DEPARTMENT OF DEFENSE
SMALL BUSINESS TECHNOLOGY TRANSFER (STTR) PROGRAM

STTR 20.B Program Broad Agency Announcement (BAA)

May 6, 2020: DoD BAA issued for pre-release
June 3, 2020: DoD begins accepting proposals
July 2, 2020: Deadline for receipt of proposals no later than **12:00 p.m. ET**

Participating DoD Components:

- Department of the Army
- Department of the Navy
- Defense Health Agency (DHA)
- Defense Threat Reduction Agency (DTRA)

IMPORTANT

Deadline for Receipt: Proposals must be **completely** submitted no later than **12:00 p.m.** ET, July 2, 2020. Proposals submitted after 12:00 p.m. will not be evaluated.

Classified proposals will not be accepted under the DoD STTR 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. The 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 at https://www.dodsbirsttr.mil/submissions as soon as possible upon identification of a proposal opportunity to avoid delays in the proposal submission process.

The Small Business Administration, through its SBIR/STTR Policy Directive, purposely departs from normal Government solicitation formats and requirements and authorizes 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 emailing DoDSBIRSupport@reisystems.com.

Help Desk: If you have questions about the Defense Department's SBIR or STTR Programs, please call the DoD SBIR/STTR Help Desk at 1-703-214-1333, or email to DoDSBIRSupport@reisystems.com.

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1.0 INTRODUCTION

The Army, Navy, DHA, and DTRA 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 Section 12.0 and to commercialize the results of that R&D are encouraged to participate.

The STTR Program, although modeled substantially on 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.

A separate BAA will not be issued requesting Phase II proposals, and unsolicited proposals will not be accepted. All firms that are awarded Phase I awards 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.

More than half of the topics in this BAA address the DoD Research, Technology & Laboratory's (RT&L) top priority technology focus areas, outlined below.

RT&L Technology Focus Area Definitions

Focus Area	Description
5G	Technologies enabling the 5G spectrum to increase speed over current networks, to be more resilient and less susceptible to attacks, and to improve military communication and situational awareness.

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

The DoD SBIR Program follows the policies and practices of the Small Business Administration (SBA) SBIR Policy Directive updated on May 2, 2019. The guidelines presented in this BAA incorporate and make use of the flexibility of the SBA SBIR/STTR Policy Directive to encourage proposals based on scientific and technical approaches most likely to yield results important to the DoD and the private sector. The SBIR Policy Directive is available at: https://www.sbir.gov/sites/default/files/SBIR-STTR_Policy_Directive_2019.pdf.

2.2 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:

3.1 Performance Benchmarks for Progress toward Commercialization

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

3.2 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.

3.3 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.

3.4 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.

3.5 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 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.

3.6 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.

3.7 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.

3.8 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 4.18 for reporting Fraud, Waste and Abuse.

3.9 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.

3.10 HBCU/MI - Historically Black Colleges and Universities and Minority Institutions

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.

3.11 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).

3.12 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.

3.13 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.

3.14 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/.

3.15 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.

3.16 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.

3.17 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 DoDD 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 (DoDD 3216.02), recruitment of military research subjects (DoDD 3216.02), and informed consent and surrogate consent (10 U.S.C. § 980) and chemical and biological agent research (DoDD 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 DoDD 3216.02 for definitions of these terms and more information about the applicability of DoDI 3216.02 to research involving human subjects.

3.18 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/2013/06/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.

3.19 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).

3.20 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.)

3.21 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.

3.22 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.

3.23 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 that:

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 for research or research and development purposes 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 3.15 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 3.10. The percentage of work is usually measured by both direct and indirect costs.
c. For both Phase I and II, the principal investigator must be primarily employed with the small business firm or the research institution. 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 (50%) of the employee'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) 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) 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.

4.4 Majority Ownership in Part

Majority ownership in part by multiple venture capital, hedge fund, and private equity firms: Small businesses that are owned in majority part by multiple venture capital operating companies (VCOCs), hedge funds, or private equity funds are ineligible to submit applications or receive awards for opportunities in this BAA. Please check Component instructions for further information.

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 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 Security Service Web site at: http://www.dss.mil/index.html.

4.7 Research Involving Human Subjects

All research involving human subjects, to include use of human biological specimens and human data, shall comply with the applicable federal and state laws and agency policy/guidelines for human subject protection (see Section 3.13).

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 subjects research until ALL approvals are granted. Submitters proposing research involving human and/or animal use are encouraged to separate these tasks in the technical proposal and cost proposal in order to avoid potential delay of contract award.**

4.8 Research Involving Animal Subjects

All research, development, testing, experimentation, education or training involving the use of animals shall comply with the applicable federal and agency rules on animal acquisition, transport, care, handling, and use (see Section 3.12).

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

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

4.9 Research Involving Recombinant DNA Molecules

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

4.10 Debriefing/Technical Evaluation Narrative

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

4.11 Pre-Award and Post Award BAA Protests

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

SBIR/STTR Contracting Office
WHS/Acquisition Directorate
1155 Defense Pentagon
Washington, DC 20301-1155

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

4.12 Phase I Award Information

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

a. **Number of Phase I Awards**. The number of Phase I awards will be consistent with the Component's RDT&E budget, the number of anticipated awards for interim Phase I modifications, and the number of anticipated Phase II contracts. 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 for the Component to which they are applying for any specific instructions regarding award size.
d. **Timing.** The SBA 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. Normally proposing firms will be notified of selection or non-selection status for a Phase I award within 90 days of the closing date for this BAA.

4.13 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.

4.14 Questions about this BAA and BAA Topics

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

(1) **Help Desk.** The DoD SBIR/STTR Help Desk is prepared to address general questions about this BAA, the proposal preparation and electronic submission process and other program-related areas. The Help Desk may be contacted from 9:00 a.m. to 6:00 p.m. ET Monday through Friday at:

- Phone: 1-703-214-1333
- E-mail: DoDSBIRSupport@reisystems.com

(2) **Web sites**. The Defense SBIR/STTR Innovation Portal (DSIP) Web site at https://www.dodsbirsttr.mil/submissions/login has information on the DoD SBIR/STTR Program, including:

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

(3) **SBIR/STTR Updates and Notices:** To be notified of SBIR/STTR opportunities and to receive e-mail updates on the DoD SBIR and STTR Programs, you are invited to subscribe to our listserv by emailing DoDSBIRSupport@reisystems.com.

b. **General Questions about a DoD Component**. General questions pertaining to a particular DoD Component should be submitted in accordance with the instructions given at the beginning of that Component's topics, in Section 12.0 of this BAA.

c. **Direct Contact with Topic Authors.** From **May 6, 2020 to June 2, 2020,** this BAA is issued for Pre-Release with the names of the topic authors and their phone numbers and e-mail addresses. During the pre-release period, proposing firms have an opportunity to contact topic authors by telephone or e-mail to ask technical questions about specific BAA topics. Questions should be limited to specific information related to improving the understanding of a particular topic's requirements. Proposing firms may not ask for advice or guidance on solution approach and you may not submit additional material to the topic author. If information provided during an exchange with the topic author is deemed necessary for proposal preparation, that information will be made available to all parties through Topic Q&A (formerly SITIS). After this period questions must be asked through SITIS as described below.

d. **SITIS Q&A System.** Once DoD begins accepting proposals on **June 3, 2020** , 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, the questioner and respondent remain anonymous and all questions and answers are posted electronically for general viewing.

Questions are limited to technical information related to improving the understanding of a topic's requirements. Any other questions, such as those asking for advice or guidance on solution approach, will not receive a response. Proposing firms may locate the topic to which they want to submit a technical question by using the Topic Search feature on this Web site. Then, using the form at the bottom of the topic description, enter and submit the question. Answers are generally posted within seven (7) business days of question submission (answers will also be e-mailed directly to the inquirer).

The Topic Q&A for this BAA opens on **May 6, 2020** and closes to new questions on **June 18, 2020 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) at: https://www.dodsbirsttr.mil/submissions/ in order to prepare and submit proposals.

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

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

In addition to the standard federal and DoD procurement certifications, the SBA 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 3.3) 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 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 False Statements

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 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: http://www.dcaa.mil and click on "Guidance" and then click on "Audit Process Overview – Information for Contractors," and also at: http://www.dcaa.mil and click on "Checklists and Tools" and then click on "Pre-award Accounting System Adequacy Checklist".

4.20 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.

4.21 Discretionary Technical and Business Assistance (TABA)

DoD is not mandating 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. The DSIP is the official portal for DoD SBIR/STTR proposal submission. Proposers are required to submit proposals via DSIP; proposals submitted by any other means will be disregarded. Proposers submitting through this site for the first time will be asked to register. It is recommended that firms register as soon as possible upon identification of a proposal opportunity to avoid delays in the proposal submission process.

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

DSIP provides a structure for providing the following proposal volumes:

Volume 1: Proposal Cover Sheet
Volume 2: Technical Volume
Volume 3: Cost Volume
Volume 4: Company Commercialization Report – not in use for 20.2 BAA
Volume 5: Supporting Documents
Volume 6: Fraud, Waste and Abuse Training

A Phase I Proposal Template is available to provide helpful guidelines for completing each section of your Phase I technical proposal. This can be found at 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.

Signatures are not required on the electronic forms at the time of submission. If the proposal is selected for award, the DoD Component program will contact the proposer for signatures at the time of award.

5.2 Summary of Component Programs

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

DoD Component	Cost	Duration	Phase I Option	Technical and Business Assistance
Army	Phase I: Base NTE $166,500	6 Month Base	Not Applicable	Available
Navy	Base NTE $140,000 + Phase I Option NTE $100,000	6 Month Base + 6 Month Phase I Option	Required	$6,500
DHA	Phase I: Base NTE $250,000	6 Month Base	Not Applicable	Not Applicable
DTRA	Phase I: Base NTE $167,500	7 Month Base	Not Applicable	$6,500

DoD Component	Volume 5 – Supporting Documents	Volume 6 – Fraud, Waste & Abuse	Technical Volume Page Limits
Army	Not Accepted	Not Accepted	10 pages
Navy	Accepted but Not Evaluated	Not Accepted	10 pages
DHA	Not Accepted		20 pages
DTRA	Not Required	Required	20 pages

5.3 Marking Proprietary Proposal Information

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

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

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

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

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

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

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

5.4 Phase I Proposal Instructions

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

On the Defense SBIR/STTR Innovation Portal (DSIP) at https://www.dodsbirsttr.mil/submissions/, prepare the Proposal Cover Sheet. The Cover Sheet must include a brief technical abstract of no more than 200 words that describes the proposed R&D project with a discussion of anticipated benefits and potential commercial applications. **<u>Do not include proprietary or classified information in the Proposal Cover Sheet</u>**. If your proposal is selected for award, the technical abstract and discussion of anticipated benefits may be publicly released on the Internet. Once the Cover Sheet is saved, the system will assign a proposal number. You may modify the cover sheet as often as necessary until the BAA closes.

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

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

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

(3) **Layout**: Number all pages of your proposal consecutively. Those who wish to respond must submit a direct, concise, and informative research or research and development proposal (no type smaller than 10-point on standard 8-1/2" x 11" paper with one-inch margins). The header on each page of the Technical Volume should contain your company name, topic number, and proposal number assigned

by the Defense SBIR/STTR Innovation Portal (DSIP) site when the Cover Sheet was created. The header may be included in the one-inch margin.

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

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

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

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

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

a. Provide an explicit, detailed description of the Phase I approach. If a Phase I option is required or allowed by the Component, describe appropriate research activities which would commence at the end of Phase I base period should the Component elect to exercise the option. The Statement of Work should indicate what tasks are planned, how and where the work will be conducted, a schedule of major events, and the final product(s) to be delivered. The Phase I effort should attempt to determine the technical feasibility of the proposed concept. The methods planned to achieve each objective or task should be discussed explicitly and in detail. This section should be a substantial portion of the Technical Volume section.
b. This BAA may contain topics that have been identified by the Program Manager as research or activities involving Human /Animal Subjects and/or Recombinant DNA. In the event that Phase I performance includes performance of these kinds of research or activities, please identify the applicable protocols and how those protocols will be followed during Phase I. Please note that funds cannot be released or used on any portion of the project involving human/animal subjects or recombinant DNA research or activities until all of the proper approvals have been obtained. (See Sections 4.7- 4.9.). **Submitters proposing research involving human and/or animal use are encouraged to separate these tasks in the technical proposal and cost proposal in order to avoid potential delay of contract award.**

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

a. short description,
b. client for which work was performed (including individual to be contacted and phone number), and
c. date of completion.

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

a. State the anticipated results of the proposed approach if the project is successful.
b. Discuss the significance of the Phase I effort in providing a foundation for Phase II research or research and development effort.

c. Identify the applicable clearances, certifications and approvals required to conduct Phase II testing and outline the plan for ensuring timely completion of said authorizations in support of Phase II research or research and development effort.

(6) **Commercialization Strategy**. Describe in approximately one page your company's strategy for commercializing this technology in DoD, other Federal Agencies, and/or private sector markets. Provide specific information on the market need the technology will address and the size of the market. Also include a schedule showing the quantitative commercialization results from this STTR project that your company expects to achieve. The Commercialization Readiness Program has been extended to STTR.

(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 3.5 of the BAA. You may be asked to provide additional information during negotiations in order to verify the foreign citizen's eligibility to participate on a 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/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 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 must be detailed at the same level as prime contractor costs with regards to labor, travel, equipment, etc. Provide detailed substantiation of subcontractor costs in your cost proposal. Enter this information in the Explanatory Material section of the on-line cost proposal form. The Supporting Documents Volume (Volume 5) may be used if additional space is needed.

When a proposal is selected for award, you must be prepared to submit further documentation to the Component Contracting Officer to substantiate costs (e.g., an explanation of cost estimates for equipment, materials, and consultants or subcontractors). For more information about cost proposals and accounting standards, see the DCAA publication called “Information for Contractors” available at http://www.dcaa.mil. Click on “Guidance” and then click on “Audit Process Overview Information for Contractors.”

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

The Company Commercialization Report (CCR) will NOT be available during the 20.2 BAA cycle for Phase I or Direct to Phase II proposals. No Commercialization Achievement Index (CAI) will be generated. The CCR will be available for future DoD BAA cycles. If the CCR is available at the time of the Phase II submission for any awarded Phase I efforts resulting from this BAA, the proposing firm is required to submit the CCR for its Phase II proposal.

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

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

Documents that are acceptable and may be included in Volume 5 are:
1. Letters of Support
2. Additional Cost Information
3. Funding Agreement Certification
4. Technical Data Rights (Assertions)
5. Lifecycle Certification
6. Allocation of Rights
7. Other

Refer to the Component-specific instructions for Volume 5 requirements.

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

Refer to the Component-specific instructions for the Fraud, Waste and Abuse Training (Volume 6) requirements.

6.0 PHASE I EVALUATION CRITERIA

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

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

Cost reasonableness and realism shall also be considered to the extent appropriate.

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

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.

If the Company Commercialization Report (CCR) is available at the time of Phase II submission for any awarded Phase I efforts resulting from this BAA, the proposing firm is required to submit the CCR for its Phase II proposal.

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 Directives provide 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 Company Commercialization Report (see Section 5.4.e) at least annually. For information on formatting, page count and other details, please refer to the Component-specific instructions.

8.0 PHASE II EVALUATION CRITERIA

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

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

Cost reasonableness and realism shall also be considered to the extent appropriate.

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 contained or referenced in the proposal and will count toward the page limit.

9.0 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.

10.0 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 and Navy) has established a Commercialization Readiness Program. Additionally, each Department has developed criteria and processes to identify projects with the potential for rapid transition to Phase III and that are expected to meet high priority needs of their Department. A project's inclusion in the CRP is by invitation and at the discretion of the Departments. CRP participants may receive a variety of assistance services and/or opportunities to facilitate the transition of their projects. Participation in the CRP may also include modifications to existing Phase II contracts with additional non-SBIR/STTR funding, as well as additional SBIR/STTR funding beyond the normal SBIR/STTR funding guidelines, to enhance ongoing projects with expanded research, development, test, or evaluation to accelerate transition and commercialization. Additional reporting on CRP participants and results achieved is required.

11.0 CONTRACTUAL REQUIREMENTS

11.1 Other Contract Requirements

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

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

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

g. **Contract Work Hours**. The contractor may not require an employee to work more than eight hours a day or forty hours a week unless the employee is compensated accordingly (that is, receives overtime pay).
h. **Equal Opportunity**. The contractor will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.
i. **Affirmative Action for Veterans**. The contractor will not discriminate against any employee or applicant for employment because he or she is a disabled veteran.
j. **Affirmative Action for Handicapped**. The contractor will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.
k. **Officials Not to Benefit**. No member of or delegate to Congress shall benefit from the contract.
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 STTR funding agreement, purchase only American-made items whenever possible.
q. **Unique Identification (UID)**. If your proposal identifies hardware that will be delivered to the government be aware of the possible requirement for unique item identification in accordance with DFARS 252.211-7003.
r. **Publication Approval**. Government review and approval will be required prior to any dissemination or publication, except within and between the Contractor and any subcontractors, of classified and non-fundamental information developed under this contract or contained in the reports to be furnished pursuant to this contract.
s. **Animal Welfare.** Contracts involving research, development, test, evaluation, or training on vertebrate animals will incorporate DFARS clause 252.235-7002.
t. **Protection of Human Subjects.** Effective 29 July 2009, contracts that include or may include research involving human subjects in accordance with 32 CFR Part 219, DoD Directive 3216.02 and 10 U.S.C. 980, including research that meets exemption criteria under 32 CFR 219.101(b), will incorporate DFARS clause 252.235-7004.
u. **E-Verify.** Contracts exceeding the simplified acquisition threshold may include the FAR clause 52.222-54 "Employment Eligibility Verification" unless exempted by the conditions listed at FAR 22.1803.
v. **ITAR.** In accordance with DFARS 225.7901-4, Export Control Contract Clauses, the clause found at DFARS 252.225-7048, Export-Controlled Items (June 2013), must be included in all BAAs/solicitations and contracts. Therefore, all awards resulting from this BAA will include DFARS 252.225-7048. Full text of the clause may be found at https://www.govinfo.gov/content/pkg/CFR-2013-title48-vol3/pdf/CFR-2013-title48-vol3-sec252-225-7048.pdf.
w. **Cybersecurity.** 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.

11.2 Commercialization Updates in Phase II

If, after completion of Phase I, the contractor is awarded a Phase II contract, the contractor shall be required to periodically update the following commercialization results of the Phase II project through the Web site at https://www.dodsbirsttr.mil/submissions/:

a. Sales revenue from new products and non-R&D services resulting from the Phase II technology;
b. Additional investment from sources other than the federal SBIR/STTR Program in activities that further the development and/or commercialization of the Phase II technology;
c. Whether the Phase II technology has been used in a fielded DoD system or acquisition program and, if so, which system or program;
d. The number of patents resulting from the contractor's participation in the SBIR/STTR Program;
e. Growth in number of firm employees; and
f. Whether the firm has completed an initial public offering of stock (IPO) resulting, in part, from the Phase II project.

These updates on the project will be required one year after the start of Phase II, at the completion of Phase II, and subsequently when the contractor submits a new STTR proposal to DoD. Firms that do not submit a new proposal to DoD will be asked to provide updates on an annual basis after the completion of Phase II.

11.3 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.

11.3 Copyrights

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

11.4 Patents

Small business firms normally may retain the principal worldwide patent rights to any invention developed with Government support. The Government receives a royalty-free license for its use, reserves the right to require the patent holder to license others in certain limited circumstances, and requires that anyone exclusively licensed to sell the invention in the United States must normally manufacture it domestically. To the extent authorized by 35 USC 205, the Government will not make public any information disclosing a Government-supported invention for a period of five years to allow the awardee to pursue a patent. See also Invention Reporting in Section 11.6.

11.5 Technical Data Rights

Rights in technical data, including software, developed under the terms of any contract resulting from proposals submitted in response to this BAA generally remain with the contractor, except that the Government obtains a royalty-free license to use such technical data only for Government purposes during the period commencing with contract award and ending five 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. Upon expiration of the five-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, "Rights in Noncommercial Technical Data and Computer Software – Small Business Technology Transfer (STTR) Program."

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

11.6 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.

11.7 Final Technical Reports - Phase I through Phase III

a. **Content:** A final report is required for each project phase. The reports must contain in detail the project objectives, work performed, results obtained, and estimates of technical feasibility. A completed SF 298, "Report Documentation Page," will be used as the first page of the report. (The Report Documentation Page may be prepared and printed from the DoD Submission Web site at http://www.dtic.mil/dtic/submit/guidance_on_submitting_docs_to_dtic.html. In addition, monthly status and progress reports may be required by the DoD Component.

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

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

(2) For each unclassified report, the company submitting the report should fill in Block 12 (Distribution/Availability Statement) of the SF 298, "Report Documentation Page," with the following statement: "Distribution authorized to U.S. Government only; Proprietary Information, (Date of Determination). Other requests for this document shall be referred to the Component SBIR/STTR Program Office." *Note: Data developed under a STTR contract is subject to STTR Data Rights which allow for protection under DFARS 252.227-7018 (see Section 11.5, Technical Data Rights). The sponsoring DoD activity, after reviewing the company's entry in Block 12, has final responsibility for assigning a distribution statement.*

For additional information on distribution statements see the following Defense Technical Information Center (DTIC) Web site: 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 terms "STTR Report".

c. **Submission:** In accordance with DoD Instruction 3200.12 and DFARS clause 252.235-7011, a copy of the final report shall be submitted (electronically or on disc) to DTIC:

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.

ARMY STTR 20.B
PROPOSAL SUBMISSION INSTRUCTIONS

The approved 20.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 are provided below with references to the appropriate section of the DoD BAA.

The STTR Program Management Office (PMO), located at the Combat Capabilities Development Command (CCDC) 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/sttr/Default.aspx.

See DoD Program Announcement Section 4.14 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.aro.mail.sttr-pmo@mail.mil

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

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 $166,500 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 (see section 6.0) 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 section 5.0 at the front of this BAA for detailed instructions on Phase I proposal format.

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 three volumes: Proposal Cover Sheet, Technical Volume, and Cost Volume. **Please note that the Army will <u>not</u> be accepting a Volume Five (Supporting Documents), nor a Volume Six (Fraud, Waste and Abuse) as noted at the DoD SBIR website for 20.B Phase I proposals.** 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: table of contents, pages left blank, references and letters of support, appendices, key personnel biographical information, 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, call the DoD SBIR/STTR Help Desk at 703-214-1333 (9:00 am to 5:00 pm ET Monday - Friday).

Proposals not conforming to the terms of this BAA will not be considered. Only Government personnel will evaluate proposals with the exception of technical personnel from ICON who will provide Advisory and Assistance Services to the Army and technical analysis in the evaluation of proposals submitted against Army topic number:

- A20B-T023 Develop and Demonstrate a Portable Device for Bacteriophage Enrichment, Screening and Isolation Technology for Field Application

The individuals from ICON 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. These institutions are expressly prohibited from competing for STTR awards and from scoring or ranking of proposals or recommending the selection of a source. In accomplishing their duties related to the selection processes, the aforementioned institutions may require access to proprietary information contained in the offerors' proposals. Therefore, pursuant to FAR 9.505-4, the institution must execute an agreement that states that they will (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. These agreements will remain on file with the Army STTR program management office at the address above."

Companies should plan carefully for research involving animal or human subjects, biological agents, etc. (see sections 4.7 - 4.9). 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 sections 3.5 and 5.4.c (8) in the DoD 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 (section 10).

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/sttr/PhaseII.aspx. 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 section 8.0 of this BAA. STTR Phase II proposals have four Volumes: Proposal Cover Sheet, Technical Volume, Cost Volume and Company Commercialization Report. **The Army STTR Program does not accept submission of Volume Five, Supporting Documents, nor a Volume Six (Fraud, Waste and Abuse) as noted at the DoD SBIR website for 20.B 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 section 5.4.e of the DoD Program BAA, 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 $1,100,000. **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 10-12 months (base effort) should be approximately $550,000; the second 10-12 months of funding should also be approximately $550,000. The entire Phase II effort should not exceed $1,100,000. 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 $550,000 if program funds are limited.

Any subsequent 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 stationed nine (9) Technical Assistance Advocates (TAAs) across the Army to provide technical assistance to small businesses that have Phase I and Phase II projects with the participating Army organizations within their regions. Details related to TABA are described in section 4.21 of the DoD BAA. Firms may request technical assistance from sources other than those provided by the Army. All such requests must be made in accordance with the instructions in Section 4.21. 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. 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, and a web site 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.

For more information go to: https://www.armysbir.army.mil/sbir/TechnicalAssistance.aspx

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.aro.mail.sttr-pmo@mail.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 **$166,500** 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 section 5.4 of the BAA.

4. STTR Phase I Proposals have three volumes: Proposal Cover Sheet, Technical Volume, and Cost Volume.

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. Requirement for Army Accounting for Contract Services, otherwise known as CMRA reporting is included in the Cost Volume (offerors are instructed to include an estimate for the cost of complying with CMRA – see website at https://www.ecmra.mil/.

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

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

9. 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.

10. 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 20.B Topic Index

Participating Organizations	**PC**	**Phone**
CCDC-Armaments Center	Benjamin Call Sheila Speroni	973-724-6275 973-724-6935
CCDC-Aviation and Missile Center	Dawn Gratz	256-842-8769
CCDC-ARL/Army Research Office	Nicole Fox	919-549-4395
CCDC-C5ISR Center	Lauren Marzocca	443-395-4665
CCDC- 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)	Patricia Roth Amanda Cecil	301-619-5047 301-619-7296
CCDC-Soldier Center	Cathy Polito	508-233-5372
CCDC-Ground Vehicle Systems Center	George Pappageorge Joseph Delfrate	586-282-4915 586-282-5568

ARMY

ARMY STTR 20.B Topic Index

A20B-T001 TITLE: Implementation of Hierarchical Phase Change Materials for Applications in Long Range Precision Fires Missions

RT&L FOCUS AREA(S): 5G, General Warfighting Requirements
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: This topic shall investigate hierarchical phase change materials that can be used for the enhancement of thermal, mechanical, and/or electromagnetic properties.

DESCRIPTION: Long Range Precision Fires (LRPF) as one of the Army Modernization Priorities seeks to develop technologies that increase weapon system range. Projectiles fitting this new paradigm must survive high-g and high-temperature environments; therefore, novel materials with enhanced thermal and mechanical properties are required to meet these emerging needs. Phase Change Materials (PCM) can address these issues by undergoing structural or phase transformations, thus allowing for the absorption of heat or mechanical stress; indeed such materials have been implemented in applications for such a purpose [1, 2]. Typical solid-liquid PCM suffer from several disadvantages [3]; therefore, other approaches such as solid-solid phase transitions and strongly correlated electron systems are attractive due to the reversible nature of their phase transitions [4, 5]. In order to ensure the survivability of internal components under the aforementioned extreme conditions, novel material design approaches are required to enable novel and/or passive coatings for LRPF platforms. To this end, this topic seeks novel solutions exploiting the phase change properties of materials in order to provide platform protection against a broad range of extreme environmental threats that are unique to the LRPF mission.

PHASE I: Phase I will focus on designing hierarchical PCM that can be synthesized and implemented as passive/active coatings or structural elements to enhance the survivability of LRPF platforms against extreme environments. The design should be informed by fundamental studies of a broad materials library that includes but is not limited to: nanostructured inorganic, organic, and/or hybrid inorganic/organic composites including low dimensional materials. The combination of physical approaches and novel nanomaterials should enable properties such as high heat capacity, thermal conductivity and mechanical strength; electromagnetic properties shall also be considered. Phase I will result in design methods, modeling and simulation analyses and material trade-off considerations for achieving the objectives. Prototype material structures will be synthesized to demonstrate the desired properties and identify the potential for implementation on LRPF platforms.

PHASE II: Modeling and simulation will be utilized to elucidate the physics behind the novel materials' properties which enable survivability against a range of extreme conditions including high-g and high temperature. The expected technology development work will include detailed investigations into the desired materials and their properties and performance in the desired application in the context of user requirements in conjunction with the Army; strong consideration will be given to the reliability and robustness in the context of real-world LRPF platforms. The successful phase II will deliver prototype material systems to the Army for testing in various extreme environments as well as independent characterization of the material properties.

PHASE III DUAL USE APPLICATIONS: Phase III will entail further research and refinement of the results of Phase II with the goal of developing an all-encompassing solution for the survivability of LRPF assets against extreme environmental conditions. Throughout the effort, coordination with the stakeholders in the U.S. Army as well as in other services in order to facilitate the requirements definition and technology transition processes will be undertaken. Potential dual-use/commercial applications will be identified and strategic partnerships fostered for development of said applications.

REFERENCES:

1. Ling, Ziye et al. "A hybrid thermal management system for lithium ion batteries combining phase change materials with forced-air cooling". Applied Energy. 2015.;
2. Kalnaes, Simen et al., "Phase change materials and products for building applications: A state-of-the-art review and future research opportunities," Energy and Buildings. 2015.;
3. Fan, Liwu et al. "Thermal conductivity enhancement of phase change materials for thermal energy storage: A review," Renewable and Sustainable Energy Reviews. 2011.;
4. Fallahi, Ali et al. "Review on solid-solid phase change materials for thermal energy storage: Molecular structure and thermal properties. Applied Thermal Engineering. 2017.;
5. Muramoto, Kei et al. "VO2-dispersed glass: A new class of phase change material". Scientific Reports. 2018. DOI:10.1038/s41598-018-20519-6

KEYWORDS: Long Range Precision Fires, hierarchical materials, phase change materials, long range, extended range, nanomaterials, low-dimensional materials

A20B-T002 TITLE: A Revolutionary RF Circuit Simulator for New Electronic Design and Analysis Capabilities

RT&L FOCUS AREA(S): 5G
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: To develop trusted computer simulation software to accurately and quickly analyze the end-to-end circuit behavior of completely general time-frequency waveforms in complex non-linear RF circuitry.

DESCRIPTION: Anecdotally, a dozen fabrication cycles, 1000 or more engineers, and billions of dollars were required to develop the prototype for a modern cellular modem. Current commercially available circuit simulation software is not capable of fast, accurate analysis of the response of an entire complex linear and non-linear circuit to modern time-frequency waveforms. RF circuits are currently designed based on intuition derived from the analysis of many summations of steady-state functions such as sine waves or the transient analysis of circuit response with relatively small dynamic range. RF circuits tend to be designed starting from a steady-state analytical solution, followed by extensive trial and error fabrications. Small parts of the circuit are simulated for short time intervals and the results are combined based on engineering intuition. However components of RF circuits can respond in unexpected modes when subjected to wave forms which have formulations in both time and frequency. A simple example is pulses of sinusoidal waves. The response of filters and in particular non-linear circuit elements to these time-frequency waveforms can be substantially different than would be expected from a steady state wave form analysis. Even relatively simple 5G waveforms such as OFDM and CDMA modulation can be hard to accurately analyze. More general time-frequency waveforms where the frequency content varies with time and RF transients can dominate the response may be of interest for jamming and EW or the construction of LPI waveforms. Circuit simulation tools commercially available do not have the dynamic range to address these waveforms, the number of state variables required can grow exponentially, and computation time can take weeks for a single circuit for even a limited circuit time period under analysis. These simulation tools can have dynamic ranges on the order of 80 dB, while a dynamic range above 140 dB may be required, as well as the capability to reduce the number of state variables. An appropriate simulation will also require the capability to handle true time delay and memory effects in a physically correct manner. Macro-models will be needed to address these performance and computational speed requirements. These can include accurate behavioral models and reduced-order models. Fractional calculus and complex basis functions such as wavelets may be useful in constructing these macro-models. The software should be capable of simulating the 5G waveform response in a generic smart phone front end, with center frequency in the 1 to 5 GHz range, four orders of magnitude faster than a Spice simulation. The approach should be state-variable based and capable of the accurate simulation of arbitrary state variables (including multi-physics variables), physically correct true time delay, circuit memory effects, stochastic circuit and component variation, and greater than 140 dB dynamic range. Consider leveraging various macro-model techniques, such as behavioral modeling, advanced basis functions, tensor trains, and fractional calculus. Leverage published or commercially available macro-models. The simulator should provide a "dial an accuracy" capability to allow user tradeoff between accuracy and speed.

PHASE I: Demonstrate the feasibility of a software approach to linear and non-linear circuit simulation capable of simulating the detailed circuit response, sampled at any point in the circuit, to complex waveforms such as a 5G OFDM (Orthogonal Frequency Division Multiplexing) or CDMA (Code Division Multiple Access), pulsed ultra-wideband, multi-carrier, frequency hopping, and non-periodic pulsed frequencies. The simulator must accurately and efficiently handle circuit non-linearity, repeated transient behavior, and full duplex operation (with simultaneous very high and very low power signals). The feasibility of the approach will be supported by a block diagram of the software routines and analysis based on performance estimation from parameters reported in the literature for the various algorithms required. Results of research in the last two decades provide optimism that such a very high performance non-linear circuit simulator can be formulated. As an example, an advanced circuit solver approach (fREEDA), from North Carolina State University, is described in ref. 1, which has a dynamic range exceeding 160 dB in transient simulation. It is publically available for download (ref. 2). It has a physically correct true time delay capability (ref. 3), can accommodate arbitrary state variables and multi-physics variables (ref. 4), and can handle distributed networks (ref. 5). Reference 11 is a link to a Sandia Laboratory generated circuit simulator (Xyce) which addresses many of the same issues as fREEDA. It is also publically available. Both have GPL public licenses. One approach to this topic would be to combine features from Xyce and fREEDA, since both can be leveraged for commercial application under their public licenses. Establish and present a transition plan for the software package, with details of specific transition partners and consideration of software documentation, maintenance and customer service.

