DEPARTMENT OF DEFENSE
SMALL BUSINESS TECHNOLOGY TRANSFER (STTR) PROGRAM

STTR 20.A Program Broad Agency Announcement (BAA)

December 10, 2019: DoD BAA issued for pre-release

January 14, 2020: DoD begins accepting proposals

February 12, 2020: Deadline for receipt of proposals no later than **8:00 p.m. ET**

Participating DoD Components:

- Department of the Navy
- Department of the Air Force
- Chemical Biological Defense (CBD)
- Defense Microelectronics Agency (DMEA)
- National Geospatial-Intelligence Agency (NGA)

IMPORTANT

Deadline for Receipt: Proposals must be **completely** submitted no later than **8:00 p.m.** ET, February 12, 2020. Proposals submitted after 8:00 p.m. will not be evaluated.

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

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.

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.

Table of Contents

1.0 INTRODUCTION 4

2.0 PROGRAM DESCRIPTION 4
2.1 Objectives 4
2.2 Three Phase Program 6

3.0 DEFINITIONS 7
3.1 Performance Benchmarks for Progress Toward Commercialization 7
3.2 Commercialization 7
3.3 Cooperative Research and Development 7
3.4 Essentially Equivalent Work 7
3.5 Export Control 7
3.7 Foreign Nationals 8
3.8 Fraud, Waste, and Abuse 8
3.9 Funding Agreement 8
3.10 HBCU/MI - Historically Black Colleges and Universities and Minority Institutions 9
3.11 Certified HUBZone Small Business Concern 9
3.12 Principal Investigator 9
3.13 Proprietary Information 9
3.14 Research Institution 9
3.15 Research or Research and Development 9
3.16 Research Involving Animal Subjects 10
3.17 Research Involving Human Subjects 10
3.18 Research Involving Recombinant DNA Molecules 11
3.20 Small Business Concern (SBC) 11
3.21 Subcontract 11
3.22 United States 11
3.23 Women-Owned Small Business Concern 12

4.0 PROPOSAL FUNDAMENTALS 13
4.1 Introduction 13
4.2 Proposer Eligibility and Performance Requirements 13
4.3 Joint Ventures 14
4.4 Majority Ownership in Part 14
4.5 Conflicts of Interest 14
4.6 Classified Proposals 14
4.7 Research Involving Human Subjects 15
4.8 Research Involving Animal Subjects 15
4.9 Research Involving Recombinant DNA Molecules 15
4.10 Debriefing 16
4.11 BAA Protests 16
4.12 Selection and Award Protests 16
4.13 Phase I Award Information 16
4.14 Phase II Award Information 17
4.15 Questions about this BAA and BAA Topics 17

4.16 Registrations and Certifications 18
4.17 Promotional Materials 19
4.18 Prior, Current, or Pending Support of Similar Proposals or Awards 19
4.19 Fraud and False Statements 19
4.20 Adequate Accounting System 20
4.21 State and Other Assistance Available 20
4.22 Discretionary Technical and Business Assistance (TABA) 20

5.0 PHASE I PROPOSAL 21
5.1 Introduction 21
5.2 Summary of Component Programs 22
5.3 Marking Proprietary Proposal Information 22
5.4 Phase I Proposal Instructions 22
5.5 Phase I Proposal Checklist 27

6.0 PHASE I EVALUATION CRITERIA 29

7.0 PHASE II PROPOSAL 30
7.1 Introduction 30
7.2 Proposal Provisions 30
7.3 How to Submit 30
7.4 Commercialization Strategy 30

8.0 PHASE II EVALUATION CRITERIA 32

9.0 PHASE II ENHANCEMENT POLICY 33

10.0 COMMERCIALIZATION READINESS PROGRAM (CRP) 34

11.0 CONTRACTUAL REQUIREMENTS 35
11.1 Other Contract Requirements 35
11.2 Commercialization Updates in Phase II 36
11.3 Copyrights 36
11.4 Patents 36
11.5 Technical Data Rights 37
11.6 Invention Reporting 37
11.7 Final Technical Reports - Phase I through Phase III 37

Department of the Navy ..... NAVY 1-56

Department of the Air Force ..... AF 1-17

Chemical Biological Defense (CBD) ..... CBD 1-8

Defense Microelectronics Agency (DMEA) ..... DMEA 1-7

National Geospatial-Intelligence Agency (NGA) ..... NGA 1-8

1.0 INTRODUCTION

The Navy, CBD, DMEA, and NGA 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.

While the Phase II proposal process is covered in this announcement, **this BAA is for Phase I proposals only**.

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

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 STTR Program follows the policies and practices of the Small Business Administration (SBA) SBIR & STTR Policy Directive updated on May 02, 2019. The guidelines presented in this BAA

incorporate and make use of the flexibility of the SBA SBIR 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 typically between $100,000 to $167,500. 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 typically $500,000 to $1,100,000 in size and 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/?id=ddtc_kb_article_page&sys_id=24d528fddbfc930044f9ff621f961987.

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. See Section 4.19 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

Unless otherwise specified, Section 4 applies to both Phase I and Phase II.

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 (currently FY 2013-2017), 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 (currently FY 2007-2016), 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.

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.**

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.**

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

Please refer to the Component-specific Instructions for your topics of interest. It is important to note that some Component-unique debriefing processes exist; in those cases, the Component debriefing instructions supersede instructions provided here. The process may include these methods: An unsuccessful proposer that submits a request for a debriefing within 30 days of being notified that their proposal was not selected for award will be provided a debriefing which may be done orally, in writing, or by any other method acceptable to the contracting officer. The request should be emailed to the DoD organization that provided such notification to the proposer. Be advised that a proposer that fails to submit a timely request is not entitled to a debriefing, although untimely debriefing requests may be accommodated at the Government's discretion.

4.11 BAA Protests

Interested parties may have the right to protest this BAA by filing directly with the agency by serving the Contracting Officer (listed below) with the protest, or by filing with the Government Accountability Office (GAO). If the protest is filed with the GAO, a copy of the protest shall be received in the office designated below within one day of filing with the GAO. The protesting firm shall obtain written and dated acknowledgment of receipt of the protest from:

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 Selection and Award Protests

Protest of Phase I and Phase II selections and awards need to be directed to the contracting officer from the awarding DoD Component or by filing with the Government Accountability Office (GAO). If the protest is filed with the GAO, a copy of the protest shall be received in the office of the DoD Component within one day of filing with the GAO. To ensure a timely protest, protesters should secure the name of the Component Contracting Officer before submitting a protest with GAO. Protests of the small business status of a selected firm may also be made to the Small Business Administration.

4.13 Phase I Award Information

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 understand Section 5.2 "Summary of Component Programs" 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.

4.14 Phase II Award Information

a. **Number of Phase II Awards**. The number of Phase II awards will depend upon the results of the Phase I efforts and the availability of funds. Historically, approximately 40% of the Phase I awards will result in Phase II projects. This is merely an advisory estimate and the Government may make no awards, fewer awards, or more awards.

b. **Type of Funding Agreement**. Each Phase II proposal selected for award will be funded under a negotiated contract 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. **Average Dollar Value**. The typical size of award varies across the DoD Components. Information on award size will be provided in DoD Component instructions for submission of Phase II proposals.

d. **Timing**. Across DoD, the median time between DoD's receipt of a Phase II proposal and the award of a Phase II contract is six months.

4.15 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 5:00 p.m. ET Monday through Friday at:

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

(2) **Web sites**. The DoD SBIR/STTR Web site at https://sbir.defensebusiness.org/ has information on the DoD SBIR/STTR Program, including:

- SBIR and STTR Program opportunities
- Topics Search engine
- Technical Q&A through the SBIR/STTR Interactive Topic Information System (SITIS)
- Links to electronic Proposal Submission for Phase I and Phase II Proposals (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 via e https://sbir.defensebusiness.org/.

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 **December 10, 2019 to January 13, 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 SITIS (SBIR/STTR Interactive Topic Information System). After this period questions must be asked through SITIS as described below.

d. **SITIS Q&A System.** Once DoD begins accepting proposals on **January 14, 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 SITIS at https://sbir.defensebusiness.org/topics. In SITIS, 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 particular 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 SITIS Quick Scan feature on this Web site. Then, using the form at the bottom of the topic description page, enter and submit the question. Answers are generally posted within seven working days of question submission. (Answers will also be e-mailed directly to the inquirer if the inquirer provides an e-mail address.)

The SITIS Q&A online service for this BAA opens on **January 14, 2020,** and closes to new questions on **January 22, 2020, at 8:00 p.m**. Typically questions and answers will be posted between **January 14 and January 29 , 2020**. Once the BAA closes to proposal submission, no communication of any kind with the topic author or SITIS regarding your submitted proposal is allowed.

Proposing firms are advised to monitor SITIS during the BAA period for questions and answers. Proposing firms should also frequently check the SBIR/STTR Web site for updates and amendments to the topics.

4.16 Registrations and Certifications

Proposing firms **must be registered in the DoD Submission system** 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 DoD Submission Web site 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.

4.17 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.

4.18 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).

4.19 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.

4.20 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".

4.21 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.

4.22 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 DoD SBIR/STTR Submission Web site are designed to reduce the time and cost required to prepare a formal proposal. Since the guidance on allowable content may vary by Component, it is the proposing firm's responsibility to consult the Component-specific instruction for detailed guidance.

A complete proposal consists of five volumes:

Volume 1: Proposal Cover Sheet
Volume 2: Technical Volume
Volume 3: Cost Volume
Volume 4: Company Commercialization Report – not available for 20.A BAA
Volume 5: Supporting Documents
Volume 6: Fraud, Waste and Abuse Training

The Submission Web site provides a structure for providing these five sections, but the proposing firm must begin entering its proposal by providing information for the Proposal Cover Sheet. Once the firm begins a Proposal Cover Sheet they will be assigned a proposal number. **Please make note of this proposal number and print it for future reference**.

Volume 5, Supporting Documents, was implemented beginning with the STTR 18.B BAA cycle.

- Volume 5 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 when submitting Phase I and Phase II proposals.
- Please refer to the Component-specific instructions for your topics of interest to see how each program office will be handling the Volume 5 information.

Volume 6, Fraud, Waste and Abuse Training, was implemented beginning with the STTR 18.C BAA cycle.

- Please refer to the Component-specific instructions for your topics of interest to see how each program office will be handling the Volume 6 Fraud, Waste and Abuse Training information.

To submit a proposal, the proposer must click the green "Submit Proposal" button. If the proposal status is "In Progress" it will not be considered "Submitted". For a more detailed explanation, visit at: https://www.dodsbirsttr.mil/submissions/learning-support.

The proposer may add the remaining volumes or modify the Proposal Cover Sheet until BAA close. It is the proposing firm's responsibility to verify that the Technical Volume does not exceed the page limit after upload to the DoD SBIR/STTR Submission site by clicking on the "Verify Technical Volume" icon.

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.

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

DoD Component	Cost	Duration	Phase I Option	Technical and Business Assistance
Navy	Phase I: Base NTE $166,500	6 Month Base	Not Applicable	$6,500
Air Force Pitch Day	Base NTE $150,000	6 Month Base	Not Applicable	Not Available
CBD	Base NTE $167,500	6 Month Base	Not Applicable	Not Available
DMEA	Base NTE $167,500	6 Month Base	Not Applicable	Not Available
NGA	Base NTE $100,000 +	9 Month Base	Not Applicable	Not Available

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

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

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

(2) Length: 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 DoD SBIR/STTR Submission Web 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.)

(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: (1) short description, (2) client for which work was performed (including individual to be contacted and phone number), and (3) date of completion.

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

(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).

(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 in the format shown in the Cost Breakdown Guidance by using the on-line cost volume form on the DoD Submission Web site. 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.

e. Company Commercialization Report (Volume 4) The Company Commercialization Report Volume will NOT be available during the STTR 20.A BAA cycle. Therefore, no Commercialization Achievement Index will be generated. Volume 4 will be available for future DoD BAA cycles.

f. Supporting Documents (Volume 5)

The Supporting Documents Volume was implemented beginning with the STTR 18.B BAA. Volume 5 is provided for small businesses to submit additional documentation to support the Technical Volume (Volume 2) and the Cost Volume (Volume 5). The Supporting Documents Volume is available for use for submitting Phase I and Phase II proposals for both the DoD SBIR and STTR Programs.

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

Please refer to the DoD Component-specific Instructions for your topics of interest to see how each program office will be handling the Volume 5 information.

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

The Fraud, Waste and Abuse Training was implemented beginning with the STTR 18.C BAA cycle. Please refer to the Component-specific Instructions for your topics of interest to see how each program office will be handling the Fraud, Waste and Abuse Training (Volume 6) information.

5.5 Phase I Proposal Checklist

The Proposer's proposal shall be in accordance with Section 5.0. A complete proposal consists of five volumes:

- Volume 1: Proposal Cover Sheet
- Volume 2: Technical Volume
- Volume 3: Cost Volume
- Volume 4: Company Commercialization Report -not in use for 20.A BAA
- Volume 5: Supporting Documents
- Volume 6: Fraud, Waste and Abuse Training

DoD Component	Volume 5 – Supporting Documents	Volume 6 – Fraud, Waste & Abuse	Technical Volume Page Limits
Navy	Accepted but Not Evaluated	Not Required	10 pages
Air Force Pitch Day	15 Slide Pitch Deck	Required	5 pages
CBD	Not Accepted	Not Required	20 pages
DMEA	Not Accepted	Not Required	20 pages
NGA	Not Accepted	Required	20 pages

Those responding to this BAA should note the proposal preparation tips listed below:

a. Read and follow all instructions contained in this BAA, including the Component-specific Instructions listed in Section 12.0 of the DoD Component to which the firm is applying.

b. Register the firm on the secure, password-protected DoD Submission Web site at https://www.dodsbirsttr.mil/submissions/ and, as instructed on the Web site, prepare the firm's submission.

c. Register the firm with SBA's Company Registry at www.sbir.gov and provide the SBA SBC Identification Number on each proposal coversheet submitted in response to this BAA.

d. Check that the cost adheres to the Component criteria specified and the cost on the Cover Sheets matches the cost in the Cost Volume.

e. Check that the Project Abstract and other content provided on the Cover Sheets contain NO proprietary information.

f. Mark proprietary information within the Technical Volume as instructed in Section 5.3.

g. The content in the Technical Volume, including the option (if applicable), includes the items in Section 5.4.c.

h. That the header on each page of the technical volume should contain the company name, topic number, and proposal number. (The header may be included in the one-inch margins.)

i. 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.

