

PHASE I: Determine feasibility and establish a plan for the design and development of UHV-SAB system to activate and bond wafers of Si, SiC, GaN, Ga2O3, AlN, and diamond.
The system should be designed to meet as many of the desired characteristics listed above as possible, providing heat treatment regimes, necessary for successful wafer bonding. The contractor shall provide a Phase II development plan addressing technical risk reduction.

PHASE II: Develop a fully-functional surface-activated bonding (SAB) system having all parameter monitoring and control tools and capable of producing ultra-low TBR bonded pairs by minimizing plasma damage from the in-situ pre-bonding cycle. The system should demonstrate uniform, void-free bonding of up to 8” wafers as required in the technical specification. A prototype of the fully operational system with appropriate control software will be delivered to the Navy/DoD and is required by the end of Phase II for evaluation.

PHASE III DUAL USE APPLICATIONS: Phase III shall address the commercialization of the product developed as a prototype in Phase II. The small business is expected to work with suitable industrial partners for this transition to military programs and civilian applications by identifying the expected final state of the technology, its use, and the platform it will be used on.

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KEYWORDS: Wafer Fusion; Ultra-Wide Bandgap; Power Switches; Wafer Bonding; Surface Activated Bonding (SAB); Residual Gas Analyzer (RAG)