PHASE II: Develop a trusted software package capable of the simulation described in phase I. Determine the fundamental limits of macro-models proposed and the measures of uncertainty introduced by each. Formulate a plan to demonstrate the capabilities of the simulation. Develop a validation plan for the simulator based on specific experiments and other limited capability simulators or simulations with extensive run time (which would not be practical for most applications). Demonstrate the simulation and validate against the criteria in the validation plan. Document the validation in a journal article for peer review which will effectively advertise and promote the simulation capabilities to the professional electronics community. Deliver a beta version of the software, including source code, to a designated government lab for testing. Provide on-site support of the government testing. Develop and deliver a comprehensive transition plan to make the software available to the government and commercial market place, with detailed outline of the roles of transition partners, an updated business model, and updated market analysis. Develop and deliver a GUI (graphical user interface) with schematic capture integrated in the simulation. The software must be implemented in a common computer language such as C++ or Python. The simulator meeting these requirements will have significant capabilities not found in commercially available software and even (to our knowledge) in dedicated software internal to industrial programs. In particular the software will be capable of comprehensively simulating relatively long time steps and time delays (milliseconds) during (for example) an EW attack, of simulating with a scalable accuracy-vs-runtime tradeoff, of accurately modeling perfectly general waveforms in two circuits coupled at major distances electromagnetically, and easily encompassing the extensive device model libraries developed for other software products.

PHASE III DUAL USE APPLICATIONS: Phase III work will advance the beta software version to a robust circuit simulator for sale to commercial and military markets. The capability to accurately and quickly simulate the propagation of advanced waveforms end-to-end and to observe the effects of individual circuit elements will significantly reduce the cost of RF chip design and therefore the electronic system itself. It is expected to be of interest to chip designers throughout the RF electronics industry, to universities and government laboratories for analysis of innovative RF circuit and waveform concepts, to agencies regulating spectrum usage, and to the electronic warfare community. The expected transition path would be for the company to establish its own software maintenance, customer support, and sales capability; to partner with an existing larger commercial software company; or to sell the license to a major software company.

REFERENCES:

1. N. M. Kriplani, S. Luniya and M. B. Steer, "Integrated deterministic and stochastic simulation of electronic circuits: application to large signal noise analysis," Int. J. Numerical Modeling: Electronic Networks, Devices and Fields 21, 303 (2008).; https://go.ncsu.edu/freeda-download;
2. S. Priyadarshi, C. S. Saunders, N. M. Kriplani, H. Demircioglu, W. R. Davis, P. D. Franzon, and M. B. Steer, "Parallel transient simulation of multi-physics circuits using delay-based partitioning," IEEE Trans. on Computer Aided Design of Integrated Circuits and Systems 31,1522 (2012).;
3. S. Priyadarshi, T. R. Harris, S. Melamed, C. Otero, N. Kriplani, C. E. Christoffersen, R. Manohar, S. R. Dooley, W. R. Davis, P. D. Franzon, and M. B. Steer, "Dynamic electrothermal simulation of three dimensional integrated circuits using standard cell macromodels," IET Circuits, Devices & Systems 6, 35 (2012).;
4. C. S. Saunders and M. B. Steer, "Passivity enforcement for admittance models of distributed networks using an inverse eigenvalue method," IEEE Transactions on Microwave Theory and Techniques 60, 8 (2012).;
5. J.C. Pedro and S.A. Maas, "A Comparative Overview of Microwave and Wireless Power-Amplifier Behavioral Modeling Approaches," IEEE Trans. Microw. Theory Tech. 53, 1150 (2005).;
6. F.M. Barradas, L.C. Nunes, T.R. Cunha, P.M. Lavrador, P.M. Cabral, and J.C. Pedro, "Compensation of Long-Term Memory Effects on GaN HEMT-Based Power Amplifiers," IEEE Trans. Microw. Theory Tech. 65, 3379 (2017).;
7. S. Barmada, A. Musolino, R. Rizzo, and M. Tucci, "Multi-resolution based sensitivity analysis of complex non-linear circuits," IET Circuits Devices Syst. 6, 176 (2012).;
8. J.S. Ochoa and A.C. Cangellaris, "Macro-modeling of electromagnetic domains exhibiting geometric and material uncertainty," Applied Computational Electromagnetics Society Journal 27, 80 (2012).;
9. A.S. Yang, X. Chen, J. E. Schutt-Ainé and A. C. Cangellaris, "Adaptive Wavelet Stochastic Collocation for Resonant Transmission Line Circuits," in Proc. 2017 IEEE 26th Conference on Electrical Performance of Electronic Packaging and Systems (EPEPS), San Jose, CA, USA, October 2017.; https://xyce.sandia.gov

KEYWORDS: circuit simulator, non-linear circuits, complex waveforms, 5G

A20B-T003 TITLE: 300W Low-Temperature SOFC Army Power Sources

RT&L FOCUS AREA(S): Microelectronics
TECHNOLOGY AREA(S): Materials

OBJECTIVE: Develop and integrate innovative materials and technologies to enable lowering the operating temperature of high power solid-oxide fuel cells to 300-600 °C.

DESCRIPTION: Advanced power sources are needed to provide electric power, which is critical to mission success, to soldiers during long-term missions especially in remote locations. Lightweight Solid Oxide Fuel Cells (SOFC) have been demonstrated that can provide power from gaseous and liquid fuels and offer 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. Currently, solid oxide systems are too large, require long start times, and have low cycle lives. This is largely driven by the requirement of operating at very high temperatures (800 -1000 °C) in conventional solid oxide fuel cells. Recent breakthroughs with triple conducing oxide perovskite and double perovskite materials such as BaCo0.4Fe0.4Zr0.1Y0.1O3-δ, NdBa0.5Sr0.5Co1.5Fe0.5O5+ δ, and PrBa0.5Sr0.5Co1.5Fe0.5O5+δ have shown significant promise at low temperatures (300-600 °C) and power densities ranging from 650 to 1100 mW/cm2. Extremely high power densities of 2 W/cm2 at 650°C have been demonstrated from a bilayer-electrolyte LT-SOFC. These remarkable breakthroughs in low-temperature solid oxide fuel cell materials offer an opportunity to develop new high performance 300W LT-SOFC system that is capable of running hydrocarbon fuels, such as propane, and operating at 300-600 °C. This topic is focused on research to develop and integrate these new materials into solid oxide fuel systems to decrease weight and start up times while increasing cycle life. A lightweight (less than 3 kg) 350W+ (>150 W/kg system) low-temperature solid oxide fuel cell system is desired for a multitude of missions ranging from dismounted solider power, UAV power, to silent watch applications. This technology could be used in a variety of roles including: direct power to Army systems or to charge lithium-ion rechargeable batteries which would significantly reduce the logistical burden (weight and volume) for dismounted soldiers by reducing the number of batteries required for extended mission time as well as for a myriad of civilian electronics applications.

PHASE I: In phase I a sub scale multicell stack using triple conductive oxide materials will be developed and evaluated using propane fuel. Stack performance data shall be evaluated and preliminary results from the stack should support the potential to develop a 3kg 300W+ system that operates below 600 °C, with a power density above 650 mW/cm2 and specific power 150 W/kg. Provide a detailed conceptual design of a 350W+ power system based upon the results generated in these efforts.

PHASE II: Based on the results from the successful phase I program, design, construct, assemble and evaluate a high performing 2.5kg 300W LT-SOFC system that operates below 600 °C, with performance degradation 4%/1000h, and lifetime 5000 hours under 350W+ power operation. Power density should be above 650 mW/cm2 and specific power 150 W/kg. Pursue the development of a system capable using liquid fuels, such as diesel or JP-8. Deliver 2 units to the Army for evaluation. Assess cost and manufacturability of demonstrated technology.

PHASE III DUAL USE APPLICATIONS: Robust low-temperature SOFC power systems with high power densities will significantly impact both military and commercial applications, accelerating product development, particularly for lightweight portable power devices. 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 SBIR effort to show applicability to field conditions and compatibility with JP-8. 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.

REFERENCES:

1. Duan, C. et al. Readily processed protonic ceramic fuel cells with high performance at low temperatures. Science 349, 1321–6 (2015);
2. Duan, C. et al. Highly efficient reversible protonic ceramic electrochemical cells for power generation and fuel production. Nat. Energy 4, 230–240 (2019).;
3. Kim, J. et al. Triple-conducting layered perovskites as cathode materials for proton-conducting solid oxide fuel cells. ChemSusChem 7, 2811–2815 (2014).;
4. Choi, S. et al. Exceptional power density and stability at intermediate temperatures in protonic ceramic fuel cells. Nat. Energy 3, 202–210 (2018);
5. Strandbakke, R. et al. Gd- and Pr-based double perovskite cobaltites as oxygen electrodes for proton ceramic fuel cells and electrolyser cells. Solid State Ionics 278, 120–132 (2015).;
6. Vøllestad, E. et al. Mixed proton and electron conducting double perovskite anodes for stable and efficient tubular proton ceramic electrolysers. Nature materials 18, 752–759;
7. S. McIntosh and R. J. Gorte, "Direct Hydrocarbon Solid Oxide Fuel Cells ", Chem. Rev. 2004, 104, 4845-4865.;
8. P. Boldrin, et al," Strategies for Carbon and Sulfur Tolerant Solid Oxide Fuel Cell Materials, Incorporating Lessons from Heterogeneous Catalysis ", Chem. Rev. 2016, 116, 13633-13684.;
9. E. D. Wachsman and K. T. Lee, "Lowering the Temperature of Solid Oxide Fuel Cells", Science 2011, 334, 935-939.;
10. J. S. Ahn, et al, "High-performance bilayered electrolyte intermediate temperature solid oxide fuel cells" Electrochemistry Communications 2009, 11, 1504–1507.;
11. Y. Zhang, et al, "Recent Progress on Advanced Materials for Solid-Oxide Fuel Cells Operating Below 500 °C", Adv. Mater. 2017, 29, Article No. 1700132, 1-33.;
12. J. Patakangas, et al, "Review and analysis of characterization methods and ionic conductivities for low-temperature solid oxide fuel cells (LTSOFC)", J. Power Sources 2014, 263, 315-331.;
13. L. Fan, et al, "Nanomaterials and technologies for low temperature solid oxide fuel cells: Recent advances, challenges and opportunities", Nano Energy 2018, 45, 148-176.;
14. A. M. Hussain, et al, "Highly Performing Chromate-Based Ceramic Anodes (Y0.7Ca0.3Cr1-xCuxO3-d) for Low-Temperature Solid Oxide Fuel Cells", ACS Appl. Mater. Interfaces 2018, 10, 36075-36081.;
15. M. Li, et al, "A niobium and tantalum co-doped perovskite cathode for solid oxide fuel cells operating below 500 °C", Nature Communications 2017, 8, Article No. 13990, 1-9.

KEYWORDS: Low temperature solid oxide fuel cell (LT-SOFC), Protonic ceramic fuel cell (PCFC), Solid oxide fuel cell (SOFC), Fuel cell, Soldier power.

A20B-T004 TITLE: Photonic Accelerators for Artificial Neural Networks

RT&L FOCUS AREA(S): Artificial Intelligence/ Machine Learning, Quantum Sciences
TECHNOLOGY AREA(S): Electronics

OBJECTIVE: To develop high-speed, scalable, power-efficient photonic accelerators for vector, matrix, and tensor operations with potential applications in artificial neural networks.

DESCRIPTION: In the post-Moore's law era, electronic hardware accelerators [1,2] with parallel computing structures and optimized local memory for special-purpose computing, as oppose to CPUs for the general-purpose von Neumann computing, have enabled new applications that circumvent physical limitations of integrated circuits (IC). These accelerators include the well-known graphical processing units (GPUs) and tensor processing units (TPUs). Benefiting from these hardware accelerators, new applications based on artificial intelligence (AI)/machine learning (ML) that utilize artificial neural networks (ANN) have proliferated at virtually every corner in academia, industry and the society in general, despite the stagnation in raw IC processing power. In particular, deep-learning neural networks (DNN), consisting of many hidden layers, have shown the ability to generate solutions that are sometimes even superior to those based on human intelligence. For example, in 2016, the Google AlphaGo AI machines, after training for only two hours by playing with each other, beat the world's best human player in the game of Go [16]. It is generally believed that the early success of AI in the last few years heralds a much wider array of AI solutions for both commercial and defense applications in the future. One of the examples of AI for defense applications is GPS-less navigation in the jammed battlefield, in which navigation is enabled by AI-based pattern recognition of scenes acquired in real time. The important role that electronic hardware accelerators played so far clearly indicate that future developments in ANNs depend on advances in both software and hardware. However, currently, electronic hardware accelerators have already been pushed to their limits in term of scalability. Against this backdrop, there have been renewed efforts in exploring the role of optics for computing [3-6]. Three major building blocks comprising the ANNs and DNNs are 1) Interconnects, 2) matrix-vector and matrix-matrix multiplication, and 3) nonlinearity. Since optics and photonics can implement the first two functions as well as, if not better than, electronics; and optical nonlinearity at the per neuron level rather than the logic level is actually quite practical, now is the right time to explore the role of optics and photonics in ANNs and DNNs. This topic focus on photonic accelerator for linear vector, matrix, and tensor operations.

PHASE I: To develop a photonic accelerator architecture, build a prototype and experimentally demonstrate the operational principle and feasibility of the photonic accelerator. The prototype should be able to perform at least 2 TOPS (tera operations per second), achieve a matrix loading speed > 100 MHz, and consumes no more than 0.5 W of electrical power. In addition, the layout of an integrated photonic accelerator with performance matching or exceeding the requirements for Phase II described below, and consistent with available fabrication platforms, should be developed.

PHASE II: To fabricate and test an integrated photonic accelerator that can perform at least 100 TOPS (tera operations per second), achieve a matrix loading speed > 500 MHz, and consumes no more than 10 W of electrical power. Investigate the performance limits of the adopted photonic accelerator architecture in terms of computational dimensionality, computing power in units of TOPS, and power efficiency as functions of the input data rate and matrix loading speed. Production-scale costs of the photonic accelerator should be studied to show viability for reasonable cost reduction at manufacturing volumes. Motivation for phase III follow-on investment should be made evident.

PHASE III DUAL USE APPLICATIONS: Pursuit system-level AI applications based upon the photonic accelerator(s) developed in phase II. Clearly identify the advantages of the photonic accelerator over the state-of-the-art electronic accelerators, and subsequently determine whether the photonic accelerator will be used for inference and/or training. The AI system should be integrated at a military installation or on a military platform in potential applications scenarios including but not limited to communications, target classification & recognition, navigation, and simulation & training. Suitability of installing the photonic accelerator on mobile platforms such UAVs, UGVs and satellite, where power supply is limited, should be investigated. Dual-use AI applications of the photonic accelerator(s) in medicine & health care, finance, gaming, marketing and autonomous vehicles are encouraged.

REFERENCES:

1. S. A. Manavski, "CUDA compatible GPU as an efficient hardware accelerator for AES cryptography," in ICSPC 2007 Proceedings - 2007 IEEE International Conference on Signal Processing and Communications, 2007.;
2. G. Quintana-Ortí, F. D. Igual, E. S. Quintana-Ortí, and R. A. van de Geijn, "Solving dense linear systems on platforms with multiple hardware accelerators," ACM SIGPLAN Not., 2009.;
3. H. J. Caulfield and S. Dolev, "Why future supercomputing requires optics," Nat. Photonics, vol. 4, no. 5, pp. 261–263, May 2010.;
4. D. Brunner, S. Reitzenstein, and I. Fischer, "All-optical neuromorphic computing in optical networks of semiconductor lasers," in 2016 IEEE International Conference on Rebooting Computing, ICRC 2016 - Conference Proceedings, 2016.;
5. T. Deng, J. Robertson, and A. Hurtado, "Controlled Propagation of Spiking Dynamics in Vertical-Cavity Surface-Emitting Lasers: Towards Neuromorphic Photonic Networks," IEEE J. Sel. Top. Quantum Electron., 2017.

KEYWORDS: lasers, modulators, photodetector, optical computing, artificial intelligence, neural networks

A20B-T005 TITLE: Cryo-CMOS Integrated Circuits

RT&L FOCUS AREA(S): Network Command, Control and Communications
TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: To develop integrated circuits based on nanoscale CMOS (complementary metal oxide semiconductor) technology for operation at deep cryogenic temperatures with low power consumption and enhanced noise performance

DESCRIPTION: Digital electronic computer based on CMOS (complementary metal oxide semiconductor) technology is the driving force that fuels the modern data and information era. As the scaling of CMOS technology is quickly approaching its physical limit, energy scaling is becoming its bottleneck. Conversely, the advantages of operating CMOS transistors at cryogenic temperature (cryo-CMOS) have always intrigued CMOS circuit designers. A number of performance figures of merit of a CMOS process are improved when operating at low temperature without scaling down device sizes. Outstanding characteristics have been reported for advanced CMOS technologies operating at cryogenic temperature in terms of on-state current, leakage current, subthreshold swing, and transconductance. This is particularly attractive for high performance computing applications. The performance gain achieved from cooling down a CMOS integrated circuit should be judged against the cost and inconvenience of refrigeration in the context of its application. However, there are specific applications where CMOS circuits designed to operate at cryogenic temperature are advantageous. Cryogenic electronics plays an important role in sensing applications such as infrared focal plane arrays, space borne electronics, high-energy physics experiments, metrology, and astronomical detectors, and so on. Cryo-CMOS also finds its applications in the study of Quantum phenomena where low temperature is essential for minimizing thermal fluctuations. Qubits for quantum information processing typically operate at the temperature range of 10-100mK while the associated control electronics is implemented at room temperature. This approach becomes increasingly challenging and less cost-effective as the number of qubits grows. Control electronics operating at cryogenic temperatures placed right next to quantum circuits can drastically reduce interconnection complexity and noise level, and result in enhanced reliability and compactness, potentially paving the way for realizing practical quantum computers.

Even though Cryo-CMOS can be traced back to the 1960s, earlier research were performed on process nodes with large feature sizes resulting limited performance in terms of power consumption and noise. Development of nanoscale CMOS process with high intrinsic frequencies (ft, fmax ~100s GHz) offers new opportunities for realizing high performance cyro-CMOS circuits. This has led to recent demonstration of circuit blocks for quantum processing controllers (an LNA using 160-nm CMOS and a microwave oscillator using 40-nm) operating at 4 K. Device characterization at 4 k for a 28-nm bulk CMOS process has also been published recently.

Despite these progresses, many challenges remain for developing deep cyro-CMOS circuits. At the device level, unfavorable effects such as higher threshold voltage, hysteresis, kink effects, mismatch, and hot-carrier lifetime degradation become non-negligible at deep cryogenic temperatures, and must be considered and mitigated. Current refrigeration technologies have also limited cooling power with 1mW at below 100mK and 1W at 4K, and thus prevent the use of large-scale cryo-CMOS circuits. Finally, lack of cryogenic device characterization, physical and compact circuit models and process design kits (PDKs) for circuit design simulators must also be overcome. This STTR topic will address device issues in order to enable development of cryo-CMOS technology.

PHASE I: Develop Low-temperature device characterization and modeling. Perform both DC and RF measurements on MOSFETs with different technology nodes and structural types (including bulk-MOSFET, finFET, FD-SOI) across the whole temperature region from room temperature to cryogenic temperature at 4 K or lower; extract the temperature-dependence of key parameters including Ion, Ioff, SS, Vt, RS, Cj, and S-matrix; investigate low-temperature effects including substrate freeze-out, kink effect, Vt mismatch, SS saturation, etc.; develop physics-based device models to match characterization; develop compact circuit models for use in circuit simulators. Phase I research will help identify one or more existing CMOS foundry processes for designing and fabricating cryo-CMOS prototype circuits in Phase II. The chosen processes must be thoroughly characterized and modeled during Phase I.

PHASE II: Design, fabricate and characterize prototype cryo-CMOS circuits against the CMOS foundry processes chosen in Phase I. The target operating temperature is at least 4 k, or lower. Prototype circuits to be demonstrated should include a low noise amplifier (LNA) and a microwave oscillator. The following metrics should be designed for operation at 4 K. The LNA should have >1GHz bandwidth, >60 dB gain, <0.1 dB noise figure across the bandwidth, and <80 mW total power dissipation. The oscillator should operate at 10 GHz, <1 KHz RMS frequency noise, <-140 dBc/Hz phase noise at 10 MHz offset, and <100 mW total power dissipation. Fabricate the circuits and characterize them at both room temperature and 4 K. Produce a process design kit (PDK) for deep cryogenic circuit against the CMOS foundry processes used in Phase II. Explore optimizing device layout within the processes for improving performance.

PHASE III DUAL USE APPLICATIONS: Qualify a dedicated cryo-CMOS process with a trusted foundry. Explore modifying the fabrication process flow to optimize performance at low temperature. Potentially approaches could include: optimize gate work function and channel doping to shift Vt towards smaller value; gate/oxide/channel engineering for interface states reduction; source/drain contact engineering; channel thickness optimization and back-gated FD-SOI device structure design; interconnect and contact material optimization for low temperature operation. Explore cryo-CMOS for digital applications. Undertake reliability testing. Produce a process design kit (PDK). Commercialize the technology via a trusted foundry for technology availability to the defense and military markets.

REFERENCES:

1. B. Patra et al., "Cryo-CMOS circuits and systems for quantum computing applications," IEEE Journal of Solid-State Circuits, vol. 53, no. 1, pp. 309-321, 2017.;
2. A. Beckers, F. Jazaeri, and C. Enz, "Cryogenic MOS transistor model," IEEE Trans. Electron Devices, vol. 65, no. 9, pp. 3617-3625, 2018.;
3. H. Homulle, F. Sebastiano, and E. Charbon, "Deep-cryogenic Voltage References in 40-nm CMOS," IEEE Solid-State Circuits Letters, vol. 1, no. 5, pp. 110-113, 2018.;
4. A. Beckers, F. Jazaeri, and C. Enz, "Characterization and modeling of 28-nm bulk CMOS technology down to 4.2 K," IEEE Journal of the Electron Devices Society, vol. 6, pp. 1007-1018, 2018.;
5. K. Das and T. Lehmann, "Effect of deep cryogenic temperature on silicon-on-insulator CMOS mismatch: A circuit designer’s perspective," Cryogenics, vol. 62, pp. 84-93, 2014.

KEYWORDS: Quantum computing, CMOS, low power electronics, low noise, cryogenic

A20B-T006 TITLE: Virtual Off-Road Simulator for Teams of Bots and Autonomous/Conventional Wheeled/Tracked Vehicles

RT&L FOCUS AREA(S): Artificial Intelligence/Machine Learning, Quantum Sciences, Autonomy
TECHNOLOGY AREA(S): Ground Sea

OBJECTIVE: Establish an open source, publicly available software platform that can be used for the simulation-based development and testing of mixed teams of robots and Autonomous/Conventional wheeled/tracked vehicles operating off-road conditions.

DESCRIPTION: Understanding through physical testing the behavior of large groups of agents operating inter-dependently in geographic and terramechanical conditions that are of relevance to the US Army is an expensive proposition that suffers from long turnaround times. Against this backdrop, the Army sees computer simulation as an avenue for accelerating the pace at which innovation permeates the broad field of autonomous operation of mixed robot-vehicle teams in off-road scenarios. The interest is in establishing a simulation platform in which scenarios that involve teams of mixed agents are analyzed expeditiously with an eye towards improving mobility/communication/navigation solutions. Thus, the simulation platform sought should address several aspects deemed critical in the economy of the practical problem of interest, e.g. agent dynamics, sensing, inter-agent communication, real time constraints, scalability, and interfacing to control strategies. Moreover, in order to ensure a lasting effect of this investment, the solution developed should be open source and available in the public domain for rapid dissemination and adoption by any interested party.

The platform should simulate the dynamics of the agents and their interaction with the surrounding environment. This is particularly critical in evaluating or developing strategies used when terramechanics factors limit the capability of the vehicle (e.g., traversal of soft soils). Furthermore, the dynamics of the vehicle-ground interaction are exceedingly important and can require highly complex modeling of granular or other deformable terrain. Beyond model fidelity constraints, computational requirements must be considered such that the simulation meets real time or performance constraints determined by the task. Alongside dynamics, the simulation technology must be able to provide accurate virtual sensing as a mechanism to introduce realistic inputs to the control strategies being tested. The sensing requirements in off-road conditions for autonomous vehicles and robots are (a) sensing of the environment, e.g. camera (mono, stereo, thermal), LiDAR, radar, ultrasonic, GPS, and (b) sensing the agent's own state, e.g. engine, driveline, suspension, brakes, IMU. This sensing simulation capability is critical as it provides the input to the control strategies used by the agent to navigate the virtual environment. While sensors provide a primary connection for the control algorithms to understand the world, these agents are also capable of inter-communication to collaborate and coordinate movements. This same capability must be provided in simulation to allow for testing connected behavior such as platooning and task coordination. Because the dynamics and sensing rely heavily on a coherent description (in both time and space) of their surroundings, management of the virtual world is a critical component of this simulation platform. The virtual world must provide an accurate representation for simulating the interaction of agents with the surrounding environment in off-road conditions. Given its correspondence to a highly rich feature set, the virtual world must include many layers including subsurface, surface, topography, vegetation, obstacles, other external agents (i.e. animals and humans), and environmental conditions. These layers must be coherent across domains such that the dynamics, camera (visible and thermal), LIDAR, radar, and ultrasonic simulations are all consistent.

PHASE I: In Phase I, the following shall be accomplished:

a) Carry out a comprehensive review of literature to produce a document detailing the state of the art vis-à-vis simulation environments for single and multiple-agent testing in both on-road and off-road conditions.
b) Establish a detailed plan to handle the four aspects (dynamics, sensing, communication, virtual world) related to the simulation of single- and multiple-agent testing in scenarios relevant to off-road operations.
c) Establish a detailed plan to address the modeling of the vehicle-terrain interaction at various levels of accuracy: from expeditious (empirical, data driven, etc.) to high fidelity (physics-based).
d) Establish a detailed plan for an open source implementation of the simulation platform that leverages parallel computing for scalability.
e) Articulate a vision for how the solution proposed, despite 3rd party software dependencies, will flourish as an open source simulation platform available for unfettered use, augmentation and distribution by other parties interested in this line of work.
f) Produce an early "demonstration of technology" prototype that showcases in a preliminary form the key components of the overall solution advanced by the project.

PHASE II: In Phase II, the following shall be accomplished: An open source simulation platform will be developed that:

a) Allows the simulation of tens of robots and autonomous/conventional wheeled/tracked vehicles operating in off-road conditions.
b) Allows simulation under "soft real time" as well as non-real time conditions.
c) Demonstrates use in deformable soil conditions
d) Possesses the interface to connect to any widely adopted control framework (e.g., ROS) and thus be able to serve as a testbed for new AI and emerging controls approaches aimed at enabling autonomy in off-road conditions typically associated with the Next Generation NATO Reference Mobility Model
e) Demonstrates the ability to simulate agent-to-agent and agent-to-infrastructure communication
f) Demonstrates the ability to emulate rich real-world scenarios that include, for instance, setups with deformable soils, various weather conditions, etc.

PHASE III DUAL USE APPLICATIONS: The modeling approaches, numerical techniques, performance and control models, and software development techniques established under this topic are positioned to aid in further advancement in the broad area of autonomy. By virtue of being publicly available and released as open source under a permissive license, this platform will have an increased likelihood of being adopted and/or extended by parties other than DOD partners; and, it will serve as a source of inspiration for commercial enterprises that can recycle, reuse, and improve the ideas embedded in this work for further refinement.

REFERENCES:

1. "AVT-248 Next-Generation NATO Reference Mobility Model (NRMM) Development," 2018
2. "On the Use of Simulation in Robotics. An NSF-DOD-NIST Workshop Report," 2018
3. Robotic Operating System (ROS), 2019

KEYWORDS: autonomous agents, computer simulation, sensing, V2X communication, dynamics simulation, open source software, artificial intelligence

A20B-T007 TITLE: Actuation for Human-Scale Dynamic Whole-Body Manipulation

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

OBJECTIVE: To provide opportunity for scientific exploration of next-generation robotic and physical human augmentation performance systems and associated controls through development of actuation technologies, and the associated framework of predictive modeling.

DESCRIPTION: Currently human-scale robots and devices employed in human-scale physical augmentation devices and prosthetics employ mostly rotary-motion electric motors or hydraulics. We have made significant advances and demonstrations through design, fabrication methods, and controls in each of these technologies over the past several years, but they are still lacking in terms of performance, cost, and fundamental physics-based criteria for systems that are used in human-scale dynamic limb-based locomotion and whole-body manipulation. These forms of actuation have also been seen as limiting factors in development of machine morphologies which can replicate the degrees of freedom of human motion and human performance needed for human prosthetics and exoskeletons. There are examples of efficient and dynamic limb-based mechanisms which have been achieved through means of iterative design in which the systems mechanics and morphology are expertly matched with highly customized and optimized forms of actuation and unique electronic controllers. They represent a state of the art which has yet to be accepted as suitable for machines that are expected to perform as physical teammates to Soldiers in high-OPTEMPO missions.

This proposal seeks to continue further and spawn new research and commercialization for forms of robotic actuation and promote a mechanism design paradigm compatible with that of open, modular software development recently being adopted within the Department of Defense and academia. The goal is to provide examples of scalable forms of actuation (size and number) which may be seen as viable options for improving the performance and efficiency of next generation robotics mechanisms. New forms actuation which can deliver human scale forces and moments in lightweight and energy efficient configurations such as hydraulically amplified self-healing electrostatic (HASEL) soft actuators or other less common electrostatic-based actuators which have potential for making systems with less mass, less cost, and compatible with morphologies requiring distributed actuation are examples. Some of these forms of actuation may be seen as complementary to established actuators such as electric rotary actuators and hydraulics. For example, this may include actuated structures which have adaptive compliance characteristics. New electric rotary actuator and hydraulics based concepts may be considered as well. For example, limb-based human-scale dynamic locomotion and whole-body manipulation requires high-torque with high-frequency control. New scalable actuator designs addressing these requirements may be considered. For new rotary electric motor designs capable of offering improved suitable performance this could mean novel coil and magnet configurations combined with new motor controller sensing techniques which optimize force generated from magnetic field interaction.

PHASE I: In Phase I, the following shall be accomplished:

a) Survey current design and approach for developing scalable actuator technology that may be employed for efficient dynamic human-scale whole-body manipulation and dynamic locomotion. Review typical applications and regimes of interest, and identify relevant physical, electronic, software specifications and parameters to demonstrate the feasibility of an analytic and engineering infrastructure for their design, fabrication, and control.
b) Analyze and identify useful families of robotic morphology and/or structures in which the actuators may be employed.

c) Develop concept(s) through which the actuators or combinations of actuators may be employed and controlled feasibly to improve performance of human-scale robotic systems.
d) Implement the concept(s) numerically and conduct the appropriate proof-of-concept computations.
e) After the concept has been numerically demonstrated, use to fabricate a prototype or demonstration which validates numerical simulation.

PHASE II: In Phase II, the following shall be accomplished:
a) The actuator technology (actuator, actuator controller, actuator feedback) from Phase I will be tested, validated, and implemented. Aspects of efficient scalable performance and fabrication for efficient custom design will be demonstrated and characterized.
b) The actuator performance characterization models and control algorithm software and from will be tested, validated, and implemented as a documented software package that can be shared or distributed. The models should have compatibility with modern physics-based simulation software such that their performance may be predicted in a mechanical device.
c) Numerically demonstrate that models characterizing the actuator and performance are compatible with a modern physics-based robot simulation and that the information feedback from the actuators and/or actuation controller is suitable for whole-body manipulation control.
d) Numerically and in device tests, demonstrate that the actuator and controls software performs as predicted. This should be demonstrated at multiple scales (2x, 3x) or in the case of distributed actuators possibly different numbers (2x, 3x) of actuators.
e) Generalize the methodology in a-d to provide a range or families of actuators which may be readily simulated and fabricated for near-term and future human-scale robot use.
f) Develop and demonstrate fabrication method for the scalable range of actuators described above. Transition the developed methods and software, including documentation, to interested users in academia, industry and government (e.g. ARL) under appropriate licensing agreement.

PHASE III DUAL USE APPLICATIONS: The actuators, numerical techniques, performance and control models, and fabri-cation techniques developed under this topic will aid in further advancement of robotic technologies for dynamic human-scale whole-body manipulation and lo-comotion. The results will be corroborated by prototype fabrication. In addition this will demonstrate a model and paradigm for robotic actuator development which is synergistic to modern dynamic robot design, modular open robotic soft-ware development and DoD interoperability protocols. This will lead to a much needed methodology for actuator design for dynamic limbed systems which is technically sound, facilitates advancements to state of the art robot design, and is commercially and fiscally viable.

REFERENCES:

1. E. Acome, S. K. Mitchell, T. G. Morrissey, M. B. Emmett, C. Benjamin, M. King, M. Radakovitz, C. Keplinger, Hydraulically amplified self-healing electrostatic actuators with muscle-like performance. Science, Vol. 359, Jan 2018, pp. 61-65.;
2. M. Mazzara, RSJPO Interoperability Profiles, Robotic Systems Joint Project Office, US Army TARDEC, Warren MI, September 2012.;

3. P. Wensing, A. Wang, S. Seok, D. otten, J. Lang, S. Kim, Proprioceptive Ac-tuator Design in the MIT Cheetah: Impact Mitigation and High-Bandwidth Physical Interaction for Dynamic Legged Robots, IEEE Transactions on Ro-botics, Vol. 33, Issue: 3, June 2017.

KEYWORDS: actuator, robot, exoskeleton, prosthetics, control, dynamics

A20B-T008 TITLE: Physical Monitoring Techniques to Improve Warfighter Performance

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

OBJECTIVE: Develop multimodal wearable monitoring devices integrated with artificial intelligence-based decision aids for tracking biophysiological states, including cognitive, in the presence of various environmental and physiological stressors.

DESCRIPTION: The explosion of new wearable medical monitoring devices, miniaturized sensors, and artificial intelligence is providing new opportunities to optimize human performance and mitigate the effects of stressors that degrade performance and health within operational settings. Taking inspiration from the use of these technologies for improving the performance of professional athletes, the Department of Defense intends to optimize warfighter performance using similar techniques. The purpose of this topic is to explore technologies that will make tomorrow's warfighter faster, smarter, and stronger than their adversaries.

The human performance focus area involves all aspects of cognition and decision-making, physiology and ergonomics, and the integrating technologies required to support a fully optimized, capable soldier; acting within a given operational setting. The goal of this is the optimization of individual and team performance in combat environments using a range of solutions, scalable across all leadership levels and command echelons. Human performance emphasizes the need to expand Warfighter capabilities while mitigating Warfighter limitations as they apply in combat.