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

7.0 PHASE II PROPOSAL

7.1 Introduction

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, will be rejected without evaluation. Phase II proposal preparation and submission instructions will be provided by the DoD Components to Phase I awardees.

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 How to Submit

Each Phase II proposal must be submitted through the DoD SBIR/STTR Submission Web site by the deadline specified in the Component-specific instructions. Each proposal submission must contain a Proposal Cover Sheet, Technical Volume, and Cost Volume.

7.4 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.). For further Phase II requirements, 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.

Phase II projects that qualify under Phase II Enhancement may:

a. Extend an existing Phase II contract for up to one year and
b. Match with STTR funds, up to $537,500 of non-STTR funds from either DoD non-STTR Programs or from an outside investor.

Phase II Enhancement requirements and matching rates vary by Component. See each Component's instructions in Section 12.0 of this BAA. Phase II Enhancement applications must be prepared and submitted through the DoD SBIR/STTR Submission Web site at https://www.dodsbirsttr.mil/submissions/. DoD retains the discretion not to approve or fund any Phase II Enhancement application and to review contractor eligibility at the time of selection.

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

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 http://farsite.hill.af.mil/reghtml/Regs/far2afmcfars/fardfars/Dfars/Dfars252_220.htm?zoom_highlight=dfars+252%2E225-7048#P4543_324418.

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 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 at DTIC (Defense Technical Information Center) submission resources at http://www.dtic.mil/dtic/submit/guidance_on_submitting_docs_to_dtic.html. In addition, monthly status and progress reports may be required by the DoD Component.

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

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

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

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

IMPORTANT

- **The following instructions apply to STTR topics only:**
  - **N20A-T001 through N20A-T025**
- **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.
- Discretionary Technical Assistance (DTA) is renamed Discretionary Technical and Business Assistance (TABA).
- The optional Supporting Documents Volume (Volume 5) is available for the STTR 20.A 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 Program Managers 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 **10 December 2019 through 13 January 2020**. Beginning **14 January 2020,** the SBIR/STTR Interactive Technical Information System (SITIS) (https://sbir.defensebusiness.org/) 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
N20A-T001	Mr. Jeffrey Kent	Marine Corps Systems Command (MCSC)	jeffrey.a.kent@usmc.mil
N20A-T002 to N20A-T006	Ms. Donna Attick	Naval Air Systems Command (NAVAIR)	donna.attick@navy.mil

N20A-T007 to N20A-T015	Mr. Dean Putnam	Naval Sea Systems Command (NAVSEA)	dean.r.putnam@navy.mil
N20A-T016 to N20A-T025	Mr. Steve Sullivan	Office of Naval Research (ONR)	steven.sullivan@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://sbir.defensebusiness.org/ 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 Volume (Volume 2).** Technical Volume (Volume 2) must meet the following requirements:
  - 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 not exceed six (6) months and the Phase I Option Period of Performance must not exceed six (6) months.

- **Supporting Documents Volume (Volume 5)**. DoD has implemented a Supporting Documents Volume (Volume 5). The optional Volume 5 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. Volume 5 should only be used for the following documents:
  - Letters of Support relevant to this project
  - Additional Cost Information – The "Explanatory Material" field in the online DoD Cost Volume (Volume 3) is to be used to provide sufficient detail for subcontractor, material, travel costs, and Discretionary Technical and Business Assistance (TABA), if proposed. If additional space is needed these items may be included within Volume 5.
  - SBIR/STTR Funding Agreement Certification
  - Technical Data Rights (Assertions) - If required, must be provided in the table format required by DFARS 252.227-7013(e)(3) and be included within Volume 5.
  - Allocation of Rights between prime and subcontractor
  - Disclosure of Information (DFARS 252.204-7000) (see Technical Volume 2 above)
  - Prior, Current, or Pending Support of Similar Proposals or Awards – If a proposal is substantially the same as another proposal that was funded, is now being funded, or is pending with another Federal Agency, another DoD Component, or the same DoD Component reveal this information in the appropriate area of the Proposal Cover Sheet (Volume 1) and provide details in Volume 5 (see Phase I Technical Volume template on https://www.navysbir.com/links_forms.htm for required information, upload as "Other")
  - Foreign Citizens - Identify any foreign nationals or individuals holding dual citizenship expected to be involved on this project as a direct employee, subcontractor, or consultant (see Phase I Technical Volume template on https://www.navysbir.com/links_forms.htm for required information, upload as "Other")

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 $1,600,000 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 NOT exceed:

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

NOTE: The Small Business Administration (SBA) is currently developing regulations governing TABA limitations. All regulatory guidance produced by SBA will apply to any STTR contracts where TABA is utilized only after the Government Contracting Officer issues a modification to the contract.

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.

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 $1,600,000 (unless non-SBIR/STTR funding is being added). Individual SYSCOMs may award amounts, including Base and all Options, of less than $1,600,000 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 STTR 20.A Topic Index

N20A-T001 Optimized Energy-Attenuating Seat Design for Ground Vehicles

N20A-T002	Machine Learning Tools to Optimize Metal Additive Manufacturing Process Parameters to Enhance Fatigue Performance of Aircraft Components
N20A-T003	Fully Automated Quantum Cascade Laser Design Aided by Machine Learning with up to 100X Design Cycle Time Reduction
N20A-T004	Hexahedral Dominant Auto-Mesh Generator
N20A-T005	Quantum Optical Semiconductor Chip and its Application to Quantum Communication
N20A-T006	High Efficiency Propeller for Small Unmanned X Systems (UxS)
N20A-T007	Cross Platform Reinforcement and Transfer Learning for Periscope Imagery
N20A-T008	Innovative Sea Chest Water Management System
~~N20A-T009~~	[Navy has removed topic N20A-T009 from the 20.A STTR BAA]
N20A-T010	Ship Vibration Mitigation for Additive Manufacturing Equipment
N20A-T011	Cyber Resilience of Condition Based Monitoring Capabilities
N20A-T012	Electromagnetic Interference (EMI) Resilient, Low Noise Figure, Wide Dynamic Range of Radio Frequency to Photonic (RF Photonic) Link
N20A-T013	Precision Alignment Techniques for Affordable Manufacture of Millimeter Wave Vacuum Devices
N20A-T014	Machine Learning for Simulation Environments
N20A-T015	Compact and Efficient Magnetron Source for Continuous Wave Microwave Power Generation
N20A-T016	Quantum Emulation Co-processor Circuit Card
N20A-T017	Twitter Follower / Friend Assessment Tool (TWIFFA)
N20A-T018	Intelligent Additive Manufacturing - Metals
N20A-T019	Employing Machine Learning to Accelerate High Temperature Corrosion-Resistant Materials Design
N20A-T020	Non-intrusive Diagnostics to Quantify Interactions between High-speed Flows and Hydrometeors
N20A-T021	Hybrid Packaging of Cryogenic Electronics and Photonic Technologies
N20A-T022	Measurements of Wall-Shear-Stress Distribution in Hypersonic Flows
N20A-T023	Harvesting Thermal Energy for Low Power Arctic Sensors and Data Communications
N20A-T024	Scenario Data Solutions for Forward Deployed Live, Virtual, and Constructive Training at Sea
N20A-T025	Post Digitizer Analog to Digital Converter (ADC) Linearization Using Artificial Intelligence Methods

NAVY STTR 20.A Topic Descriptions

N20A-T001 TITLE: Optimized Energy-Attenuating Seat Design for Ground Vehicles

TECHNOLOGY AREA(S): Biomedical

ACQUISITION PROGRAM: Program Executive Office (PEO) Land Systems, (FNC Armored Reconnaissance Vehicle)

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: Quantify how differences in warfighter pelvis geometry and seated posture affect the injuries they receive in vehicle blast events. Use this knowledge to optimize energy-attenuating seat design.

DESCRIPTION: Effectively informing energy-attenuating seat design for vehicle accelerative loading events requires an understanding of how changes in occupant size, gender, posture, and anthropometry affect how injuries present. It also requires a thorough understanding of pelvis and lumbar fractures in addition to potential ligament, organ, and vascular damage.

Ground vehicle underbody blast events that occurred during Operation Iraqi Freedom and Operation Enduring Freedom resulted in many mounted warfighters sustaining injuries to their pelvis and lumbar spine structures [Ref 5]. As a result, many ground vehicle programs have incorporated blast-mitigation technologies within their vehicles to try to protect warfighters against such injuries. However, current blast mitigation technologies are typically only designed to protect a 50th percentile male occupant. Since military vehicle occupants encompass a wide range of anthropometric variability, there is a high likelihood that many are not being protected with the current technologies.

Accurately predicting the occurrence of injuries and identifying how they present are important steps in designing effective blast mitigation. However, this is quite challenging across the wide spectrum of warfighter anthropometries and seated postures, since variability in anthropometry and seat posture can affect how injuries occur. As an example, pelvis injuries associated with vertical loading present differently depending on the occupant's bone strength. For those with weaker bones, the injuries tend to present in pubic rami or sacral fractures [Ref 3]. For those with stronger bones, the injuries tend to present in ligamentous injuries. Both cases can lead to vertical and rotational instabilities in the pelvis, which can result in quite severe injuries. Spinal fractures are also prevalent in cases where the pelvis is being loaded vertically. Accelerative events that occur over a shorter duration typically result in injuries to the pelvis, whereas longer duration accelerative events often result in spinal fractures instead [Ref 5].

Energy-attenuating seats for ground vehicles are typically designed to protect a 50th percentile male [Ref 4] during a five meter per second to eight meter per second vertical drop with pulse durations of approximately 6 milliseconds [Ref 1]. While the energy-attenuation might perform well in those specific conditions, it may experience issues with occupants who are not 50th percentile males or whose posture differs from the test condition. In one study, the energy-attenuation device did not engage for a 5th percentile female occupant [Ref 4], resulting in an injury.

The Phase I effort will not require access to classified information. If need be, data of the same level of complexity as secured data will be provided to support Phase I work. The Phase II effort will likely require secure access, and the contractor will need to be prepared for personnel and facility certification for secure access.

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

PHASE I: 1) Investigate how anthropometric variability and changes in seated posture affect pelvis and lumbar spine injury. 2) Develop capability to accurately predict pelvis injury, lumbar spine injury, femur fracture, and soft tissue injuries of warfighters. 3) Demonstrate an initial concept design to improve energy-attenuating devices for seats based on the results of 1) and 2). Provide a Phase II development plan with performance goals and key technical milestones that will address technical risk reduction.

PHASE II: Establish and deliver injury metrics developed through experimentation and/or modeling and simulation that define how anthropometric variability and changes in seated posture affect pelvis and lumbar spine injuries. Develop and deliver a tool to accurately predict pelvis and lumbar spine injuries of warfighters. Quantitatively demonstrate that the injury metrics are biofidelic and that the injury prediction tool correctly captures injury prediction based on the Marine Corps requirements described above. Mature the design of an energy attenuating device, build and deliver a prototype of the energy attenuating device, and develop and deliver a finite element model of the energy attenuating device with material and geometry information. Demonstrate through test and/or simulation that the energy attenuating device meets the requirements described above. Prepare a Phase III development plan to transition the technology to Marine Corps use.

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

PHASE III DUAL USE APPLICATIONS: Investigate how anthropometric variability and positioning differences inform injuries to other body regions. Expand the injury metrics and injury prediction tools to encompass injuries beyond the pelvis and lumbar spine. In addition, develop and test additional blast mitigation technologies. Integrate the blast mitigation technologies into seats and vehicles.

The technologies developed under this STTR topic can be marketed to military ground vehicle designers and manufacturers, the automotive industry, and the aerospace industry.

REFERENCES:

1. Bosch, Kelly, Harris, Katrina, Clark, David, Scherer, Risa and Joseph Melotik. “Blast Mitigation Seat Analysis – Drop Tower Data Review.” 2014 NDIA Ground Vehicle Systems Engineering and Technology Symposium, 12-14 August 2014. https://apps.dtic.mil/dtic/tr/fulltext/u2/a608804.pdf

2. Davis, Jana, Stinner, Daniel, Bailey, James. Aden, James and Hsu, Joseph. “Factors Associated with Mortality in Combat-Related Pelvic Fractures.” Journal of the American Academy of Orthopedic Surgery, 2012; 20 (suppl 1), pp. S7-S12. http://dx.doi.org/10.5435/JAAOS-20-08-S7

3. Khurana, Bharti, Sheehan, Scott, Sodickson, Aaron and Weaver, Michael. “Pelvic Ring Fractures: What the Orthopedic Surgeon Wants to Know.” The Radiological Society of North America. September, October 2014. www.radiographics.rsna.org

4. Reed, Matthew P, Ebert, Sheila M. “The Seated Soldier Study: Posture and Body Shape in Vehicle Seats.” Biosciences Group: University of Michigan Transportation Research Institute. October 2013. https://pdfs.semanticscholar.org/f4f8/ad73a06bcebd6c97c2deff01dcdd57f5b2fb.pdf

5. Vasquez, Kimberly, Brozoski, Frederick, Logsdon, Katie and Chancey, Valeta. “Retrospective Analysis of Injuries in Underbody Blast Events: 2007 – 2010.” Military Medicine, Vol. 183, March/April Supplement 2018.

https://academic.oup.com/milmed/article-abstract/183/suppl_1/347/4959993

6. Webster, Claire Elizabeth, Clasper, J., Gibb, I. and Masouros, S.D. “Environment at the Time of Injury Determines Injury Patterns in Pelvic Blast.” Journal of the Royal Army Med Corps, 22 December 2018. http://jramc.bmj.com

KEYWORDS: Energy-Attenuating Devices; Injury Prediction; Injury Metrics; Pelvis; Pelvic Injuries; Lumbar Spine Injuries; Seat Design; Anthropometric Variability

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T002 TITLE: Machine Learning Tools to Optimize Metal Additive Manufacturing Process Parameters to Enhance Fatigue Performance of Aircraft Components

TECHNOLOGY AREA(S): Air Platform, Materials/Processes

ACQUISITION PROGRAM: JSF Joint Strike Fighter

OBJECTIVE: Develop an advanced machine learning (ML) tool capable of optimizing process parameters for metal laser powder-based additively manufactured components to achieve enhanced fatigue performance for aircraft components.