To ensure mission superiority, the information about a Soldier's mind-body state must be successfully acquired and understood within the context of the Warfighter's cognitive capacity being stressed by fatigue, heat, altitude, interruptions, etc. This challenge is further magnified when a team or multiple teams are required to act together on the same mission. Methods and processes need to be explored that enhance peer-to-peer collaboration, shared situation awareness, and rapid decision making.
In the field, warfighters are exposed to a complex set of stressors affecting their physical and cognitive abilities; often altering their physiological well-being (e.g., sleep deprivation, biological rhythm changes, heavy equipment loads, demanding physical tasks, extreme weather/environmental conditions, and inadequate/improper nutrition). The impact of many of these stressors on performance is poorly understood and their combined effects on health and combat effectiveness are virtually unknown. Furthermore, what little is known about the mitigating effects of training and self-management on physical and physiologic viability has not been rigorously applied to the challenge of enhancing Warfighter performance nor has it been demonstrated to be viable in operational or synthetic training environments.

There is a need for a novel wearable monitoring solution to promote sustained performance and Warfighter health while helping to offset: 1) training related injuries during physical training across operational environments; 2) fatigue and other performance decrements in extreme environments combined with other stressors; 3) combat performance decrements related to sleep quality, sleep deprivation and sustained operations; 4) impacts of individual stress reactions during performance of operational tasks on overall warfighter health.

Gap 1: Insufficient understanding of individual physiological performance markers.
Gap 2: Insufficient understanding of the interaction between physical environment (stress, noise, fatigue hydration) and cognitive demands (workload, multitasking, and interruptions) on combat readiness and performance

Gap 3: Inadequate automation methods to support information gathering, analysis, and processing leading to more effective and timely decisions at every command echelon.

PHASE I: Identify the proper form factor of a multimodal biophysiological wearable solution for combat and training environments. This solution should be evaluated for the appropriate sensors required to enable accurate classification of biophysiological states (e.g. from cardiac, respiratory, ambulatory and/or neural) and physical activities (running and climbing, etc). Continued evaluation of materials used in the form factor for strength and durability should begin during Phase I and can continue into Phase II.

PHASE II: Develop artificial intelligence algorithms for classification of multi-sensor biophysiological data while a subject is performing complex motion under varying environmental conditions. Customized sensors for motion and altitude may be required here. Phase II should include a pilot study to validate classification accuracy while the device is being worn during strenuous physical activities. Data analysis and classification should begin with the goal of identifying the appropriate state-space for providing individualized biophysiological state assessment.

PHASE III DUAL USE APPLICATIONS: Establish methods and conduct focused studies to measure sets of biophysiological markers, classify mind-body states related to performance and incorporate an artificial intelligence-based decision aid to provide performance augmentation and resilience recommendations. This will require a population of individuals from within the appropriate environment and age group. The studies will require the establishment of baselines on individuals with further 'deep dives' in simulated environments.

REFERENCES:

1. Karl E. Friedl, "Military applications of soldier physiological monitoring" Journal of Science and Medicine in Sport, Volume 21, Issue 11, November 2018, Pages 1147-1153;
2. Thomas Wyss et al, "The comfort, acceptability and accuracy of energy expenditure estimation from wearable ambulatory physical activity monitoring systems in soldiers", Journal of Science and Medicine in Sport, November 2017, Volume 20, Supplement 2, Pages S133–S134;
3. Gina Pomranky-Hartnett et al, Army Research Lab Aberdeen Proving Ground MD Human Research And Engineering Directorate, "Soldier-Based Assessment of a Dual-Row Tactor Display during Simultaneous Navigational and Robot-Monitoring Tasks"; Final Report, 1 Feb 2014-31 Mar 2015, DTIC Accession Number ADA623857;
4. Patricia Kime, "Engineering Supersoldiers: Boost In Lethality May Come From Within", https://www.ausa.org/articles/engineering-supersoldiers-boost-lethality-may-come-within, Oct 24, 2018;
5. Lauren Fish and Paul Scharre, "The Soldier's Heavy Load" https://www.cnas.org/publications/reports/the-soldiers-heavy-load-1, Sept 26, 2018

KEYWORDS: Human Performance, Physical Training, Wearable Technology, Medical Wearables, Physiological Performance Markers

A20B-T009 TITLE: Three-Dimensional Microfabricated ion Traps for Quantum Sensing and Information Processing

RT&L FOCUS AREA(S): Quantum Sciences
TECHNOLOGY AREA(S): Electronics

OBJECTIVE: Innovate, develop, demonstrate, and commercialize three-dimensional microfabricated ion traps needed for the robust and high-performance operation of ion-based quantum sensors, clocks, and other precision measurement systems.

DESCRIPTION: Recently several basic research advances Refs. (1-9) have been made in ion-trap quantum systems that have significantly improved the performance of these systems. These research advances include micro-fabricated surface ion traps that have been very successful in quantum technology applications. However, surface ion traps make many design compromises such as the trap depth, ion height from the surface, among others that may not be best suited for all potential quantum technology applications. In particular, anomalous ion heating and stray charges have been a significant hurdle to advancing ion trap experiments. Three-dimensional traps provide an alternate set of design parameters enabled by geometry that may overcome some of the compromises of surface ion traps. To date, typical microfabricated three-dimensional traps have been assembled by hand. The poor precision of hand assembly has significantly limited the performance of these three-dimensional traps. Modern microfabrication techniques such as additive manufacturing, three-dimensional printing, photo-chemical structuring of fused silica, among others, permit monolithic high-precision three-dimensional ion trap geometries to be pursued. In addition, three-dimensional geometry provides the space and path for innovative laser light delivery, microwave delivery, shielding, and wiring. The design trade-space provided by three-dimensional geometry, in combination with matched high-precision microfabrication techniques and new materials, provides the opportunity to develop high-performance integrated ion-trap quantum systems, while maintaining small size and form factor. There are several technical challenges that must be addressed that integrate the versatility of the design space of three-dimensional geometry with matched materials and monolithic micro-fabrication techniques. Machine-learning techniques may help optimize the design space combined with the constraints of fabrication and materials. Further research and development is needed that holistically views ion trap design and fabrication to address these challenges. For many potential applications, holistic designs must provide a high degree of optical access covering a wide range of wavelengths that can span the near ultra-violet to the near infra-red, microwave access, electrodes and electrode wiring for ion control, high operating voltages, and be compatible with other components needed for operating a complex ion-trap system. Room temperature operation is desired. Materials used must be compatible with ultrahigh vacuum processing and operation. Low residual magnetic fields are needed for magnetic sensor applications.

PHASE I: Innovations and explorations are needed with the design trade space offered by three-dimensional ion traps in combination with and matched to modern techniques for the high-precision microfabrication of these traps to develop a high-performance compact integrated ion-trap quantum system. Effort should focus on design and proof-of-concept demonstration of critical fabrication steps, materials, and system components comprising an integrated design of a three-dimensional ion trap, including optical and/or microwave access and electrode wiring. Modeling and simple experiments should be performed to demonstrate feasibility of the proposed approach. An example application of trapped ions should be identified and used for the proof-of-concept demonstration of trap performance.

PHASE II: Finalize design and build prototypes of the three-dimensional microfabricated ion-trap quantum system. Provide a demonstration deployment that validates the technology at a laboratory that does suitable ion-trap quantum system experiments. The Phase-II program shall provide a plan to transition the technology to commercial development and deployment, wherein the three-dimensional traps are available for purchase by the user community.

PHASE III DUAL USE APPLICATIONS: The three-dimensional ion traps developed in Phase II will provide a versatile platform for the successful development and demonstration of quantum sensors, quantum computing, and other precision measurement systems based on ion chip traps. Potential customers include researchers in universities, industry, DoD laboratories, and DoD contractors and system integrators. Partnerships with system integrators developing gravity gradiometers, timing systems, navigation systems, and similar such sensor and measurement systems is another Phase III avenue. Other Phase III opportunities include the leverage of IP generated from component technology for other applications requiring monolithic precision microfabrication requiring high optical, microwave, or wiring access. Further commercial applications could include the mining industry.

REFERENCES:

1. D. Stick, W. K. Hensinger, S. Olmschenk, M. J. Madsen, K. Schwab, and C. Monroe, "Ion trap in a semiconductor chip," Nature Phys. 2, 36-39 (2006).;
2. J. Chiaverini, R. B. Blakestad, J. Britton, J. D. Jost, C. Langer, D. Leibfried, R. Ozeri, and D. J. Wineland, "Surface-Electrode Architecture for Ion-Trap Quantum Information Processing," Quantum Inf. Comput. 5, 419 (2005).;
3. K. R. Brown, R. J. Clark, J. Labaziewicz, P. Richerme, D. R. Leibrandt, and I. L. Chuang, "Loading and characterization of a printed-circuit-board atomic ion trap," Phys. Rev. A 75, 015401 (2007).;
4. S. Seidelin, J. Chiaverini, R. Reichle, J. J. Bollinger, D. Leibfried, J. Britton, J. H. Wesenberg, R. B. Blakestad, R. J. Epstein, D. B. Hume, W. M. Itano, J. D. Jost, C. Langer, R. Ozeri, N. Shiga, and D. J. Wineland, "Microfabricated Surface-Electrode Ion Trap for Scalable Quantum Information Processing," Phys. Rev. Lett. 96, 253003 (2006).;
5. J. M. Amini, J. Britton, D. Leibfried, and D. J. Wineland, "Microfabricated Chip Traps for Ions," arXiv:0812.3907 (2008).;
6. G. Wilpers, P. See, P. Gill, and A. G. Sinclair, "A monolithic array of three-dimensional ion traps fabricated with conventional semiconductor technology," Nature Nanotech. 7, 572-576 (2012).;
7. Maryse Ernzer. Challenges in design and fabrication of a scalable 3D ion trap. Master’s thesis, ETH Zurich, 2018.;
8. D. T. C. Allcock et al. A microfabricated ion trap with integrated microwave circuitry. Appl. Phys. Lett., 102:044103, 2013.;
9. K. K. Mehta, C. D. Bruzewicz, R. McConnell, R. J. Ram, J. M. Sage, and J. Chiaverini. Integrated optical addressing of an ion qubit. Nat. Nanotechnol, 11:1066, 2016.

KEYWORDS: ion traps, three-dimensional ion traps, quantum sensors, quantum computing

A20B-T010 TITLE: Additive Manufacturing of Thermally Cured Thermoset Polymers

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

OBJECTIVE: Develop an additive manufacturing technique that allows for processing of thermally-cured thermoset polymers.

DESCRIPTION: Thermally cured thermosets, such as polyurethanes and polydimethylsiloxes (PDMS), are widely used in a myriad of industrial and military-relevant applications, such as machine parts, protective coatings, and medical devices, as they possess high thermal and mechanical stability. Additionally, as polymers, these materials possess the attractive features of being lightweight, ease of manufacturing relative to other high strength materials (e.g., metals/alloys), and inexpensive. Because of these attributes, thermally-cured thermosets currently dominate the traditional manufacturing space for thermoset materials. Highly desirable, however, is an additive manufacturing (AM) methodology amenable to processing these materials, as this would enable an "on demand", energy-efficient means of their production. AM has also been demonstrated as a platform to rapidly fabricate customizable parts. This would be particularly impactful for DOD applications where manufacturing at the point of use may provide critical capabilities while decreasing and/or eliminating supply chain and logistical challenges. To date, the difficulty in 3D printing thermally-cured thermosets largely stems from a need for extremely rapid heating/cooling cycles (sub microsecond) that span large temperature changes – a requirement that cannot be easily met using conventional bulk heating. Recently, researchers have demonstrated novel methods of internal heating using nanoscale heat sources, such as photothermal curing (ref 1), or pulsed microwave irradiation (ref 2) that could support the rapid cure cycles required with additive manufacturing. Additionally, the aforementioned photothermal curing method has demonstrated tunable mechanical and physical properties based on the intensity of light irradiation, thus offering potential access to 3D printed parts with tailored properties (ref 3).

There is an essential need to develop an additive manufacturing technique that enables the processing of purely thermally-cured thermoset polymers. The technique should also be generalizable include different types of thermally-cured thermosets. Additionally, the proposed method should not require an oven to fix the final print, and the final part should demonstrate mechanical and thermal stability akin to cast parts made from the same polymer formulation.

PHASE I: Develop a methodology that enables only thermally-activated curing of 1 of the following thermosets: epoxy-amines, PDMS, or polyurethanes, using only commercially available components. Please note that resins that are easily polymerized via photoinitiation, such as cationic epoxies and (meth)acrylates, will not be considered. The 3D printing technique should be capable of curing at the point of extrusion, and preferably not require and oven to fix the print. If an oven is used to post-cure, the printed part should be stable for 1hr prior to oven curing. The printer should have a minimal average speed of 10mm/s throughout a print and be able to continuously print for a minimum of 20 minutes. The technique should also demonstrate the ability to stop/restart after 10 minutes with no need to clean the printer. The final print part should demonstrate a resolution (layer thickness and length) less than 1mm. 3DBenchy and other common 3D printing stress tests should be performed to ensure (i) the Young's modulus, tensile strength, and glass transition temperature are similar to cast parts from the same polymer formulation, (ii) good adherence between layers, and (iii) solvent and light resistance similar to cast parts from the same polymer formulation. The performers should demonstrate the ability to systematically and controllably vary the thermal and mechanical properties to render parts that range from elastomeric to glassy.

PHASE II: Demonstrate the method developed in Phase I can be extend to use a different thermally-cured thermoset than the one the team selects in Phase I and should also extend Phase I capabilities to enable print speeds to a minimum of 50 mm/s continuously for 4 hours. Additionally, the printer should be able to change the resolution of the print (1mm to 0.1mm) and the print speed (10mm/s to 50mm/s), and also demonstrate the ability to print without user intervention. The final print parts for both classes of thermosets should demonstrate a resolution down to 0.1mm, enable printing of complex shapes, and demonstrate inclusion of specified hollow features. To validate the ability to cure and lock in the part, key structures should be printed. One such example include scaffolds and a mathematical geometric comparison of the printed geometry vs the expected geometry should be determined. Another example includes a tall structure, such as a cylinder, should be prepared to assess for slumping of the part as pressure from above layers could cause not fully cured towards the bottom of the part to flow and cause distortions and slumping of the part. Additionally, the final printed parts should demonstrate mechanical, thermal, and performance properties that exceed that of common AM resins. Solutions that also demonstrate the ability to monitor stress-development during cure, as well as the ability to co-print two different thermally-activated thermosets are highly desired.

PHASE III DUAL USE APPLICATIONS: The proposed technology has a broad range of civilian and military applications as thermoset polymers are widely used as machine parts for automotive and aerospace applications, as wound dressings for biomedical applications, as well as protective coatings. This technology could have transformative implications for DoD as it will enable the ability to print thermally-cured thermosets “on-demand” greatly simplifying the supply chain. In the civilian sector, in addition to health care implications, this technology may also enable mass customization of consumer products comprised of thermoset materials.

REFERENCES:

1. Fortenbaugh, R.J.; Lear, B.J., On-demand Curing of Polydimethylsilozane (PDMS) using the photothermal effect of gold nanoparticles. Nanoscale 2017, 9, 8555.;
2. Choi, W.; Choi, K.; You, C., Ultrafast Nanoscale Polymer Coating on Porous 3D Structures Using Microwave Irradiation. Advanced Functional Materials 2018, 28, 1704877.;
3. Fortenbaugh, R.J.; Carrozzi, S.A.; Lear, B.J., Photothermal Control over the Mechanical and Physical Properties of Polydimethylsiloxane. Macromolecules 2019, 52, 3839.

KEYWORDS: thermoset polymers; additive manufacturing; 3D printing; polymer curing; mechanical stability

A20B-T011 TITLE: Cost Effective Synthesis of Linear Ring Opening Metathesis Polymers

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

OBJECTIVE: Develop and demonstrate a cost-effective method to produce linear ring opening metathesis polymers of poly(dicyclopentadiene).

DESCRIPTION: Recent work on ring opening metathesis-based polymers (ROMP) like poly(dicyclopentadiene) (pDCPD) and poly(ethylidene norbornene) (pENB) have shown remarkable high velocity impact performance 1, which is relevant for soldier and vehicle protection applications. Tailoring of the non-covalent interactions in crosslinked ROMP polymers with polar monomers has resulted in remarkable control over polymer modulus and strength 2, while linear non-polar ROMP polymers (i.e., those that are not crosslinked like pENB) have shown remarkable toughness and high velocity impact performance 3. This impact performance, however, can be degraded by oxidative or thermally driven crosslinking due to aging 4. Linear pDCPD that is resistant to crosslinking during aging would be particularly attractive due to the low cost of DCPD monomer, low polymer density, reasonable modulus and yield strength, high glass transition temperature, and low susceptibility to water degradation. So, ideal ROMP chemistries would involve linear polymerization of pDCPD along with the ability to tailor the polymer polarity and include stabilizing additives.

Currently available commercial strategies for polymerizing pDCPD result in crosslinked networks of polymers upon reaction facilitated by Grubbs catalyst or tungsten-based catalysts. These crosslinked systems have the following drawbacks: (1) they cannot be used in solvent-based processing (e.g., for composite prepreg production) due to insolubility in solvents and (2) high levels of crosslinking reduce the fracture toughness and can result in poor high velocity impact behavior. Furthermore, using monomers other than dicyclopentadiene (e.g., those that only linearly polymerize such as ethylidene norbornene) result in large increases in cost, making the materials no longer competitive with conventional structural resins. In contrast, linear poly(dicyclopentadiene) is expected to have the following decided advantages: (1) excellent high velocity impact performance and toughness, (2) potential for solution-based processing into composite prepregs and (3) the potential for polymerization of polar-group containing monomers (e.g., 5-norbornene-2-methanol) or post-processing heteroatom functionalization through secondary mechanisms.

Thus, we seek the development of novel techniques or novel use of existing techniques that can be used to synthesize linear ROMP polymers, specifically pDCPD and other monomers like 5-norbornene-2-methanol that are stable and resistant to environmentally driven crosslinking. This method must be usable with solvent and without solvent (neat) to allow for the full breadth of polymer processing options. The method should also provide a long shelf life for the linear pDCPD (i.e., it should prevent ambient crosslinking of linear polymers).

PHASE I: The offeror(s) shall develop a technique to synthesize linear polymers of dicyclopentadiene (100%) and co-polymers of other ROMP-capable monomers (e.g., 50% DCPD and 50% of another monomer) both in solvent and in the absence of solvent (i.e., neat). The offeror(s) shall demonstrate the use of the solvent-less version of the method to fabricate 6 inch by 6 inch by 0.25 inch thick plates of material. The offeror(s) shall perform rheological or mechanical measurements of the entanglement molecular weight of the synthesized polymers and target overall polymer molecular weights that are 100 times higher than the entanglement molecular weight. The offeror(s) shall also perform a preliminary short (days to weeks) study of the environmental aging of the synthesized polymers to identify the mechanisms involved in undesirable crosslinking (e.g., oxidative aging or aging due to exposure to sunlight).

PHASE II: The offeror(s) shall expand the method developed in Phase I to the use of ROMP monomers containing polar functional groups (e.g., hydroxyl, carboxylic acid, epoxy) and surface-active groups (e.g., trimethoxysilane, thiols, phosphonic acids), again achieving both solvent-based and solvent-less synthesis. Alternatively, the offeror(s) may develop a method of functionalizing linear pDCPD post-synthesis with the groups listed above using a scalable, cost effective method. The offeror(s) shall further demonstrate the processability of the material by solvent casting 12 inch by 12 inch sheets of linear pDCPD and other linear ROMP polymers to thicknesses of 20-500 microns. 3D printing is not desired and will not be considered. Due to the unsaturated nature of pDCPD and other polymers, the offeror(s) will determine the longer term (months-years) aging characteristics of their fabricated polymers and develop means of arresting or mitigating aging (e.g., by using stabilizing additives or including such stabilizers in the polymer itself).

PHASE III DUAL USE APPLICATIONS: The offeror is expected to aggressively pursue opportunities to market the method developed herein for use in adhesives, prepregs, consumer products, fiber reinforced composite applications, and electronic encapsulants in both military and commercial applications.

REFERENCES:

1. Knorr Jr, D. B.; Masser, K. A.; Elder, R. M.; Sirk, T. W.; Hindenlang, M. D.; Yu, J. H.; Richardson, A. D.; Boyd, S. E.; Spurgeon, W. A.; Lenhart, J. L., Overcoming the structural versus energy dissipation trade-off in highly crosslinked polymer networks: Ultrahigh strain rate response in polydicyclopentadiene. Composites Science and Technology 2015, 114, 17-25.;
2. Elder, R.; Long, T.; Bain, E.; Lenhart, J. L.; Sirk, T., Mechanics and nanovoid nucleation dynamics: Effects of polar functionality in glassy polymer networks. Soft Matter 2018.;
3. Long, T. R.; Elder, R. M.; Bain, E. D.; Masser, K. A.; Sirk, T. W.; Yu, J. H.; Knorr, D. B.; Lenhart, J. L., Influence of molecular weight between crosslinks on the mechanical properties of polymers formed via ring-opening metathesis. Soft Matter 2018, 14 (17), 3344-3360.;
4. Richaud, E.; Le Gac, P.Y.; Verdu, J., Thermo-oxidative aging of polydicyclopentadiene in glassy state. Polymer Degradation and Stability 2014, 102 (4), 95-104.

KEYWORDS: Polymerization, composites, manufacturing processes, fabrication, durability, ballistics, protection

A20B-T012 TITLE: An Accurate Missile Plume Flowfield and Signature Analysis Tool

RT&L FOCUS AREA(S): Hypersonics
TECHNOLOGY AREA(S): Weapons

OBJECTIVE: Develop a methodology and analysis package for the accurate prediction of missile afterburning plume signatures capturing the effect of afterburning shutdown at high altitude.

DESCRIPTION: Predicting the emission signature and radar cross-section of rocket exhaust plumes is of vital interest to the Missile Defense Agency and the U.S. Army to protect the U.S. homeland and our forces abroad. Threat detection and identification can be enhanced by understanding the basic physics of rocket exhaust plumes interacting with the ambient atmosphere, in particular the phenomena of plume afterburning and afterburning shutdown. Plume afterburning is the combustion of rich rocket exhaust with the surrounding air, leading to increased plume temperatures and enhanced thermal emission up to altitudes on the order of 30 km. Accurately modeling this phenomenon depends on knowing the engine exhaust composition and conditions, the interaction of the engine exhaust with the base area of the rocket, and the flow field surrounding the vehicle. In addition, the turbulent combustion model must be capable of accurately capturing ignition, extinction, and reignition behavior in the plume shear layer while remaining computationally tractable. With the advancement of current sensor technology, the effects of turbulent combustion are now detectable and must be modeled.

PHASE I: Predicting the emission signature and radar cross-section of rocket exhaust plumes is of vital interest to the Missile Defense Agency and the U.S. Army to protect the U.S. homeland and our forces abroad. Threat detection and identification can be enhanced by understanding the basic physics of rocket exhaust plumes interacting with the ambient atmosphere, in particular the phenomena of plume afterburning and afterburning shutdown. Plume afterburning is the combustion of rich rocket exhaust with the surrounding air, leading to increased plume temperatures and enhanced thermal emission up to altitudes on the order of 30 km. Accurately modeling this phenomenon depends on knowing the engine exhaust composition and conditions, the interaction of the engine exhaust with the base area of the rocket, and the flow field surrounding the vehicle. In addition, the turbulent combustion model must be capable of accurately capturing ignition, extinction, and reignition behavior in the plume shear layer while remaining computationally tractable.

PHASE II: Implement the plan identified in Phase I to develop an integrated procedure to generate rocket plume flowfields that accurately capture the afterburning plume and afterburning shutdown phenomena. The metric is to include targeted experiments to confirm critical aspects of the CFD and turbulent combustion models. These models are expected to run within a reasonable time period and on a reasonable amount of computing resources. The model algorithm must be more efficient or reduce the chemistry mechanism (compared to current models) without enlarging the grid space or computational nodes. Additionally, identify approaches to incorporate the effect of particles in the plume and extract useful IR/UV/VIS/Radar signature predictions.

PHASE III DUAL USE APPLICATIONS: For military applications, this technology will be directly relevant to the identification of high-speed threats and launch early warning, including hypersonic airbreathing missiles. In the commercial and civil space arenas this capability would enable better predictions of the base heating environment of launch vehicles. The most likely customer and source of Government funding for Phase-III will be those service project offices responsible for the development of threat identification and launch early warning surveillance, however the development of highly accurate and computationally tractable turbulent combustion models can be expected to be commercially valuable for the simulation of gas turbine, diesel, and scramjet engines as well as conventional furnaces or boilers.

REFERENCES:

1. Anon. (2019). “2019 Missile Defense Review,” U.S. Department of Defense, Office of the Secretary of Defense. Accessed at: https://media.defense.gov/2019/Jan/17/2002080666/-1/-1/1/2019-MISSILE-DEFENSE-REVIEW.PDF;
2. Bauer, C., Koch, A., Minutolo, F., and Grenard, P. (2013). “Engineering model for rocket exhaust plumes verified by CFD results,” presented at the 29th International Symposium on Space Technology and Science (ISTS), 2 -9 June, Nagoya,Japan. Accessed at: https://www.researchgate.net/publication/259898258_Engineering_model_for_rocket_exhaust_plumes_verified_by_CFD_results;
3. Klimenko, A. Y. and Bilger, R. W. (1999). “Conditional Moment Closure for Turbulent Combustion,” Progress in Energy and Combustion Science, Vol. 25, pg 595-687.;
4. Sitte, M. S. and Mastorakos, E. (2017). "Modeling of Spray Flames with Doubly-Conditional Moment Closure," Flow, Turb. and Comb., Vol. 99, pg 933-954.;
5. Turanyi, T. and Tomlin, A. (2014). “Analysis of Kinetic Reaction Mechanisms,” Springer, Heidelberg.;
6. Zhou, C.-W., Y. Li, U. Burke, C. Banyon, K.P. Somers, S. Ding, S. Khan, J.W. Hargis, T. Sikes, O. Mathieu, E.L. Petersen, M. al Abbad, A. Farooq, Y. Pan, Y. Zhang, Z. Huang, J. Lopez, Z. Loparo, S.S. Vasu, and H.J. Curran (2018). “An experimental and chemical kinetic modeling study of 1,3-butadiene combustion: Ignition delay time and laminar flame speed measurements,” Combustion and Flame 197, 423-438.

KEYWORDS: plume afterburning, turbulent combustion, reduced mechanism, ignition, extinction, reacting flow CFD

A20B-T013 TITLE: Quasi-Orthogonal Doppler Waveform Applications

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

OBJECTIVE: Develop one or more applications to demonstrate performance improvements within reciprocal bistatic or other multiple-channel radar systems achieved through the use of Quasi-Orthogonal Doppler waveforms.

DESCRIPTION: To address complex battlefields of the future the U.S. Army requires enhancements in the performance and multi-functional capabilities of bistatic and multiple-channel radar systems. To achieve such improvements the use of Quasi-Orthogonal Doppler waveforms is proposed. Systems utilize multiple transmitters emitting identical frequencies which include transmitter-induced Doppler frequency offsets. For example, if a pair of waveforms was transmitted with the first having the same starting phase on every pulse and the second having $n\pi$ radians of starting phase added for $1 \leq n \leq N$ pulses, where N is the number of pulses in a coherent processing interval (CPI), the waveform returns could be separated on receive by using a low-pass and a high-pass filter.

As transmitted signals are finite in time thus their Doppler spectra will be infinite; however the waveforms can be separated by Doppler filtering. Hence they are considered to be quasi-orthogonal. Doppler-Division Multiple Access (DDMA) waveforms used in some Multiple-Input Multiple-Output (MIMO) radars are an example of quasi-orthogonal waveforms.

A reciprocal bistatic radar is defined to be a radar in which the two antennas can both transmit and receive. Simultaneously transmitting a signal from the first antenna (or element of an array antenna) and receiving it on a second antenna (or array element) would have the same propagation characteristics as transmitting a waveform on the second antenna (or array element) and receiving it on the first (to within the tolerances of the transmitter and receiver hardware). The two-way antenna patterns and propagation paths are therefore identical.

By transmitting a pair of quasi-orthogonal waveforms it is plausible to achieve novel range sidelobe suppression, simultaneous orthogonal polarization benefits, and other performance enhancements. For example, techniques such as Golay codes would have virtually identical sidelobe magnitude but opposite signs, causing the range sidelobes to become zero, independent of the antenna pattern, platform motion, time delay, etc. Also, polarization measurements could be made without distortions caused by the effects of pulse-to-pulse radar and target position changes. Cooperation of ground based radars using Quasi-Orthogonal Waveforms can lead to radar performance greater than the combination of single, non-cooperative radars.

PHASE I: Develop concepts and provide analysis of one or more applications of quasi-orthogonal Doppler waveforms in reciprocal bistatic, multistatic and or multiple-channel radar applications. The analysis will include factors that would impact the radar performance such as, performance estimates, simulation results, hardware requirements, effects of platform motions during a CPI, limitations and other factors relative to a conventional monostatic, bistatic, multistatic or MIMO radar. This effort proposes one or more experiments that could be conducted to demonstrate these effects/concepts in Phase II.

PHASE II: Design and conduct hardware experiments demonstrating the performance highlighting benefits and limitations regarding the use of Quasi-Orthogonal Doppler waveforms in relation to conventional radar.

PHASE III DUAL USE APPLICATIONS: Incorporate Quasi-Orthogonal Doppler waveforms into a current U.S. Army or developmental radar systems.

REFERENCES:

1. Jian Li, Luzhou Xu, P. Stoica, K. W. Forsythe and D. W. Bliss, Range Compression and Waveform Optimization for MIMO Radar: A Cramer-Rao Bound Based Study, IEEE Transactions on Signal Processing, Jan., 2008;
2. Sun, H. et al, Analysis and comparison of MIMO radar waveforms, 2014 International Radar Conference, October 2014. Levanon, N. and Mozeson, E., Radar Signals, Wiley, 2004.

KEYWORDS: Doppler Division Multiple Access (DDMA), quasi-orthogonal, reciprocal bistatic radar

A20B-T014 TITLE: High-Speed III-V-Based Infrared Detectors with Selectable Internal Gain

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: Design and implementation of high-speed III-V quantum photodetectors for the mid- or long-wavelength infrared on commercially available substrates which provide bias-controllable internal current gain with limited excess noise.

DESCRIPTION: III-V infrared materials have undergone a rapid technical maturation. Superlattice-based absorbers have enabled access to infrared wavelengths beyond those available via bulk III-V alloys while remaining strain balanced to large commercially-available substrates. The simultaneous development of unipolar barriers and the nBn architecture has largely controlled unwanted shunt currents. As a result, high uniformity, large format (greater than HD) focal planes have been demonstrated using a commercial foundry business model1. The wide design space available for band engineering with III-V material systems offers flexibility for the design of future sensor systems.

Alongside higher pixel density for improved size, weight and power, future sensors will incorporate additional capabilities to achieve improved target detection at range. Detectors which can internally amplify their received photocurrent enable technologies such as range-gating for removal of obscurants/clutter or 3D imagery for computer vision or navigation. At the same time, these sensors should still be able to be used in a traditional passive imaging mode for situational awareness.
A drawback to internal detector gain is that it typically introduces an additional source of noise due to the uncertainty in the stochastic amplification process. HgCdTe, the incumbent avalanche photodiode technology in the midwave infrared (MWIR), has exceptionally low excess noise due to fortuitous electronic band structure at the alloy compositions in question2. Competing III-V materials will need to be designed to prevent or limit excess noise. This could be achieved at the material level3 (e.g. through engineering of carrier ionization coefficients) or preferably at the device level (e.g. by engineering amplification to occur deterministically only at certain locations via device architecture). The level of gain delivered by the device should be controlled by the applied bias and should operate in a linear mode – Geiger mode detectors are inappropriate for this imaging application. A final consideration is that detectors should have response times suitable for frame rates which would achieve range resolution on the order of tens of centimeters4.

Existing III-V commercial infrastructure, including growth foundries and focal plane array processors, will enable rapid adoption. Suitable technologies can be transitioned for insertion into future U.S. Army and other DoD systems, delivering multi-tasking sensors capable of multiple missions to the Warfighter. These sensors will enable improved target identification compared to traditional passive sensors, obscurant penetration, clutter rejection, and ranging for autonomous navigation and would directly benefit the Future Vertical Lift and Next Generation Combat Vehicle modernization priorities. Additionally, devices could have commercial applications in safety and security monitoring, aircraft warning systems, and in autonomous vehicles.

PHASE I: Determine the feasibility of novel absorption and multiplication material combinations compatible with commercial growth on GaSb or GaAs substrates which would be capable of linear-mode internal gain (> 10) with response times suitable for range-gated imaging of man-sized targets (< 0.5 nanoseconds) with limited excess noise (equivalent McIntyre model |k| < 2).

PHASE II: Execute growth, characterization, and fabrication plans developed in Phase I. Design layer growth recipe for MWIR or LWIR sensitive avalanche photodiode technologies determined in Phase I. Provide growth strategy with any experimental parametric variations to growth foundry for fabrication. Characterize growth efficacy (photoluminescence, crystallinity, defect density). Process large area test devices suitable for cryogenic testing. Demonstrate effectiveness of sensor at unity gain via quantum efficiency and dark current characterization. Quantitative metric goals will depend on targeted cutoff wavelength; preference will be given to proposals designed for >9µm operation. Demonstrate a linear-mode internal gain greater than 10 with response times below 0.5 nanoseconds and limited excess noise lower than a McIntyre model |k| = 2. Characterize gain and dark current as a function of bias and demonstrate transition between passive imaging mode and gained mode. Develop mini-arrays for small-pixel characterization. Investigate feasibility of small-format focal plane array development including specific features required for a compatible read-out integrated circuit.