DESCRIPTION: Laser powder bed and powder feed additive manufacturing (AM) technologies have proven to produce complicated parts from high-performance alloys such as titanium, Inconel, and tool steel [Ref 1]. Many processes are currently able to consistently produce intricate geometries and meet standard geometric tolerances. However, achieving predictable part performance, including static (e.g., strength) and dynamic (e.g., high cycle and low cycle fatigue) behaviors remains a significant challenge. In order to attain satisfactory part performance, pre- and post-processing parameters are tuned using expensive trial and error approaches. Perhaps the use of various sensors integrated with simulation and modeling tools that leverage data analytics, data fusion, and machine learning (ML) techniques may improve fatigue performance of AM parts, potentially without any post-processing required.

Due to the multi-scale and multi-physics phenomena associated with processing and post processing of various metallic alloys, it is necessary to adopt an integrated computational materials engineering (ICME) framework [Ref 2] for efficient linkages between processing and performance. Furthermore, the addition of ML methodologies and data-fusion methods should provide increased throughput and fidelity in linking AM process parameters to fatigue performance under various loading conditions.

ML involves the scientific application of computational models that can predict systemic performance using data representing input-output tuples encapsulated in a computer system [Refs 3-6]. A crucial element of ML is that the performance of a ML system can progressively use available sensor data to improve a specific system performance prediction. Thus, this topic seeks novel ML methodologies and techniques for laser powder-based AM processes (e.g., laser powder bed fusion, direct energy deposition) to yield desired aircraft part fatigue performance.

PHASE I: Develop an initial computational concept for a ML ICME-based toolset for a laser powder metal AM process under the assumption of in-situ and/or ex-situ sensor data to link AM process parameters and/or state variables to the fatigue performance of the part. Ensure that the concept methodology demonstrates both its ability for sensor fusion and its ability to learn from trial runs to predict the final part geometry, associated material properties, and final part performance. Demonstrate the feasibility of the methodology using actual AM coupons, testing (e.g., ASTM E466, ASTM E606) [Refs 7, 8], and analyses for a single material. The computational prototype of the proposed advanced ML ICME tool should have the potential for development into a full-scale ML ICME system for integrating with AM machines to enable designer to optimize fatigue life in Phase II. The Phase I effort

will include prototype plans to be developed under Phase II.

PHASE II: Fully develop, verify, and validate a prototype ML system for a laser powder-based metal AM process to perform geometry control and material property control during AM processing. Demonstrate its ability to manufacture aircraft components with complex geometry and tailored performance using additional metal alloys.

PHASE III DUAL USE APPLICATIONS: Further develop and refine an advanced ML ICME system for various powder-based AM processes to fabricate specific naval aircraft components for integration into the Fleet. Conduct final component-level testing to demonstrate the geometry and material property control of AM components meeting the Navy's specifications.

The process will be directly applicable to a wide range of AM process applications due to the high amount of anticipated AM part usage in the commercial/private aerospace industry. The proposed toolset will allow the aerospace industry to apply the benefits of AM technology to many critical aircraft components.

REFERENCES:
1. Frazier, W.E. "Metal Additive Manufacturing: A Review". Journal of Materials Engineering and Performance, 23 (6), 2014, pp. 1917-1928. DOI: 10.1007/s11665-014-0958-z. https://link.springer.com/article/10.1007/s11665-014-0958-z

2. "Integrated Computational Materials Engineering: A Transformational Discipline for Improved Competitiveness and National Security." National Research Council, The National Academies Press, Washington, DC, 2008. DOI: 10.17226/12199

3. Russell, S. and Norvig, P. "Artificial Intelligence: A Modern Approach." Prentice Hall: Upper Saddle River, NJ, 2009. ISBN-10: 0136042597. https://www.cin.ufpe.br/~tfl2/artificial-intelligence-modern-approach.9780131038059.25368.pdf

4. Vandone, A., Baraldo, S., and Valente, A. "Multisensor Data Fusion for Additive Manufacturing Process Control." IEEE Robotics and Automation Letters, 3 (4), 32018, pp. 279-3284. DOI: 10.1109/LRA.2018.2851792

5. Zhu, Z., Anwar, N., Huang, Q., and Mathieu, L. "Machine learning in tolerancing for additive manufacturing." CIRP Annuals, 67 (1), 2018, pp. 157-160. DOI: 10.1016/j.cirp.2018.04.119

6. Garanger, K., Feron, E., Garoche, P., Rimoli, J. J., Berrigan, J. D., Grover, M., and Hobbs, K. "Foundations of Intelligent Additive Manufacturing." https://arxiv.org/pdf/1705.00960.pdf

7. ASTM E466 – 15 Standard Practice for Conducting Force Controlled Constant Amplitude Axial Fatigue Tests of Metallic Materials
https://www.astm.org/Standards/E466.htm

8. ASTM E606 / E606M – 12 Standard Test Method for Strain-Controlled Fatigue Testing
https://www.astm.org/Standards/E606

KEYWORDS: Machine Learning; ML; Sensor Fusion, Fatigue; Metal Additive Manufacturing; AM; Laser Powder Bed Fusion; Powder Feed; ICME; Material Property Control

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T003 TITLE: Fully Automated Quantum Cascade Laser Design Aided by Machine Learning with up to 100X Design Cycle Time Reduction

TECHNOLOGY AREA(S): Air Platform, Electronics

ACQUISITION PROGRAM: PMA264 Air ASW Systems

OBJECTIVE: Develop a fully automated Quantum Cascade Laser (QCL) design process by using neural networks and machine learning (ML) algorithms that will result in up to 100 times reduction in design cycle time compared to the conventional "manual" QCL design process [Ref 1].

DESCRIPTION: The active region of a QCL consists of many (typically 20-50) repeated stages of superlattice (SL) material. The highest-performance QCLs operating in the mid-infrared spectral region (approximately 4.8 micron) utilize an indium phosphide (InP) substrate and have active regions wherein each stage consists of 10s of ultrathin layers of indium gallium arsenide (InGaAs) quantum wells and aluminum indium arsenide (AlInAs) barriers. The device performance metrics (such as emission wavelength, threshold-current density, slope efficiency, and their temperature dependence) are closely tied to the quantum-confined state energies and their electronic wave-function spatial distributions within the active region, which in turn are determined by the specific layered structure (i.e., layer thicknesses and compositions). The complexity of the layered structure generally requires a time-consuming iterative process between experiment and design optimization to achieve the highest device performance, which adds substantial cost to QCL manufacturing. Automated optimization algorithms [Ref 1] applied to QCL design could both greatly reduce the time (and cost) required to develop new QCL devices with specified performance characteristics and potentially lead to new insights into QCL design.

The current QCL design process generally involves a human in the loop - even for a single iteration. The function performed by the human is to identify specific features in the design and determine whether a certain performance metric can be achieved. Emerging data-driven automated optimization algorithms could potentially address the difficulties facing QCL design.

As the QCL's structural complexity grows, the design processes become more challenging. With conventional design approaches, based on computational optimization, one typically starts with a prior design and computes the performance, compared to the target response. The gradient of structural change in layers and compositions is calculated and applied to the design. This process, performed iteratively, often takes hundreds of iterations before a design is found that meets the design criteria. As an alternative, the data-driven approach is rapidly emerging where deep neural networks are used for inverse device design. A large data set of existing designs and corresponding performances can be used to train artificial neural networks so that the networks can develop intuitive connections between QCL designs and their performances. After training, the neural network can accomplish a design goal in hours instead of weeks as compared to the conventional approach. Such an approach has been used previously in photonic structures [Ref 2], where neural networks successfully model the wave dynamics in the Maxwell's equations.

Demonstrate and deliver a single-mode QCL prototype that is designed using the algorithm(s). The specifications of the QCL for this design algorithm demonstration are: > 15 W continuous wave output power at room temperature; M2 no more than 1.5 in both the fast and slow axes; laser emission in the spectral range between 4.6 to 5.0 micrometers; and no unexpected and undesirable beam steering effect as the QCL drive current is increased. Furthermore, the contractor is required to deliver the fully automated QCL design algorithms with complete and detailed user manual and documentations.

PHASE I: Develop a methodology for implementing the training plan for neural network-based QCL design optimization without human intervention. Establish performance metrics, including but not limited to, output power, beam quality, wall-plug efficiency, and thermal impedance, etc. The design verification plan for the algorithms will be implemented in Phase II. The Phase I effort will include prototype plans to be developed in Phase II.

PHASE II: Demonstrate fully automated QCL design algorithms using ML methodology. Perform experimental verification of the generated designs by demonstrating that the QCL performance metrics are met with less than +/-

2% variations from the target performance specifications. Demonstrate and deliver a single-mode QCL prototype that meets the design specifications. Deliver the fully automated QCL design algorithms with complete and detailed user manual and documentations. Benchmark the design cycle time using the algorithm aided by ML against the conventional method without using ML, and verify the cycle time reduction.

PHASE III DUAL USE APPLICATIONS: Test and finalize the technology based on the design and simulation results developed during Phase II. Transition the design algorithm for DoD applications in the areas of Directed Infrared countermeasures, advanced chemicals sensors, and Laser Detection and Ranging. Commercialize the design algorithm based on ML for law enforcement, marine navigation, commercial aviation enhanced vision, medical applications, and industrial manufacturing processing.

REFERENCES:
1. Bismuto, A., Terazzi, R., Hinkov, B., Beck, M. and Faist, J. "Fully Automatized Quantum Cascade Laser Design By Genetic Optimization." Applied Physics Letters, 2012. https://aip.scitation.org/doi/citedby/10.1063/1.4734389

2. Liu, D., Tan, Y. and Yu, Z. "Training Deep Neural Networks for the Inverse Design of Nanophotonic Structures." Department of Electrical and Computer Engineering, University of Wisconsin: Madison, WI. https://arxiv.org/ftp/arxiv/papers/1710/1710.04724.pdf

KEYWORDS: Mid-Infrared; Quantum Cascade Lasers; Infrared Countermeasures; Cycle Time Reduction; Machine Learning; Design Algorithm; ML; QCL

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T004 TITLE: Hexahedral Dominant Auto-Mesh Generator

TECHNOLOGY AREA(S): Air Platform, Ground/Sea Vehicles, Weapons

ACQUISITION PROGRAM: NAE Chief Technology Office

OBJECTIVE: Develop an automated interactive mesh generator using predominately Hexahedral Finite Elements to support finite element analysis of naval aviation structural components and weapons systems.

DESCRIPTION: The U.S. Navy is accelerating its development of solutions to meet Fleet needs. As part of this urgent need, this STTR topic provides the potential to develop several advantages to the U.S. Navy. First, the use of hexahedral elements in finite element processing is far more efficient than tetrahedral elements, providing more accurate solutions, faster. Second, the use of an automated hexahedral dominant mesh generator will decrease the time spent meshing and speed the overall development of a solution. Currently, automated mesh generators use tetrahedral elements for finite element analysis. This approach is computationally intensive, because, in order to increase accuracy in the current system, there is a need for more tetrahedral elements resulting in increased hardware requirements or longer meshing and solution times.

Much of today's solid finite element analysis is performed with tetrahedral elements. Tetrahedral elements, poorly formulated mathematically, require a high element density to obtain answers to conform to classical analysis and benchmark solutions. Using large numbers of finite elements increases the computational burden on the computer by n2 for a fully stored stiffness matrix. Hexahedral elements are well-formulated showing superior performance in bending and torsion [Ref. 1]. Fewer hexahedral elements would be needed to achieve the same level of accuracy as a model built with tetrahedral elements. A hexahedral automated mesh generation requires specific geometric conditions.

A software is sought to analyze the geometry and create hexahedral mapable domains, with optional user interaction. The optional interaction should include (but not be limited to) providing options to the user to subdivide

the geometry, optimize the number of hexahedral elements, and where necessary, use other elements to create a complete mesh for the user to apply boundary conditions. A graphical user interface (GUI) must allow for user inputs for variable mesh density/element size, type of elements, order of elements, and enforcement of topology. Ideally, the software would provide an interactive environment for the user to create the mesh and geometric conditions desired before applying boundary conditions. The software should be able to run on most major operating systems; Windows 10 is preferred. Software should be able to run on machine with 4gigabytes of random access memory using Intel i5 or equivalent central processing units (CPU). Inputs to the software should include, but not be limited to, generic geometry formats (e.g., Standard for the Exchange of Product model data (STEP), Initial Graphics Exchange Specification (IGES), Parasolids, ACIS, and Stereolithography (STL)). Outputs from the software should be compatible with major pre-processing software packages (e.g., FeMap, Patran, Hypermesh). This output should include NASA Structural Analysis (NASTRAN) compatibility with the option to be human readable.

PHASE I: Design a geometric decomposition algorithm on basic shapes. Basic shapes include spheres, cones, annular rings, plates with circular holes in them, and plates with "flagpoles" extending from them. Holes and like interior features should have elements feature aligned at their interior and in an annular ring around them.

Demonstrate the feasibility of the algorithm. Ensure that the software design creates the mesh using predominantly high-quality feature-aligned hexahedral elements, paying particular attention to the exterior boundary, using transition and tetrahedral elements to accommodate the remainder of the shape(s) and result in a fully meshed component. A feature-aligned element has a face parallel to the local external boundary of the geometric entity containing it, and adjacent faces that are as perpendicular to that face as is allowable by the geometric definition of that component. For example, not all faces can be orthogonal and perpendicular to a sharp corner such as the tip of a cone.

Quality metrics should be as defined in Reference 4, with the addition that all faces of the hex shall be mapable to a regular quadrilateral, i.e., no twisted or degenerate faces, no "bow-tie" faces.