PHASE III DUAL USE APPLICATIONS: Mature technologies developed in Phase II for potential commercial uses in law enforcement, rescue and recovery operations, maritime and aviation collision avoidance sensors, autonomous vehicles, homeland defense, and other infrared detection and imaging applications. Multi-functional sensors such as those proposed in this topic would be useful for a wide range of military applications. For ground vehicle systems, this technology would enable the fusion of passive imagery for wide-angle situational awareness with near-simultaneous range-gating for clutter rejection and obscurant removal to improve detect/ID probability at long range. For rotary aircraft, this sensor technology could function in a dust/fog-penetrating situational awareness camera with range information for pilotage/landing assist.

REFERENCES:

1. Ting, D.Z., Soibel, A., Khoshakhlagh, A., Höglund, L., Keo, S.A., Rafol, B., Hill, C.J., Fisher, A.M., Luong, E.M., Nguyen, J. and Liu, J.K., 2017, May. Antimonide type-II superlattice barrier infrared detectors. In Infrared Technology and Applications XLIII (Vol. 10177, p. 101770N). International Society for Optics and Photonics.;
2. Beck, J., Wan, C., Kinch, M., Robinson, J., Mitra, P., Scritchfield, R., Ma, F. and Campbell, J., 2006. The HgCdTe electron avalanche photodiode. Journal of electronic materials, 35(6), pp.1166-1173.;
3. Marshall, A.R., Tan, C.H., Steer, M.J. and David, J.P., 2009. Extremely low excess noise in InAs electron avalanche photodiodes. IEEE Photonics Technology Letters, 21(13), pp.866-868;
4. McManamon, P., 2012. Review of ladar: a historic, yet emerging, sensor technology with rich phenomenology. Optical Engineering, 51(6), p.060901.

KEYWORDS: Infrared detectors, long wavelength infrared (LWIR), material growth, III-V material, avalanche photodiodes, gain, LADAR

A20B-T015 TITLE: Distributed Tactical Communications with LPD/LPI and AJ Capabilities in Heavily Congested or Contested RF Environments

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

OBJECTIVE: Develop a Distributed Tactical Communication System with beamforming to support low probability of detection (LPD) and interception (LPI) with anti-jam (AJ) properties under congested and/or contested radio frequency (RF) conditions.

DESCRIPTION: Based on the Army Modernization Priorities there is an urgent need to support communications in a contested and congested electromagnetic environment. Distributed beamforming offers the potential to maximize signal-to-noise ratio at the intended recipient while minimizing the residual signal in the environment that can be observed by adversarial sensors. Some current approaches leverage an advantaged node (or base station) that can communicate to a single cluster of dismounts acting as a distributed antenna array. The Army seeks more general approaches that support distributed beamforming between multiple clusters of dismounted nodes (i.e. squad-to-squad, platoon-to-platoon) that can function without the aid of a base station. The proposed approach should keep scalability in mind and account for a wide range of use cases including reach back communications to a distant vehicle that could act as a base station when available. The effort shall focus on balancing scalability while maintaining LPD/LPI and AJ capabilities. The described objective of the topic is tied to Army's Non-Traditional Waveforms (NTW) effort and will address the gaps that exists now in the NTW approach. This proposed topic directly supports, the Army's Network Modernization Priority with application to several other Army Priorities (e.g. fire support for Long Range Precision Fires).

Based on the prior research [1, 2, 3, and 4], the objective of the new technology to be developed under this STTR topic shall include:

- Utilizing both receive and transmit beamforming techniques
- Support dismount clusters (Squads) with at least 11 participants spaced 5m to 100m apart
- Communicate with the base which is mounted on a vehicle at a distance of greater than 2-5 kms.
- Support squad to squad communication where the squads may be separated by 500 m or more
- Scale to a variety of dismounted combat team formation which can support dismounted IBCT, ABCT, and SBCT
- Provide voice and data modes
- Latency not to exceed 100 msec (lower the better)
- Scalable to support a network of up to 50 nodes
- Defined frequency range which can be supported with the proposed technical approach

PHASE I: Conduct a feasibility study that identifies and addresses the problems that must be overcome in order to successfully demonstrate the above listed capabilities. Demonstrate the feasibility at the bench level resulting in a TRL 4. Deliver a final report that covers the outcome of this study, performance specifications, any models developed, and future plan details.

PHASE II: Fabricate proof-of-concept prototype hardware to test, demonstrate and validate the feasibility of a beamforming system with the performance specifications listed above. These should be provided to a

Government facility to assess performance of the system. The final report, TRL 5 prototype systems (5 units), prototype specifications and operation guide, and test reports will be delivered.

PHASE III DUAL USE APPLICATIONS: Productize the above system that can be demonstrated at TRL 6 by partnering with DOD vendor(s). This technology also has potential commercial applications, such as law enforcement and first responder communications, to enable range extension between clusters of low-power devices. These devices may be operating from low prime power constraints or may face transmit power restrictions due to FCC compliance. Such use cases are expected to expand with the emergence of the Internet of Things.

REFERENCES:

1. D. Mudumbai, D. R. Brown, U. Madhow and H. V. Poor, "Distributed Transmit Beamforming: Challenges and Recent Progress," IEEE Communications Magazine, vol. 47, no. 2, pp. 102-110, 2009.;
2. T. P. Bidigare, U. Madhow, D. R. Brown, R. Mudumbai, A. Kumar, B. Peiffer and S. Dasgupta, "Wideband Distributed Transmit Beamforming using Channel Reciprocity and Relative Calibration," in Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, 2015.;
3. B. Peiffer, R. Mudumbai, A. Kruger, A. Kumar and S. Dasgupta, "Experimental Demonstration of a Distributed Antenna Array Pre-synchronized for Retrodirective Transmission," in Information Science and Systems (CISS), Princeton, NJ, 2016.;
4. R.D. Dybdal and K.M.Soohoo, "LPI/LPD Detection Sensitivity Limitations", 2014 IEEE MILCOM pp 1657-1662

KEYWORDS: Dismounted Tactical Communication, LPI / LPD Communication, congested or contested RF environments Communication, AJ Communication

A20B-T016 TITLE: A Capability for Measuring Attenuation and Backscatter of Experimental Microwave Aerosols

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

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: To develop a methodology and a facility to measure attenuation and backscatter of a microwave-obscuring aerosol. In addition the system must be able to effectively disseminate small quantities.

DESCRIPTION: Smoke and obscurants play a crucial role in protecting the Warfighter by decreasing the electromagnetic energy available for the functioning of sensors, seekers, trackers, optical enhancement devices and the human eye. Recent advances in materials science now enable the production of precisely engineered obscurants with nanometer level control over particle size and shape. Numerical modeling and many measured results on metal nanorods affirm that more than order of magnitude increases over current performance levels are possible if high aspect-ratio conductive particles can be effectively disseminated as an unagglomerated aerosol cloud. By gaining a better understanding of the absorption and scattering properties of materials that are currently only available in lab scale quantities, future research can be better directed into areas that show the greatest promise.

PHASE I: Develop a methodology to measure attenuation and backscatter for a microwave-obscuring aerosol. Describe the test fixture required to prepare an experimental material sample, disseminate it, produce an aerosol and measure its attenuation, backscatter and concentration. Provide descriptions of the instrumentation/hardware required to scan from 2 – 40 GHz, produce an aerosol and make the measurements. Entire system should fit within a 15-feet wide by 15-feet long by 10-feet high room.

PHASE II: Fabricate, test and demonstrate a measurement system that meets the specifications developed in Phase I and with expanded capability for 2 – 150 GHz. Demonstrate that system can measure attenuation and backscatter of known materials (to be supplied by Army) to within 10% of published quantities. Prepare a cost estimate for building the system in quantity.

PHASE III DUAL USE APPLICATIONS: The microwave measurement system developed in this program can be used by research and development organizations to evaluate obscurant materials. It has application in other DoD interest areas including electronic warfare, foreign item evaluation, meteorology and pollution control. It can be used by numerous organizations to establish and publish electromagnetic spectrum data for a variety of new materials used in disparate industries (signal suppression, EMI shielding, etc.).

REFERENCES:

1. Bohren CF, Huffman DR: Absorption and Scattering of Light by Small Particles. Wiley-Interscience, New York, 1983.;

2. Shanna KK: Fundamentals of Microwave and Radar Engineering. S. Chand & Co Ltd, 2011;
3. Newsom, R. K., and Bruce CW. "Orientational Properties of Fibrous Aerosols in Atmospheric Turbulence." Journal of Aerosol Science 29.7 : 773-797, 1983;
4. Alyones S, Bruce CW, and Buin AK. "Numerical Methods For Solving the Problem of Electromagnetic Scattering By a Thin Finite Conducting Wire." IEEE Transactions on Antennas and Propagation 55.6: 1856-1861, 2007.;
5. Bruce, CW., et al. "Millimeter-Wavelength Investigation of Fibrous Aerosol Absorption and Scattering Properties." Applied Optics 43.36: 6648-6655, 2004.;
6. Waterman PC, "Scattering, Absorption and Extinction by Thin Fibers", J. Opt. Soc. Amer., vol. 22, no. 11, pp. 2430-2441, 2005;
7. Hart M and Bruce CW, "Backscatter Measurements of Thin Nickel-Coated Graphite Fibers," in IEEE Transactions on Antennas and Propagation, vol. 48, no. 5, pp. 842-843, 2000.

KEYWORDS: Microwave, attenuation, backscatter, concentration, dissemination, obscurants

A20B-T017 TITLE: Stereo Line-Scan Camera System For Surface Distress Identification

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

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 near real time pavement imaging system, using a line-scan camera stereo pair which measures deflection depth trailing, and leads a moving wheel load on concrete & asphalt surfaces.

DESCRIPTION: The military pavements community is lacking in detail the true effects of vehicle-pavement interaction necessary to adequately adapt and validate more complex finite element models in the development of next generation combat vehicles (NGCV's) and assessment of aging and contingency infrastructure. In assessing the physical influence of a tire moving along a pavement surface, research has centered on the measurement of stresses beneath a static or moving wheel load, and determining an assumed deflection basin surrounding the tire-pavement contact location based on pavement model parameters [1]. To advance the knowledge of how distresses are imparted to the pavement surface from vehicle or aircraft tires at varying loads, speeds, and pressures, current imaging techniques involve either the use of light detection and ranging systems (LiDAR), or line-scan laser systems, both of which have significant cost, and are complex to operate and interpret data [2]. Of interest to the Army and the broader commercial and academic sector is the potential of introducing the technology of low-cost line-scan camera pairs to create similar data quality of the laser systems, but adopting the more approachable photogrammetry point cloud development commonly used in modern full frame image processing [3]. Line-scan cameras have a long history of use in the manufacturing and food handling industries being utilized to rapidly detect defects in metal objects, food products, or other fast moving, repetitive objects. Further, newer color based line-scan cameras work effectively at imaging long continuous objects that are otherwise cumbersome to capture with a single photograph or scan, this technology is an ideal candidate for adaptation to rail or pavement systems [4]. Line-scan cameras can produce very detailed, sub-millimeter point clouds in real time, and combining two cameras in a stereo pair can create a depth map to coincide with the real time scan [5]. It is anticipated that this approach can achieve faster and more accurate point cloud rendering of the pavement surface than traditional photogrammetry and at a comparable accuracy to that of laser based systems, all in a more deployable and price-competitive system.

PHASE I: This research will involve demonstration of a stereo color-line-scan camera system that can measure surface deflection near a wheel load. The investigators will confirm whether smooth asphalt and concrete pavements provide sufficient point correspondences at line-scanner resolutions for photogrammetric reconstruction. Whether the introduction of red green blue (RGB) pixels in place of grey-scale pixels influences feature detection should be investigated. Further, the influence of changing lighting conditions must be quantified and addressed.

This research will require development of algorithms that should provide depth data sufficient for determining deflections at every line-scan frame within a highly accurate (sub-cm) local or global reference frame. Algorithms produced from this effort should be deployable to a Windows (.NET) platform and should be written in an open-source, widely-used programming language.

PHASE II: Research at this phase will involve development of a deployable system that must include a stereo-pair of line-scan cameras for both the trailing and leading side of a moving wheel load. The reconstructed data from each stereo-pair should be fused for accuracy determination as well as to measure deflection differences in leading and trailing loading conditions. It is desired that the vertical and horizontal resolution of the developed line-scan camera system be tunable to match a variety of loading systems without excess data to accommodate variable tire configurations present within the military inventory. It is intended that during the Phase II effort, a demonstration of the system capability will include mounting of the stereo-pair system on the U.S. Army Engineer Research and Development Center (ERDC) Heavy Vehicle Simulator (a unique testing apparatus to the military pavements community) to capture pavement distresses on a moving aircraft wheel load.

PHASE III DUAL USE APPLICATIONS: The development of a stereo line-scan camera system that is deployable either on a fixed or moving data collection system will support a number of commercial and military evaluation efforts. The military has interest in evaluation of pavement surfaces undergoing novel tire loading from newly developed vehicle prototypes to determine the impact of NGCV's. A deployable system would also support evaluation of standard or prototype vehicles on novel pavement designs to assess real-time constitutive pavement behavior. From a commercial standpoint, Federal or State Departments of Transportation would find relevance in such an inexpensive pavement evaluation technology for assessing pavement condition for routine maintenance inspections and institutional pavement research on the national transportation infrastructure.

REFERENCES:
1. Tarefder, R.A. and Ahmed, M.U., "Modeling of the FWD Deflection Basin to Evaluate Airport Pavements," Intl. J. of Geomechanics 14(1), April, 2014.;
2. Wang, K., Gong. W., Tracy, T. and Nguyen V., "Automated Survey of Pavement Distress based on 2D and 3D Laser Images," Univ. of Arkansas Mack-Blackwell Rural Transportation Center Report, MBTC DOT 3023, Nov. 2011.;
3. Westoby, M.J., Brasington, J., Glasser, N.F., Hambrey, M.J., and Reynolds, J.M., "Structure-from-Motion Photogrammetry: A low-cost effective tool for geoscience applications," Geomorphology, Vol. 179, Dec. 2012.;
4. Deutshl, E., Gasser, C., Neil, A., Werschonig, J., "Defect detection on rail surfaces by a vision based system," IEEE Intellingent Vehicles Symposium, Oct. 2008.;
5. Valentín, Reinhold Huber-Mörk, Svorad Štolc, "Binary descriptor-based dense line-scan stereo matching," J. Electron. Imaging 26(1), 013004 (2017).

KEYWORDS: line-scan; light detection; ranging systems; LiDAR; photogrmmetric

A20B-T018 TITLE: Tool Informed By Geomaterial Microstructure To Predict Electromagnetic Properties

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)
TECHNOLOGY AREA(S): 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 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 computational tool which integrates geomaterials chemistry and microstructure in 3D in order to predict bulk electromagnetic responses to various remote sensing modalities.

DESCRIPTION: This work focuses on the need to predict the electromagnetic properties of geomaterials such that computational prototyping of sensors and analysis procedures can be performed on an array of different material compositions to predict material response to a variety of remote sensing modalities. The needs focus on informing multi-physics based tools with 3D geo-material microstructures that include a heterogeneous mixture of chemical compositions, phases, particle size distributions, and porosity in their microstructures. Based on 3D solid microstructures with representatives volumes on the scale of centimeters and heterogeneity modeled on the scale of millimeters to 10s of micrometers, prediction of bulk electromagnetic properties is needed.

The goal of this work is to develop a computational tool that utilizes 3D microstructures of geomaterials such as concrete, rock, and soil with identification of phase, chemistry, porosity, particle size, and texture distributions and predict the electromagnetic properties and response to a variety of sensing modalities. Targeted sensing modalities span a wide range of the electromagnetic spectrum from visible to microwave and radar. As such, prediction of material properties including electrical, magnetic, and thermal is necessary. In addition, this will require an understanding of the propagation of various energy forms into and out of the material being interrogated.

PHASE I: Demonstrate the feasibility of integrating at least three different geomaterial types (e.g., concrete, rock, soil, or multiple or one or more types) that exhibit variations in chemistry, phase composition, and microstructure into a 3D model that predicts electromagnetic properties. The model may be a meso-scale multi-physics based model that discretely represents each phase or some other means to obtain bulk electromagnetic properties in a multi-phase heterogeneous material. Demonstrate the use of this model to predict basic electromagnetic properties including electrical, thermal, and magnetic properties. Demonstrate the use of these properties, along with the 3D modeled microstructure, to predict the response of each material to one specific remote sensing modality such as an infrared or microwave spectrum. Deliver a report documenting the initial research activities under Phase 1 including the material analysis, simulations using the developed tool, and their initial demonstration to predict material response to various remote sensing modalities. The most effective tool will directly utilize 3D solid models of material microstructures including assigned phase structures and compositions to accurately predict electromagnetic properties. Tools that effectively predict properties when compared with physical measurements will be determined and proposed for Phase 2.

PHASE II: Advance the computational tool beyond initial versions developed under Phase 1 and exercise against a variety of geomaterials to predict response to a variety of remote sensing modalities. With materials supplied by the Government (three concretes, two rock types, and three soils), characterize and initialize the developed multi-physics modeling tool with material microstructures, constituent properties, etc and determine each material's electromagnetic properties. Compare predictions of properties determined using the developed computational tool with physical measurements of these properties. Predict material response to contact and non-contact remote sensing modalities including hyperspectral, radar, etc. Then predicted responses should be validated against physical sensing systems using bench-scale experiments.

Deliver a reporting document that includes a description of each material, the characterization performed to ascertain the material's microstructure, chemistry, particle size, or other relevant features, how these are integrated into the electromagnetic property prediction tool, and example uses of the tool to predict response to various remote sensing modalities. All algorithms, materials, experimental design, etc should be documented along with the performance of developed tools against each problem set examined.

PHASE III DUAL USE APPLICATIONS: The work has a broad range of applications of infrastructure and environmental sensing. In addition to applications for military infrastructure material assessment, the development technology will be useful for general infrastructure assessment such as civilian bridges, dams, urban environment monitoring, etc. General tools that enable the fast-running computational prediction of material electromagnetic properties also have a broad range of applications in the field of geomaterials such as agricultural and environmental needs along with the extension of these technologies to other fields and material types.

REFERENCES:

1. L Sandrolini, U Reggiani, and A Ogunsola, Modelling the electrical properties of concrete for shielding effectiveness prediction, Journal of Physics D: Applied Physics, 40 (17) 2007.;
2. MI Khan, Factors affecting the thermal properties of concrete and applicability of its prediction models, 37(6) 2002.;
3. HC Rhim, O Buyukozturk, Electromagnetic Properties of Concrete at Microwave Frequency Range, 95(3) 1998.;
4. MQ Chandler, WL Lawrimore, M Edwards, RD Moser, JD Shannon, JL O'Daniel, Mesoscale Modeling of Cementitious Materials: Phase 1, USACE ERDC Technical Report ERDC/GSL TR-19-25 2019.

KEYWORDS: geomaterial; electromagnetic; microstructures; computational; prototyping; multi-physics

A20B-T019 TITLE: Liquid Waste Utilization/Treatment with Energy Production

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

OBJECTIVE: Develop novel solutions to produce energy and low tier water from black water and other high water content wastes to support distributed military operations.

DESCRIPTION: The Army needs improved capability to enable self-sufficiency and reduce sustainment demands during distributed operations. Black water and high water content wastes (e.g., food wastes) are both sources of waste that have a high potential for energy production. Instead of disposing them as wastes (at a high disposal cost), the Army proposes to develop a novel treatment/utilization method that will utilize them to produce water suitable for low tier applications in conjunction with generating energy for heating, cooling, or as stored electrical energy. The treatment/utilization system shall be able to treat mixtures of black water and high-water-content wastes with a minimum Total Suspended Solid (TSS), Biochemical Oxygen Demand (BOD5), and Chemical Oxygen Demand (COD) of 1450, 1170, and 2930 mg/L, respectively.

The Army does not currently have the capability to treat black water or high water content wastes (e.g., food wastes) during expeditionary operations. Conventional approaches to treating or disposing these wastes are logistically intensive and increase the operational energy burden. Existing approaches to recover energy from wastewater are either large, slow, and/or require complex processes to convert products to useful energy. The goal of this topic is to spur novel integration of mechanical, electrical, chemical and biological processes to develop new technologies that maximize the performance of liquid waste treatment/utilization and energy production. The technology development will require holistic approaches to create a compact, robust, rapid, and simple utilization system that generate energy and produce water for low tier applications.

PHASE I: Project needs to demonstrate feasibility of the proposed technologies in a laboratory setting. Novel liquid waste treatment/utilization methods need to be tested and evaluated at the bench-scale for energy and low tier water production from mixture wastes of black water and high water content solid wastes. System analysis is required to verify the technology that can meet the requirements and address potential integration issues while showing a pathway to scale to a full sized system.

PHASE II: Based on the performance and design parameters elucidated in Phase I, a tricon (8x6.5x8') sized demonstrator needs to be designed, fabricated, and demonstrated. The demonstrator is required to be able to treat a minimum of 1500 gallons of liquid waste per day that produces water suitable for low tier uses and energy in the form of heating, cooling, or stored electrical energy for distributed military operations. The delivered demonstrator should be suitable for laboratory and field demonstration but the design does not need to be ready for manufacturing, nor is military standard durability required. The demonstrator shall be able to treat the black water and other wastes defined above while meeting the size and energy metrics of a full sized system.

PHASE III DUAL USE APPLICATIONS: Technology developed under this STTR topic could have an effect on military sustainment independence / self-sufficiency and reduce sustainment demands during distributed operations. The intended transition would be planned into a future energy positive wastewater/waste management system for distributed military operations. This technology has the potential to be utilized in commercial and municipal operations that need a way to process waste streams with the benefit of energy reduction.

REFERENCES:

1. U.S. Army Public Health Command's TB MEDD 577 SANITARY CONTROL AND SURVEILLANCE OF FIELD WATER SUPPLIES http://phc.amedd.army.mil Note: This fully explains all field military operations that concern this topic author for the above topic;
2. Standard Methods for the Examination of Water and Wastewater, a joint publication of the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF). http://www.standardmethods.org/ Note: This reference is the benchmark for all analyses and source of approved methods for regulatory compliance.

KEYWORDS: water, water treatment/utilization, black water, wastewater, food waste, energy reduction, energy production

A20B-T020 TITLE: Validating Communications between Trusted and Untrusted Vehicle Control Systems

RT&L FOCUS AREA(S): Network Command, Control and Communications, Cybersecurity
TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: The idea is to implement a solution to decentralize and distributed blockchain security solution on the vehicle network to enable a form of incorruptible data and resiliency.

DESCRIPTION: Cybersecurity of the Army's ground systems is a critical priority to national defense in the 21st century. Recent events have shown that modern commercial vehicles are vulnerable to attack and subversion through buggy or sometimes malicious devices that are present on intra-vehicle communication networks. The issue is current solutions require a centralize security measure such as an Intrusion Detection/Prevention System IDS/IPS to detect and/or prevent malicious communications. Since vehicles can be compromised at a single point yet effects can propagate across the entire vehicle, GVSC is looking for a solution that eliminates that single point of failure through a form of decentralized and distributed security validation to verify communications with certainty despite there being valid node on the network acting maliciously. GVSC would like to see this technology applied on an intra-vehicle communication network such as Controller Area Network (CAN) that can perform validation of messages in a form of decentralized security distributed amongst vehicle controllers as well as provide a sense of resiliency.

PHASE I: In the first phase of this effort, the contractor shall demonstrate a decentralized and distributed security solution that performs validation of communications on vehicle network such as Controller Area Network (CAN). The implemented technology shall have a low resource consumption on the vehicle network. In addition, message validations should minimally affect the vehicle network latency. The demonstration shall be a proof of concept in the form of a simulation or mathematical description.

PHASE II: Implement the concept developed in Phase I on real vehicle network such as Controller Area Network (CAN) using physical vehicle controllers. The contractor shall demonstrate the operation of the technology in a live vehicle or systems integration lab (SIL) environment. The demonstration shall include an ECU and at least one safety controller. The contractor shall validate the effectiveness of the technology by showing that other controllers reject valid but malicious messages sent by another controller. The contractor shall perform penetration testing with an independent team to identify other attack vectors against the technology.

PHASE III DUAL USE APPLICATIONS: The contractor shall package the technology to be retrofit into an existing vehicle system. The contractor shall collaborate with a vehicle original equipment manufacturer (OEM) to demonstrate their technology during normal vehicle operations on a test track. The contractor shall demonstrate the same validations shown in Phase II.

REFERENCES:

1. https://www.researchgate.net/publication/330879157_Security_Approach_for_In-Vehicle_Networking_Using_Blockchain_Technology;
2. https://www.iota.org/get-started/what-is-iota; https://digitpol.com/portfolio/blockchain-patent-for-automotive-cyber-security/

KEYWORDS: Vehicle Networks, Fault Tolerance, CAN, ECU, Cybersecurity, Trusted Computing, Communication Protocols, Ground Based, Data Transmission System, Intrusion Detection/Prevention System, Threat, Protection, Decentralize Security, Blockchain, Fault Tolerance,

A20B-T021 TITLE: Physiological Status Monitoring Nanorobotics

RT&L FOCUS AREA(S): Biotechnology, Network Command, Control and Communications
TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: To explore the feasibility and effectiveness of a Wireless Physiological Status Monitoring Nanorobotic (Nanobot) capability that can be ingested by a casualty to provide streaming vital signs data.

DESCRIPTION: In the Multi-Domain Operation of 2030, all indications are that future operations will be significantly different than the recent past. The need for U.S. forces to use more innovative ways to overcome peer and near-peer challenges to outmaneuver adversaries. This different kind of warfare has already arrived with the hybrid warfare in the Middle East and Eastern Europe, which is leading to the next fight to be with violent intensity. American power and security will be challenged by peer and near-peer actors. To be ready, U.S. forces must effectively innovate and adapt concepts for the Multi-Domain Operation to shape the fight.

The U.S. military can no longer expect technology superiority in a Multi-Domain Operation and with expectation that communication and cyber systems will be compromised. In this environment, the service's medical commands need to commence research into Virtual Health capabilities for the forward operational medics and corpsmen. These forward medical providers will be isolated, over tasked with casualties, and with limited supplies; innovative medical capabilities to support distributed operations will be a need for Prolonged Field Care in treating casualties for 24-72 hours before medical evacuation can occur. The need to monitor multiple casualties wirelessly will be essential and machine learning predictive algorithms will be a requirement in a no-communication prolonged care environment.

The Medical Capabilities provided by this Nanobot system will enhance medical personnel to continuously monitor multiple casualties at the same time, plus the data being presented will be used in upcoming Machine Learning Predictive Algorithms. The algorithms will provide medical personnel the tool to predict a patient's status and provide up to 20 minute warnings when things are not going well. Also with machine learning tools and artificial intelligence, the medic will be provided treatment options to keep the casualty alive until evacuation to a higher level of care. In a no communication prolonged care environment, evacuating casualties maybe under medical personnel's care from 24-72 hours. The Nanobot system is another tool to enhance medical personnel's ability to monitor and treat multiple casualties during limited resources availability at the point of injury location.

PHASE I: Researchers will quantitative stage to identify and investigate futuristic capabilities of using medical nanobot technology that can be ingested to provide vital signs data wirelessly from the soldier/marine to a medic's/corpsman's End User Device (EUD) and provide feasibility documentation. Also, researchers will send out Requests for Information through the BAA to get an understanding of where industry and academia is on nanobot technology. These single or multiple nanobots will act as a physiological status monitor that will be ingestible and function for 24-72 hours or longer providing a wireless status of the soldier's health. The possible concept will be that the soldier will have the medical sensor nanobot ingested prior to the mission, the medic then will be able to monitor the soldier's condition during the patrol and if the soldier is injured. The medical data coming wirelessly from the physiological status monitor will be received by the medic's EUD which can be viewed by the medic and be alerted by predictive algorithms by any abnormal readings or anomalies.

This Phase will demonstrate the feasibility of the proposed approach through successful demonstration of breadboard concept of a Personal Status Monitor (PSM) Nanobot sensor, and will inform success criteria and performance metrics for the Phase II system design.

RESEARCH INVOLVING ANIMAL OR HUMAN SUBJECTS: The SBIR/STTR Programs discourage offerors from proposing to conduct Human or Animal Subject Research during Phase I due to the significant lead time required to prepare the documentation and obtain approval, which will delay the Phase I award.

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

Research involving the use of human subjects may not begin until the U.S. Army Medical Research and Materiel Command's Office of Research Protections, Human Research Protections Office (HRPO) approves the protocol. Written approval to begin research or subcontract for the use of human subjects under the applicable protocol proposed for an award will be issued from the U.S. Army Medical Research and Materiel Command, HRPO, under separate letter to the Contractor.
Non-compliance with any provision may result in withholding of funds and or the termination of the award.

PHASE II: From the results of the Phase I feasibility and effectiveness, develop a preliminary design of the PSM Nanobot system to develop a conceptual prototype that can possibly be taken to the field for initial concept demonstration of the technology with medics to provide usability and feasibility feedback toward the future development of the PSM Nanobot system. If a field research study and data collection event is possible, the medics attending can provide their guidance, feasibility of use, and recommendations on the continued development of the device. Consider developing a ruggedization plan for Phase III and Advance development.

Develop a commercialization plan. If an IRB is required during Phase II, submit an IRB package to US Army MRDC HRPO/IRB.

PHASE III DUAL USE APPLICATIONS: A single PSM Nanobot sensor may not have the capability to monitor all vital signs needed, a teaming concept of multiple PSM Nanobot sensor may need to be explored. The PSM Nanobot swarm would designated a specific Nanobot to track a specific vital sign, i.e. one PSM Nanobot just reporting ECG, another PSM Nanobot just reporting Blood Pressure, etc.

Swarming is actually a central concept to agility. It is not something that is done "when there are problems". Swarming, in its simplest form, means that teams work collaboratively on items (stories) and work them to completion.

Continue development and refinement of the prototype PSM Nanobot sensor, explore additional concept of deployment, add additional capabilities to the PSM Nanobot swarm as recommended during the field research study and data collection events, and continue the capability that is ruggedized, complies with space, weight, and power specifications informed by the Phase II medic field evaluations and moves the prototype capability towards advanced development/acquisition.

Refine the development of a commercialization plan that may include development of different pathways, including both military and private sectors. If required; submit an Institutional Review Board (IRB) package for approval for possible research involving human subjects or human use. Evaluate the impacts of PSM Nanobot sensor on a patient/casualty.

While, the planning for the Phase III work needs to be oriented towards technology transition to Acquisition Programs of Record and/or private sector commercialization, we also use SBIRs and STTRs as enabling technology input to our longer term Science & Technology Research Programs

The end-state of this research is to provide a near-production ready capability that can allow continuous streaming of medical sensor data/vital signs wirelessly to a Medic's End User Device. The medical data being transmitted to the Medic's EUD will enhance the medic's ability to continuously monitor multiple patients at a distance and with the capability of Artificial Intelligence and Machine Learning, this capability can provide predictive algorithms to alert the medic if life threating conditions will occur and take step to rectify the situation.

REFERENCES:

1. https://newatlas.com/nanobot-micromotors-deliver-nanoparticles-living-creature/35700/;
2. http://www.microscopemaster.com/nanobots.html;
3. https://singularityhub.com/2017/03/07/4-ways-scientists-hope-nanobots-will-make-you-healthier/;
4. https://www.theatlantic.com/technology/archive/2015/08/nanobot-treatment-doctors-cancer/400613/;
5. Mobile Devices and Health, by Ida Sim, M.D., New England Journal of Medicine, 05Sep19

KEYWORDS: Nanorobots, Swarms, Teaming, Personal Status Monitoring, medical sensors

A20B-T022 TITLE: To Develop and Demonstrate a Technology That Would Enable Precise, Multiplexed, Stepwise Modulation of Gene Expression (including single cell polymorphism) and Protein Levels in Mammalian Cells

RT&L FOCUS AREA(S): Biotechnology
TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: Develop/demonstrate a technology that enable precise, multiplexed, stepwise modulation of gene expression (including single nucleotide polymorphism and protein levels with the assessment of specific regions of interest.

DESCRIPTION: There are many host biomarkers, quantifiable indicators of a biological state, with clinical utility today. Single-analyte biomarkers, such as the erythrocyte sedimentation rate and C-reactive protein, have been utilized for decades as general markers of inflammation (Pearson et al 2003; Holcomb et al 2017). Single nucleotide polymorphism (SNP) of genes have been effectively connected to phenotypes; for instance Cytochrome P450 SNPs has been linked to metabolism rate of drugs (Abubakar, Bentley 2018, Deardorff et al 2018). However, while each biomarker has its diagnostic niche, most single-analyte biomarkers are associated with limited sensitivity and specificity and demonstrate efficacy only in highly focused clinical syndromes. Subtle changes in gene expression can have important biological consequences in cells (Michaels et al 2019). Multi-analyte markers to diseased state perturbations may offer the potential for greater specificity and broader applicability to a wide array of clinical settings. There are several examples of multi-analyte biomarkers that have already demonstrated diagnostic utility, including tests that measure gene expression, protein panels, metabolite panels, cytokine panels, and others. Since gene expression is rapidly altered in many cell types in response to a variety of exposures utilizing this information has several advantages. Furthermore, the widespread availability of quantitative reverse transcriptase PCR (qRT-PCR) platforms in clinical laboratories allows gene expression-based diagnostics to be more easily and directly translatable to patient care. Multi-analyte assays will provide high-resolution snapshots of complex physiology and further multiplexing of these markers will be highly relevant in the field as it moves forward.

Several gene expression techniques exist for quantifying gene expression (Padovan-Merhar et al 2003). Initially, low-throughput technologies were used to assess biomarkers composed of a small number of clearly defined genes. Unfortunately, qPCR can be labor intensive and time consuming and requires a large quantity of cDNA. Other possibilities include hybridization-based expression assays such as Nanostring™, Bioplex-based branched DNA assays (Qi et al 2016). The multiple steps from sample collection, RNA extraction, reverse transcription, and data acquisition provide opportunities for introduction of errors. The ability to examine a specific set of genes on a wide range of samples, using only minimal sample and reagents with a relatively short turnaround time for results with reduced man-hours per sample, makes the methods suitable for use in candidate gene validation and for use as clinical tools.