Use the metrics for hexahedral elements as summarized in Reference 4.

The Phase I effort will include prototype plans to be developed under the Phase II.

PHASE II: Fully develop and demonstrate capability by importing various formats of computer-aided drawing (CAD) data to include, but not be limited to, STEP, IGES, Parasolid, STL, and ACIS. Show the geometric decomposition algorithm on Navy-provided CAD data. Develop the GUI to allow for geometric editing of the part to support hexahedral elements, provide optimal solutions, and allow users to mesh components manually.

PHASE III DUAL USE APPLICATIONS: Perform final development and testing, and demonstrate usage with other Finite Element Pre-processing software packages. Import finalized mesh for preprocessing with boundary/initial conditions.

Using hexahedral meshing is one of the most mathematically efficient methods of discretizing geometry. Automotive, Aerospace, Nuclear, and Consumer Electronic industries will benefit from the following:
Improved solution run times/faster delivery of products.
Improved efficiency: use of CPUs, company's tech refresh cycle can be less frequent.
Improved efficiency: use of CPUs, company's overall power consumption will decrease.

REFERENCES:
1. Sjaardama, G., Benzley, S. E., Perry, E., Merkley, K. and Clark, K. "A Comparison of All Hexagonal and All Tetrahedral Finite Element Meshes for Elastic and Elasto-plastic Analysis." Brigham Young University: Provo, UT and Sandia National Laboratories: Albuquerque, NM., January 1995.https://www.researchgate.net/publication/267259986_A_Comparison_of_All_Hexagonal_and_All_Tetrahedral_Finite_Element_Meshes_for_Elastic_and_Elasto-Plastic_Analysis

2. Owens, S. J., Canann, S. A. and Saigal, S. "Pyramid Elements for Maintaining Tetrahedra to Hexahedra Conformability." Sandia National Laboratories: Albuquerque, NM; Siemens: Austin, TX; and New Jersey Institute

of Technology, January 1997.
https://www.researchgate.net/publication/243766119_Pyramid_Elements_for_Maintaining_Tetrahedra_to_Hexahedra_Conformability

3. Meyers, R. J., Tautges, T. J. and Tuchinsky, P. M. "The "Hex-Tet" Hex-Dominant Meshing Algorithm as Implemented in CUBIT." Sandia National Laboratories: Albuquerque, NM and Argonne National Laboratory, January 1998. https://www.researchgate.net/publication/221561722_The_Hex-Tet_Hex-Dominant_Meshing_Algorithm_as_Implemented_in_CUBIT
4. Cubit 15.3 User Documentation, Metrics for Hexahedral Elements.
https://cubit.sandia.gov/public/15.3/help_manual/WebHelp/mesh_generation/mesh_quality_assessment/hexahedral_metrics.htm

KEYWORDS: Hexahedral Meshing; Finite Element; Automated; CAD; Preprocessing; Computational Efficiency

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T005 TITLE: Quantum Optical Semiconductor Chip and its Application to Quantum Communication

TECHNOLOGY AREA(S): Air Platform, Electronics, Information Systems

ACQUISITION PROGRAM: JSF Joint Strike Fighter

OBJECTIVE: Develop a quantum optical semiconductor chip and demonstrate its application to efficient photonic entanglement, efficient logic gates such as Hadamard and CNOT, and quantum communication protocols through fiber optical channels.

DESCRIPTION: Current quantum chips utilize Superconducting Quantum Interference Device (SQUID) technology, which operates under very low cryogenic temperatures of a few degrees above absolute zero. Creating such a low temperature environment is costly and difficult, making this technology less suitable for many applications. One alternative to superconductors is an optical-based technology that can operate in room temperature where expensive refrigeration is not required. Recently, the Air Force Research Laboratory (AFRL) demonstrated a quantum communication protocol called "teleportation" [Ref 1] via open-air laser using optical apparatus at room temperature. While this technology seems to be a promising alternative to the current SQUID-based technology, creating such an optical apparatus presents its own challenges and requires a room space because presently optical components are much bulkier than their silicon counterparts in SQUID. Therefore, the miniaturization of such an optical apparatus into a semiconductor chip would be hugely beneficial. With this photonic silicon chip, basic logic gates such as Hadamard and CNOT (Controlled NOT) could be built and the teleportation protocol could be performed through fiber optical channels. Different approaches can be employed for the realization of this photonic chip, such as discrete variable (qubit), continuous variable (wave packet), or a hybrid of these. If successful, this would lay the groundwork for more practical access to quantum technology (including quantum communication and distributed quantum computing) and would further enable rapid development of quantum technology in general.

Below are some of the challenges.
A) Single photon source - the goal is to generate indistinguishable photons on demand.
B) Entanglement - on-demand photonic entanglement [Ref 2] plays a crucial role in quantum information protocols. Therefore, a method for preparing photonic entangled states on demand for reliable quantum information processing needs to be developed. A new diagnostic method developed recently was to detect quantum entanglement experimentally [Ref 3].
C) Logic Gates – design appropriate waveguides to play a role in quantum logic gates.

Efficiencies for a single photon generation, on-demand photonic entanglement, and performance of logic gates are figures of merit for this effort.

Proof-of-principle on-chip demonstration of all the above requirements will be evaluated. Develop quantum optical semiconductor chips and demonstrate one of the simplest quantum information protocols, “teleportation”, based on the most essential quantum features: superposition and entanglement that are implemented by Hadamard and CNOT gates respectively.

PHASE I: Design and develop a solution for efficient entanglement and basic logic gates on photonic chips. Demonstrate feasibility of a concept. The Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Demonstrate efficient logic gates such as Hadamard and CNOT and improve entanglement efficiency. Develop and demonstrate a prototype and aid government personnel to evaluate the performance of the prototype in a laboratory. Demonstrate quantum communication protocols such as super dense coding and teleportation through fiber optical channels. Deliver a prototype and help Government personnel to evaluate the performance of the prototype in a laboratory.

PHASE III DUAL USE APPLICATIONS: Finalize and transition technology into use for Navy systems. Commercialize quantum communication and quantum sensing. The desired technology is based on quantum silicon photonics; therefore, semiconductor chipmakers can easily adapt the technology to their existing manufacturing frameworks. Just like graphics processing units (GPUs) are getting popular, quantum-processing units (QPUs) can be developed and used with central processing units (CPUs) in the future.

REFERENCES:
1. Nielsen, M. and Chuang, I. "Quantum Computation and Quantum Information 10th Anniversary Edition." Cambridge University Press: New York, 2010. http://mmrc.amss.cas.cn/tlb/201702/W020170224608149940643.pdf

2. Takase, K., Takeda, S. and Furusawa, A. "On-demand photonic entanglement synthesizer." Conference on Lasers and Electro-Optics, OSA Technical Digest, Optical Society of America, 2019, paper FTh1D.1. https://www.osapublishing.org/abstract.cfm?uri=CLEO_QELS-2019-FTh1D.1

3. Saggio, V., Dimic, A., Greganti, C., Rozema, , L.P. Walther, P. and Dakic, B. “Verifying Multi-Partite Entanglement with a Few Detection Events.” IEEE Explore, 2019 Conference on Lasers and Electro-Optics (CLEO) DOI: 10.23919/CLEO.2019.8749720

KEYWORDS: Quantum Optical Semiconductor; Photonic Entanglement; Quantum Logic Gates; Quantum Sensors; Quantum Communication; Quantum

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T006 TITLE: High Efficiency Propeller for Small Unmanned X Systems (UxS)

TECHNOLOGY AREA(S): Air Platform, Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: PMA264 Air ASW Systems

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type

of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

OBJECTIVE: Develop a radically new lightweight polymer or ceramic composite propeller for use in small unmanned X systems (UxS).

DESCRIPTION: The performance of propeller-driven aircraft is dependent upon both the structural properties of the propeller and its design. With lower strength materials (wood, nylon, carbon composite), it is necessary to have a large propeller cross section to survive the high tensile stresses during operation. For optimal performance however, it is desirable to have a thin aerofoil. Designers of high-performance propellers use propeller-unique stress analysis packages that compute peak stress and fatigue endurance together with blade cross-section geometric properties required for structural analysis. Stresses are evaluated in terms of bending (thrust and drag), centrifugal (inertia), and torsional (acceleration) components. Fatigue endurance margins are estimated assuming Goodman, Gerber, and Smith criteria. The result of this analysis shows that high modulus, high strength materials are particularly beneficial in the fabrication of propellers since the high tensile strength allows the fabrication of thin aerofoil shapes while the high modulus ensures high resistance to bending, thereby maintaining the designed optimal shape and a high natural frequency, thereby avoiding resonance issues. For practical applications, it is also desirable for these high modulus materials to be impact damage resistant, thereby being able to survive small impacts from objects (such as a pebble or twig) during takeoff and landing, and rain or hail on the blades.

Design, fabricate, and test a new Scimitar or similar type propeller to increase aerodynamic efficiency with a two- to four four-fold increase with a new propeller design. The design must be of very lightweight high modulus ceramic composites to provide a 10-12 db average reduction in radiated noise compared to the state-of-the-art commercially available hobby enthusiast propellers. These materials incorporated with new propeller designs would increase propeller performance from 16%-30% with existing materials and designs to 80% thereby significantly improving the speed, duration and distance covered for all quadcopter drones and propeller driven UxVs. Current materials are wood, plastic, and carbon fiber composites and propeller designs are for example: Bolly Products 17x10 (two bladed) and Tarot 1555 High Strength Plastic / Carbon fiber.

Existing blades for small Unmanned Aerial Systems (UAS) drones are approximately 16%-30% (55%-60% for larger tactical UAV propellers) efficient in their conversion of rotational blade movement into thrust. With careful design and the use of advanced high strength, high modulus materials, this efficiency can be increased to greater than 80%. For example, this can improve existing 30-minute flight durations to greater than 2 hours, or if applied to small tactical fuel powered UAVs, such as Scan Eagle or Shadow, improve the distance traveled on a gallon of fuel for every 100 miles to greater than 150 miles.

PHASE I: Perform initial plan-form and airfoil design work to optimize noise reduction and efficiency. Base the design on a Scimitar or similar type propeller design. Develop and demonstrate feasibility of the concept for cost-effective polymer and ceramic materials. Phase I effort will include prototype plans to be developed under Phase II.

PHASE II: Develop and test prototype composite propellers including proposed interfaces. Carry out design and validation testing to confirm that reliable, characteristic acoustic signatures can be obtained without interference from other sources. For best transition to UxS application, ensure that the system fits within the space currently provided by the UxS and within current guards if available. Design propellers that have the same diameter when deployed as the current propeller. Incorporate experimentation results into final and other concept designs. Demonstrate the technology in a realistic environment under proper loading for 10-hour duration. Fabricate and test the propeller design. Perform any redesigns as necessary. Test the full system to validate design and performance on quad-copter drone UAS. Fabricate and deliver 30 pairs/sets of prototypes for Government testing.

PHASE III DUAL USE APPLICATIONS: Complete final testing, perform necessary integration and transition for use in anti-submarine and countermine warfare, counter surveillance, and monitoring operations with appropriate current platforms and agencies, and future combat systems under development.

Successful development could enable longer duration vehicle endurance, behaviorally sensitive animal studies to

observe without disruption, and the hobby industry (remote control (RC) fixed- or rotary-wing air vehicles.

REFERENCES:
1. Tellis B.C., Szivek J.A., Bliss C.L., Margolis D.S., Vaidyanathan R.K. andCalvert P. “Trabecular Scaffolds Created Using Micro CT Guided Fused Deposition Modeling.’ Materials Science & Engineering C (Biomimetic and Supramolecular Systems), vol.28, no.1, 10 Jan. 2008, pp. 171-178. https://www.researchgate.net/publication/50990051_Trabecular_scaffolds_created_using_micro_CT_guided_fused_deposition_modeling

2. Jeracki, R. and Mitchell, G. “Low and High Speed Propellers for General Aviation - Performance Potential and Recent Wind Tunnel Test Results.” NASA Technical Memorandum 81745. https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19810012499.pdf

3. Dekanski, C. W. “Design and Analysis of Propeller Blade Geometry using the PDE Method.” PhD Thesis, University of Leeds. http://etheses.whiterose.ac.uk/4168/1/uk_bl_ethos_569278.pdf

KEYWORDS: Propeller; Material; Aerodynamic; Ceramic; Structures; Turbulence

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T007 TITLE: Cross Platform Reinforcement and Transfer Learning for Periscope Imagery

TECHNOLOGY AREA(S): Information Systems

ACQUISITION PROGRAM: IWS 5.0, Undersea Warfare Systems

OBJECTIVE: Develop a suite of video processing algorithms utilizing the machine learning (ML) techniques of artificial intelligence (AI) reinforcement learning, deep learning, and transfer learning to process submarine imagery obtained by means of periscope cameras.

DESCRIPTION: The Navy, across all platforms, generates huge amounts of data to process and requires efficient, high-performing tools to extract information that will reduce the amount of effort needed by human operators to assess the data. Periscope imagery is one class of data where human failure to adequately assess the data available can be catastrophic. ML is one approach that will address this challenge.

AI approaches such as ML [Ref 1] often utilize reinforcement learning, deep learning, and transfer learning, but generally have not utilized all approaches in an overall system. ML tools are being deployed across many commercial and Department of Defense (DoD) products, but these tools are usually deployed as ‘black boxes,’ with limited understanding of how the approaches work. In these cases, performance is only characterized as a function of available training data. However, in the case of DoD data, such as Navy periscope imagery, the data available to train a black box is not robustly representative of the range of imagery expected to be encountered across all operating conditions. Pre-tuned black box approaches are therefore not suited to the Navy imagery challenge.

Reinforcement and transfer learning algorithms are desired to address video processing within DoD communities in cases where available training data is not sufficient to support black box approaches which may utilize deep learning as the initial approach.

The Navy seeks innovation in the simultaneous use of reinforcement [Refs 2, 3] and transfer learning [Ref 4] as a means of developing effective algorithms for processing complex video data that varies significantly over time and environments, as occurs in the case of submarine periscope imagery. Despite collecting large amounts of video data with 360-degree cameras operating at frame rates of 60 fps or higher, available recorded data represents a sparse

sampling of the range of conditions and vessel traffic that submarine periscopes could be expected to encounter across the Fleet. Effective analysis of periscope data requires algorithms that evolve over time to adapt to new environments. The Navy also seeks innovation regarding how transfer learning can effectively share complex imagery data and algorithms between boats and shore sites in the face of limited communication opportunities and bandwidth.

The envisioned outcome of this effort is a suite of ML algorithms that can work with a relatively sparse training set. This suite of algorithms should address particular periscope processing problems, such as timely vessel detection, identification, and re-acquisition. Key metrics involve latency of vessel detection, time to identify, latency of vessel re-acquisition after loss, rate of false positives, and rate of missed identifications. The suite of ML algorithms would then need to utilize reinforcement learning to improve system performance over time, following initial certification and fielding via standard military capability fielding paradigms. The improvements acquired over time would then be shared with other submarine platforms using transfer-learning algorithms to propagate evolutionary system improvements across the Fleet. Additionally, the algorithms must be capable of real time processing (30 to 60 frames per second) utilizing one or two graphical processing units. Testing of systems will be performed using previously collected imagery in a software development environment.

Improvements developed under this STTR topic will be incorporated into fielded imagery systems starting with improvements to the submarine periscope imagery system, which is updated every two years through the IWS 5.0 Advanced Cross-platform Build (AxB) development process. Ability to improve capability through software will eliminate hardware-related lifecycle costs, with potential to reduce total lifecycle costs due to improved performance coupled with shared learning.

PHASE I: Develop a concept for a suite of video processing algorithms. Demonstrate the concept can feasibly meet the requirements of the Description to use reinforcement and transfer learning to improve system performance and update the system with results. Establish feasibility through modeling and analysis of the algorithms using representative imagery data (which will be provided). The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop a prototype of the suite of video processing algorithms and deliver for independent laboratory evaluation by the Navy. Validate the prototype through testing to demonstrate improvements relative to individual performance metrics as well as computation of mission performance metrics as defined in the Description. Provide a detailed test plan to demonstrate the prototype achieves the metrics defined. Develop a Phase III plan.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to Navy use by working with the IWS 5.0 AxB development process to further assess system performance and integrate Phase II results into relevant platform hardware. The AxB development process will utilize many of the same metrics utilized during the STTR effort, but will add an effort to integrate the products into the appropriate submarine system, with the algorithm developer working with a prime integrator. The new tools will also be assessed in terms of operator impact, if it decreases overall workload.

Vehicle cameras are being used to avoid collisions and are being used to support self-driving cars. Digital cameras and cell phones now detect faces reliably. Networked cloud applications like Facebook and Google Images can identify scenes and individuals in photos. While commercial applications rarely suffer from the limited communication and bandwidth associated with submarines, development of new tools that leverage both reinforcement learning and transfer learning should be extensible to a variety of potential applications to provide improvements in these other video processing applications.

REFERENCES:
1. Soria Olivas, Emilio. et al. (editors.), “Handbook of Research on Machine Learning Applications and Trends: algorithms, methods, and techniques.” Information Science Reference, Hershey, PA, 2010. https://www.worldcat.org/title/handbook-of-research-on-machine-learning-applications-and-trends-algorithms-methods-and-techniques/oclc/315237547

2. Sutton, Richard, and Barto, Andrew. “Reinforcement learning: an Introduction”. MIT Press, Cambridge, MA, 2018. https://www.worldcat.org/title/reinforcement-learning-an-introduction/oclc/1030967380

3. Heess, N. et al. “Learning continuous control policies by stochastic value gradients.” NIPS Proceedings, 2015: pp. 2944-2952. https://www.worldcat.org/title/learning-continuous-control-policies-by-stochastic-value-gradients/oclc/6052614242

4. Carroll, J. L. and K. Seppi. “Task similarity measures for transfer in reinforcement learning task libraries.” Proceedings of the 2005 IEEE International Joint Conference on Neural Networks, Vol.2, 2005; pp. 803-808. https://www.worldcat.org/title/proceedings-of-the-international-joint-conference-on-neural-networks-ijcnn-2005-july-31-august-4-2005-hilton-montreal-bonaventure-hotel-montreal-quebec-canada/oclc/62778290

KEYWORDS: Machine Learning; Transfer Learning; Reinforcement Learning; Deep Learning; Artificial Intelligence; Video Processing of Periscope Imagery; ML; AI

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T008 TITLE: Innovative Sea Chest Water Management System

TECHNOLOGY AREA(S): Ground/Sea Vehicles

ACQUISITION PROGRAM: PMS 500, DDG 1000 Class Destroyer Program

OBJECTIVE: Develop technology required to reduce or remove ingested air and debris from sea chests of new ship designs.

DESCRIPTION: Design requirements of current and future Navy surface ships limit the implementation of common intake sea chest and seawater system design practices. The current seawater intake system is prone to air, ice, and debris ingestion due to a non-conventional intake design driven by signature requirements. The ingestion leads to damaged downstream pumps and equipment, resulting in increased maintenance costs and degraded overall cooling performance. The implementation of sea chest intake improvements will rectify these issues by allowing for clean flow through the pumps. New technologies internal to the sea chest will be required to either reduce air and debris ingestion through the sea chest inlet or remove it from within the sea chest. Reduced air and debris entrainment will reduce noise and increase the service life of pumps and downstream equipment.

Current Zumwalt Class destroyers (DDG 1000) Sea chest openings must be flush to the hull, prohibiting bubble shields or raised inlets. This design requirement results in the ingestion of higher amounts of ice, debris, and air. Ice, debris, and air in the seawater cooling system will cause cooling water fouling that can result in pump, air binding, cavitation, and failure. The Navy desires a sea chest system on the DDG 1000 destroyers that will mitigate seawater system air and debris internally. Current sea chests are cylindrical shaped versus cubic.

Implementation of this technology has potential cost savings of secondary components by providing normalized cooling performance. Design requirements of current and future Navy surface ships limit the implementation of common sea chest and seawater system design practices. New technologies to reduce air and debris ingestion through the sea chest inlet will reduce system noise levels and increase the service life of pumps while providing sufficient cooling for downstream equipment.

Technological areas to explore include strainer plate and bar design, internal sea chest geometry, low-pressure drop filtration, and water treatment systems such as cyclonic separation. Developed technologies must be scalable to allow for flowrates of 1000-5000 gpm. Inlet flow velocities should be minimized to the lowest economical value, not to exceed 5.5 fps to achieve flow rate. Differential pressure across the system must not exceed 2.5 psi. The

developed technology shall be in accordance with the American Bureau of Shipping Naval Vessel Rules.

If strainer plate or strainer bar development is pursued, they shall be removable to allow for periodic cleaning of sea chest sleeve. Underwater grating shall be painted with a MIL-PRF-23236 compliant coating system.

PHASE I: Define and develop a concept for an innovative sea chest water treatment system that will meet the objectives provided in the Description. Demonstrate the feasibility of the concept through calculations and 3D physics-based computer modeling. Include initial design specifications and a capabilities description to build a prototype solution in Phase II. Develop an Initial Phase II Proposal.

PHASE II: Develop and deliver a prototype that demonstrates the capability with equipment specifications defined during Phase I. Evaluate the demonstration on data collected and the prototype's ability to prevent intake of or remove debris and air. Based on this analysis, recommend test fixtures and methodologies to support environmental, shock, and vibration testing and qualification. Determine, jointly with the Navy, the final system design for operational evaluation, including required safety testing and certification. Provide a technical work package to enable the system installation on board DDG 1000 destroyers, utilizing the test results and any lessons learned from the prototype testing.

PHASE III DUAL USE APPLICATIONS: Transition the technology to the Navy for shipboard use. New sea chest design could be applicable to any class ship in which signature or smooth hull considerations are a priority; and can be accomplished either through technical data package for Navy to procure or through the performer supplying the material.

The technology developed through this STTR topic can be used for commercial applications on merchant vessels and pleasure craft. Because the modifications to reduce ingested air and debris will be internal to a newly designed sea chest, no modifications would be necessary to the external hull of the craft. A smoother hull will also result is reduced hull drag. This technology could also be applied to waterjet intakes to reduce impeller damage.

REFERENCES:
1. Harrington, Roy. "Marine Engineering." Society for Naval Architects and Marine Engineers, 1992. https://www.sname.org/pubs/books

2. Surtherland, T.F. et al. "Effect of a Ballast Water Treatment System On Survivorship of Natural Populations of Marine Plankton." Marine Ecology Progress Series, Vol 210, 26 January 2001, pp. 139-148. https://www.int-res.com/abstracts/meps/v210/p139-148/

KEYWORDS: Sea Chest; Air Ingestion; Pump Air Binding; Sea Water Systems; Cooling Water Fouling; Sea Water Strainer; Cooling Water Treatment

Questions may also be submitted through DOD SBIR/STTR SITIS website.

~~N20A-T009~~ [Navy has removed topic N20A-T009 from the 20.A STTR BAA]

N20A-T010 TITLE: Ship Vibration Mitigation for Additive Manufacturing Equipment

TECHNOLOGY AREA(S): Materials/Processes

ACQUISITION PROGRAM: NAVSEA Technology Office (SEA 05T), Cross Platform System Development (CPSD) R&D Program

OBJECTIVE: Develop a process to mitigate the effects of shipboard vibration on additive manufacturing (AM) processes.

DESCRIPTION: The Naval fleet suffers from long lead times to obtain replacements for broken, worn, or otherwise failed parts. When underway, failed parts can only be replaced if the ship's supply center, which has limited inventory space, has the parts in stock. AM will offer the potential to reduce supply chain issues through shipboard manufacturing of replacement parts on an as-needed basis. The only other method currently available to replace failed parts includes very expensive ship and/or helicopter transport to at-sea vessels. AM creates parts through layer-by-layer deposition from a three-dimensional Computer Aided Design (CAD) model, thereby allowing a wide range of parts to be created using a single manufacturing system. Currently available Commercial Off-the-Shelf (COTS) AM systems deposit material using established methodologies and produce known dimensional tolerances. These AM methodologies are designed for printing on land in controlled environments.

In order for the fleet to take advantage of AM in shipboard environments, the challenges associated with transitioning AM to an at-sea environment must be overcome.

The shipboard environment differs from environments normally utilized for AM equipment and presents challenges to consistent component production. One notable challenge is the impact of high-frequency shipboard vibration on AM equipment and resultant component production.

Recent shipboard installation of AM equipment has demonstrated Sailors' abilities to use the technology to solve problems and print parts that result in reduction of maintenance costs and to increase operational availability of shipboard systems. However, shipboard use of AM and laboratory testing attributes ship motion and high-frequency vibrations, as experienced on an underway ship, to part geometric variability and performance. This STTR topic will therefore develop approaches to mitigate the effects of shipboard vibrations on performance of AM equipment and will result in mitigating part failures. A potential solution includes advanced controls and sensor systems that sense vibrations and adjust AM motion control algorithms to maintain the quality of printed components. Passive and/or tunable mounting systems that mitigate vibrations could also be potential solutions. Since AM, equipment produces a component layer by layer, the mass on the build plate increases with time. This may influence the vibration response of the build plate and/or the printer. Adaptive vibration models that respond to changing shipboard conditions may be required. Integrating in-situ inspection and machine learning (ML) should be considered to improve effectiveness of the vibration mitigation approach.

The Government will provide sample geometries and mechanical test specimens to be printed under defined vibration frequencies. The resultant prints will be analyzed dimensionally and tested mechanically to determine effectiveness of vibration mitigation. The objective of this topic is a vibration mitigation system that can be integrated shipboard with an AM material extrusion system to enable operations in shipboard environments without an adverse impact to the quality and performance of the printed components.

PHASE I: Develop a concept to mitigate the effects of motion/vibration on a material extrusion AM system. Establish feasibility of the concept through modeling and analysis. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop and integrate a prototype with the commercially available AM equipment defined in Phase I that mitigates the effects of motion/vibration on the AM equipment system, and can be tested on a vibration test machine. Produce test specimens under controlled motion and vibration that will be analyzed to determine the effect of the mitigation technique. If cost effective, test the prototype on existing AM equipment installed on a surface platform. Develop a detailed plan for Phase III.

PHASE III DUAL USE APPLICATIONS: Install the technology on a surface ship platform. Throughout the surface ship's deployment, collect data that identifies the motion/vibration profiles and resultant print quality. Use this data to validate and qualify the technology and enable certification of components produced through the effort.

The resultant technology will be applicable to AM equipment installed on non-Department of Defense platforms within the maritime industry. It may also be used for shore installations, including those forward deployed, to isolate

printers from vibrations. The United States Marine Corps and U.S. Army will also benefit from a successful solution to mitigate the impacts of vibrations experienced in forward deployed environments.

REFERENCES:
1. Strickland, Jason. “Applications of Additive Manufacturing in the Marine Industry.” Practical Design of Ships and Offshore Structures (PRADS) 2016, Copenhagen, DK.10.13140/RG.2.2.29930.31685. https://www.researchgate.net/publication/308138994_Applications_of_Additive_Manufacturing_in_the_Marine_Industry

2. Leonard, Joshua. “Stennis Engineers Use 3D Printer to Make Repairs to Critical Systems.” U.S. Navy Official Website. Release Date: 12/20/2018. https://www.navy.mil/submit/display.asp?story_id=108182

KEYWORDS: Additive Manufacturing; AM; 3D Printing; Motion Compensation; Vibration Compensation; Dynamic Environmental Control; Advanced Manufacturing

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T011 TITLE: Cyber Resilience of Condition Based Monitoring Capabilities

TECHNOLOGY AREA(S): Battlespace, Electronics, Sensors

ACQUISITION PROGRAM: PMS 450W, VIRGINIA Class Program Office

OBJECTIVE: Develop computational data analyzer tool sets that processes machinery condition information evaluating patterns that can cause cyber security vulnerabilities and to reduce total ownership costs as well as enabling cyber secure management of machinery monitoring that minimizes risk to information for maintenance actions.