The aim of this STTR is to develop a method that delivers an unbiased answer to the biological question being asked by the researcher. The following factors should be considered when choosing a method for targeted gene expression analysis:

1. development of an automated procedure;
2. investigation is on targeted region(s) of specific gene(s) of interest
3. amount and character of sample requirements. Consider clinical samples, whole blood or saliva or urine could be sample of choice.
4. Multiplexing capability.
5. sensitivity and specificity of the assay proposed

6. robustness and simplicity of the method.
7. simplicity of software for analysis and interpretation of the data;
8. Effortless use of specialized equipment and reagents;
9. Turn-around time to result
10. Assay cost.

PHASE I: Given the short duration of Phase I, this phase should not encompass any human use testing that would require formal IRB approval. Phase I should focus on system design for gene expression and proteins assays using any gene/region of interest and data compared to housekeeping genes. Genes of interest can be selected from cytokine and interleukin genes and for the SNP CYP2D6 and CYP2C19 can be used for a proof of principle. At the end of this phase, a working prototype of the assay (s) should be completed and 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 using some targeted genes/regions/proteins/SNP of interest for evaluation of the operation and effectiveness of utilizing an integrated system and its capability to demonstrate the utility in a diseased condition such as sepsis, coagulopathy, differential metabolism rate (poor vs. ultra-rapid metabolizer). 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. These protocols should be presented in multimedia format.

PHASE III DUAL USE APPLICATIONS: The ultimate goal of this topic is to develop and demonstrate a technology enabling the gene expression including SNPs and protein changes with respect to diseased state. This assay format should also be seamlessly integrated so that it can be used as monitoring tools for long term health assessment. Once developed and demonstrated, the technology can be used for identification of risk, diagnostic, prognostic, monitoring and/ or predictive biomarkers for diseased state. Development of new technique for gene/protein/SNP analysis will open a multitude of possibilities for biomarker development and might become extremely valuable in clinical practice.

REFERENCES:
1. Thomas A. Pearson, George A. Mensah, R. Wayne Alexander, Jeffrey L. Anderson, Richard O. CannonIII, Michael Criqui, Yazid Y. Fadl, Stephen P. Fortmann, Yuling Hong, Gary L. Myers, Nader Rifai, Sidney C. SmithJr, Kathryn Taubert, Russell P. Tracy, and Frank Vinicor Application to Clinical and Public Health Practice: A Statement for Healthcare Professionals From the Centers for Disease Control and Prevention and the American Heart Association Circulation. 2003;107:499–511;
2. Holcomb ZE, Tsalik EL, Woods CW, McClain MT. 2017. Host-based peripheral blood gene expression analysis for diagnosis of infectious diseases. J Clin Microbiol 55:360 –368. https://doi.org/10.1128/ JCM.01057-16;
3. Abubakar, A. & Bentley, O. Precision medicine and pharmacogenomics in community and primary care settings. Pharmacy Today 24, 55-68 (2018).;
4. Jenne, V. & Leonard, B. L. Making sense of CYP2D6 and CYP1A2 genotype vs phenotype. Current Psychiatry 17, 41-45 (2018);

5. Michaels YS, Barnkob MB, Barbosa H, et al. Precise tuning of gene expression levels in mammalian cells. Nat Commun. 2019;10(1):818. Published 2019 Feb 18. doi:10.1038/s41467-019-08777-y;
6. Padovan-Merhar O, Raj A. Using variability in gene expression as a tool for studying gene regulation. Wiley Interdiscip Rev Syst Biol Med. 2013;5(6):751–759. doi:10.1002/wsbm.1243; Zhenhao Qi, Lisu Wang, Aiqing He, Manling Ma-Edmonds, and John Cogswell

KEYWORDS: Gene Expression, QPCR, Technology, Military Health, Solider Lethality, Biomedical

A20B-T023 TITLE: Develop and Demonstrate a Portable Device for Bacteriophage Enrichment, Screening and Isolation Technology for Field Application

RT&L FOCUS AREA(S): Biotechnology
TECHNOLOGY AREA(S): Bio Medical

OBJECTIVE: Develop and demonstrate a portable technology to enable rapid bacteriophage (phage) enrichment, screening and isolation from suspension samples in remote and austere environments on user-selected permissive and target bacterial strains.

DESCRIPTION: Multidrug-resistant organisms (MDRO) have spread worldwide and triggered a major public health crisis. U.S. military service members wounded in combat are susceptible to infection by MDRO at a much higher rate than civilian population due to penetrating combat wounds being accompanied by foreign body inoculum (metal fragments, rocks, dirt), large zones of bone and soft tissue disruption, nerve damage and localized ischemia (tourniquet /edema), as well as severe hemorrhage with resuscitation (often severe, >10U) of 1:1:1 – pRBCs, plasma, and platelets that will systemically disturb overall physiology [immune system dysfunction, some degree of traumatic brain injury (TBI)]. Furthermore, the current concept of war into urban dense terrain (UDT) and multi-domain operations (MDO) are expected to generate complex wounds that will require advanced prolong field care and stabilization when tactical evacuations to robust rear element medical care infrastructures are delayed. In these instances, the potential for life threating infection by MDRO is even higher and the need for solution is urgent. ESKAPEE pathogens (Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, Enterobacter spp., and Escherichia coli) frequently colonize healthy military personnel (1) and are causative agents of persistent infections of traumatic and burn wounds that are prone to biofilm formation and multidrug resistance (2). Limited to no options in antibiotic therapy warrants the development of alternative potent antibacterials, e.g. phages.

Phages are natural viruses that specifically kill bacteria to include pathogenic bacteria resistant to antibiotic treatment. Phages exhibit extraordinary specificity to target bacterial strains and can eliminate them without affecting normal microflora. A major advantage of phage therapy is the ability to exploit the constant natural evolution of phages to overcome phage resistance, infect and kill the host bacteria. Phages have demonstrated high efficacy against ESKAPEE infections in laboratory, domestic and farm animals and promising data in expanded access treatment of humans and even in recent clinical trials, especially in combination with antibiotics (3,4). Phages are becoming a very important adjunct therapy against MDR bacterial infections in civilian and military patients.

When multidrug-resistant bacterial strains are identified in geographic areas of interest, it is more efficient to search for co-located phages against these strains in environmental samples from the same geographic region. Thus, natural therapeutic phages are more likely to be in the host nations of interest where highly drug resistant organisms that infect wounded soldiers deployed in military operations reside such as OEF/OIF. From Soldier Lethality and performance perspective to include staying-in-the fight, recovery and rehabilitation, the problem of infection by MDRO and ensuing sepsis or chronic infection has the solution for the infection near the site of injury. Although it is impractical to isolate phages under fire, the medical surveillance activities of pre- MDO could include surveillance of phages in area of interest so as to stage phage cocktails as adjuvant therapy. However, the ability to isolate and assess phages in remote areas away from a specialized laboratory does not yet exist.

PHASE I: Specimens currently have to be transported over long distances to a specialized laboratory for labor intensive phage enrichment and isolation procedures that will result in the loss of phages because of non-specific adsorption to particulate matter in samples and because phages are unstable at low titers (5,6).

The purpose of this STTR is to enable relatively rapid sample purification and sterilization, phage enrichment (propagation on a permissive strain of interest), screening of phages on target strains of interest, phage isolation and concentration in the field using a portable device at or near the site of specimen collection. The end product of the system sought through this process is a cocktail of phages with activity against strain of interest and system designs enabling individual phages are encouraged but not required. This capability will drastically improve force health protection at large but will more directly enable the formulation of better therapeutic phage cocktails using diverse phages with broad killing spectra isolated from remote areas around the world. The device should be easy to handle with minimal operator training. The technology should enable isolation, concentration, stabilization, and sterilization of natural phages. Users should have the freedom to select permissive and target screening strains of interest. The technology could be based on micro-filtration systems, microfluidics, centrifugation, nano-materials, gel or polymer matrix or any combination of relevant technologies. The device can be a closed or open modular portable system.

The following features will be critical to consider when proposing a technology:

1. System should remove particulate matter from suspension without eliminating viable phage particles and sterilize the sample
2. System should enable users to select and input permissive strains of choice for phage propagation and target strains of choice for activity assessment
3. System should perform the enrichment (propagation) and concentration of viable phage particles
4. System should enable screening of phage activity against multiple target strains of interest
5. The field-deployable system may not exceed 30 lbs and none of its dimensions should exceed 16 inches, with minimal battery operation for 12 hrs.

PHASE I should focus on the design of proof-of-concept prototype technology/device that enables removal of debris from phage source suspension, sterilization and phage enrichment (propagation) on permissive strains of choice to produce a sterile enriched viable phage mix. At the end of this phase, working prototype (s) should demonstrate particulate removal, permissive strain input access and propagation capability of the system as well as post propagation stability and sterility of the cocktail of phages. Performance (i.e. turnaround time to enriched phage cocktails) should be compared to classical manual in vitro approaches over 24, 48, and 72 hrs.

PHASE II: PHASE II: During this phase, the integrated system should be refined to expand on the proof-of-concept into a product that enables high-throughput screening of cocktail of phages against diverse MDRO strains of choice. Further optimization of technology should miniaturize and ruggedize the device, combine additional access and incorporate phage enrichment step with screening on target strains and stabilization. This testing should be controlled and rigorous. Testing and evaluation of the prototype to demonstrate operational effectiveness in simulated environments (i.e. extreme heat, cold, wet environment) should be demonstrated. Here, selected contractor may coordinate with WRAIR to collaborate in optimizing and validating system. This phase should also demonstrate evidence of commercial viability of the product and articulate plans to meet field-deployable requirements. Accompanying application instructions, simplified procedures, and training materials should be drafted in a multimedia format for use and integration of the product into market.

PHASE III DUAL USE APPLICATIONS: PHASE II: The end-state for this product is a commercially viable technology the will democratize phage harvest effort both in medical institutes, bio-pharma, educational institutes, and most importantly warfighter health protection efforts within DOD particularly the preventive medicine and medical surveillance efforts of our mission. The end product will be system ready and validated by WRAIR team for performance. Provided phages have applications beyond medical therapeutic use such as food preservation, veterinary and agricultural applications, environmental sterilization and cleaning of bacterial biofilms, etc., selected contractor should articulate plans for spin-off application and partners during this phase.

REFERENCES:

1. Vento TJ, Cole DW, Mende K, Calvano TP, Rini EA, Tully CC, Zera WC, Guymon CH, Yu X, Cheatle KA, Akers KS, Beckius ML, Landrum ML, Murray CK. Multidrug-resistant gram-negative bacteria colonization of healthy US military personnel in the US and Afghanistan. BMC Infect Dis. 2013;13:68.;
2. Akers KS, Mende K, Cheatle KA, Zera WC, Yu X, Beckius ML, Aggarwal D, Li P, Sanchez CJ, Wenke JC, Weintrob AC, Tribble DR, Murray CK; Infectious Disease Clinical Research Program Trauma Infectious Disease Outcomes Study Group.Biofilms and persistent wound infections in United States military trauma patients: a case-control analysis. BMC Infect Dis. 2014 Apr 8;14:190.;
3. Romero-Calle D, Guimarães Benevides R, Góes-Neto A, Billington C. Bacteriophages as alternatives to antibiotics in clinical care. Antibiotics 2019; 8(3):138.;
4. C. Rohde, J. Wittmann, E. Kutter Bacteriophages: a therapy concept against multi-drug-resistant bacteria Surg. Infect. 2018; 19: 737-744.;
5. Sambrook J, Fritsch EF, Maniatis T. Molecular cloning: a laboratory manual, 2nd ed. Cold Spring Harbor Laboratory Press, 1989, Cold Spring Harbor, NY.

KEYWORDS: bacterial infections, multidrug resistance, phages as alternative antibacterials, environmental samples, debris removal, sterilization, phage enrichment, phage screening and separation, phage isolation, portable phage enrichment/isolation device, therapeu

A20B-T024 TITLE: Soldier-borne Radar Detector

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

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with 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 design, fabricate, and demonstrate a radar early warning receiver for the dismounted soldier's uniform, armor or battle kit that identifies and locates a Ground Surveillance Radar (GSR) threat.

DESCRIPTION: In the modern operating theater the dismounted warfighter faces a network of sensors searching from fixed and mobile ground and air platforms. Ground Surveillance Radar (GSR) or Battlefield Surveillance Radar (BSR) are long range sensor threats that can identify and track ground movement over kilometer scale distances, posing a threat of the maneuverability, survivability and ultimately the lethality of dismounted units. The ability to detect a GSR at a distance greater than its maximum range will turn the squad into a distributed sensor to locate advisory assets and take appropriate action.

Commercial GSR systems advertise single dismount detection ranges up to 23km [1]. With smaller man portable systems able to detect 12km with traditional pulse Doppler [2] or 9km with low probability of intercept (LPI) frequency modulated continuous wave (FMCW) [3]. Systems are also available coupled with day/night electro-optical sensors [4]. Threat systems are line of sight and maximum ranges assume systems are placed at sufficient elevation.

To contour the availability of these long-range systems the Government requires a radar early warning receiver for the individual dismounted soldier. Due to the ever-growing number of threats and potential technological capabilities for the dismounted warfighter, the Government must manage the total soldier burden of adding additional equipment to the battle kit. The Government therefore requires that this radar early warning receiver be a low profile integrated part of the uniform, armor or kit rather than an additional item mounted on the warfighter. The design should consider options such as wearable antennas and flexible electronics while considering associated challenges with these technologies for X and Ku Band (8-18 GHz) operation.

The system shall intercept and identify a GSR threat at a distance greater than its maximum range for detecting a single dismounted person. The system should also be capable of finding the angle of arrival of the GSR signal and estimate the location of the emitter. Output will integrate with the Android Tactical Assault Kit (ATAK), a government owned mapping application, for communicating with the soldier. All members of a squad of 9 soldiers will have the receiver and will be networked through Bluetooth.

PHASE I: Phase I must show the feasibility of the technical approach through a demonstration of the preliminary designs including breadboard or demonstration board of electronic components, signal processing, electronic integration with uniform, armor, or soldier kit, and detailed plans for placement as well as size, weight and power. The sensor should capture sufficient information to identify the GSR system from a library of waveforms. It must also be able to find angle of arrival and estimate of the location relative the user. The system must perform for signals in the X and Ku Bands (8-18 GHz). It is not necessary to demonstrate the integration of the technology into a complete system, however, the planned technical approach and feasibility for system integration for Phase II must be included. Phase I deliverables will include, (1) a final report detailing technical approach, design, implementation, tests, data analysis, conclusions, and proposed path for integration with the soldier's kit. (2) All test data. (3) A working breadboard prototype with software. Phase I deliverables do not have to be implemented on ATAK but this will be a requirement of subsequent phases.

PHASE II: Phase II will produce a prototype of a soldier worn radar early warning receiver that identifies and locates a Ground Surveillance Radar (GSR) threat. The system shall discriminate the threat from other radio frequency (RF) sources. The system shall be a low profile integrated part of the soldier's kit rather than an additional item mounted on the warfighter. The system shall intercept and identify a GSR threat at a distance greater than its maximum range of detection for a single dismounted person. The system shall find the angle of arrival of the GSR signal and estimate the location of the emitter. Assume that the system is worn by all members of a 9 soldier squad. Location estimations shall improve as successive samples are collected and from aggregation of data from the detectors worn by all members of the squad. Software shall be implemented on the ATAK mapping platform and display to the user an estimation of the GSR location and detection range. The system must be ruggedized to operate in all operationally relevant environments, -30 – 125ºF high and low humidity, rain, dust, fog, etc. However, it must still be a low profile integrated part of the uniform, armor or kit rather than an additional item mounted on the warfighter. The system must operate in a cluttered RF environment with many signals and sources of electromagnetic interference. The final deliverable must also include an assessment of viability of producing the developed technology including an estimated system price.

Phase II deliverables will include, (1) a critical design review in which the contractor will provide in depth details on the design or their prototype system. (2) 4 copies of the prototype soldier worn radar detector system implemented on a smart phone running ATAK. (3) Source code for the ATAK application. (4) A final report detailing technical approach, design, implementation, tests, data analysis, and conclusions. (5) All test data.

PHASE III DUAL USE APPLICATIONS: Phase III will demonstrate the operability, and reliability in field tests. It will be used to warn soldiers of the presence of a GSR threat, identify the threat while discriminating it from other RF signals, estimate location and range of the GSR source, arrogate data from sensors worn by all members of a 9 soldier squad to refine location estimation, display threat information to the user through an ATAK application, and relay information back to higher level command and control. The result of this research will be the integration of counter radar technology into the soldier's existing uniform, armor or kit which will improve their survivability and lethality through a multifunctional materials that minimize additional burden.

REFERENCES:

1. THALES Observer 80, https://www.thalesgroup.com/sites/default/files/database/document/2019-03/2019_GO80_leaflet.pdf;
2. "SR Hawk Ground Surveillance Radar", https://www.srcinc.com/pdf/Radars-and-Sensors-SRHawkV2E.pdf;
3. THALES SQUIRE Ground Surveillance Radar, https://www.thalesgroup.com/sites/default/files/database/d7/asset/document/03_p185749_thales_squire_leaflet.pdf

KEYWORDS: Radar, Radar Detector, Radar Early Warning Receiver, Wearable Electronics

A20B-T025 TITLE: Chemical Sensors for Toxic Industrial Chemicals/Toxic Industrial Materials (TICs/TIMs) Filtration Performance Monitoring

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

OBJECTIVE: To develop a prototype handheld device that provides a real-time assessment of the efficacy of a TICs/TIMs filter being used to purify water from any indigenous source.

DESCRIPTION: Soldiers require upwards of 15L of water/day to properly sustain adequate hydration levels on an extended mission. This water is either carried by the individual Soldier on their person in the form of the MOLLE hydration pack, canteens, and water bottles, or can be obtained from indigenous water sources in an emergency using purification tablets. Recent investment in filtration technologies by the US Army has led to the development of toxic industrial chemicals/toxic industrial materials (TICs/TIMs) filters that are compatible with the MOLLE hydration pack. However, there is no way to assess the continued efficacy of the filtration system, including when the filtration media is saturated or breached. In addition, although the filters have been developed to function for up to 135 L of water in a laboratory setting, there is no way to ensure that the filters would function as designed in an operational setting over their intended lifespan. The additional sources of fouling found in indigenous waters cannot be accounted for in the development and prototype stages.

Currently, the only way to assess water quality is to obtain a sample, send it back to a centralized laboratory facility, and obtain test results in 4-6 weeks. This is an unacceptable timeframe for a Soldier needing emergency water, and puts them at risk for acute or chronic health effects if they choose to drink the water without any knowledge of the risks.

Therefore, we are soliciting new ideas for a handheld sensor device that could provide assurance of water quality, after filtering, such that the Soldier could determine whether the filter is still functioning, or needs to be replaced. The sensor system shall sense for representative classes of TICs/TIMs (heavy metal, organophosphate, volatile), and salt in any source water. The limits of detection of the sensor should be commensurate with the Army Public Health Command minimum exposure levels for each class of threat. Higher consideration will be given to technologies that meet or approach the following guidelines:

- Handheld device or compatible with the MOLLE hydration system;
- Lightweight, with a total system weight not to exceed < 1lb/person;
- Simple sampling interface producing minimal waste;
- Minimal supplies to test against each class of threat;
- Provide instantaneous and easily understandable output of threats from the indigenous water source;
- Satisfy a 6 foot drop to concrete and 300 lbs dynamic and static compression while dry;
- No power/low power requirements are preferred. If batteries or other electronic components are required, they shall be commercially available and included in the total system weight for the entire service life of the device;
- Capable of being used and operated with water temperatures from 4°C to 49°C, in environments with temperature from -33°C to 52°C;
- System cost of <$200 at full scale manufacturing.

The device should be lightweight, easy to use, with a simple interface that provides an easy to understand readout.

PHASE I: The STTR Phase I should result in an innovative proof of concept device that incorporates sensing capabilities of at least three TIC/TIM threats, as well as salt, at concentrations equal to or below minimum exposure limits, defined by Army Public Health Command and TBMED 577. Phase I is to determine the scientific and technical merit and feasibility of the proposed cooperative effort. Phase I deliverables would include a bench scale demonstration of the technology, cost/benefit analysis report, a plan to scale technology, and technical report .Specifically, the device should be able to sense for threats from toxic industrial chemicals and materials, and high salt concentrations (>1000 ppm).

PHASE II: This phase of the program should expand upon the capabilities of the proof of concept devices from Phase I, to include sensing of at least 10 TIC/TIM threats, as well as salt, at concentrations equal to or below minimum exposure limits defined by Army Public Health Command and TBMED 577. Development should result in at least 10 useable prototypes, which shall be tested against artificial water spiked with threats, as well as real-world water sources (e.g. fresh, brackish, and seawater) to prove they meet the above requirements. Phase II deliverables would also include a final report documenting the development of the device, test results compared to the objectives and the technical data package to build the device, and a plan for commercialization.

PHASE III DUAL USE APPLICATIONS: The initial use of this technology will be to provide Army Soldiers with instantaneous analysis of the efficacy of their TICs/TIMs water purification system. This should easily transition to other branches of the Armed Forces as well. If successful, this technology will find use in a number of other sectors. The most immediate need is in underdeveloped countries where access to clean drinking water is scarce and purification is expensive. As the world's water supply becomes more contaminated, the ability to identify whether indigenous water sources are safe, and if not, what threat needs to be addressed through purification, is a powerful tool to better ensure water quality for individuals, small groups or communities. Another area of interest is in the commercial outdoors sector, in which a small, handheld device can provide threat information from indigenous water sources for the camper, hiker, or backpacker.

REFERENCES:

1. Technical Bulletin Medical (TB MED) 577: Sanitary Control and Surveillance of Field Water Supplies. United States Department of the Army, 2013. https://dmna.ny.gov/foodservice/docs/references/tbmed577.pdf;
2. NSF Protocol P248: Military Operations Microbiological Water Purifiers, NSF International, 2012.;ATP 4-44 MCRP 3-17.7Q Water Support Operations https://www.marines.mil/Portals/1/Publications/MCRP%203-40D.14.pdf?ver=2017-03-27-095057-740;
3. Water Requirement and Soldier Hydration: https://ke.army.mil/bordeninstitute/published_volumes/mil_quantitative_physiology/QPchapter07.pdf

KEYWORDS: Hydration, sensor, individual protection, water, purification, Soldier, TICs/TIMs

A20B-T026 TITLE: Robust, High Stretch, Flame Resistant, Breathable Textile for Lightweight Moisture Management

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

OBJECTIVE: To develop a fabric with the durability of a woven fabric and the stretch and breathability of a knitted fabric

DESCRIPTION: Current duty uniforms are made of woven fabrics however, the Army has fielded and has in acquisition garments with woven and knitted materials. The knit can only be placed in strategic locations where stretch and comfort are required and durability is not a critical issue. The use of a durable stretch fabric would increase the comfort and breathability of any woven garment. An FR material that provides the strength and abrasion resistance is needed to survive the wear and tear in the field and provide FR protection. The woven fabrics currently fielded are not as comfortable against the skin as knit fabrics, are not as breathable, and do not stretch enough isotropically1 to make the conformal fitting garments necessary for heat management and reduced bulk and movement hinderance3. Knitted fabrics have very low durability compared to woven materials2. Current methods for functionalizing woven fabrics often have detrimental effects to the intrinsic properties of the fabric such as durability, and air or water vapor permeation.4 This novel fabric should have robustness, stretch and breathability to allow for the design of a more comfortable, close fitting uniform that would increase thermal and moisture management of the wearer.

This novel textile should have the following properties:

1. Comfort of knit fabrics as measured in terms of bi-axial stretch, water vapor transport, wicking
2. Durability of woven fabrics as measured in terms of abrasion resistance, tear strength, bursting strength
3. The final weight and thickness of the textile should be comparable to the existing textiles used in standard duty uniforms
4. The textile should be no melt/no drip (T), flame resistance is required

To develop a fabric with the durability of a woven fabric and the stretch and breathability of a knitted fabric while retaining Army requirements for flame resistance (FR) and vector protection. The improved fabric properties will enable the manufacture of comfortable fabrics, conformal garments, with good heat management, and garments for a variety of applications both military and civilian. The new textile will have the above attributes and maintain the variety of finishing processes currently in use, including Dye-ability, permanent press and permethrin treatments.

PHASE I: Develop a proof of concept to incorporate durability, stretch, breathability, wicking, and comfort into a textile. Air permeation, stretch and recovery, flame resistance, moisture wicking, abrasion testing, and burst strength will be tested on the material IAW the ASTMS listed below in table 1.0. The detailed conditions of testing must be approved by the TPOC. At the end of Phase I, swatch sized samples will be delivered to the TPOC. Table 1.0 Phase 1 test methods and requirements will be uploaded with topic

PHASE II: The full scale manufacturing process must be demonstrated in Phase II. Further improvements on the textile properties are also the objectives of this phase of research, as needed. Full capability to sew into a garment must be demonstrated, seaming issues must be overcome. Continued testing on the scaled textile, as detailed in Phase I, will be conducted to ensure no loss in performance during scaled up production. This phase will demonstrate textile uniformity across the width and length of the production

PHASE III DUAL USE APPLICATIONS: The novel textile developed in this work with the aforementioned properties would have applications far beyond the standard issue uniforms, and could apply to improve a host of technologies, including equipment, CBRNe garments, and temporary structures such as tents. Use of the textile outside of direct military applications include; first responders, outdoor clothing and equipment, sports clothing, etc.

REFERENCES:
1. Senthilkumar, M.; Anbumani, N.; Hayavadana, J., Elastane fabrics - A tool for stretch applications in sports. Indian J. Fibre Text. Tes. 2011, 36 (3), 300-307.;
2. Malshe, P.; Mazloumpour, M.; El-Shafei, A.; Hauser, P., Functional Military Textile: Plasma-Induced Graft Polymerization of DADMAC for Antimicrobial Treatment on Nylon-Cotton Blend Fabric. Plasma Chemistry and Plasma Processing 2012, 32 (4), 833-843.;
3. Petrulis, D., The influence of fabric construction and fibre type on textile durability: woven, knitted and nonwoven fabrics. In Understanding and Improving the Durability of Textiles, Annis, P. A., Ed. Woodhead Publ Ltd: Cambridge, 2012; pp 3-30.;
4. Tang, K. P. M.; Kan, C. W.; Fan, J. T.; Sarkar, M. K.; Tso, S. L., Flammability, comfort and mechanical properties of a novel fabric structure: plant-structured fabric. Cellulose 2017, 24 (9), 4017-4031. https://www.researchgate.net/publication/318163344
5. Table 1.0 Phase I Test Methods and Requirements:

Characteristic	**Test Method**	**Requirement**
Isotropic Stretch	ASTM D2594	15%
Air Permeation	ASTM D737	=<30 $ft^3/min/ft^2$
Flame Resistance	ASTM D6413	After Flame 2 Seconds After Glow 15 Seconds Char Length 4.5 inches
Abrasion testing	ASTM D3884	=<500 cycles
Burst Strength	ASTM D3787	=<125 pounds
Moisture Wicking	AATCC TM 197	3 inch/hr

KEYWORDS: Textiles, heat management, moisture management, stretch fabrics, fibers, nonwovens, fabrics

A20B-T027 TITLE: Neural Network Based Pedestrian Dead Reckoning Navigation

RT&L FOCUS AREA(S): Network Command, Control and Communications
TECHNOLOGY AREA(S): Information Systems

OBJECTIVE: Develop a capability to maintain the accuracy, integrity and reliability of tracking dismounted soldier trainees as they perform their exercises in the field.

DESCRIPTION: The Army's current modernization of live training requires accurate dismounted soldier trainee position/tracking to enable the convergence of Live, Virtual, and Constructive (LVC) training environments. Currently, live soldier trainees, when represented virtually, are often seen to have position jitter, or can be seen floating or jumping to positions not physically possible in the real world. Currently, under conditions of GPS satellite signal attenuation or blockage due to terrain features is conducted by a concept called dead reckoning, which is similar to a flywheel effect, which are relative estimates of position and heading using inertial sensors: accelerometers to measure linear motion, and gyroscopes to measure angular rate change. These sensors estimate position, velocity, and heading measured from a last known trusted GPS receiver position measurement (latitude and longitude) when the satellite signal reception is attenuated, distorted, or blocked by land features such as trees or buildings. Accelerometers simultaneously detect walking steps and estimate stride length to derive an estimate for position and velocity. Gyroscopes measure angular rate changes and are used to estimate heading. The last known GPS receiver position measurement also receives timestamps from received satellite signals that are referenced and tracked by crystal oscillators for keeping time reference measurements to estimate velocity. All of these sensors have error modes that degrade Position, Velocity, and Timing (PVT) measurement estimates proportional to distance travelled and elapsed time. Current state-of-the-art dead reckoning error rate is approximately 2% of distance travelled on flat, even, terrain.

We are seeking innovative dead reckoning techniques based on time series-based algorithmic solutions that exploit artificial neural networks that have PVT estimate error equal to, or less than, 0.2% of distance travelled and is able to maintain estimate performance in challenging terrain to include stairs, tunnels, and steep mountain terrain. Solutions using low cost Micro-electro Mechanical Systems (MEMS) based Inertial Measurement Units (IMUs) are preferred to keep cost, weight, and power consumption low. Soldier trainees often perform their exercises in the field which are often in environments where GPS satellite signals are substantially degraded or altogether unavailable, such as during maneuvers in indoor urban training center buildings.

PHASE I: Develop detailed analysis of predicted performance and perform modeling and simulation of technical approach. Phase I deliverables will include a design concept and analysis of expected performance capability with supporting rationale.

PHASE II: Develop, demonstrate, and validate a proposed dead reckoning system using a Linux Operating System (OS) that meets the topic objectives. Phase II deliverables will be dead reckoning system prototype that can demonstrate meeting topic objectives in an outdoor test environment. The use of an Android smartphone to demonstrate the technology capability is acceptable. The proposed solution must be mounted on the body's upper torso.

PHASE III DUAL USE APPLICATIONS: Potential military applications would include dismounted soldier navigation under tactical operational conditions where GPS satellite signals are attenuated or obscured or under electronic warfare situations. Commercial applications would include vehicle fleet tracking, Unmanned Aerial Vehicles (UASs) performing aerial surveying data collections in GPS-challenged environments to maintain public safety, or for wearable gait analysis to detect changes in the neural control of gait linked to ageing or Parkinson's disease.

REFERENCES:

1. Q. Wang, L. Ye, H. Luo, “Pedestrian Stride-Length Estimation Based on LSTM and Denoising Autoencoders”,Sensors 2019, https://www.mdpi.com/1424-8220/19/4/840;
2. Q. Wang, L. Ye, H. Luo, “Pedestrian Walking Distance Estimation Based on Smartphone Mode Recognition”, Remote Sensing 2019, https://www.mdpi.com/2072-4292/11/9/1140;
3. G. Guo, R. Chen, “A Pose Awareness Solution for Estimating Pedestrian Walking Speed”, Remote Sensing 2019, https://www.mdpi.com/2072-4292/11/1/55;
4. C. Chen, C. Lu, B. Wang, “DynaNet: Neural Kalman Dynamical Model for Motion Estimation and Prediction”, https://arxiv.org/pdf/1908.03918.pdf;
5. S. Rangapuram, M. Seeger, “Deep State Space Models for Time Series Forecasting”, NeurIPS 2018 https://pdfs.semanticscholar.org/7b8f/97663a190ddaf599f83d3ab6204639f8881a.pdf?_ga2.57350316.789179070.1569364791-670032685.1569364791

KEYWORDS: Machine Learning, Neural Networks, Time Series Forecasting, Kalman Filter, and Pedestrian Dead Reckoning

A20B-T028 TITLE: Reducing COVID-19 Mortality by Reducing Post-Hyperimmunity Period Immune Suppression

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

OBJECTIVE: To reduce soldier and civilian mortality from COVID-19 and other viruses by reducing post-hyperimmunity period immune suppression.

DESCRIPTION: Serious illness or trauma often induces a hyperimmune response, which marshals the body defenses to fight off the illness or effects of the trauma and promote survival. However the hyperinflammatory period is often followed by a period of immune suppression. During this period of immune suppression the patient often succumbs to the effects of microorganisms that would normally be easily neutralized. There is evidence to suggest that the intensity of the hypoimmune phase can be suppressed with compounds that are already part of the human diet and have already been demonstrated to be safe. The intent of this STTR call for proposals is to demonstrate and validate that increasing the amount of specific compounds in the human diet can improve survivability after COVID-19 infection, or to demonstrate that those humans that already consumed increased amounts of specific dietary factors have an increased survival rate. The ultimate intent is to then use that data and knowledge to prescribe specific dietary interventions to improve survival in humans facing severe biological challenges, whether civilians facing challenges such as COVID-19 or soldiers on the battlefield facing a wide variety of severe challenges such as IED injuries and trauma.

PHASE I: The investigators will obtain anonymized samples from COVID-19 patients and measure the levels of the candidate compound(s) in serum or other samples. Samples will be normalized by age, sex and other known risk factors and then mortality and recovery data will be gathered and used to determine whether higher levels correlate with increased survival. Data from phase I should clearly indicate that a phase II investment is justified.

PHASE II: In phase II the investigators will gather more samples if necessary. If the data supports human intervention trials then the investigators will obtain the necessary IRB approvals for a human trial. By the end of phase II the investigators will have either determined that 1) human mortality from challenges such as COVID-19 is reduced by dietary interventions that reduce the post hyperinflammatory period immune suppression or 2) COVID-19 survival cannot be increased by targeted altering of the human diet prior to infection.

PHASE III DUAL USE APPLICATIONS: In phase III it is anticipated that successful phase II work will lead to recommendations to increase the intake of specific dietary compound(s) to reduce mortality from COVID-19 and other severe infections. Although levels could be increased by increasing consumption of certain foods, it is likely that a pharmaceutical would also be created, tested and marketed as protection against COVID-19.

REFERENCES:

1. Bortolotti P, Faure E, Kipnis E. Inflammasomes in tissue damages and immune disorders after trauma. (2018) Front Immunol. 16;9:1900.;
2. Bouras M, Asehnoune K, Roquilly A. Contribution of dendritic cell responses to sepsis-induced immunosuppression and to susceptibility to secondary pneumonia. (2018) Front Immunol. 13;9:2590.;
3. Conti P, Ronconi G, Caraffa A, Gallenga CE, Ross R, Frydas I, Kritas SK. Conti P, et al. Induction of pro-inflammatory cytokines (IL-1 and IL-6) and lung inflammation by

Coronavirus-19 (COVID-10 or SARS-CoV-2): anti-inflammatory strategies. (2020) J. Biol Regul Homeost Agents. 34(2):1.;
4. Channappanavar R, Perlman S.Channappanavar R, et al. (2017) Pathogenic human coronavirus infections: causes and consequences of cytokine storm and immunopathology. (2017) Semin Immunopathol. 39(5):529-539.;
5. Mehta P, McAuley DF, Brown M, Sanchez E, Tattersall RS, Manson JJ; COVID-19: consider cytokine storm syndromes and immunosuppression. (2020) Lancet 16:S0140-6736(20)30628-0.

KEYWORDS: COVID-19, hyperimmunity, immune suppression

DEPARTMENT OF THE NAVY (DON)
20.B Small Business Technology Transfer (STTR)
Proposal Submission Instructions

IMPORTANT

- **The following instructions apply to STTR topics only:**
  - **N20B-T026 through N20B-T030**
- **The information provided in the DON Proposal Submission Instruction document takes precedence over the DoD Instructions posted for this Broad Agency Announcement (BAA).**
- **DON updates the Technical Volume (Volume 2) page limit to not exceed 10 pages.**
- A Phase I proposal template specific to DON topics will be available to assist small businesses to generate a Phase I Technical Volume (Volume 2). The template will be located on https://www.navysbir.com/links_forms.htm.
- The DON provides notice that Basic Ordering Agreements (BOAs) may be used for Phase I awards, and BOAs or Other Transaction Agreements (OTAs) may be used for Phase II awards.
- The optional Supporting Documents Volume (Volume 5) is available for the STTR 20.B BAA cycle. The optional Supporting Documents Volume is provided for small businesses to submit additional documentation to support the Technical Volume (Volume 2) and the Cost Volume (Volume 3). Volume 5 is available for use when submitting Phase I and Phase II proposals. DON will not be using any of the information in Volume 5 during the evaluation.

INTRODUCTION

The Program Manager of the DON STTR Program is Mr. Steve Sullivan. For program and administrative questions, contact the SYSCOM Program Manager listed in Table 1; **do not** contact them for technical questions. For technical questions about a topic, contact the Topic Authors listed within the topic during the period **6 May 2020 through 2 June 2020**. Beginning **3 June 2020,** the SBIR/STTR Interactive Technical Information System (SITIS) (https://www.dodsbirsttr.mil/submissions) listed in Section 4.15.d of the Department of Defense (DoD) SBIR/STTR Program Broad Agency Announcement (BAA) must be used for any technical inquiry. For general inquiries or problems with electronic submission, contact the DoD SBIR/STTR Help Desk at 1-703-214-1333 (Monday through Friday, 9:00 a.m. to 5:00 p.m. ET) or via email at dodsbirsupport@reisystems.com.

TABLE 1: DON SYSTEMS COMMAND (SYSCOM) STTR PROGRAM MANAGER

Topic Numbers	Point of Contact	SYSCOM	Email
N20B-T026 to N20B-T030	Ms. Donna Attick	Naval Air Systems Command (NAVAIR)	navairsbir@navy.mil

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

PHASE I GUIDELINES

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

PHASE I PROPOSAL SUBMISSION REQUIREMENTS

The following MUST BE MET or the proposal will be deemed noncompliant and may be REJECTED.

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

- **Technical Proposal (Volume 2).** Technical Proposal (Volume 2) must meet the following requirements:
  - Content is responsive to evaluation criteria as specified in DoD SBIR/STTR Program BAA section 6.0
  - Not to exceed **10** pages, regardless of page content
  - Single column format, single-spaced typed lines
  - Standard 8 ½" x 11" paper
  - Page margins one-inch on all sides. A header and footer may be included in the one-inch margin.
  - No font size smaller than 10-point*
  - Include, within the **10-page limit of Volume 2**, an Option that furthers the effort in preparation for Phase II and will bridge the funding gap between the end of Phase I and the start of Phase II. Tasks for both the Phase I Base and the Phase I Option must be clearly identified.

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

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

Disclosure of Information (DFARS 252.204-7000)

In order to eliminate the requirements for prior approval of public disclosure of information (in accordance with DFARS 252.204-7000) under this or any subsequent award, the proposer shall identify and describe all fundamental research to be performed under its proposal, including subcontracted work, with sufficient specificity to demonstrate that the work qualifies as fundamental research. Fundamental research means basic and applied research in science and engineering, the results of which ordinarily are published and shared broadly within the scientific community, as distinguished from proprietary research and from industrial development, design, production, and product utilization, the results of which ordinarily are restricted for proprietary or national security reasons. Simply identifying fundamental research in the proposal does NOT constitute acceptance of the exclusion. All exclusions will be reviewed and noted in the award. NOTE: Fundamental research included in the technical proposal that the proposer is requesting be eliminated from the requirements for prior approval of public disclosure of information, must be uploaded in a separate document (under "Other") in the Supporting Documents Volume (Volume 5).

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

- **Cost Volume (Volume 3).** The Phase I Base amount must not exceed $140,000 and the Phase I Option amount must not exceed $100,000. Costs for the Base and Option must be separated and clearly identified on the Proposal Cover Sheet (Volume 1) and in Volume 3.

- **Period of Performance.** The Phase I Base Period of Performance must be exactly six (6) months and the Phase I Option Period of Performance must be exactly six (6) months.

- **Company Commercialization Report (Volume 4)**. Volume 4 is not available for the 20.B BAA. Please refer to the DoD SBIR/STTR BAA section 5.4(e) for further information.

- **Supporting Documents (Volume 5)**. The optional Volume 5 is provided for small businesses to submit additional documentation to support the Technical Proposal (Volume 2) and the Cost Volume (Volume 3). Volume 5 is available for use when submitting Phase I and Phase II proposals. A template for Volume 5 is available on https://navysbir.com/links_forms.htm. DON will not be using any of the information in Volume 5 during the evaluation.

  Note: Even if you are not providing documentation within Volume 5, DSIP will require you to respond to a "yes" or "no" question regarding the volume. Failure to respond may stop you from submitting and certifying your proposal.

  - Letters of Support relevant to this project
  - Additional Cost Information
  - SBIR/STTR Funding Agreement Certification
  - Technical Data Rights (Assertions)
  - Allocation of Rights between Prime and Subcontractor
  - Disclosure of Information (DFARS 252.204-7000)
  - Prior, Current, or Pending Support of Similar Proposals or Awards
  - Foreign Citizens

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

  A font size smaller than 10-point is allowable for documents in Volume 5; however, proposers are cautioned that the text may be unreadable.

- **Fraud, Waste and Abuse Training Certification (Volume 6)**. DoD has implemented the optional Fraud, Waste and Abuse Training Certification (Volume 6). DON does not require evidence of Fraud, Waste and Abuse Training at the time of proposal submission. Therefore, DON will not require proposers to use Volume 6.

DON STTR PHASE I PROPOSAL SUBMISSION CHECKLIST

- **Subcontractor, Material, and Travel Cost Detail.** In the Cost Volume (Volume 3), proposers must provide sufficient detail for subcontractor, material and travel costs. Enter this information in the "Explanatory Material" field in the online DoD Volume 3. Subcontractor costs must be detailed to the same level as the prime contractor. Material costs must include a listing of items and cost per item. Travel costs must include the purpose of the trip, number of trips, location, length of trip, and number of personnel. When a proposal is selected for award, be prepared to submit further documentation to the SYSCOM Contracting Officer to substantiate costs (e.g., an explanation of cost estimates for equipment, materials, and consultants or subcontractors).

  For Phase I a minimum of 40% of the work is performed by the proposing firm, and a minimum of 30% of the work is performed by the single research institution. The percentage of work is measured by both direct and indirect costs.

  To calculate the minimum percentage of effort for the proposing firm the sum of all direct and indirect costs attributable to the proposing firm represent the numerator and the total proposals costs (i.e. costs before profit or fee) is the denominator. The single research institution percentage is calculated by taking the sum of all costs attributable to the single research institution as the numerator and the total proposal costs (i.e. costs before profit or fee) as the denominator.

- **Performance Benchmarks.** Proposers must meet the two benchmark requirements for progress toward Commercialization as determined by the Small Business Administration (SBA) on June 1 each year. Please note that the DON applies performance benchmarks at time of proposal submission, not at time of contract award.

- **Discretionary Technical and Business Assistance (TABA).** If TABA is proposed, the information required to support TABA (as specified in the TABA section below) must be added in the "Explanatory Material" field of the online DoD Volume 3. If the supporting information exceeds the character limits of the Explanatory Material field of Volume 3, this information must be included in Volume 5 as "Additional Cost Information" as noted above. Failure to add the required information in the online DoD Volume 3 and, if necessary, Volume 5 will result in the denial of TABA. TABA may be proposed in the Base and/or Option periods, but the total value may not exceed $6,500 in Phase I.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

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

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

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

TABA must NOT:

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

TABA must be included in the Cost Volume (Volume 3) as follows:

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

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

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

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

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

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

EVALUATION AND SELECTION

The DON will evaluate and select Phase I and Phase II proposals using the evaluation criteria in Sections 6.0 and 8.0 of the DoD SBIR/STTR Program BAA respectively, with technical merit being most important, followed by qualifications of key personnel and commercialization potential of equal importance. As noted in the sections of the aforementioned Announcement on proposal submission requirements, proposals exceeding the total costs established for the Base and/or any Options as specified by the sponsoring DON SYSCOM will be rejected without evaluation or consideration for award. Due to limited funding, the DON reserves the right to limit awards under any topic.

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

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

Protests of Phase I and II selections and awards must be directed to the cognizant Contracting Officer for the DON Topic Number, or filed with the Government Accountability Office (GAO). Contact information for Contracting Officers may be obtained from the DON SYSCOM Program Managers listed in Table 1. If the protest is to be filed with the GAO, please refer to the instructions provided in section 4.11 of the DoD SBIR/STTR Program BAA.

Protests to this BAA and proposal submission must be directed to the DoD SBIR/STTR BAA Contracting Officer, or filed with the GAO. Contact information for the DoD SBIR/STTR BAA Contracting Officer can be found in section 4.11 of the DoD SBIR/STTR Program BAA.

CONTRACT DELIVERABLES

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

AWARD AND FUNDING LIMITATIONS

Awards. The DON typically awards a Firm Fixed Price (FFP) contract or a small purchase agreement for Phase I. In addition to the negotiated contract award types listed in Section 4.14.b of the DoD SBIR/STTR Program BAA for Phase II awards, the DON may (under appropriate circumstances) propose the use of an Other Transaction Agreement (OTA) as specified in 10 U.S.C. 2371/10 U.S.C. 2371b and related implementing policies and regulations. The DON may choose to use a Basic Ordering Agreement (BOA) for Phase I and Phase II awards.

Funding Limitations. In accordance with the SBIR and STTR Policy Directive section 4(b)(5), there is a limit of one sequential Phase II award per firm per topic. Additionally, to adjust for inflation DON has raised Phase I and Phase II award amounts. The maximum Phase I proposal/award amount including all options (less TABA) is $240,000. The Phase I Base amount must not exceed $140,000 and the Phase I Option amount must not exceed $100,000. The maximum Phase II proposal/award amount including all options (including TABA) is $1,700,000 (unless non-SBIR/STTR funding is being added). Individual SYSCOMs may award amounts, including Base and all Options, of less than $1,700,000 based on available funding. The structure of the Phase II proposal/award, including maximum amounts as well as breakdown between Base and Option amounts will be provided to all Phase I awardees either in their Phase I award or in a minimum of 30 days prior to the due date for submission of their Initial Phase II proposal.

PAYMENTS

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

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

TRANSFER BETWEEN SBIR AND STTR PROGRAMS

Section 4(b)(1)(i) of the SBIR and STTR Policy Directive provides that, at the agency's discretion, projects awarded a Phase I under a BAA for STTR may transition in Phase II to SBIR and vice versa. Please refer to instructions provided in section 7.2 of the DoD SBIR/STTR Program BAA.

ADDITIONAL NOTES

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

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

International Traffic in Arms Regulation (ITAR). For topics indicating ITAR restrictions or the potential for classified work, limitations are generally placed on disclosure of information involving topics of a classified nature or those involving export control restrictions, which may curtail or preclude the involvement of universities and certain non-profit institutions beyond the basic research level. Small businesses must structure their proposals to clearly identify the work that will be performed that is of a basic research nature and how it can be segregated from work that falls under the classification and export control restrictions. As a result, information must also be provided on how efforts can be performed in later phases if the university/research institution is the source of critical knowledge, effort, or infrastructure (facilities and equipment).

Partnering Research Institutions. The Naval Academy, the Naval Postgraduate School, and other military academies are Government organizations but qualify as partnering research institutions. However, DON laboratories DO NOT qualify as research partners. DON laboratories may be proposed only IN ADDITION TO the partnering research institution.

PHASE II GUIDELINES

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

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

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

PHASE III GUIDELINES

A Phase III SBIR/STTR award is any work that derives from, extends, or completes effort(s) performed under prior SBIR/STTR funding agreements, but is funded by sources other than the SBIR/STTR programs. This covers any contract, grant, or agreement issued as a follow-on Phase III award or any contract, grant, or agreement award issued as a result of a competitive process where the awardee was an SBIR/STTR firm that developed the technology as a result of a Phase I or Phase II award. The DON will give Phase III status to any award that falls within the above-mentioned description, which includes assigning SBIR/STTR Technical Data Rights to any noncommercial technical data and/or noncommercial computer software delivered in Phase III that was developed under SBIR/STTR Phase I/II effort(s). Government prime contractors and/or their subcontractors must follow the same guidelines as above and ensure that companies operating on behalf of the DON protect the rights of the SBIR/STTR firm.

NAVY SBIR 20.B Topic Index

N20B-T026 TITLE: Rapid Material Development for Lightweight Additive Manufactured (AM) Structures and Repairs

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)
TECHNOLOGY AREA(S): Air Platform, Materials, Weapons

OBJECTIVE: Develop a novel high-performance alloy for structural components and repairs capable of being produced by Additive Manufacturing (AM), and that exhibits high strength, low density, high corrosion resistance, and improved process-ability traits. Tools such as integrated computational materials engineering (ICME), AM, accelerated testing concepts, and data mining to accelerate the development and qualification of the alloy should be used.

DESCRIPTION: Magnesium (Mg) is the lightest structural metal with a density that is 35% lower than aluminum, making it a prime candidate for light weighting in the aerospace and automotive industries [Ref 1]. The helicopter industry has capitalized on the low density of Mg in the past, mainly in transmission casings (e.g., H-60, H-53) [Ref 2]. However, most applications of Mg are non-structural or semi-structural due to the limited mechanical properties of legacy Mg alloys. Mg's process-ability issues (i.e., flammability) and poor corrosion resistance further restricts the use of Mg on U.S. Navy (USN) aircraft [Ref 2]. In fact, many components manufactured from legacy Mg alloys corrode relatively quickly in-service, which leads to unscheduled maintenance to repair or replace those components. The various forms of AM can provide opportunities to repair those components or to build one-off replacements for them, which could help reduce life-cycle maintenance time and costs for USN aircraft. However, the legacy Mg alloys are currently limited to wrought/cast product forms due to Mg's high oxygen affinity and low melting/evaporation points, which make it difficult to process with AM [Refs 2-4].

A novel high-performance alloy for structural components and repairs that possesses high strength, low density, high corrosion resistance, and improved process-ability traits is sought. To decrease development time, an ICME framework should be used to design the alloy. The alloy should be designed to be produced in powder form, and to be processed using powder-based AM to further reduce development time [Ref 5]. Flammability and oxidation should be key design considerations to improve the process-ability of the alloy by reducing the risk of ignition during production and post-processing. The alloy should have a density comparable to that of a magnesium alloy (less than 0.0838 lb/in^3) and mechanical properties that meet or exceed the following:

- Specific Ultimate Strength: 700 ksi /(lb/in^3)
- Specific Yield Strength: 500 ksi /(lb/in^3)
- Ultimate Elongation: 8%.

The alloy should have improved corrosion resistance and improved fatigue resistance in comparison to legacy Mg alloys such as AZ31 or WE43. Experimentally show the feasibility of the alloy design, and once the material composition has been refined, coupons should be produced and tested to verify the performance of the new, lightweight alloy.

The results of this STTR effort could reduce lifecycle maintenance and costs for USN aircraft: the alloys created could be an alternative to conventional magnesium alloys, albeit with superior corrosion resistance and better process-ability for component maintenance/rework. This alloy could also reduce the logistical footprint of USN aircraft by providing the capability to replace cast Mg components with AM equivalent components without the high costs and lead-times associated with foundries. A new high-strength, lightweight alloy that is capable of being produced with AM would allow newly designed components to have increased structural efficiency (i.e., higher strength to weight ratios), and would enable the production of ultra-lightweight topology optimized parts.

PHASE I: Formulate a novel high-performance alloy using ICME tools and produce a sample batch of the alloy in powder form. Process the demonstration powder in a powder-based AM system and establish the feasibility of the alloy design by generating limited test data, such as static/fatigue strength data (per ASTM E8 and ASTM E466, respectfully), microstructural characterization (per ASTM E3, ASTM E112, and ASTM E407). The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Refine the alloy composition through an iterative approach that includes modeling, AM fabrication, and testing of ASTM E8/E466 [Refs 6,7] coupons and prototype parts. Initiate the development of the material properties database for an optimized alloy design. Develop an optimized heat-treatment for the alloy if heat treatment is required to achieve desired properties.

PHASE III DUAL USE APPLICATIONS: Fully develop the design allowable database for the high-performance alloy. Demonstrate and validate the performance of the new material through component testing in a service environment. Transition the newly developed alloy for use in the fabrication of USN and commercial aircraft structural components.

The high-performance alloy developed in this effort could be directly transitioned into applications for both commercial aerospace and automotive industries. Beyond aircraft applications, the missile and satellite industries are long-time users of magnesium components and could also benefit from an improved lightweight structural alloy. This effort would also produce the groundwork needed to develop additional AM-tailored materials for other commercial applications. For example, an excellent fit for an AM-capable magnesium is the biomedical industry. Magnesium offers properties that makes it suitable as a biodegradable metal [Ref 3], which would be useful in applications such as repairing fractured bones.

REFERENCES:
1. Luo, A. A. "Application of Computational Thermodynamics and Calphad in Magnesium Alloy Development." 2nd World Congress on Integrated Computational Materials Engineering (ICME), 2013, pp. 3-8. https://link.springer.com/chapter/10.1007/978-3-319-48194-4_1

2. Czerwinski, F. "Controlling the Ignition and Flammability of Magnesium for Aerospace Applications." Corrosion Science, September 2014, pp. 1-16. https://www.sciencedirect.com/science/article/pii/S0010938X14002182

3. Zumdick, N., Jauer, L., Kutz, T. & Kersting, L. "Additive Manufactured WE43 Magnesium: A Comparative Study of the Microstructure and Mechanical Properties with those of Powder Extruded and As-Cast WE43." Materials Characterization, Volume 147, January 2019, pp. 384-397. https://www.sciencedirect.com/science/article/pii/S1044580318324689

4. Pawlak, A., Rosienkiewicz, M. & Chlebus, E. "Design Experiments Approach in AZ31 Powder Selective Laser Melting Process Optimization." Archives of Civil and Mechanical Engineering, Volume 17, Issue 1, January 2017, pp. 9-18. https://www.sciencedirect.com/science/article/abs/pii/S1644966516300917

5. Dietrich, S., Wunderer, M., Huissel, A. & Zaeh, M. "A New Approach for a Flexible Powder Production for Additive Manufacturing." Procedia Manufacturing, Volume 6, December 2016, pp. 88-95. https://www.sciencedirect.com/science/article/pii/S2351978916301482

6. "ASTM Standard E8/8a 16: Standard Test Methods for Tension Testing of Metallic Materials." ASTM International: West Conshohocken, PA, 2016. https://www.astm.org/search/fullsite-

search.html?query=Standard%20Test%20Methods%20for%20Tension%20Testing%20of%20Metallic%20Materials&

7. "ASTM Standard E466 15: Standard Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials." ASTM International: West Conshohocken, PA, 2015. https://www.astm.org/Standards/E466

8. "ASTM Standard E3-11 2017: Standard Guide for Preparation of Metallographic Specimens." ASTM International: West Conshohocken, PA, 2017. https://www.astm.org/Standards/E3.htm

9. "ASTM Standard E11213:Standard Test Methods for Determining Average Grain Size." ASTM International: West Conshohocken, PA, 2014, https://www.astm.org/Standards/E112

10. "ASTM Standard E407(2015)e1:Standard Practice for Microetching Metals and Alloys." ASTM International: West Conshohocken, PA, 2015. https://www.astm.org/Standards/E407

KEYWORDS: Additive Manufacturing, AM, Powder, Integrated Computational Materials Engineering, ICME, Magnesium, Material, Structure

N20B-T027 TITLE: High Speed Vertical Cavity Surface Emitting Laser (VCSEL)

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)
TECHNOLOGY AREA(S): Electronics, Air Platform, Ground Sea

OBJECTIVE: Develop and package an uncooled vertical cavity surface emitting laser (VCSEL) that operates error free in a fiber optic transmitter at no less than 100 gigabits per second binary non-return to zero serial for air platform fiber optic link applications.

DESCRIPTION: Current airborne military (mil-aero) core avionics, electro-optic (EO), communications and electronic warfare systems require ever-increasing bandwidths while simultaneously demanding reductions in space, weight and power. The replacement of shielded twisted pair wire and coaxial cable with earlier generation length-bandwidth product multimode optical fiber has given increased immunity to electromagnetic interference, bandwidth, and throughput, and a reduction in size and weight on aircraft. For Ethernet, the serial rate using binary non-return to zero signaling for multimode fiber links has increased from 1 gigabit per second in 1998 to 25 gigabits per second in 2015 [Ref 1]. To meet commercial sector demands for higher aggregate bandwidth capacity, optical interconnects based on 850 nanometers (nm) VCSELs have evolved to higher lane rates, more parallel architectures, and more advanced modulation formats [Ref 2]. Digital fiber optic transmitters employing VCSELs have been shown to operate reliably at extended temperatures (-40 to +85-degrees Celsius) without active cooling. Current digital fiber optic transmitters consist of an uncooled VCSEL operating at 850 nm wavelength and custom designed integrated circuitry (IC) to drive the VCSEL. The IC includes electrical waveform shaping to improve the signal response of the VCSEL. A slightly overdamped frequency response can limit the amount of optical overshoot and but can be effectively controlled with electrical pre-emphasis [Ref 3]. Oxide confined VCSELs have been matured for use in digital multimode fiber optic links up to about 50 gigabits per second [Refs 4-5]. Microwave and optical test procedures have evolved to characterize VCSEL responses including relative intensity noise, optical modulation response (scattering parameter 21 (S21)), and high-resolution optical spectra [Ref 6]. Research is ongoing exploring more advanced VCSEL technology [Ref. 7].

Historically, avionics has mostly preferred the use of conventional binary non-return to zero serial/single lane links over higher numbered lane links, parallel links, pulse amplitude modulated links and wavelength division multiplexed links. To meet the expected growth in aggregate bandwidth required onboard future generation aircraft, new optical component technologies that enable much higher speed binary non-return to zero serial links will be required. It is envisioned that a VCSEL based transmitter operating in a single lane at no less than 100 gigabits per second at a yet to be determined or specified emission wavelength or optical fiber type can be enabled by the development of more advanced VCSEL technology. One aspect of this research is to specify the VCSEL bandwidth requirement, S21, for a VCSEL operating in a transmitter at no less than 100 gigabits per second. Another related VCSEL design consideration relates to the average fiber coupled power based on typical avionics link-loss power budget and link margin requirements, i.e., 5 connectors in series and 3 dB end-of-life margin [Refs 8-9]. Another related VCSEL design consideration relates to the reliability and technology readiness. Highly accelerated life testing can be used to assess VCSEL technology readiness [Ref. 10].

It is anticipated that an uncooled VCSEL based transmitter and the corresponding receiver will include electrical equalization in order to achieve necessary performance. The VCSEL therefore must be capable of working with these electronic benefits. The desired high speed VCSEL mounted on a carrier in a fiber optic transmitter will be capable of transmitting error free digital data and video over optical fiber in a short reach (30 to 100 meters), binary non-return to zero serial link operating at no less than 100 gigabits per second. The uncooled VCSEL mounted on a carrier must perform reliably over a -40 degrees Celsius to +95 degrees Celsius temperature range, and maintain EO performance upon exposure to typical Naval air platform vibration, humidity, temperature, altitude, thermal shock, mechanical shock, and temperature cycling environments [Refs 11-14].

PHASE I: Design an uncooled high speed VCSEL and provide an approach for determining VCSEL performance parameters and testing. Demonstrate feasibility of the laser design, showing path to meeting Phase II goals. Design a high-speed VCSEL laser package prototype that is compatible with digital fiber optic transmitter interface circuitry and coupling to optical fiber. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Optimize the VCSEL and VCSEL package designs from Phase I. Build and test the VCSEL, and packaged VCSEL, to meet performance requirements. Characterize the VCSEL over temperature and perform highly accelerated life testing. If necessary, perform root-cause analysis and remediate VCSEL and/or packaged VCSEL failures. Deliver packaged VCSEL prototype for 100 Gb/s transmitter application.

PHASE III DUAL USE APPLICATIONS: Verify and validate the VCSEL performance in an uncooled 100 Gb/sec fiber optic transmitter that operates from -40 to +95 degrees Celsius for transition to military and commercial fiber optic transmitter manufacturing sites.
Commercial sector telecommunication systems, fiber optic networks, and data centers optical networks could benefit from the development of high speed VCSELs.

REFERENCES:
1. Larsson, A., Gustavsson, J., Westbergh, P., Haglund, E., Haglund, E., Simpanen, E., . . . and Karlsson, M. “VCSEL design and Integration for High-Capacity Optical Interconnects.” Optical Interconnects XVII, 2017, San Francisco: SPIE. https://www.spiedigitallibrary.org/conference-proceedings-of-spie/10109/101090M/VCSEL-design-and-integration-for-high-capacity-optical-interconnects/10.1117/12.2249319.short?SSO=1

2. Szczerba, K., Lengyel, T., He, Z., Chen, J., Andrekson, P., Karlsson, M., . . . and Larsson, A. “High-Speed Optical Interconnects with 850nm VCSELS and Advanced Modulation Formats.” Vertical-Cavity Surface-Emitting Lasers XXI, 2017, San Francisco: SPIE. https://www.spiedigitallibrary.org/conference-proceedings-of-spie/10122/101220G/High-speed-optical-interconnects-with-850nm-VCSELS-and-advanced-modulation/10.1117/12.2256992.short

3. Tatum, J., Gazula, D., Graham, L., Guenter, J., Johnson, R., & King, J. “VCSEL-Based Interconnects for Current and Future Data Centers.” Journal of Lightwave Technology, 2014, pp. 727-732. https://ieeexplore.ieee.org/document/6955704

4. Kuchta, D., Rylyakov, A., Schow, C., Proesel, J., Baks, C., Westbergh, P., . . . and Larsson, A. “A 50 Gb/s NRZ Modulated 850nm VCSEL Transmitter Operating Error Free to 90°C.” Journal of Lightwave Technology, 2013. https://vdocuments.site/a-50-gbs-nrz-modulated-850-nm-vcsel-transmitter-operating-error-free-to-90.html

5. Feng, M., Wu, C.-H. & Holonyak, N. “Oxide Confined VCSELs for High Speed Optical Interconnects.” IEEE Journal of Quantum Electronics, 2018. https://ieeexplore.ieee.org/document/8319410

6. O'Brien, C., Majewski, M. & Rakic, A. “A Critical Comparison of High-Speed VCSEL Characterization Techniques.” Journal of Lightwave Technology, 2007, pp. 597-605. https://ieeexplore.ieee.org/document/4142813

7. Deppe, D., Li, M., Yang, X. & Bayat, M. (2018). Advanced VCSEL Technology: Self-Heating and Intrinsic Modulation Response. IEEE Journal of Quantum Electronics. https://ieeexplore.ieee.org/document/8337728

8. "AS5603A Digital Fiber Optic Link Loss Budget Methodology for Aerospace Platforms." SAE International, 2018. https://saemobilus.sae.org/content/as5603a

9. "AS5750A Loss Budget Specification for Fiber Optic Links. SAE International, 2018. https://saemobilus.sae.org/content/as5750a

10. "ARP6318 Verification of Discrete and Packaged Photonic Device Technology Readiness." SAE international, 2018. https://saemobilus.sae.org/content/arp6318

11. "MIL-STD-810G: Environmental Engineering Considerations and Laboratory Tests." Department of Defense, 2008.http://everyspec.com/MIL-STD/MIL-STD-0800-0899/MIL-STD-810G_12306/

12. "MIL-STD-883K: Test Method Standard Microcircuits." Department of Defense, 2016. http://everyspec.com/MIL-STD/MIL-STD-0800-0899/MIL-STD-883K_54326/

13. "MIL-STD-38534J: General Specification for Hybrid Microcircuits." Department of Defense, 2015. http://everyspec.com/MIL-PRF/MIL-PRF-030000-79999/MIL-PRF-38534J_52190/

14. "DO-160F: Environmental Conditions and Test Procedures for Airborne Equipment." RTCA, 2010. https://my.rtca.org/NC__Product?id=a1B36000001IcnSEAS

KEYWORDS: Vertical Cavity Surface Emitting Laser, VCSEL: Digital Fiber Optic Transmitter, Binary Non-return to Zero Signaling, 100 Gigabits per Second, Highly Accelerated Life Testing

N20B-T028 TITLE: Advanced Electromagnetic Modeling and Analysis Tools for Complex Aircraft Structures and Systems

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

OBJECTIVE: Develop a software package that ensures geometric fidelity is not compromised for the generation of a computational electromagnetics (CEM) mesh formed by high-order curved elements. Apply the software package to model large-scale problems (thousands of wavelengths long in each dimension) using exact physics methods.

DESCRIPTION: The field of computational electromagnetics (CEM) came to existence in the middle 1960s. Since that time, there has been substantial progress in the mathematical aspects of CEM as well as in taking advantage of advances in computer technology. The combination of these two has resulted in electromagnetic modelling and simulation (EM&S) software that can successfully address a variety of EM scenarios. There are still, however, problems of large electrical size that current CEM technologies cannot address. One example of interest is the radiation characteristics of installed antenna arrays coupled with radomes with the cavity-like structures where the array resides (and other objects within that cavity) and with the external structure of the aircraft platform. Another example of equal importance is the signature of maritime targets in a variety of sea states. The computational domain in this case can be enormous especially for near-grazing incidence. It is not possible to address such problems with sufficient accuracy using approximate (high frequency) methods; moreover, near-field parameters of interest may not be obtainable at all by such methods as, for example, the driving point or the mutual impedance of a platform installed antenna array. Exact-physics methods, on the other hand, generate such a large number of unknowns that would challenge even the largest computer clusters. For these reasons, there has been a movement in recent years in both time-domain and frequency-domain, toward high-order algorithms that use large cell sizes (~10 wavelengths) to minimize the number of cells in the volume computational domain and thus the computational burden for solving very large problems that are in thousands of wavelengths in each dimension [Refs 1-2]. While using such large cell sizes, however, it is imperative to use high-order curved elements [Refs 3-6] instead of many small, flat facets to capture the geometry with the necessary fidelity. For targets with small- and large-scale geometric features, the process of creating high-order, curved elements is still in a state of infancy to guarantee no grid crossovers and no negative Jacobian in any cell in the computational domain.

Develop methods for generating curved volume meshes for complex targets that will conform to a prescribed geometry and be suitable for use with high-order solvers. This should lead to more robust and computationally efficient EM tools to predict the near- and far-field characteristics of large-scale problems that involve complex structures, installed antenna arrays, radomes and interior regions accurately. The number of unknowns generated should be such that the solver could run in low-level clusters (128-256 cores and 2-4 GB standard memory size per core). A graphical user interface (GUI) that encompasses the entire computational process that includes the preprocessing tools for geometry import and generation of high-order curved elements, high-order processing tools, and a comprehensive set of post processing tools for data output and visualization, should intelligently guide the user through any projected application. The design of the GUI should consider ISO/IEC 25022:2016 usability metrics. While the main thrust of this SBIR topic is to develop a high-order mesh generation capability, there is also interest in producing an integrated high-order CEM environment. The environment must be capable of addressing large-scale problems accurately and efficiently, while utilizing minimal computational resources. The process of combining high-order curved elements with high-order solvers and large cell sizes (up to 10 wavelengths) must be demonstrated through test problems, such as a perfect electric conductor (PEC) sphere of 100-wavelength in diameter.

PHASE I: Develop and demonstrate procedures for high-order mesh generation from a hybrid linear element mesh, while retaining computer aided design (CAD) geometry fidelity. Develop a preliminary software package design that can create a high-order (up to 10th order) curved elements for a complex geometry. Demonstrate the process of combining high-order, curved elements with high-order solvers and large cell sizes (up to 10 wavelengths), for test problems such as a PEC sphere of 100-wavelength diameter, and provide accuracy measures when compared to Mie series solution for bistatic radar cross section. The Phase I effort will include plans for software to be developed in Phase II.

PHASE II: Complete the development of the software package from Phase I, compatible with existing high-order CEM software tools (time and frequency domain). The delivered software package, compatible with Windows and Linux OS platforms, must predict near-field and far-field characteristics of complex systems. Ensure the high-order curved elements preserve the small- and large-scale critical features of the geometry. Implement the tool(s) with a GUI for problem setup and results analysis. Ensure that the GUI design emphasizes ease-of-use in the context of configuring, visualizing, and executing on arbitrary complex targets. Port codes on clusters of central processing units and/or graphical processing units (CPUs/GPUs). Test and demonstrate the resulting codes on cases of interest.

PHASE III DUAL USE APPLICATIONS: Complete development of the CEM software application suitable for transition and for commercial use. The CEM software application will have widespread use in the DoD, industry and academia for analysis of highly complex electromagnetic problems.