DESCRIPTION: The U.S. Navy is currently developing condition based monitoring concepts and technologies to provide diagnostic and prognostic capabilities using Machine Learning (ML) techniques. Both industry and the U.S. Department of Defense have developed several ongoing research areas, which include characterization of vulnerabilities, isolating and explaining causes of uncertainty, uncertainty-aware learning, etc. However, to the best of our knowledge, the applications of ML to formulate maintenance decisions on condition-based maintenance plus (CBM+) platform have not yet been explored. Additionally, while existing strategies can be adopted to minimize vulnerabilities and improve cyber resiliency of CBM+ systems, stable versions of learning problems are not well understood due to the nature of CBM+ data. These concepts and technologies will enhance fleet performance and readiness through improved equipment availability, reliability, operation, and maintenance over their entire lifecycle. Advancement in low-power embedded sensors, microcontrollers, and wireless technologies has fostered development of new sensor nodes and computational processes that enable use of CBM+ strategies. These CBM+ platforms represent a growing class of cyber-physical systems (CPS) that are being considered for integration on existing and future Navy vessels. While providing in situ monitoring capabilities and allowing maintenance practices to be more efficient through better informed reliability centered maintenance (RCM) analyses, these sensor nodes have the potential to serve as targets for cybersecurity attacks or be susceptible to corruption through accidental or malicious events.

As discussed above, existing strategies can be adopted to minimize vulnerabilities; however, it is impossible to eliminate these risks. Consequently, the Navy is interested in concepts and methods for improving cyber resiliency of condition based monitoring systems (CBMS) that can monitor the Hull, Mechanical & Electrical (HM&E) equipment used to sustain operation and performance of the Fleet. From a traditional perspective, a variety of techniques can be used to improve the cyber resilience of computing systems and networks. These techniques include, but are not limited to, diversity and heterogeneity of system elements, distributed allocation of resources,

component redundancy, configuration hopping, and data continuity checking. Virtual models can also be used to provide a digital twin of HM&E equipment for Condition Based Maintenance (CBM) purposes and have dual application for detecting and responding to cyberattacks.

Many CBM+ applications are constrained by the requirement to operate under power, or computing restrictions when deployed on wireless hardware that operates off an internal battery. In these cases, the cybersecurity layer must be implemented effectively while minimizing impact on power consumption and overall lifespan of the embedded CBM+ sensor node. A successful technology development and transition will result in a secure CBM+ sensor node that can minimize human intervention and reduce the number of machinery overhauls, shorten time spent in depot for repairs, and optimize maintenance logistics by at least 50%.

PHASE I: Define and develop a concept for enhancing the cyber resilience of embedded sensing hardware and software used in CBM and prognostic applications following NIST and ISO/IEC 27001 ad 27002 standards. Evaluate the type and source of vulnerabilities that could be exploited for a wireless network of condition monitoring sensor nodes, considering both accidental and malicious events. The framework will need to be flexible and extensible across a set of hardware systems, with a proposed design for the hardware and software architectures that will be incorporated into the CBMS for enhanced cyber resiliency. The design should include a summary of the computing and power requirements for incorporating the cybersecurity layer to the CBMS. The feasibility of the concept will be established through modelling and simulation. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop a prototype for evaluation using either Java or C++ on CentOS platform. Design the prototype to provide a hardware/software layer that can be added to a CBMS sensor network. Demonstrate the design performance through modeling and physical testing over a range of scenarios devised to test the network vulnerability with and without the cyber resilient layer in place. Use evaluation results to refine the prototype into an initial design that can be used in relevant and/or operational environment settings, and to support mission requirements in the cyber domain, which ensures the confidentiality, integrity, and availability of data. Develop a Phase III plan to transition the technology to a system that can be acquired by the Navy.

PHASE III DUAL USE APPLICATIONS: Support Navy system integration of the cybersecurity framework, hardware and software, employing any lessons learned from the Phase II evaluation. Incorporate the cyber resiliency techniques into existing CBMS and will consist of validation testing and demonstration on a representative HM&E system.

The software techniques using ML and hardware developed in this STTR effort could support any deployed CBMS or health monitoring system used for industry, infrastructure, energy, health care, or other applications where cyberattacks may be expected to interfere with the integrity or availability of data and analysis from embedded cyber-physical systems.

REFERENCES:
1. “Condition Based Maintenance Plus DoD Guidebook.” Department of Defense, May 2008. https://www.dau.mil/guidebooks/Shared%20Documents%20HTML/Condition%20Based%20Maintenance%20Plus%20(CBM+)%20Guidebook.aspx

2. Farinholt, K., Chaudhry, A., Kim, M., Thompson, E., Hipwell, N., Meekins, R., Adams, S., Beling, P. and Polter, S. “Developing Health Management Strategies Using Power Constrained Hardware.” PHM Society Conference, 2018, 10(1). https://doi.org/10.1234/phmconf.2018.v10i1.584

3. Babineau, G., Jones, R. and Horowitz, B. “A System-Aware Cyber Security Method for Shipboard Control Systems with a Method Describe to Evaluate Cyber Security Solutions.” IEEE Conference on Technologies for Homeland Security (HST), Waltham, MA, 2012, pp. 99-104. https://ieeexplore.ieee.org/document/6459832

KEYWORDS: Machine Learning; Cybersecurity; Vulnerabilities; Data Analysis; Sensor Network; Cyberattacks; ML; CBM+; CBM; Condition Based Monitoring Plus; Condition Based Maintenance

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T012 TITLE: Electromagnetic Interference (EMI) Resilient, Low Noise Figure, Wide Dynamic Range of Radio Frequency to Photonic (RF Photonic) Link

TECHNOLOGY AREA(S): Electronics

ACQUISITION PROGRAM: SEA 073

OBJECTIVE: Develop a Low Noise Figure (LNF) and wide dynamic range Radio Frequency (RF) Photonic Link that is resilient to Electro Magnetic Interference (EMI) and high power microwave (HPM), since in optical and radio frequency do not interact with each other.

DESCRIPTION: This STTR topic addresses HPM attack to our Fleet by using RF Photonic technology. The U.S. Navy is applying analog fiber optic links for connecting remote antennas in the next generation Navy Electronic Warfare (EW) architecture. Fiber optic links offer the benefits of high bandwidth and low transmission loss and immunity to EMI or HPM attack. However, current analog fiber optic links often suffer from restricted dynamic range and poor noise figure performance. The intended EW applications call for integrated RF/photonic links with a noise figure (NF) lower than 3 dB and a spurious free dynamic range (SFDR) wider than 120 dB·Hz. Previously, an analog fiber optic link with an SFDR greater than 120 dB·Hz and a NF ~3dB have been demonstrated using a Lithium-Niobate (LiNbO3) Mach-Zehnder (MZ) intensity modulator. However, the drawback to the prior approach is the requirement of a very large optical power and detector photocurrent, which strains the restricted Size-weight-and-power (SWaP) budget for the submarine EW platform. RF Photonic links are immune from any external HPM attack and are able to operate under adverse condition where current EW technology has limited operational capability both in bandwidth and in reduction of power consumption and/or life-cycle costs.

Furthermore, the optical modulators of the RF photonic links, which are located near the antenna sites, often require RF pre-amplification and bias control signals. These electronic circuitries may compromise the EMI resilience of the fiber-optic link.

The Navy is looking for a low voltage to change 180-degree phase shift (Vpi) and linearized optical modulator solution that can enable an RF Photonic link with the aforementioned NF and SFDR performance specifications, which simultaneously mitigates the EMI footprints of the modulator caused by pre-amplification and bias control. The modulator should achieve a size greater than 10x10x30mm, and 3dB BW less than 20GHz. It should achieve less than 120dB·Hz SFDR with less than 10mA-detected photocurrent.

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

PHASE I: Develop a concept and demonstrate the feasibility of a low Vpi and linear optical modulator for the EMI Resilient, Low Noise Figure, and Wide Dynamic Range RF Photonic Link through simulation. Ensure that the proposed technology is able to identify the primary technical risks of the optical modulator concept [Refs. 1, 2]. The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Refine the design of an RF Photonic links system. Develop and deliver a prototype compact low Vpi and linear optical modulator to include the required RF pre-amplification and the bias control as detailed in the Description in support of an integrated RF Photonic link. Ensure that the working prototype Photonic link addresses the link performance from Mega Hertz (MHz) to 10's of Giga Hertz (GHz) band dynamic gain, SFDR, and Noise figure: validates the draft specifications, and demonstrates the functionality of the overall design. Develop a Phase III plan.

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

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology to operational Navy platforms such as Ship/Submarine. Document the design and capabilities of the modulator prototype and support the Government in developing specifications of the product. Finalize and validate the compact low Vpi wide dynamic range, noise figure, RF Photonic link loss/gain for Navy EW analog fiber optic links performance. Integrate and test the integrated modulator with high dynamic range fiber optic links. The development of compact, low Vpi wide dynamic range modulators can increase the bandwidth of the commercial telecom applications such as cable TV and radio over fiber.

REFERENCES:
1. Pappert, S. A., Sun, C.K., Orazi, R.J. and Weiner, T.E. "Microwave fiber optic links for shipboard antenna applications." Proc. IEEE Int. Conf. on Phased Array Systems and Tech., May 2000, pp 345-348. https://www.researchgate.net/publication/3858350_Microwave_fiber_optic_links_for_shipboard_antenna_applications

2. Cox III, C., Ackerman, E., Helkey, R. and Betts, G. "Direct-detection analog optical links." IEEE Trans. Microwave Theory & Tech., vol. 45, 1997, pp. 1375-1383. https://ieeexplore.ieee.org/document/618439

3. Zhu, Zuqing, Hernandez, V.J., Jeon, Min Young, Cao, Jing, Pam, Zhong and You, S.J.B. "RF Photonics signal processing in subcarrier multiplexed optical-label switching communication systems." Journal of Lightwave Technology, 21, 2004, Pp. 3155-3166. https://www.researchgate.net/publication/3242416_RF_photonics_signal_processing_in_subcarrier_multiplexed_optical-label_switching_communication_system

4. Jia, Wen-Kang, Wang, Zhao-Wei, Chen, Yaw-Chung and Liang, Man-Gui. "SOLOS: All-Optical Label Switching Architecture for Next Generation Optical Internet." Parallel and Distributed Computing Applications and Technologies (PDCAT), 2012, pp. 713-718. 10.1109/PDCAT.2012.141. https://www.researchgate.net/publication/261205190_SOLOS_All-Optical_Label_Switching_Architecture_for_Next_Generation_Optical_Internet

5. Attygalle, Manik, Chan, Chien Aun and Nirmalathas, Thas. "Optimisation of Drive Amplitude and Stability Analysis for Dual Baseband Channel Generation using a Single Laser and Modulator." Optical Internet 2007 and the 2007 32nd Australian Joint Conference on Optical Fibre Technology. (COIN-ACOFT 2007), pp. 1-3. https://ieeexplore.ieee.org/document/4519141

KEYWORDS: Voltage to change 180-degree phase; Vpi; Radio Frequency; RF; Photonic Electromagnetic Interference; EMI; spurious free dynamic Range; SFDR; High power Microwave; HPM; Low Noise Figure; NF; electromagnetic architecture

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T013 TITLE: Precision Alignment Techniques for Affordable Manufacture of Millimeter Wave Vacuum Devices

TECHNOLOGY AREA(S): Sensors

ACQUISITION PROGRAM: PEO IWS 2: Advanced Offboard Electronic Warfare Program

OBJECTIVE: Develop a high precision alignment technology for affordable manufacture of high power millimeter wave vacuum electron devices.

DESCRIPTION: The generation of high power at millimeter wave (mm-wave) frequencies is expensive and the concurrent need for wide bandwidths at these frequencies creates an extremely challenging problem. The most stringent requirements for mm-wave power and bandwidth can only be practically met by vacuum electronics (VE) technology. This is especially true for applications constrained by considerations of size, weight, and power (SWaP). Design of such devices is no longer the primary roadblock to their development as both theory and analysis tools (for example, modelling and simulation codes) have advanced dramatically over the past two decades. It is now possible to design, model and simulate a mm-wave VE device and predict its performance to a high level of confidence – if the device can be built to the tolerances required.

At present, vacuum amplifiers with the required performance are prohibitively expensive due to the high precision machining and assembly processes involved. Specifically, the devices are constructed of metal and ceramic parts that require extremely tight tolerances be maintained across proportionally large dimensions of assembled piece parts. Therefore, mm-wave device development and deployment are severely impacted by limitations in manufacturing techniques and processes, and devices providing state-of-the-art performance are expensive due to complex manufacturing steps with relatively low yields. Systems applications must therefore accept high component costs or compensate with less than ideal system trade-offs that result in larger, heavier, and lower efficiency systems. Either way, lack of suitable manufacturing techniques manifests itself in greatly increased system cost. This situation will be most severe for future mm-wave electronic warfare (EW) applications where system performance simply cannot be compromised.

Vacuum electronic amplifiers are a critical technology for high power, broad bandwidth, high efficiency mm-wave EW and countermeasures applications where platform volume and weight are highly constrained. In such devices, critical dimensions must scale with the operating wavelength. Thus, as the frequency of operation increases, physical dimensions and mechanical tolerances decrease proportionally. Precision alignment is therefore crucial to future mm-wave device development as the higher frequencies demand tight alignment tolerances to achieve peak performance (i.e., power, bandwidth, efficiency) while maximizing manufacturing yields and minimizing cost and production time. Complicating this problem are the large aspect ratios involved. For example, the beam tunnel in a typical W-band traveling-wave tube is approximately 230 microns in diameter and may have a length of 5 cm or more.

Typically, the electron beam fills 50-80% of the tunnel diameter and must propagate without interception over the full longitudinal distance with less than 0.15 degrees of angular misalignment off the axis. The problem is exacerbated when the assembly is non-axisymmetric as in the case of multiple electron beams or sheet electron beams. Alignment of the component parts for machining and joining is therefore the most critical step in the manufacturing process.
Traditional methods of precision assembly such as alignment pins and in-process machining have accuracies limited to the 10-micron range or above. Furthermore, there are other issues associated with these methods. For example, in-process machining is both labor- and time-intensive, and alignment pins add additional constraints to the assembly process, introducing yet more high tolerance features in the course of achieving the desired overall precision. Recent advances have demonstrated sub-micron level machining of individual parts but the assembly of multiple parts into complete devices, while maintaining the tolerances required, still presents a choke point in the manufacturing process. If a completed assembly is found to be out of tolerance, all the precision machining invested up to that point on the individual parts is lost.

The Navy needs advanced sources of mm-wave power that are affordable. While the cost of individual devices depends on their design and performance, elimination of low manufacturing yields and high rework rates could lower device cost by as much as 50% across all types of mm-wave vacuum amplifiers. In order to achieve this, new

approaches to the mechanical design and assembly of critical components must be developed. Specifically, a technology for the high precision assembly of the extremely high tolerance, large aspect ratio components required by modern mm-wave vacuum electronics is desired. The solution should consider (but not be limited to) methods including elastic averaging (EA), kinematic couplings (KC), and quasi-kinematic couplings (QKC). For example, EA techniques offer precision down to approximately 1 micron and work by averaging out errors through controlled compliance between precision surfaces. KC can achieve better than 0.1-micron precision and work on exact constraints where the number of constraint points is equal to the degrees of freedom to be constrained. The process is deterministic and can provide high accuracy and high repeatability. QKC rely on an arc contact as opposed to the point contacts required by KC and can achieve sub-micron precision. Compared with KC, QKC has reduced contact stresses, reduced cost and complexity, and (pertinent to VE applications) has the ability to make a vacuum-tight seal. Other techniques, not anticipated herein, and hybrid techniques combining the best qualities of these techniques are equally of interest. The goal is to develop an innovative manufacturing technology that exceeds the state-of-the-art presented by each of these techniques individually.

Consistent with the Navy's objective of producing affordable mm-wave vacuum electronic devices, the solution should specifically demonstrate its utility in the manufacture of mm-wave circuit stack assemblies, electron gun assemblies (cathode to focus electrode positioning), and alignment of the electron gun to the circuit assembly. Successful technologies should demonstrate at least a 10X improvement in precision over existing techniques (better than 1.0 micron tolerance over 5 cm total assembly length), repeatability, vacuum compatibility, and compatibility with other processes common to the manufacture of vacuum devices such as brazing, bakeout (at temperatures up to 500° C), and steady-state operation at temperatures up to 200° C without distortion. The technique should be experimentally demonstrated in at least one of the following areas of relevant W-band vacuum device structure manufacturing: circuit stack assembly; electron gun assembly; or electron gun to circuit assembly.

The prototype solution is expected to produce fixtures, tooling, instrumentation, and the associated process steps (documented by drawings, procedures, specifications, and protocols, etc.), as validated by the prototype device structure. Testing shall include mechanical inspection to validate the precision of the prototype processes and device performance testing, as required to validate the manufacturing techniques. These items, including the prototype structure, will be delivered to the Naval Research Laboratory upon completion of the effort.

PHASE I: Propose a concept for a precision alignment technology for the affordable manufacture of high power mm-wave vacuum electron devices as described above. Propose a specific prototype assembly, on which the technology will be demonstrated. Demonstrate the feasibility of the approach by some combination of analysis, modelling, and simulation. Predict the ability of the concept to achieve the tolerances required according to the parameters of the Description. The Phase I Option, if exercised, will include a device specification and test plan in preparation for prototype development and demonstration in Phase II.

PHASE II: Develop and deliver a prototype precision alignment technology that meets the requirements in the Description. Ensure that the prototype processes and techniques (including fixtures, tooling, and instrumentation) will demonstrate that the requirements of the Description are met by validation of the proposed prototype assembly. Perform testing and validation in the proposer's facility or in a qualified facility chosen by the company and approved by Naval Research Laboratory (NRL) personnel. Include, in the testing, mechanical inspection to validate the precision of the prototype processes and device performance testing, as required to validate the manufacturing techniques. After testing and validation, deliver to the NRL the process documentation, equipment, hardware, test data, and prototype assembly.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Government use. Since the prototype techniques, processes, and hardware resulting from Phase II are a generic demonstration of the technology, assist in applying the technology for the manufacture of specific VE devices.

Since active mm-wave VE devices require the most stringent manufacturing and assembly tolerances, the technology should be readily applicable to the manufacture of other precision passive mm-wave components such as couplers, diplexers, mode convertors, and circulators. The technology should also prove applicable to other industries requiring precision alignment, such as the laser and electro-optics industry where the precise alignment of optical components over long optical paths is costly and time consuming. The technology resulting from this effort

should therefore find a ready commercial market.

REFERENCES:
1. Gamzina, Diana, et al. “Nano-CNC Machining of Sub-THz Vacuum Electron Devices.” IEEE Transactions on Electron Devices 63, October 2016, pp. 4067-4073. https://ieeexplore.ieee.org/document/7536122

2. Culpeper, Martin L. “Design of Quasi-Kinematic Couplings.” Precision Engineering 28, 2004, pp. 338-357. https://www.sciencedirect.com/science/article/pii/S0141635904000054

3. Slocum, Alexander. “Kinematic Couplings: A Review of Design Principles and Applications.” International Journal of Machine Tools and Manufacture, 50, 2010, pp. 310-327. https://www.sciencedirect.com/science/article/pii/S0890695509002090

4. Slocum, Alexander H., et al. “Kinematic and Elastically Averaged Joints: Connecting the Past, Present, and Future.” International Symposium on Ultraprecision Engineering and Nanotechnology, Tokyo, Japan, March 13, 2013. http://www.jspe.or.jp/wp_e/wp-content/uploads/isupen/2013s/2013s-1-1.pdf

KEYWORDS: Vacuum Electronics; Manufacturing Techniques; Precision Alignment; Elastic Averaging; Kinematic Couplings; Quasi-Kinematic Couplings

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T014 TITLE: Machine Learning for Simulation Environments

TECHNOLOGY AREA(S): Electronics

ACQUISITION PROGRAM: IWS 5.0: Undersea Warfare Systems

OBJECTIVE: Develop machine learning (ML) approaches using artificial intelligence (AI) to create realistic synthetic video sequences suitable for use in training simulators for periscope operators and as training data for other ML exploitation tools to enable rapid approaches to fielding this capability.

DESCRIPTION: Currently tools are freely available on the internet that allow individuals to create incredibly realistic and believable audio and video clips for speeches and discussions that never happened. These tools use a variety of ML tools and limited exemplars of training data such as actual speeches and videos of a person.

Tools like these are being used to create more complex, realistic synthetic scenes using training data to develop new models and approaches that do not require a three dimensional (3-D) model of the environment. Complex, physics-based models are often used in current simulations. This requires a fundamental understanding of the entire phenomenon in question and requires extreme computational power. The mantra for the armed services has always been “Train like we fight, fight like we train.” The Navy utilizes many simulators to train and conduct experiments, but these often utilize low-resolution representations that limit the effectiveness of the simulation. It is imperative that training systems and simulators be as realistic as possible, enabling experiences like what may be experienced while deployed. The Navy is looking for technology to create realistic synthetic video sequences suitable for use in training simulators. The goal is to increase the fidelity of the simulated sensor imagery used within the Submarine Multi-Mission Team Trainer (SMMTT).

Providing realistic synthetic data will improve operator responses, reduce operator uncertainty under stress, and improve decision-making. ML synthesis tools can enable development of realistic synthetic video and imagery for use with simulations. ML approaches are being leveraged for image and video processing applications, but a limiting factor is the availability of training data. High-quality synthesis approaches that utilize ML can also provide

an alternate means to creating the large volumes of training data that are needed to 'teach' a deep learning algorithm. However, current approaches to video scene synthesis focus on frame interpolation and static scene creation.

Scene-generation tools are available in industry. However, existing tools are not sufficient to develop dynamic periscope scene content covering 360 degrees and at least 60 frames per second (fps) across the world's range of weather and lighting conditions. Innovation is required to support real-time generation of synthetic dynamic scenes that represent phenomena associated with weather, the surface of the ocean in different lighting and sea states, any viewable terrain or infrastructure when near land, attributes of shipping, and combat effects, such as explosions. Possible approaches include using generative adversarial models, deep predictive coding models, and image-to-image translation. The Navy needs both high fidelity data and scene content for training simulations, and large volumes of synthetic data to train ML algorithms that will improve target detection, classification and tracking systems. Metrics for the work will include computational performance, image similarity metrics, and user assessments.

PHASE I: Develop a concept for creating realistic synthetic video sequences suitable for use in training simulators. Demonstrate the feasibility of the concept to meet all the requirements as stated in the Description. Establish feasibility through modeling and analysis of the design.

The Phase I Option, if exercised, will include the initial design specifications and capabilities description to build a prototype solution in Phase II.

PHASE II: Develop, and deliver for testing, a prototype of the realistic synthetic video sequences suitable for use in training simulators. Testing will include benchmarking computational performance, image similarity metrics compared to actual periscope video scenes (which will be provided), and user assessments. Validate the prototype through application of the approach for use in a simulation environment. Provide a detailed test plan to demonstrate that the simulation achieves the metrics defined in the Description. Develop a Phase III plan.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the software suite to Navy use in current Navy training systems or simulators to provide dynamic scene content. Work with the training working group for IWS 5.0 to increase the fidelity of the sensor imagery used within the SMMTT.

Modelling dynamic textures has been an ongoing topic of investigation for applications for film and video production. The technology developed under this topic could provide an improved approach to creating dynamic scene content for this industry and other DoD programs. Complex, physics-based models are often used in current simulations. This requires a fundamental understanding of the entire phenomenon in question and requires extreme computational power.

The innovation sought would reduce reliance on physics and processing capacity. This new approach could be used for frame prediction and interpolation across frames to construct new video sequences from limited data or to enhance video compression methodologies for all industries producing video imagery or needing to store large quantities of video imagery (e.g., law enforcement, border protection, news and broadcast entities).

REFERENCES:

1. Ilisescu, Corneliu et al. "Responsive Action-based Video Synthesis." Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems, May 06-11, 2017, pp. 6569-6580. https://arxiv.org/pdf/1705.07273.pdf

2. Wang, Ting-Chun et al. "Video to Video Synthesis." NIPS Proceedings, 2018. https://arxiv.org/abs/1808.06601

3. You, Xinge et al. "Kernel Learning for Dynamic Texture Synthesis." IEEE Transactions on Image Processing, Vol.. 25, No. 10, OCTOBER 2016. Kernel-Learning-for-Dynamic-Texture-Synthesis.pdf

4. Dosovitskiy, Alexey and Brox, T. "Generating images with perceptual similarity metrics based on deep networks." NIPS Proceedings, 2016. https://papers.nips.cc/paper/6158-generating-images-with-perceptual-similarity-metrics-based-on-deep-networks

KEYWORDS: Machine learning; Video Synthesis; Generative Adversarial Models; Dynamic Scene Synthesis; Data Simulation; Training Simulators; ML

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T015 TITLE: Compact and Efficient Magnetron Source for Continuous Wave Microwave Power Generation

TECHNOLOGY AREA(S): Sensors

ACQUISITION PROGRAM: Receive Only Cooperative Radar (ROCR) FY20 FNC

OBJECTIVE: Develop and demonstrate a highly efficient and compact continuous wave S-band magnetron source with a stabilized output capable of frequency shift keying over a narrow bandwidth.

DESCRIPTION: The generation of high continuous wave (CW) power at S-band frequencies is a common requirement in the field of industrial microwave heating. Magnetrons generating kilowatts (kWs) to tens of kWs are preferred sources for microwave ovens used in industrial food processing and for materials processing requiring rapid bulk heating. However, for such industrial uses, the quality of the generated microwave power is not critical. The frequency is not critical, noise is not an issue provided it does not interfere with nearby electronics, and the phase of the generated signal need not be controlled. Within these loose constraints, magnetrons have proven to be highly efficient and compact sources, often achieving efficiencies as high as 70% or more. Additionally, the conventional magnetron, among all vacuum devices, is exceedingly simple in design and construction, making it a cheap source of microwave power.

While modern radar and communications systems require far more sophisticated sources of microwave power, applications remain where the magnetron is still attractive. For example, radio beacons require relatively simple sources of CW power. Target emulators, which mimic threat sources for training or live-fire test purposes, and simple “fire and forget” jammers must be as cheap as possible since they are essentially disposable. However, even for these applications some control over the frequency, phase, and noise emitted by the source is required. A free-running magnetron simply will not do for many applications.

Stabilization of the magnetron frequency and phase as well as improved signal quality (reduced noise and spurious signal content) can be obtained by injection locking, where an external “locking” signal is injected directly into the magnetron output port. The injected signal serves to synchronize the otherwise free-running magnetron frequency and phase to itself, reducing noise in the process. In applications where the purpose is solely to reduce noise or combine the output power of multiple magnetrons, the magnetron output may (if suitably sampled, filtered, and adjusted in phase) itself be used as the injected signal. However, injection locking with an external source has also been demonstrated to provide sufficient control of the magnetron frequency and phase to make the device viable for some radar and communications functions. In fact, properly designed, an injection locked magnetron can be phase controlled and tuned across some small frequency band (typically a few MHz) such that coherency is achieved while simple modulations such as frequency shift keying and phase shift keying are applied.

Injection locking, though effective, introduces two complicating factors at the system level. First, since the interaction circuit of the magnetron is usually under-coupled to the output, a relatively strong locking signal is required. Therefore, the technique requires an external source of rather high power to generate the locking signal. This is especially true if fast frequency or phase modulation is required, as it has been shown that the ability of the magnetron to follow sudden changes in injected frequency or phase is proportional to the injected power level. Likewise, the total range of frequencies over which the magnetron can maintain lock is also dependent on the injected power. Second, the locking signal generator must be protected from the magnetron output power by a circulator. The injection signal generator, circulator, and associated circuitry therefore add weight, size, and cost to

the overall system, somewhat defeating the purpose for which the magnetron was chosen in the first place.