REFERENCES:
1. Hesthaven, J. & Warburton, T. “Nodal Discontinuous Galerkin Methods.” Springer: New York, 2000. https://link.springer.com/book/10.1007/978-0-387-72067-8#about

2. Huttunen, T., Malinen, M. & Monk, P. “Solving Maxwell's Equations Using The Ultra Weak Variational Formulation.” Journal of Computational Physics, 2007, pp. 731-759. https://www.sciencedirect.com/science/article/pii/S0021999106004712

3. Fidkowski, K. & Darmofal, D. “A Triangular Cut-Cell Adaptive Method for High-Order Discretizations of the Compressible Navier-Stokes Equations.” Journal of Computational Physics, 2007, pp. 1653-1672. https://www.sciencedirect.com/science/article/pii/S0021999107000757

4. Sanjaya, D. & Fidkowski, K. “Improving High-Order Finite Element Approximation Through Geometrical Warping.” American Institute of Aeronautics and Astronautics, 2016, pp. 3994-4010. https://arc.aiaa.org/doi/abs/10.2514/1.J055071

5. Persson, P.-O. & Peraire, J. “Curved Mesh Generation and Mesh Refinement Using Lagrangian Solid Mechanics.” 47th AIAA Aerospace Sciences Meeting Including the New Horizons Forum and Aerospace Exposition, Orlando, 2009. https://arc.aiaa.org/doi/abs/10.2514/6.2009-949

6. Xie, Z., Sevilla, R., Hassan, O. & Morgan, K. “The Generation of Arbitrary Order Curved Meshes for 3D Finite Element Analysis.” Computational Mechanics, 2013, pp. 361-374. https://link.springer.com/article/10.1007/s00466-012-0736-4

KEYWORDS: Computational Electromagnetics, Modeling, Curved Surfaces, Software Applications, High-Order Solver, Electrically Large, Perfect Electric Conductor, PEC: Electromagnetic Fields

N20B-T029 TITLE: Accelerated Burn-In Process for High Power Quantum Cascade Lasers to Reduce Total Cost of Ownership

RT&L FOCUS AREA(S): Quantum Sciences, Directed Energy
TECHNOLOGY AREA(S): Air Platform

OBJECTIVE: Develop and fully validate an accelerated burn-in process for high power continuous wave (CW) Quantum Cascade Lasers (QCLs) that minimizes burn-in time.

DESCRIPTION: Quantum Cascade Lasers (QCLs) capable of delivering several watts of CW optical power in a high-quality beam in the emission wavelength range between 4.6 to 5 microns are of great interest to the Navy for a number of existing and emerging defense applications. The high price of Commercial Off-The-Shelf (COTS) QCLs is one of the main hurdles impeding widespread use by the U.S. warfighter. The Navy has recently initiated several programs to reduce QCL fabrication cost. However, post-production laser failure is one of the main contributors to the high price of QCL-based products. To avoid costly integration of defective high power QCLs into infrared system platforms, devices with short life expectancies must be screened out at an early fabrication/packaging stage. To minimize QCL fabrication cost, a large decrease in infant mortality of the QCLs reaching post-production must be achieved at either the chip or chip-on-submount levels.

Accelerated burn-in testing for diode lasers is typically done at an elevated current and/or temperature and laser degradation models are used to predict their long-term reliability based on observed changes in measured laser characteristics [Refs 1-2]. In contrast to diode lasers, a well-accepted burn-in process for QCLs does not exist [Refs 3-6]. The main goal for this STTR topic is to develop and experimentally validate an accelerated QCL burn-in process that is effective in screening out devices with infant mortality and accurately predicts lifetime [Ref 7] for high power QCLs suitable for DOD applications, while at the same time minimizes required burn-in time. The later requirement is critical for total cost QCL minimization by a factor of 5 in large volume applications.

PHASE I: Design and develop a QCL degradation model. Collect accelerated burn-in data for a statistically significant number of multi-watt continuous wave QCLs. Demonstrate that the new model is consistent with collected experimental data. Develop Phase II work plan that refines and further validates the model.

PHASE II: Build a multichannel QCL burn-in setup and collect long-term burn-in data for at least thirty devices under normal operational conditions. Demonstrate that the new accelerated burn-in process is an effective tool for screening out devices with infant mortality and for accurately predicting lifetime for high-power QCLs. Fully validate and document accelerated burn-in process for QCLs that requires minimal burn-in time.

PHASE III DUAL USE APPLICATIONS: Test and finalize the technology and methodology based on the research and development results developed during Phase II. Develop a cost-effective process for manufacturing high-reliability QCLs to be transitioned and integrated into Directional Infrared Counter Measures (DIRCM) systems for field deployment in a Navy platform.

Commercialize the technology based on the burn-in process developed from this program for law enforcement, marine navigation, commercial aviation enhanced vision, medical applications, and industrial manufacturing processing.

REFERENCES:

1. Johnson, L. "Laser Diode Burn-In and Reliability Testing." IEEE, 2006. https://ieeexplore.ieee.org/document/1593543

2. Lam, S., Mallard, R. & Cassidy, D. "Analytical Model for Saturable Aging in Semiconductor Lasers." Journal of Applied Physics, 2003, pp. 1803-1809. https://aip.scitation.org/doi/pdf/10.1063/1.1589594

3. Myers, T., Cannon, B., Brauer, C., Phillips, M., Taubman, M. & Bernacki, B. "Long-Term Operational Testing of Quantum Cascade Lasers." SPIE, 2016. https://spie.org/Publications/Proceedings/Paper/10.1117/12.2015479?SSO=1

4. Myers, T., Cannon, B., Taubman, M. & Bernacki, B. "Performance and Reliability of Quantum Cascade Lasers." SPIE, 2013. https://www.spiedigitallibrary.org/conference-proceedings-of-spie/9836/98362J/Long-term-operational-testing-of-quantum-cascade-lasers/10.1117/12.2223129.short?SSO=1

5. Razeghi, M. "Quantum Cascade Lasers Ready for IRCM Applications." SPIE: Edinburgh, 2012. https://www.spiedigitallibrary.org/conference-proceedings-of-spie/8543/854304/Quantum-cascade-lasers-ready-for-IRCM-applications/10.1117/12.956504.short

6. Lyakh, A., Maulini, R., Tsekoun, A. & Patel, C. "Progress in High-Performance Quantum Cascade Lasers." SPIE, 2010. https://www.spiedigitallibrary.org/journals/Optical-Engineering/volume-49/issue-11/111105/Progress-in-high-performance-quantum-cascade-lasers/10.1117/1.3506192.short

7. "MIL-STD-810G: Environmental Engineering Considerations and Laboratory Tests." Department of Defense, 2008. Everyspec. http://everyspec.com/MIL-STD/MIL-STD-0800-0899/MIL-STD-810G_12306/

KEYWORDS: QCL, Burn-In Process, Thermal Load, Reliability, Mid Wave Infrared (MWIR), Brightness

N20B-T030 TITLE: 1 Micrometer Integrated Transmitter for Balanced Radio-Frequency-Over-Fiber Photonic Links

RT&L FOCUS AREA(S): General Warfighting Requirements (GWR)
TECHNOLOGY AREA(S): Ground Sea, Electronics, Air Platform

OBJECTIVE: Develop and package a heterogeneously integrated optical transmitter operating at a wavelength near 1 micrometer for balanced radio-frequency (RF) photonic link applications on air platforms.

DESCRIPTION: Current airborne military communications and electronic warfare systems require ever-increasing bandwidths while simultaneously requiring reductions in space, weight, and power (SWaP). The replacement of the coaxial cable used in various onboard RF/analog applications with RF/analog fiber optic links will provide increased immunity to electromagnetic interference, reduction in size and weight, and an increase in bandwidth. Typically, RF-to-optical transmitters are made by integrating many discrete components into a single large module that routinely exceeds 300 cm^3. However onboard RF/analog applications require the development of high performance, high linearity optoelectronic components that can operate over extended temperature ranges. Additionally, avionic platforms pose stringent SWaP requirements on components such as optical transmitters for avionic fiber communications applications. New optical component and packaging technology is needed to meet future requirements. Current analog optical transmitter technology typically consists of discrete lasers and modulators operating at 1550 nanometers (nm), with active cooling for operation in military environments. To meet avionic requirements, the transmitter should integrate a laser and modulator into a compact uncooled package that can maintain performance over full avionic temperature range (minimum -40 to +85 Celsius). It is envisioned that a laser emitting at approximately 1 micrometer wavelength can serve as the laser source in the transmitter. Innovative Lithium Niobate modulator design including heterogeneous packaging is necessary to integrate a wide-band dual-output (1X2) intensity modulator with the laser and a dual-core single mode fiber output. Recently low relative intensity noise (RIN) lasers and small form factor modulators have become commercially available. However, the challenges posed by integrating both components together in a package less than 150 cm^3 via heterogeneous integration has yet to be accomplished for high performance wideband RF over fiber links, as typically the laser and modulator are of differing materials. Some work has been done to integrate optical components monolithically [Ref 1], and heterogeneously [Ref 2], but researchers have yet to demonstrate an integrated laser and modulator design with the low noise figures (sub-15dB) needed for practical RF/analog photonic links operating over extended temperature ranges.

The optical transmitter component is to be based on integration of a dual-output analog transmitter with a dual-core single mode optical fiber [Ref 3] pigtail with a multicore fiber connector at the end of the pigtail. Simultaneously, the transmitter must have performance requirements that support high-performance balanced RF link specifications such as RF noise figures below 25 dB (no RF or optical amplification) when connected directly to a separate balanced high current photodiode pair (0.7 Amp/Watt responsivity); and spur free dynamic ranges (SFDR) above 110 dB-Hz^2/3. The laser source must have a linewidth of <100 kHz, a wavelength of around 1,000 nm, and an output power greater than 200 mW, with RIN spectrum of -165 dBc/Hz from 50 MHz to 20 GHz. The optical modulator is required to operate at up to 20 GHz, and have dual output configuration for applications requiring noise cancellation utilizing balanced detection. The modulator's power output and modulation efficiency should be optimized to meet the 25 dB noise figure target utilizing both modulator outputs with the above photodiode specifications operated in a balanced detection configuration [Refs 4, 5].

Ideally, the transmitter should operate uncooled over a minimum temperature range of -40 to +85 degrees Celsius while maintaining RIN and linewidth performance. A dual output optical transmitter including an integrated optical intensity modulator packaged in a ruggedized package is envisioned. It is desirable for this transmitter module to have a package dimension no greater than 17.5 × 65 × 115 mm when both the bias control circuits for the modulator and the low noise CW laser power supply are contained in the module. The packaged transmitter must perform over the specified temperature range and maintain hermeticity and optical alignment upon exposure to typical Navy air platform vibration, humidity, thermal shock, mechanical shock, and temperature cycling environments [Ref 6].

PHASE I: Develop and analyze a new design and packaging approach for an uncooled 1 micrometer optical transmitter that meets the requirements outlined in the Description section. Develop fabrication process, packaging approach, and test plan. Demonstrate the feasibility that the optical transmitter can achieve the desired RF performance specifications with a proof of principle bench top experiment or preferably in an initial prototype. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Optimize the Phase I transmitter and package design and develop a prototype. Test prototype transmitter to meet design specifications in a Navy air platform representation of a relevant application environment [Ref 6], which can include unpressurized wingtip or landing gear wheel well (with no environmental control [Ref 7]) to an avionics bay (with environmental control). The prototype transmitter should be tested in a balanced RF photonic link over temperature with the objective performance levels reached. Demonstrate a prototype fully packaged transmitter for direct insertion into balanced analog fiber optic links.

PHASE III DUAL USE APPLICATIONS: Perform extensive operational reliability and durability testing [Refs 8, 9], as well as optimize manufacturing capabilities. Transition the demonstrated technology to Naval Aviation platforms and interested commercial applications.

Commercial sector data centers, industries utilizing local area networks, and telecommunication systems, as well as companies that install networks and telecommunications systems would benefit from the development of this transmitter technology.

REFERENCES:
1. Pappert, S., Esman, R. and Krantz, B. "Photonics for RF Systems." IEEE Avionics Fiber Optics and Photonics Conference, 2008. https://ieeexplore.ieee.org/document/4653148

2. Novak, D, and Clark, T. R. "Broadband adaptive feedforward photonic linearization for high dynamic range signal remoting." IEEE Military Communications Conference, 2007. https://ieeexplore.ieee.org/document/4454898

3. Diehl, J., Nickel, D., Hastings, A., Singley, J., McKinney, J. and Beranek, M. "Measurements and Discussion of a Balanced Photonic Link Utilizing Dual-Core Optical Fiber." Proc. IEEE Avionics Fiber-Opt. Photon. Technol. Conf., 2019. https://ieeexplore.ieee.org/document/8908161

4. McKinney, J.D., Godinez, M., Urick, V.J., Thaniyavarn, S., Charczenko, W. and Williams, K.J. "Sub-10-dB Noise Figure in a Multiple-GHz Analog Optical Link." IEEE Photonics Technology Lett., vol. 19, no. 7, April 2007, pp. 465-67. https://ieeexplore.ieee.org/document/4126564

5. Williams, K.J., Nichols, L.T. and Esman, R.D. "Externally-Modulated 3 GHz Fibre Optic Link Utilising High Current and Balanced Detection." Electronics Letters. vol. 33, no. 15, 1997, pp. 1327-1328. https://ieeexplore.ieee.org/document/606085

6. "MIL-STD-810H, DEPARTMENT OF DEFENSE TEST METHOD STANDARD: ENVIRONMENTAL ENGINEERING CONSIDERATIONS AND LABORATORY TESTS (31-JAN-2019)." http://everyspec.com/MIL-STD/MIL-STD-0800-0899/MIL-STD-810H_55998/

7. "DO-160F Environmental Conditions and Test Procedures for Airborne Equipment." http://www.rtca.org/store_product.asp?prodid=759-

8. "MIL-HDBK-217F, Reliability prediction of electronic equipment. http://everyspec.com/MIL-HDBK/MIL-HDBK-0200-0299/MIL-HDBK-217F_NOTICE-2_14590/

9. "ARP 6318 "Verification of Discrete and Packaged Photonic Device Technology Readiness." https://www.sae.org/standards/content/arp6318/

KEYWORDS: Multicore Fiber, Connector, 1 Micrometer, Responsivity, Avionics, Wide Band Dual-Output

DEFENSE HEALTH AGENCY
20.B Small Business Technology Transfer (STTR) Program
Proposal Submission Instructions

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. Specific questions pertaining to the DHA STTR Program should be submitted to the DHA STTR Program Management Office (PMO) at:

E-mail - usarmy.detrick.medcom-usamrmc.mbx.dhpsbir@mail.mil
Phone - (301) 619-7296

The DHA Program participates in three DoD STTR BAAs each year. Proposals not conforming to the terms of this BAA will not be considered. Only Government personnel will evaluate proposals with the exception of technical personnel from Oak Ridge Institute for Science and Engineering who will provide technical analysis in the evaluation of proposals submitted against DHA topic number:

- DHA20B-002 In-Ear Exposure Sensor with Integrated Noise Attenuation and Communications Capabilities

PHASE I PROPOSAL SUBMISSION

Follow the instructions in the DoD Program BAA for program requirements and proposal submission instructions.

STTR Phase I Proposals have three Volumes: Proposal Cover Sheets, Technical Volume, and Cost Volume. **Please note that the DHA STTR will not be accepting a Volume Five (Supporting Documents) as noted at the DoD BAA website**. The Technical Volume has a 20-page limit including: table of contents, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes) and any other 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 20-page limit.

Only the electronically generated Cover Sheets and Cost Volume are excluded from the 20-page limit. Technical Volumes that exceed the 20-page limit will be reviewed only to the last word on the 20th page. Information beyond the 20th page will not be reviewed or considered in evaluating the offeror's proposal. To the extent that mandatory technical content is not contained in the first 20 pages of the proposal, the evaluator may deem the proposal as non-responsive and score it accordingly.

Companies submitting a Phase I proposal under this BAA must complete the Cost Volume using the on-line form, within a total cost not to exceed $250,000 over a period of up to six months.

The DHA STTR Program will evaluate and select Phase I proposals using the evaluation criteria in Section 6.0 of 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.

Proposals not conforming to the terms of this BAA, and unsolicited proposals, will not be considered. Awards are subject to the availability of funding and successful completion of contract negotiations.

If a small business concern is selected for a 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. Please refer to the DoD Instructions, section 4.2.f to view a "Model Agreement for the Allocation of Rights".

RESEARCH INVOLVING HUMAN OR ANIMAL SUBJECTS

The DHA STTR Program discourages offerors from proposing to conduct human subject or animal research during Phase I due to the significant lead time required to prepare regulatory documentation and secure approval, which will significantly delay the performance of the Phase I award.

The offeror is expressly forbidden to use or subcontract for the use of laboratory animals in any manner without the express written approval of the US Army Medical Research and Development Command's (USAMRDC) Animal Care and Use Review Office (ACURO). Written authorization to begin research under the applicable protocol(s) proposed for this award will be issued in the form of an approval letter from the USAMRDC ACURO to the recipient. Furthermore, modifications to already approved protocols require approval by ACURO prior to implementation.

Research under this award involving the use of human subjects, to include the use of human anatomical substances or human data, shall not begin until the USAMRDC's Office of Research Protections (ORP) provides authorization that the research protocol may precede. Written approval to begin research protocol will be issued from the USAMRDC ORP, under separate notification to the recipient. Written approval from the USAMRDC ORP is also required for any sub-recipient that will use funds from this award to conduct research involving human subjects.

Research involving human subjects shall be conducted in accordance with the protocol submitted to and approved by the USAMRDC ORP. Non-compliance with any provision may result in withholding of funds and or termination of the award.

PHASE II PROPOSAL SUBMISSION

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 SBIR electronic proposal submission system (https://www.dodsbirsttr.mil/submissions/login). This site contains step-by-step instructions for the preparation and submission of the Proposal Cover Sheets, the Company Commercialization Report, the Cost Volume, and how to upload the Technical Volume. For general inquiries or problems with proposal electronic submission, contact the DoD SBIR/STTR Help Desk (1-703-214-1333) or Help Desk email at DoDSBIRSupport@reisystems.com.

The DHA STTR Program will evaluate and select Phase II proposals using the evaluation criteria in Section 8.0 of 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 (please refer to DoD Instructions, section 7.4) describing feasible approaches for transitioning and/or commercializing the developed technology in their Phase II proposal. This plan should be included in the Technical Volume.

The Cost Volume submitted must contain a budget for the entire 24-month Phase II period not to exceed the maximum dollar amount of $1,100,000. These costs must be submitted using the Cost Volume format (accessible electronically on the DoD submission site), and may be presented side-by-side on a single Cost Volume Sheet.

DHA STTR Phase II Proposals have four Volumes: Proposal Cover Sheets, Technical Volume, Cost Volume and Company Commercialization Report. The Technical Volume has a 40-page limit including: table of contents, pages intentionally left blank, references, letters of support, appendices, technical portions of subcontract documents (e.g., statements of work and resumes) and any attachments. Do not include blank pages, duplicate the electronically generated Cover Sheets or put information normally associated with the Technical Volume in other sections of the proposal as these will count toward the 40-page limit.

Technical Volumes that exceed the 40-page limit will be reviewed only to the last word on the 40th page. Information beyond the 40th page will not be reviewed or considered in evaluating the offeror's proposal. To the extent that mandatory technical content is not contained in the first 40 pages of the proposal, the evaluator may deem the proposal as non-responsive and score it accordingly.

PHASE II ENHANCEMENTS

The DHA STTR Program has a Phase II Enhancement Program which provides matching STTR funds to expand an existing Phase II contract that attracts investment funds from a DoD Acquisition Program, a non-STTR government program or eligible private sector investments. Phase II Enhancements allow for an existing DHA STTR Phase II contract to be extended for up to one year per Phase II Enhancement application, and perform additional research and development. Phase II Enhancement matching funds will be provided on a dollar-for-dollar basis up to a maximum $550,000 of STTR funds. All Phase II Enhancement awards are subject to acceptance, review, and selection of candidate projects, are subject to availability of funding, and successful negotiation and award of a Phase II Enhancement contract modification.

TECHNICAL AND BUSINESS ASSISTANCE (TABA)

The DHA STTR 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 STTR Program has a Technical Assistance Advocate (TAA) who provides technical and commercialization assistance to small businesses that have Phase I and Phase II projects.

PROTEST PROCEDURES

Please refer to the DoD Program Announcement for procedures to protest an Announcement. As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to:

Ms. Micaela Bowers
SBIR/STTR Contracting Officer
U.S. Army Medical Research Acquisition Activity
Phone: (301)-619-2173
Email: micaela.l.bowers.civ@mail.mil

DEFENSE HEALTH AGENCY STTR 20.B Topic Index

DHA20B-001 TITLE: Refresher Training and Assessment in Austere Environments using a High Fidelity, Low Resource, Screen Based Virtual Patient Simulator

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

OBJECTIVE: Design, develop, demonstrate, and evaluate the effectiveness of a mobile screen based virtual patient simulator with a high level of fidelity/realism allowing for just-in-time refresher training for emergency medical care for frontline service members in austere environments (land and sea).

DESCRIPTION: Service members, with a high degree of reliability, receive training in emergency medical care through established training courses: Advanced Trauma Life Support (ATLS), Advanced Care Life Support (ACLS), and Pediatric Advanced Life Support (PALS). Through these courses, service members receive the foundational training to provide frontline care in emergency medical situations in theater. The courses provide standardized training for what to do when faced with a decompensated patient. However, there is minimal training on how to recognize the early signs of decompensation in patients such as respiratory distress, shock and poor perfusion. As a result, there is a lack of demonstrated methods to measure readiness for these skills. Little to no implementation has occurred to enable corresponding assessments for use in refresher training. An additional shortcoming of the current training model is the lack of a practical, mobile and easy to use standardized refresher approach. As time passes from the initial training, knowledge and skills wane,1,2,3 decreasing the readiness of service members to appropriately respond when faced with medical emergencies.

The goal of this topic submission is to create a mobile screen based tool with established integrated readiness measurement and corresponding assessments for just-in-time refresher training around the early recognition and management of medical emergencies in adults and children with a variety of underlying causes. The system will have objective readiness measurement capability within a robust system of high resolution images, videos, simulation, augmented reality and virtual reality components to help leaners recognize potential life threating signs and symptoms in patients such as respiratory distress, shock, CNS injury, ocular trauma, poor skin perfusion, etc. These signs are not always as obvious as, for example, frank hemorrhage and lifesaving procedures may be delayed if early recognition is missed. The interest in addressing management of children comes from recent data demonstrating that approximately 11% of ICU bed days in theater were occupied by pediatric patients4. While the focus of service member medical training is and should be on caring for adults, the reality of current global conflicts and disasters is that the US military is the most adept medical facility providing care for all in distress. This effort will focus on both adults and children and can be used in military conflicts and humanitarian disasters.

In order to provide relevant and effective assessment for refresher training, the system must accurately display the presenting findings of Tactical Combat Casualty Care specific medical training scenarios such as blunt force or penetrating trauma (tension pneumothorax), airway compromise, shock (hemorrhagic or septic), and ACLS scenarios. The creation of realistic models that allow for 3D navigation on a mobile device will allow full assessment of clinical findings and enhanced fidelity of training. Additionally, the system must allow the service member to determine the problem at hand, identify, and apply the needed key interventions to facilitate transfer to a higher level of care or await advanced medical support. Solutions must address any limitations in simulation fidelity that in turn limit the ability to implement measures for readiness assessment.

In order to be effectively deployed in theater, the system needs to be accessible on readily available devices that are feasible for deployed service members (i.e. a screen based mobile phone or tablet). Additionally, to ensure reliable use in theater, the system needs to be accessible without com access, facilitating use by those who truly are isolated from advanced support and would benefit the most from real time access to training.

PHASE I: Phase I will develop a proof of concept assessment capability for a simulation-based medical emergency recognition/response refresher tool. The medical case focus is how to recognize the early signs of decompensation in patients such as respiratory distress, shock and poor perfusion. Readiness measures should be developed and implemented within the training solution, and an initial concept design of the platform should be developed.

The following technological challenges should be addressed with proof-of-concept that demonstrate the feasibility of creating visually high fidelity representations of actual clinical presentations encompassing the key conditions faced by presenting service members and children in theater. Additionally, the feasibility of displaying necessary content on readily available screen based phones and tablets that allows for 3D evaluation of clinical findings should be addressed. Phase I solutions should also address the feasibility of integrating key content around recognition of findings and appropriate responses and the feasibility of delivering the content at the point of need, i.e. without the need for communication links in austere environments.

The intent of this phase is for the performer to produce the initial software, application design, and proof of concept that demonstrates the new innovation of the assessment platform that is being tested and indicate the types of risk anticipated. The performer will submit a final report and provide an initial demonstration describing the stage of the software development and application, along with details of what will be further developed in Phase II.

PHASE II: Building upon the development and lessons learned of Phase I, Phase II will focus on a proof of concept design for the robust refresher training platform in terms of functional requirement, content design, architecture design, component design, coding, testing of the platform, and delivery of the platform.

Currently available government-approved screen based phones and tablets that are utilized in theater should be identified as candidate devices for testing the developed platform. It will additionally need to demonstrate medical accuracy and user functionality for all necessary training scenarios included within the Tactical Combat Casualty Care specific medical training scenarios as well as common pediatric presenting conditions.

The Phase II product will need to demonstrate the usefulness of the platform developed with appropriate collection of usability and reliability data from participants who would use the product in the demonstration phase. The Phase II product will need to demonstrate readiness measurement solutions that have sufficient discrimination. Solutions should provide data to enable assessment and modeling of initial acquisition, maximum proficiency, retention, and relearning. The performer will provide a demonstration of the product and discuss potential Phase III developments.

PHASE III: Concluding in Phase III, the performer will have built a viable, commercially available software product accessible in a downloadable application that can be used to train and assess in any location that medical first responders are deployed. Preferably, the capability will be based on state of the art software and hardware principles, use validated data from publicly available sources, and be clinically accurate and relevant to allow for effective refresher training. Solutions should conform to allowable (deployable) technologies (i.e., not Bluetooth reliant) and should function in austere environments.

The system will perform without degradation due to dust, sand, rain, humidity, wind, extremes in temperature and electromagnetic interference and will withstand repeated drops on all axes.

Environmental performance specifications will be determined before final design. A successful system will be expected to pass MIL STD 810G certification on all approved system specifications. The training solution is not anticipated to be permanently installed inside an aircraft; therefore standards from the Joint Enroute Care Equipment Test Standard must be tailored from the original guidelines.

It is anticipated that DoD customers will include Medical Department personnel, TCCC participants, Reserve components, and Federal Agencies involved in disaster assistance.

Commercial markets that could benefit from this novel product would include: emergency/first responder training, undergraduate/graduate medical training, and nursing training. Societies responsible for first responder training such as the AHA and institutions responsible for local emergency medical services support and training could benefit from such a product.

Upon completion, the performer will submit a final report describing the software application and the demonstration results.

REFERENCES:

1. Berden H. J., Willems F. F., Hendrick J. M., Pijls N. H., Knape J. T. (1993). How frequently should basic cardiopulmonary resuscitation training be repeated to maintain adequate skills? BMJ, 306(6892), 1576-1577.
2. Ciurzynski, Susan M. PhD, RN-BC, MS, PNP et al. (2017). Impact of Training Frequency on Nurses' Pediatric Resuscitation Skills. Journal for Nurses in Professional Development. 33(5):E1-E7, September/October 2017.
3. Smith K. K., Gilcreast D., Pierce K. (2008). Evaluation of staff's retention of ACLS and BLS skills. Resuscitation, 78, 59-65. doi:10.1016/j.resuscitation.2008.02.007
4. Borgman M, Matos RI, Blackbourne LH, Spinella PC. Ten years of military pediatric care in Afghanistan and Iraq. J Trauma Acute Care Surg. 2012 Dec;73(6 Suppl 5):S509-13. doi: 10.1097/TA.0b013e318275477c.

KEYWORDS: Refresher Training; Recognition and Management; Readiness Assessment; Virtual Patients; Decompensation in Patients

DHA20B-002 TITLE: In-Ear Exposure Sensor with Integrated Noise Attenuation and Communications Capabilities

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

OBJECTIVE: Develop, demonstrate, and deliver an inner-ear sensor device that integrates three functions: 1) sensing and recording head response to both blast and blunt impact events, 2) communications, and 3) continuous and impulse noise attenuation. This STTR aims to develop a device that provides the ability to monitor multiple types of exposure (blunt impact and blast) to Service Members during training and combat operations for potential traumatic brain injuries.

DESCRIPTION: The Defense and Veterans Brain Injury Center (DVBIC), in conjunction with the Armed Forces Health Surveillance Center, tracks traumatic brain injury (TBI) diagnoses for all U.S. military personnel (deployed and non-deployed). There were 383,947 TBI diagnoses of all severities between 2000 and Q1-2018 (DVBIC, 2019). Depending on the severity of the TBI, symptoms may last from a couple of days to multiple years following the injurious event. Moreover, repeated TBIs may result in more severe and long-term consequences. There have been several attempts to record the exposure conditions related to mild traumatic brain injuries (mTBI) in the military, beginning with an effort directed by the Vice Chief of Staff of the Army (VCSA) in 2007. Existing technologies that are usable in a military environment only measure blast exposure or suffer from poor coupling to the head and require substantial post-processing of the data to correlate the sensor motion to head motion. Commercially available technologies developed for athletics environments are not broadly compatible with the military environment due to interactions with protective equipment and coupling to the head under extreme conditions (Rooks et al., 2015). Additionally, no current capability (military or civilian) integrates the ability to measure both impact and blast exposures in a single package to an acceptable degree.

Additionally, currently available commercial technologies suffer from insufficient battery life and a large overhead of personnel to manage the use of the technology (Rooks et al., 2015). Studies have shown that sensors deeply inserted into the ear canal can have better coupling to the head and can represent head motion accurately (Salzar, 2008; Panzer et al., 2009; Christopher et al., 2013). Additionally, in-ear sensors have been used in the motorsports industry to monitor driver head accelerations during crash events (Knox et al., 2008) as well as measuring head accelerations in rough stock riders (Mathers et al., 2012). Current in-ear sensor systems do not combine the sensor technology with other essential functions that an earpiece must provide to the military Service Member: communications and continuous steady-state and impulse noise attenuation.

This STTR aims to develop a device that provides the ability to monitor Service Members during combat operations for potential traumatic brain injuries. Additionally, the device will integrate with existing Service Members' communication systems, while not hindering communication and providing noise attenuation. This increased monitoring will allow Soldiers to receive medical attention sooner to address potential injuries prior to any additional or compounding injuries. By quickly addressing injuries, Soldier return-to-duty may be accelerated, thus maintaining combat power and increasing Soldier lethality.

PHASE I: Develop device concepts and designs that integrate the desired functions of recording blast and blunt impact exposure, providing communications ability, and providing hearing protection. Additionally, perform a technical trade assessment of the conceptual designs, to include: sensor recording requirements, communications requirements, and noise attenuation requirements for military-specific applications.

The proposed device must integrate all three functions (ability to sense and record head response to blast and blunt exposures, communication, and continuous steady-state and impulse noise attenuation) into a single device. Ideally, the proposed device should be electronically readable, scan-able, or transmittable to DOD approved devices and to manage data and alert team members and medics of a potentially injurious exposure. The device should be capable of integrating with currently fielded Department of Defense (DoD) communications systems, to include drawing power from the radio battery packs (if required for operation) and transmitting data through secure communication channels. If self-powered, the device must have a battery life of at least 72 hours of continuous operation with the ability to be recharged. The device should have minimal power consumption, be low-weight, capable of accommodating the range of Soldiers' ear sizes, comfortable for extended wear, durable, cheap, and re-usable. The target storage capability for the device is 1000 time-trace events before downloading. The target response range for the device is ± 500 G, ± 6,000 deg/sec, and ±100 psi. The target sampling rate for the device is 100,000 Hz, with a minimum duration of 100 ms. Data acquisition should have a minimum of 16-bit resolution, and measurement error should be less than 0.01% for all sensors. Trigger threshold should be adjustable in sensor configuration settings. The timestamp should be accurate to less than 1-second and should have no more than 1-second of drift for a minimum of seven days without synchronizing with a source. Sensor settings (i.e., unique identifier, timestamp, trigger threshold) and data should be stored on non-volatile memory. A time-stamp indicator should be documented before device power depletion and for every recorded event.

Work in Phase I should demonstrate the field compatibility of the design by delivering two weight and geometrically representative mock-ups. Additionally, work completed in Phase I should demonstrate the ability to integrate all three desired functions into a single platform. Along with the mock-ups, the contractor shall deliver documentation on the most promising concept design(s), anticipated developmental testing requirements, proposed test procedures, and preliminary data to demonstrate functionality, compatibility, working principles, and use. The contractor will develop the work plan for subsequent development and prototyping.

PHASE II: Using results from Phase I, construct and demonstrate the operation of a prototype that integrates the three desired functions of recording exposure, communications, and hearing protection. The prototype will also include any hardware/software interfaces that are required for system functionality (data download and processing). Upon successful demonstration of an operational prototype to government representatives, mature the selected design for wear by Service Members and construct working prototypes for limited field testing and evaluations.

Required Phase II deliverables include: 12 working prototype units and associated hardware/software interfaces required for system functionality, documentation on use of the device, a report on the limited field testing and evaluations, and a final report on device design and validation testing.

PHASE III: Mild TBI and the ability to identify potentially injurious events is not solely a military concern. Significant efforts are being made to improve the ability to identify and diagnose mTBI both within the military and commercially. While sensors have been developed and used extensively in athletics, there remains a gap on the market for wearable sensor technologies that can be used occupationally, whether that is in the military (operationally) or commercially. For instance, law enforcement personnel are routinely exposed to similar threats as many military applications, and there is no current sensor that can measure both blast and blunt impact sufficiently within either group. Commercially, an inner-ear multipurpose sensor could become standard issue equipment for the civilian law enforcement community, bomb squads, miners, flight-line personnel, and construction personnel, to name a few occupations. For use with many of the civilian and law enforcements occupations, additional development may be required. Many of the non-military environments use wireless data transmission (e.g., Bluetooth, local wifi networks, etc.) and may use commercially available radio and communication systems rather than DOD approved systems. During phase III, the performer will be encouraged to further develop the prototype device to facilitate use with non-DOD occupations and communities.

Ongoing research efforts in the DOD are using COTS devices that partially fill the gap; however, the devices available are not final solutions for occupational monitoring in training and operational environments. A successfully developed sensor would be integrated into ongoing research, surveillance, and evaluation efforts conducted through the Environmental Sensors in Training (ESiT) program as well as efforts under development to address the 2018 and 2020 National Defense Authorization Acts calling for occupational monitoring of blast exposure.

REFERENCES:

1. Christopher, J. J., et al. (2013). "Assessment of Ear- and Tooth-Mounted Accelerometers as Representative of Human Head Response." SAE International Paper doi:10.4271/2013-01-0805.
2. Knox, T., et al. (2008). "New Sensors to Track Head Acceleration during POssible Injurious Events". SAE International Paper doi: 10.4271/2008-01-2976
3. Mathers, C.H., et al. (2012). "Using In-ear Accelerometers to Measure Head Acceleration in Rough Stock Riders: A Pilot Study." Athletic Training and Sports Health Care. 2012; 4(4); 158-164. doi: 10.3928/19425864-20120309-01
4. Panzer, M., et al. (2009). "Evaluation of Ear-mounted Sensors for Determining Iimpact Head Acceleration." IRCOBI 2009.
5. Rooks, T.F., et al. (2015). "Environmental Sensors in Training: Pilot Field Studies." U.S. Army Aeromedical Research Laboratory (USAARL) Technical Report 2015-17.
6. Salzar, R. S. (2008). "Improving Earpiece Accelerometer Coupling to the Head." SAE International Journal of Passenger Cars - Mechanical Systems 1(1): 15.

KEYWORDS: Concussion, Blast, Impact, Head impact, mTBI, TBI, Environmental Sensor, Noise Attenuation, Earphones, Headset, Radio Headset

DHA20B-003 TITLE: Develop and Demonstrate a Technology for Isolation of Bacteriophages with Enhanced Anti-Biofilm Activity

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

OBJECTIVE: Develop and demonstrate a technology to enable rapid enrichment and isolation of bacteriophages (phages) with enhanced biofilm dispersal activity for the treatment of recalcitrant infections of the Warfighter in the post-antibiotic era.

DESCRIPTION: Multidrug-resistant organisms (MDRO) have spread worldwide and triggered a major public health crisis. U.S. military service members wounded in combat are susceptible to infection by MDRO, including biofilm-mediated infection, at a much higher rate than civilian population due to penetrating combat wounds being accompanied by foreign body inoculum (metal fragments, rocks, dirt), large zones of bone and soft tissue disruption, nerve damage and localized ischemia (tourniquet /edema). Biofilms may begin to form in wounds in as little as a few hours post-infection, and their extracellular matrices provide the bacteria protection from the human host immune response and antibiotic therapy. Furthermore, the current concepts of war moving towards urban dense terrain (UDT) and multi-domain operations (MDO) are expected to generate complex wounds that will require advanced prolonged field care and stabilization when tactical evacuations to robust rear element medical care infrastructures are delayed. Such a delay in evacuation and limit on comprehensive care for combat wound orchestrate the ideal conditions for biofilm formation in severely traumatized tissue. To make matters worse, the potential for life threating infection by MDRO, particularly biofilm-mediated infection, is even higher under the MDO and UDT settings and the need for novel solutions is urgent. ESKAPEE pathogens (Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, Enterobacter spp., and Escherichia coli) frequently colonize healthy military personnel (1) and are causative agents of persistent infections of traumatic and burn wounds that are prone to biofilm formation and multidrug resistance (2).A scarcity in effective antibiotic therapy options warrants the development of alternative potent antibacterials, e.g. phages.

Phages are natural viruses that specifically kill bacteria resistant to antibiotic treatment and have been shown to be able to disperse biofilms by their polysaccharide depolymerase activity and to efficiently kill bacteria in biofilms both in vitro and in vivo (3). Phages exhibit extraordinary specificity to target bacterial strains and can eliminate them without affecting normal microflora. In vitro studies have shown that bacteriophage can penetrate mature biofilms and cause bacterial cell lysis. A major advantage of phage therapy is the ability to exploit the constant natural evolution of phages to overcome phage resistance, infect and kill the host bacteria. Phages have demonstrated high efficacy against ESKAPEE infections in laboratory, domestic and farm animals and promising data in expanded access treatment of humans and even in recent clinical trials, especially in combination with antibiotics (4,5). Phages are becoming a very important adjunct therapy against MDR bacterial infections in civilian and military patients.

The gold standard method for isolating phages is via planktonic growth of bacteria in the presence of a phage source (e.g., sewage). The phages isolated under such conditions would bind to and infect bacteria displaying receptors expressed during planktonic growth, which will not necessarily be the same receptors expressed during biofilm growth. Thus, taking these planktonic growth-isolated phages, assembling them in cocktails and attempting to treat biofilm-mediated infections could be a flawed methodology.

The purpose of this STTR is to enable relatively rapid phage enrichment, screening, and isolation on biofilm of a permissive strain of interest. The end products of the system sought through this process are phages with enhanced biofilm degradation activity against strains of interest. This capability will drastically improve force health protection at large and will more directly enable the formulation of better therapeutic phage cocktails using diverse phages with broad killing spectra isolated from bacterial biofilms, to target biofilm-mediated infections.

Users should have the freedom to select permissive and target screening strains of interest. The technology may be, but is not limited to, micro-filtration systems, microfluidics, centrifugation, nano-materials, gel or polymer matrix or any combination of relevant and novel technologies. The device can be a closed or open modular system. The following features will be critical to consider when proposing a technology:

1) System should enable users to select and input permissive strains of choice for optimized biofilm formation, and to propagate phages on target strains of choice for activity assessment
2) System should perform the enrichment on bacterial biofilms and isolate viable phages with enhanced polysaccharide depolymerase and biofilm dispersal activity
3) System should enable isolation of phages against multiple target strains of interest simultaneously
4) System should enable quantitative screening of phage activity against biofilms of multiple target strains of interest simultaneously
5) Portability of system is preferred but not a requirement
6) Reusable design of consumables are preferred features but not a requirement

PHASE I: This phase should focus on the design of a proof-of-concept prototype technology/device that enables phage enrichment (propagation) on biofilms to produce viable phage particles with enhanced anti-biofilm activity. During this phase, STTR performer should focus on maturing stable biofilm formation on at least, but not limited to, two strains (i.e. permissive strain) of choice on design of choice for screening phages. Phages can be isolated from sewage, environmental waters such streams and ponds, farm run-offs, and harbors. Anticipated components of new device may include, but not limited to, 1) a consumable that allows biofilm growth of permissive cell; 2) a sensor for a qualitative or quantitative assessment of anti-biofilm activity of phages compared to control; 3) a smart device to analyze and interpret data; 4) a method to recover and preserve phages for further testing and validation. System does not need be integrated at this stage but should have a workflow. However, at the end of this phase, working prototype(s) should demonstrate permissive strain input access, mature biofilm formation, and phage propagation capability of the system. Performance (i.e. turnaround time to enriched phages) should be compared to classical manual in vitro approaches over 24, 48, and 72 hrs. Ideally,with regards to portability, performer should also explain how the proposed device can be made suitable for use in a field environment with further development (i.e. the field- testable system should not exceed 30 lbs, self-contained and none of its dimensions should exceed 16 inches, with minimal battery operation for 12 hrs.) The size and cost of the consumable components should be no greater than the currently available fluidic biochips on the market. Provide a written plan for Phase II to reduce the size, simulate field use, and cost of the consumable component. The goal is to reduce size of consumable to less than $10 per test if performer is unable to design reusable consumables.

PHASE II: During this phase, the technology/device should be integrated into a system. The workflow from Phase 1 should be refined to expand on the proof-of-concept into a product that enables high-throughput screening of phages against biofilms of diverse MDRO strains of choice. STTR performer should address features listed as critical features of technology include quantitative assessment of anti-biofilm phage activity, portability of system and reusability of consumables. This testing should be controlled, rigorous, and reproducible. Here, STTR performer may choose, but not required, to coordinate with WRAIR subject matter experts to freely collaborate in optimizing and validating system. This phase should also demonstrate evidence of commercial viability of the product.

PHASE III: This phase should focus on scaling production, marketing of technology to distributors, and contracts. Accompanying application instructions, simplified procedures, and training materials should be drafted in a multimedia format for use and integration of the product into market. The end-state for this product is a commercially viable technology that will be incorporated to the preventive medicine and medical surveillance mission for Force Protection by the Department of Defense by establishing a National Stock Number (NSN) as the first step towards the potential inclusion into appropriate "Sets, Kits and Outfits" that are used by deployed medical forces in the Defense Acquisition System. Furthermore, performer should pursue a commercial path to democratize phage-harvest efforts across medical institutes, bio-pharma and educational institutes.

REFERENCES:

1. Vento TJ, Cole DW, Mende K, Calvano TP, Rini EA, Tully CC, Zera WC, Guymon CH, Yu X, Cheatle KA, Akers KS, Beckius ML, Landrum ML, Murray CK. Multidrug-resistant gram-negative bacteria colonization of healthy US military personnel in the US and Afghanistan. BMC Infect Dis. 2013;13:68.
2. Akers KS, Mende K, Cheatle KA, Zera WC, Yu X, Beckius ML, Aggarwal D, Li P, Sanchez CJ, Wenke JC, Weintrob AC, Tribble DR, Murray CK; Infectious Disease Clinical Research Program Trauma Infectious Disease Outcomes Study Group.Biofilms and persistent wound infections in United States military trauma patients: a case-control analysis. BMC Infect Dis. 2014 Apr 8;14:190.
3. Hansen, M. F., Svenningsen, S. L., Roder, H. L., Middelboe, M., and Burmolle, M. (2019). Big impact of the tiny: bacteriophage-bacteria interactions in biofilms. Trends Microbiol. 27, 739–752. doi: 10.1016/j.tim.2019.04.006
4. Romero-Calle D, Guimarães Benevides R, Góes-Neto A, Billington C. Bacteriophages as alternatives to antibiotics in clinical care. Antibiotics 2019; 8(3):138.
5. C. Rohde, J. Wittmann, E. Kutter Bacteriophages: a therapy concept against multi-drug-resistant bacteria Surg. Infect. 2018; 19: 737-744.

KEYWORDS: Bacterial Infections, Biofilms, Multidrug Resistance, Phages as Alternative Antibacterials, Environmental Samples, Phage Enrichment, Phage Screening and Separation, Phage Isolation, Therapeutic Phage Cocktails

DEFENSE THREAT REDUCTION AGENCY (DTRA)
Small Business Technology Transfer (STTR) Program
STTR 20.B Proposal Instructions

I. 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 and Nuclear) and Improvised Threat Networks. The DTRA STTR program is consistent with the purpose of the STTR Program – i.e., to stimulate a partnership of ideas and technologies between innovative small business concerns and Research Institutions through Federally-funded research or research and development (R/R&D).

The approved FY20.B list of topics solicited for in the Defense Threat Reduction Agency (DTRA) Small Business Technology Transfer (STTR) Program are included in these instructions followed by full topic descriptions. Offerors responding to this Broad Agency Announcement must follow all general instructions provided in the related Department of Defense 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 should be submitted to:

Mr. Mark 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 topics during the pre-release (6 May 2020 to 3 June 2020) 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.

For general inquiries or problems with the electronic submission, contact the DoD SBIR/STTR Help Desk 1-703-214-1333 or email: dodsbirsupport@reisystems.com (Monday through Friday, 9:00 a.m. to 7:00 p.m.)

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.
The STTR Policy Directive is available at:
https://www.sbir.gov/sites/default/files/SBIRSTTR_Policy_Directive_2019.pdf.

II. 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. Those small businesses selected for award will also be required to submit a Funding Agreement Certification document prior to award.

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 STTR program. For more information, please visit the SBA's Firm Registration Page: https://www.sbir.gov/user/login/.

III. USE OF FOREIGN NATIONALS, GREEN CARD HOLDERS AND DUAL CITIZENS

See the "Foreign Nationals" section of the DoD STTR 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.

IV. EXPORT CONTROL RESTRICTIONS

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.

V. FRAUD, WASTE, and ABUSE

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.

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.

Abuse includes any intentional or improper use of Government resources, such as misuse of rank, position, or authority or resources.

Offerors shall complete the SBIR/STTR Program training related to Fraud, Waste and Abuse and provide documentation of completion with proposal submissions. Training is available at: https://www.sbir.gov/tutorials/fraud-waste-abuse/tutorial-1. Please follow guidance provided on the site to complete the required training.

VI. CYBER SECURITY

Any Small Business Concern receiving a 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.

VII. PROPOSAL FUNDAMENTALS

Proposal Submission

All proposals MUST be submitted online using the DoD SBIR/STTR submission system https://www.dodsbirsttr.mil/submissions/. Any questions pertaining to the DoD SBIR/STTR submission system should be directed to the DoD SBIR/STTR Help Desk: 1-703-214-1333, or email to: dodsbirsupport@reisystems.com.

Classified Proposals

Classified proposal are NOT accepted under the DTRA STTR Program and 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.

Proposal Status

The DTRA program office will distribute selection and non-selection email notices to all firms who submit a DTRA STTR proposal. The email will be distributed to the "Corporate Official" and "Principal investigator" listed on the proposal coversheet.

Proposal Feedback

DTRA will provide written feedback to unsuccessful offerors regarding their proposals upon request. Requests for feedback must be submitted in writing to the DTRA SBIR/STTR within 30 calendar days of non-selection notification. Non-selection notifications will provide instructions for requesting proposal feedback.

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 and commercializing new commercial products and processes resulting from such projects.
- Meeting cyber security requirements.

If you are proposing use of Discretionary Technical & 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 & 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 Business and Technical 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 of 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

VIII. PHASE I PROPOSAL GENERAL INFORMATION

<u>Proposal Evaluation</u>

DTRA will evaluate Phase I proposals using the criteria specified in Section 6.0 of the DoD STTR Program BAA during the review and evaluation process. 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, and followed by the commercialization potential. With other factors being equal, cost of the proposal may be included in the evaluation. DTRA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. 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). Phase I contracts are limited to a maximum of $167,500 over a period not to exceed seven months. For clarity, the stated maximum dollar amount is exclusive of the Discretionary Technical and Business Assistance (TABA) that firms may request.

DTRA participates in one DoD STTR BAA each year and anticipates funding one or possibly two Phase I contracts to small business concerns for each topic.

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: Cherokee Nation Strategic Programs, LLC (contract specialist support), Kent, Campa, and Kate, Inc. (contract closeout support), Engility Corporation (a company under SAIC, Inc), (advisory and assistance services), Quanterion Solutions, Inc. (DTRIAC), Kforce Government Solutions, Inc. (financial/accounting support), and CACI (contract writing system administration). This list is not all-inclusive (e.g., subcontractors) and is subject to change.

IX. PHASE I PROPOSAL GUIDELINES

The DoD SBIR/STTR Proposal Submission system is available at https://www.dodsbirsttr.mil/submissions/ and will lead you through the preparation and submission of your proposal. Read Section 5.0 of the DoD Announcement for detailed instructions on proposal format and program requirements. Proposals not conforming to the terms of this Announcement will not be considered. To be considered for evaluation the proposal package must be formally submitted on the DoD SBIR/STTR submission system by clicking the green "SUBMIT PROPOSAL" button. Proposals addressing the topics will be accepted for consideration if received no later than the specified closing hour and date in the DoD Announcement – **12:00 p.m. Eastern Time, Thursday, 2 July 2020.** The Agency requires your entire proposal to be submitted electronically through the DoD Submission Web site https://www.dodsbirsttr.mil/submissions/. A hardcopy is NOT required and will not be accepted. Hand or electronic signature on the proposal is also NOT required.

MAXIMUM PHASE I PAGE LIMIT FOR DTRA IS 20 PAGES FOR VOLUME 2, TECHNICAL VOLUME

Any pages submitted beyond the 20-page limit within the Technical Volume (Volume 2) will not be evaluated**.** Letters of support and TABA requests should be included as part of Volume 5 so it will not count towards the 20-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. DTRA's objective for the Phase I effort is to determine the merit and technical feasibility of the concept. The contract period of performance for Phase I shall be seven (7) months (approx. 6 months technical work plus 1 month final report preparation) and the award shall not exceed $167,500. A list of topics currently eligible for proposal submission is included in these instructions, followed by full topic descriptions.

Phase I Proposal

A complete Phase I proposal consists of six volumes:

- Volume 1. Proposal Cover Sheet (required) does not count towards the 20-page limit.
- Volume 2. Technical Volume (required). DTRA has established a **20-page limitation** for Technical Volumes submitted in response to its topics. The Technical Volume includes, but is not limited to: table of contents, pages left blank, references, appendices, key personnel biographical information.
- Volume 3. Cost Volume (required) does not count towards the 20-page limit. DTRA requires that small business concerns complete the Cost Volume form on the DoD Submission site versus submitting it within the body of the uploaded volume.
- Volume 4. Company Commercialization Report Volume 4 is not available for the 20.2 BAA. Please refer to the DoD SBIR/STTR BAA section 5.4(e) for further information.
- Volume 5. Supporting Documentation Volume (optional) does not count towards the 20-page limit. The Supporting Documentation Volume will be considered part of the evaluation documentation. It

allows for additional specific documents limited to: (a) any additional letters of support, (b) additional cost information. (c) Funding Agreement Certification, (d) Technical Data Rights (Assertions support), (e) TABA, and (f) how you are meeting Cyber Certification requirements.

- Volume 6. Fraud, Waste, and Abuse Training Certification (required) does not count towards the 20-page limit.

Proposal Submittal

Proposals are required to be submitted in Portable Document Format (PDF), and it is the responsibility of submitters to ensure any PDF conversion is accurate and does not cause the Technical Volume portion of the proposal to exceed the 20-page limit. **Any pages submitted beyond the 20-page limit, will not be read or evaluated.** If you experience problems uploading a proposal, call the DoD SBIR/STTR Help Desk from 9:00 a.m. to 5:00 p.m. Eastern Time Monday through Friday at: 1-703-214-1333 or E-mail: dodsbirsupport@reisystems.com

Animal and Human Research

Companies should plan carefully for research involving animal or human subjects, biological agents, etc. (see Sections 4.7 - 4.9 in the DoD Program Announcement). The few months available for a Phase I effort may preclude plans including these elements unless coordinated before a contract is awarded.

X. DECISION and NOTIFICATION

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.

Following the EA decision, the DTRA SBIR/STTR office will release notification e-mails for each accepted or rejected offer. 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 20.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.

XI. 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), 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 DoD SBIR/STTR Submission Web site by the deadline as specified in the Phase II Proposal Guidelines, or in the Phase I award or subsequent notification. Each proposal submission must contain a Proposal Cover Sheet, Technical Volume, Cost Volume, a Company Commercialization Report (see Sections 5.4.c.and 5.5 of the BAA Announcement) and Volume 5. The format should be similar to Phase I proposal except the Phase II Technical Proposal is limited to 40 pages. The Commercialization Strategy Volume should more specific than was required for Phase I.
As instructed in Section 5.4.e of 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 Section 7.4 of the DoD STTR 20.B BAA.

Phase II Evaluation Criteria

Phase II proposals will be reviewed for overall merit based upon the criteria in Section 8.0 of this Broad Agency Announcement and will be similar to the Phase I process.

XII. 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.

XIII. PROTESTS

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 Ms. Megan Faherty, Contracting Officer, as follows) by obtaining written and dated acknowledgment of receipt from (if mailed letter) Defense Threat Reduction Agency, ATTN: AL-AC (Ms. Megan Faherty), 8725 John J. Kingman Road, M.S. 6201, Fort Belvoir VA 22060. If Federal Express is used for the transmittal, the appropriate address is: Defense Threat Reduction Agency, ATTN: AL-AC (Ms. Megan Faherty), 6200 Meade Road, Fort Belvoir, VA 22060.

(b) The copy of any protest shall be received in the office designated above within one day of filing a protest with the GAO.

(End of provision)

DTRA STTR 20.B Topic Index

NOTE: The technology within some of the topics may be restricted under the International Traffic in Arms Regulation (ITAR), which controls the export and import of defense related material and services. Offerors must disclose any proposed use of Foreign nationals, their country of origin, and what tasks each would accomplish in this statement of work in accordance with section 3.5.b(7) of the solicitation.

DTRA20.B-001	Fast, Radiation Hard Scintillation Materials for Nuclear Battlefield Search and Identification
DTRA20.B-002	Integrated Circuits for Gamma Detector Read Out and/or Gamma Spectral Signal Analysis
DTRA20.B-003	Field Detection of Trace Elements and Chemicals

DTRA20B-001 TITLE: Fast, Radiation Hard Scintillation Materials for Nuclear Battlefield Search and Identification

RT&L FOCUS AREA(S): Nuclear
TECHNOLOGY AREA(S): Battlespace, Materials, Nuclear, Sensors

OBJECTIVE: To investigate and develop fast scintillation materials that can be operated under nuclear battlefields for nuclear search, identification, and dose rate estimation. The new scintillators must have ultra-fast decay time, with very limited to no slower decay components, good luminosity, and capable of radioisotope identification. Demonstrate materials performance in prototype detector and develop a cost model and commercial production path.

DESCRIPTION: Most radiation detection systems utilize scintillators as detectors. However in high dose rate environment the majority of scintillators are too slow and often subject to radiation damage. Hence, the alternative sensors used under these conditions are often limited to GM-tubes or silicon diodes. While simple and effective, these detectors have their drawbacks: They provide count rates only rather than spectroscopic information which leads to inaccurate isotope identification and dose rate estimation [1]. In addition, the high dead time under high radiation environment will result in the loss of triggers, or lead to detector paralysis. The inoperability of the advanced scintillators at high dose environment has severely limited the mission capabilities in search and identification of radioactive materials in the nuclear battlefield.

In order to improve radioisotope identification and dose rate estimation for very high dose rate environment, new detector materials are sought. Potential solutions include the development of fast and high radiation-tolerant spectroscopic scintillators. Such scintillators shall possess very fast decay time (shorter than 5 ns), very low to absence of slower decay components, high enough light yield (> 1,000 photons/MeV) to allow the detection of photons down to 60 keV, sufficient energy resolution for spectroscopy based dose measurement, and high enough radiation hardness to survive and operate in intense dose rate environment, up to 1,000 cGy/h.

Examples of existing fast scintillators include halide scintillators [2], e.g. BaF_2, CLYC, etc. These scintillators decay with < 1 ns time constant and have good luminosity of ~2,000 photons/MeV. However, these scintillators often have slower scintillation decay components that would create significant baseline detrimental for the detector under high radiation fields. In addition, halides are also prone to radiation damage during prolonged exposure to high radiation doses. Oxides, on the other hand, can be radiation hard and provide fast decay time, such as $PbWO_4$ (PWO) commonly used in high energy physics experiments [3]. PWO has high density and fast decay time, but the light yield is not high enough [4]. Even more interesting are the rare earth oxides, such as Lu_2O_3, have exhibited much higher light yield and faster decay time than PWO. These oxides are often prepared in the form of ceramic scintillators, which makes them more robust and radiation hard than single crystals [5].

To leverage the ongoing research momentum in fast and radiation hard scintillator materials, DTRA seeks innovative ideas for ultra-fast scintillation materials capable of achieving high count rate with sufficient energy resolution for dose evaluation and isotope identification at both low dose rate environments and nuclear battlefield conditions. The materials must be rugged and can operate over DoD's wide range of environments. Phase I development must demonstrate feasibility of selected materials to provide high count rate, acceptable energy resolution for reliable dose calculation and isotope identification, and adequate radiation hardness. Phase II development will further optimize the down selected materials to achieve the following performance thresholds {objectives}:

1) Decay time: < 5 ns {< 1 ns}
2) Light yield: > 1,000 photons/MeV {> 2,000 photons/MeV}

3) FWHM energy resolution at 662 keV: 10-15% {7-10%, or approaching that of NaI:Tl}
4) Capable of operating in high dose rate environment: up to 1,000 cGy/h {3,000 cGy/h}
5) Materials unit cost: less than the cost of PWO {similar to the cost of the NaI:Tl}
6) Materials must be environmentally rugged for DoD applications
7) Neutron detection: optional {required}

The materials performance must be demonstrated in the prototype detector configuration by the end of Phase II program.

PHASE I: Identify the scintillator materials and their potential. Demonstrate pathways for meeting the Phase II performance goals through feasibility studies at the end of Phase I. Demonstrate radiation hardness capabilities. By the end of the Phase I, single or multiple candidate materials shall be down selected for further development in Phase II.

PHASE II: Further optimize the selected material(s) to produce detector-size samples at the targeted performance parameters. Demonstrate the performance in prototype detectors that accomplish the goals of reliable gamma-ray (and/or neutron) detection and identification under both low dose rate environments and fallout conditions. The detectors shall demonstrate radioisotope identification capabilities consistent with ANSI N42.34 [6]. Demonstrate ability to measure dose/dose rate under fallout conditions accurate to ±20% or ±15 cGy. Develop manufacturing and commercialization plans for implementing the research in production and dissemination of the scintillators, respectively.

PHASE III DUAL USE APPLICATIONS: Further optimize the selected material(s) to produce detector-size samples at the targeted performance parameters. Demonstrate the performance in prototype detectors that accomplish the goals of reliable gamma-ray (and/or neutron) detection and identification under both low dose rate environments and fallout conditions. The detectors shall demonstrate radioisotope identification capabilities consistent with ANSI N42.34 [6]. Demonstrate ability to measure dose/dose rate under fallout conditions accurate to ±20% or ±15 cGy. Develop manufacturing and commercialization plans for implementing the research in production and dissemination of the scintillators, respectively.

REFERENCES:
[1] National Urban Security Technology Laboratory for the U.S. Department of Homeland Security, Science and Technology Directorate, June 2016. Radiation Dosimeters for Response and Recovery Market Survey Report. Homeland Security
[2] P. Rodnyi, Core-valence luminescence in scintillators, Rad. Meas., Vol. 38, p. 343, 2004.
[3] P. Lecoq and M. Korzhik, Scintillator developments for high energy physics and medical imaging, NIM A Vol. 47, p. 1311, 2000.
[4] L. van Peiterson, et al., Charge transfer luminescence of Yb3+, J. Lum Vol. 91, p. 177, 2000.
[5] T. Yanagida, et al., Optical and scintillation properties of transparent ceramic Yb:Lu2O3 with different Yb concentrations, Optical Material, Vol. 36, p. 1044, 2014.
[6] ANSI N42.34, American National Standard Performance Criteria for Hand-Held Instruments for the Detection and Identification of Radionuclides.

KEYWORDS: scintillation materials, high radiation field, dose measurements, gamma-ray detection, radio-isotope identification, RIID

DTRA20B-002 TITLE: Integrated Circuits for Gamma Detector Read Out and/or Gamma Spectral Signal Analysis

RT&L FOCUS AREA(S): Nuclear
TECHNOLOGY AREA(S): Battlespace, Electronics, Materials, Nuclear, Sensors

OBJECTIVE: Improve radiation detector capabilities by reducing the size, weight, and power requirements of the associated electronics. Other performance characteristics may be enhanced.

DESCRIPTION: Over the past decades significant improvements have been made to materials that detect radiation. Over the same time, development with electronics components, circuits, and systems has improved even more dramatically. However, much of the development with electronics has not been successfully applied to radiation detection systems. Just as with consumer applications, these developments have the potential of providing users of radiation detectors with desired system improvements such as lower weight, smaller size, reduced power consumption, and better heat management. Other functional improvements could be improved signal-to-noise and additional computational resources.

This topic seeks the development of integrated circuits (IC) for 1) gamma detector read out and/or 2) gamma spectral signal analysis. The developed solution should not be designed around or for any proprietary system but must be able to integrate with any detector head for the detection material it was designed around using common inputs, outputs, and commands. The deliverables need not be just an IC but could also be the IC integrated into a circuit, however, the IC must be designed such that it could be readily engineered into another system for improved capability. The project must demonstrate the form and/or functional improvement, such as those mentioned above, that would be gained by this effort. Applications for which this development could be applied include, but are not limited to:

- Front end data acquisition
- Multi-channel analyzer
- Elemental and isotopic identification processing
- Associated detector control circuitry
- Enhanced gain stabilization and calibration
- Pulse shape analysis

PHASE I: Development of the design approach to include risk reduction followed by design. The design should have simulated electrical performance and estimated power consumption by the end of Phase I. This phase should demonstrate the ability to meet the performance goals agreed upon in the Statement of Work (SOW). Consideration should be given to the use of standard practices available for high volume /low cost manufacture. The phase I deliverable is a final report detailing overall system design, circuit level simulation results, and choice of circuit manufacturing process.

PHASE II: Phase II projects should develop a prototype device. At least one IC fabrication should be performed, although more may be required to reduce development risk. The prototype should be characterized and tested in a laboratory environment. The prototype should demonstrate the capabilities as agreed upon in the SOW. The phase II deliverable is a final report. Samples for delivery to the Government for internal testing or integration into systems may be negotiated.

PHASE III DUAL USE APPLICATIONS: The ICs developed would have wide commercial applications including for power plant, environmental, and incident management monitoring. Finalize and commercialize IC for use by customers (e.g. DTRA, industry). Although additional funding may be provided through DoD sources, the awardee should look to other public or private sector funding sources for assistance with transition and commercialization.

REFERENCES:

[1] Samuel J. Murray, Joseph A. Schmitz, Sina Balkir, and Michael W. Hoffman, “A Low Complexity Radioisotope Identification System using an Integrated Multichannel Analyzer and Embedded Neural Network.” 2019 IEEE International Symposium on Circuits and Systems. (2019): 1-5.
[2] Vernon, Emerson et al. “Front-End ASIC for Spectroscopic Readout of Virtual Frisch-Grid CZT Bar Sensors.” Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment 940 (2019): 1–11.
[3] G. Knoll, Radiation Detection and Measurement, Wiley, 2010.

KEYWORDS: Integrated Circuit, ASIC, Gamma, Detector

DTRA20B-003 TITLE: Field Detection of Trace Elements and Chemicals

RT&L FOCUS AREA(S): Nuclear
TECHNOLOGY AREA(S): Battlespace, Bio Medical, Nuclear,Sensors

OBJECTIVE: Develop a capability to collect and provide immediate presumptive analysis of radiological/nuclear samples of concern in field environments.

DESCRIPTION: The Defense Threat Reduction Agency seeks technologies that can detect and identify trace quantities of elements and/or chemicals with a preference for both. Target elements and chemicals must include those containing plutonium and uranium. Of interest are chemicals specific to the nuclear fuel cycle. Current capabilities require samples to be sent to a location other than the location of collection requiring more time than is desired. This topic seeks to allow for presumptive analysis to be obtained at the source of collection.

Samples, which could include swipes, must be obtained from solid surfaces; air sampling is not sought. The prototyped device must be compact and able to demonstrate that a commercialized version could be carried by one person. It must also be able to operate for 4-6 hours on battery power. The resulting analysis must provide quantitative measurements. The threshold sensitivity for the detection and identification of uranium and plutonium should be 1 part per million (or 5 nanograms for uranium). Isotopic identification is required while the determination of isotopic ratios is desired. Minimal sample preparation and time is required with no more than single-step wet chemistry allowed. The process should not contain harsh separation/dissolution chemicals, such as perchloric acid. Sample analysis from dry surfaces is required with analysis from wet surfaces desired. The analysis should be non-destructive such that samples, or a portion of the original sample, could be retained for further analysis. The operator must be able to collect and prepare samples with nitrile gloves.

A commercialized version must be able to operate in a “hot zone” without concern of internal contamination while the exterior could be decontaminated following use. The prototype system must provide an analysis of the sample within 5 minutes and allow for an immediate follow on analysis. The system should have a volume <0.1 m3 and a mass <15 kg. The prototype should require only minimal, low-cost consumables, which can be packaged with the system.

PHASE I: A trade study should be conducted to assess the possible methods for sample analysis. Although a full prototype is not necessary, the work should demonstrate the necessary basic physical principles for meeting performance goals in Phase II. Consideration should be given to the analytical accuracy and precision of the system, the ease of measuring samples in the field, and the portability of the system. Phase I proposals should indicate the need for and planned access to characterization samples (e.g., uranium, plutonium, etc.) under a Phase II development.

PHASE II: Phase II projects should develop a prototype device. The prototype should be man-portable and capable of being used in a field test. The prototype should demonstrate accurate elemental and/or chemical analysis of samples containing plutonium and uranium for the requirements listed in the topic description. The Government will not provide characterization samples (e.g., uranium, plutonium, etc.). The proposal should indicate the need for and access to such samples.

PHASE III DUAL USE APPLICATIONS: DUAL USE APPLICATIONS: A field-deployable trace element and chemical analyzer would have wide commercial applications including for environmental and industrial sampling. Although additional funding may be provided through DoD sources, the awardee should look to other public or private sector funding sources for assistance with transition and commercialization.

REFERENCES:

[1] Jacqueline Q. McComb, Christian Rogers, Fengxiang X. Han, and Paul B. Tchounwou. "Rapid Screening of Heavy Metals and trace Elements in Environmental Samples using Portable X-ray Fluorescence Spectrometer, A Comparative Study." Water Air Soil Pollut. (2014) 225: 2169

[2] Zuzanna SZCZEPANIAK, Mateusz SYDOW, Justyna STANINSKA-PIĘTA. "Monitoring and Remediation of Heavy Metal Polluted Soils – A Review." Journal of Research and Applications in Agricultural Engineering" 2016, Vol. 61(4)

[3] ANSI. 1996. Measurement and Associated Instrument Quality Assurance for Radioassay Laboratories, N42.23

[4] ISO. 2010. Determination of the characteristic limits (decision threshold, detection limit and limits of the confidence interval) for measurements of ionizing radiation — Fundamentals and application, 11929:2010(E)

KEYWORDS: Trace element, presumptive analysis, surface sampling, in-field analysis