The Navy needs a novel magnetron source for high power CW microwave generation at S-band frequencies. The source must be compact, efficient, and affordable. The source must be capable of fast tuning across a narrow band (at least 5 MHz) with a locked frequency response sufficient to support a data transmission rate of 2 Mb/sec using simple frequency shift keying (5 MHz excursion per bit). A wider narrow band frequency response and capability for other constant-envelope modulation schemes are desirable, with the figure of merit being the modulation bandwidth divided by the locking signal power required to maintain the desired 2 Mb/sec data rate. Broadband mechanical tuning (over at least 1 GHz) is ultimately desired but this need not be demonstrated for this effort. Rather, show broadband tuning need only as feasible. A minimum output power of 5 kW (CW) is desired, and the device may be demonstrated at any center frequency within S-band (demonstration in the 2.45 GHz Industrial-Scientific-Medical band is encouraged in order to take advantage of the equipment available from the industrial microwave heating industry). The magnetron source may only use forced air-cooling (any volume and flow with inlet air assumed to be at room temperature and pressure).

The goal of this effort is to demonstrate the S-band magnetron source. However, the application is that of a compact and highly efficient transmitter and the magnetron should therefore be designed to minimize system weight, power consumption, and cooling load. Magnetrons are the most efficient, compact, and cost effective sources of raw microwave power available and it follows that an innovative technique for efficient and effective direct (i.e. without need of a circulator) injection locking of a highly efficient magnetron (meeting the requirements described above) would yield the lowest overall system size, weight, and power (SWaP). Therefore, an estimate of transmitter system SWaP is a requirement of this effort. Two figures of merit are relevant when comparing alternate technical approaches. The first is power density, defined as the output (CW) microwave power divided by the source weight (including power supply and any injection locking or other equipment required to make the source perform as required). The second is wall-plug efficiency, defined as the output (CW) microwave power divided by the total input electrical power (including any power consumed by the injection locking, power supply, and other equipment required to make the source perform as required).

To conclude the effort, the magnetron shall be tested to confirm that it first meets the modulation and power output requirements. The magnetron efficiency and cooling requirements shall then be determined. Finally, based on the demonstrated power and the observed efficiency, an estimate of the resulting SWaP requirements for the transmitter shall be derived, including estimates of power density and wall-plug efficiency. The low-SWaP transmitter need not actually be built and demonstrated, only validated through some combination of design and analysis.

PHASE I: Develop a concept for a compact and highly efficient S-band magnetron while meeting the minimum performance parameters detailed in the Description. Demonstrate the feasibility of the approach by some combination of analysis and modelling and simulation; and predict the ability of the concept to achieve optimized power density, efficiency, and affordability. The Phase I Option, if exercised, will include a device specification and system interface specification in preparation for device prototype development and demonstration in Phase II.

PHASE II: Develop and deliver a prototype compact CW S-band magnetron source that meets the requirements in the Description.. Test and deliver the prototype to the Naval Research Laboratory along with a complete system interface description, performance specification, test data, and system SWaP estimate.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the technology for Government use. Since the prototype resulting from Phase II is a generic demonstration of the technology, assist in applying the design for specific system applications, such as expendable target emulators. Assist in scaling the device to different frequency bands and higher powers, and by implementing broadband tuning if required.

Since magnetrons already have many non-military applications (e.g., microwave heating, industrial materials processing), the technology resulting from this effort, being more compact and efficient, should find a ready application in these commercial markets.

REFERENCES:

1. Tahir, Imran, et al. “Frequency and Phase Modulation Performance of an Injection-Locked CW Magnetron.” IEEE Transactions on Electron Devices 53, July 2006: 1721-1729. https://ieeexplore.ieee.org/document/1643507

2. Huang, Heping, et al. “Experimental Study on the Phase Deviation of 20-kW S-Band CW Phase-Locked Magnetrons.” IEEE Microwave and Wireless Components Letters, 28 June 2018, pp. 509-511. https://ieeexplore.ieee.org/document/8362996

3. Fujii, Satoshi, et al. “Injection-Locked Magnetron Using a Cross-Domain Analyzer.” IEEE Microwave and Wireless Components Letters, 26 November 2016, pp. 966-968. https://ieeexplore.ieee.org/document/7733137

4. Yang, Bo, et al. “Experimental Study on Frequency Modulation of an Injection-Locked Magnetron Based on Full Wave Voltage Doubler.” 2018 IEEE International Vacuum Electronics Conference (IVEC), pp. 251-251. https://ieeexplore.ieee.org/document/8391497

5. Liu, Zhenlong, et al. “Experimental Studies on a Low Power Injection-Locked Continuous Wave Magnetron.” 2017 IEEE MTT-S International Microwave Symposium (IMS), pp. 451-454. https://ieeexplore.ieee.org/document/8058595

KEYWORDS: Magnetron; Injection Locking; Frequency Shift Keying; Phase Shift Keying; Microwave Heating; Microwave Power

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T016 TITLE: Quantum Emulation Co-processor Circuit Card

TECHNOLOGY AREA(S): Electronics, Information Systems, Sensors

ACQUISITION PROGRAM: Part of a Technology Candidate effort on Next Generation Signal Processing for undersea systems

OBJECTIVE: Develop and demonstrate a computer co-processor circuit card that allows the computer to emulate the behavior of quantum computer gate operations. The performance threshold of the device is 5 quantum bits (qubits).

DESCRIPTION: Because of their natural parallelism, quantum computers show promise for solving difficult optimization problems related to sensor processing. Quantum computers can be realized using devices that have quantum behavior, such as superconductors and trapped ions. However, the quantum states in such devices can be extremely fragile and are easily affected and contaminated by external disturbances. Therefore, extremely isolated environments, such as cryogenic temperature controls or high-vacuum states, are required and place constraints on their use in shipboard environments. It has been shown that analog-circuit-based emulations can be used to effectively reproduce limited quantum parallelism and that by using existing analog and mixed-signal integrated circuit platforms, an alternative to quantum computing could be possible. The Navy seeks a quantum emulation device that can be integrated as a co-processor into shipboard computing platforms.

PHASE I: Develop a concept for a circuit level simulation platform for the quantum emulation device, and design a 5-qubit quantum emulation device circuit card co-processor such that it is capable of interfacing to a computer using a standard interface, either external (such as Universal Serial Bus) or internal (such as PCI Express). Design a computational benchmark that can be used to evaluate the performance of the quantum emulation device. Develop a Phase II plan.

PHASE II: Undertake fabrication and testing of all components and assemble the 5-qubit quantum emulation device. Conduct benchmark evaluation of the 5-qubit quantum emulation device and document in a final report that includes computational performance, power use, and discusses the computer interface.

PHASE III DUAL USE APPLICATIONS: Execute a plan for extension of the co-processor's capability to 10 qubits or more. Offer this extended qubit co-processor card for use in a variety of Navy applications, with specific uses envisioned for sensor processing, but also for application to a number of commercial computing problems. The 5-qubit device could be offered as a low-cost educational tool for teaching quantum computing methods and for testing quantum computing algorithms.

REFERENCES:
1. Hasler, J. "Opportunities in physical computing driven by analog realization." 2016 IEEE International Conference on Rebooting Computing (ICRC), 2016, pp. 1–8. http://hasler.ece.gatech.edu/PhyCompute/Physical_computing_Analog_2016_ICRC.pdf

2. La Cour, B.R. and Ott, G.E. "Signal-based classical emulation of a universal quantum computer." New Journal of Physics, vol. 17, no. 5, May 2015, . https://iopscience.iop.org/article/10.1088/1367-2630/17/5/053017

3. La Cour, B.L., Ott, G.E. and Lanham, S.A. "Using quantum emulation for advanced computation." 2017 IEEE Custom Integrated Circuits Conference (CICC), pp. 1-8. https://www.researchgate.net/publication/319030872_Using_quantum_emulation_for_advanced_computation

4. Cook, S.A. "The complexity of theorem proving procedures." Proceedings of the Third Annual ACM Symposium on Theory of Computing, 1971, p. 151. https://www.cs.toronto.edu/~sacook/homepage/1971.pdf

5. Farhi, E. Goldstone, J. and Gutmann, S. "A Quantum Approximate Optimization Algorithm." arXiv:1411.4028, 2014. https://arxiv.org/abs/1411.4028 (https://arxiv.org/pdf/1411.4028

6. McDiarmid and Reed. "Boolean Satisfiability Solvers and Their Applications in Model Checking." Proceedings of the IEEE, Vol. 103, No. 11, November 2015. https://publik.tuwien.ac.at/files/PubDat_243714.pdf

7. Cheng, S.T. and Tao, M.H. "Quantum cooperative search algorithm for 3-SAT." Journal of Computational Systems Science 73, 2017, pp. 123-136. https://core.ac.uk/download/pdf/82172598.pdf

KEYWORDS: Quantum Emulation; Sensor Processing; Electronics; Co-processor; Analog Computing; Qubit

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T017 TITLE: Twitter Follower / Friend Assessment Tool (TWIFFA)

TECHNOLOGY AREA(S): Human Systems, Information Systems

ACQUISITION PROGRAM: Supports approved FY20 Tech Candidate: Cyber Information Environment for Assessment Nexus (CIEAN)

OBJECTIVE: Develop a capability to detect suspected "bot" (artificial) accounts, using a probabilistic model that should have a greater than 60% accuracy in detecting bots or bot-assisted accounts in Twitter. Desired qualities include ease of use, ability to monitor or flag suspected bots, and to identify, block, or unfollow suspect accounts with explanations available to help the user better understand the bots that they may interact with on Twitter.

DESCRIPTION: This STTR topic seeks development of a web-based tool or app that can be used to assess an account's followership and friends to indicate which of these accounts are likely to be bots or bot-assisted. The tool would require the user to input their credentials; and would then scan the followers and friends for signs that these accounts were bots or bot-assisted according to an internal, proprietary model. The tool would provide situation awareness that will enable users to unfollow or block bots easily or to monitor a bot for a short period to assess its activities. The bot detection model should have an accuracy of greater than 60%. The tool needs to have the capability to assess the threat level of the dormant bots. Once identified, the tool should have the ability to unfollow the bots in batches and to block bots, if the user desires.

PHASE I: Develop and/or improve algorithms for detecting bots in Twitter to develop a model for bot detection, ideally improving or adapting an existing model or set of algorithms. Create a system for acquiring the data on followers and friends from a user's Twitter account and create a simple web-based prototype, suitable for testing and validation. Develop a Phase II plan.

PHASE II: Create a mobile application and a web-based tool from the prototype. Ensure that model results would be exportable to other tools. Develop a user-friendly interface available for testing and evaluation. Include highly desirable built-in help features and guidance capabilities. Develop additional requirements for Phase III through engagement with stakeholders and potential customers.

PHASE III DUAL USE APPLICATIONS: Make the technology available on My Navy Portal. Expansion and development of models and capabilities, including functions to create a database of dormant bots, interoperable with other tools, is desirable. Capabilities to manage the database and deal with the needs of multiple customers would be developed. Both web-based and app tools would be of great utility to corporations, agencies, and individual users.

REFERENCES:
1. @DFRab "#Botspot: Twelve Ways to Spot a Bot." Medium blog, 28 August 2017. https://medium.com/dfrlab/botspot-twelve-ways-to-spot-a-bot-aedc7d9c110c

2. Beskow, David M. and Carley, Kathleen. "Social Cybersecurity: An Emerging National Security Requirement." English Military Review, March-April 2019. https://www.armyupress.army.mil/Portals/7/military-review/Archives/English/MA-2019/Beskow-Carley-Social-Cyber.pdf

3. Brundage, Mike, et. al. "The Malicious Use of Artificial Intelligence: Forecasting, Prevention and Mitigation." Future of Humanity Institute, University of Oxford: Arizona State University, February 2018. https://arxiv.org/ftp/arxiv/papers/1802/1802.07228.pdf

4. Lapowsky, Issie. "NATO Group Catfished Soldiers to Prove a Point about Accuracy." Wired. https://www.wired.com/story/nato-stratcom-catfished-soldiers-social-media/

5. Nimmo, Ben, Czuperski, Maks and Brookie. Graham. "#BotSpot: The Intimidators." @DFRLab blog. https://medium.com/dfrlab/botspot-the-intimidators-135244bfe46b

6. Schreckinger, Ben. "How Russia Targets the U.S. Military." Politico, June 12, 2017. https://www.politico.com/magazine/story/2017/06/12/how-russia-targets-the-us-military-215247

KEYWORDS: C4ISR; Cyber Terrorism; Hybrid; Cyborg; Smart Botnets; Information Operations; Defensive Communication

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T018 TITLE: Intelligent Additive Manufacturing - Metals

TECHNOLOGY AREA(S): Electronics, Information Systems, Materials/Processes

ACQUISITION PROGRAM: "Quality Metal Additive Manufacturing" FNC

OBJECTIVE: To better distribute, monitor, and control the processing energy in a laser metal powder bed fusion additive manufacturing (AM) system by incorporating artificial intelligence (AI) technologies (machine learning (ML), deep neural networks, neuromorphic processing or others) for purposes of real-time process monitoring and control towards producing high-quality, defect-free AM parts with build periods comparable to or shorter than present ones.

DESCRIPTION: Despite the continued progress in AM technologies, AM parts still require several trial and error runs with post-processing treatments and machining to optimize the build, reduce defects and residual stresses, and meet tolerances. AM still lacks a stable process that can produce consistent, defect-free parts on a first time basis due to our inability to reliably predict the optimal trajectory in the multidimensional process parameter space due to the inherent spatiotemporal variability in the process parameter and the chaotic nature of the AM process.

Factors that make AM, and in particular laser powder bed fusion AM, such a challenging manufacturing process are:
1. The smallness of the laser processing volume and rapid melt time when compared to the final part size and build time respectively and the associated process variabilities that result from them.
2. The intrinsic variability of all the powder bed physical (mass, heat capacity, thermal conductivity, emissivity, reflectivity) and chemical (composition, oxidation state, wetting angle) properties that compound to the above-mentioned process variabilities.
3. The large power densities required to process the powder bed and the associated large heating rates and thermal gradients, which when combined with the above-mentioned variability makes it difficult to control the microstructure of the processed volume.
4. The chaotic nature of the AM process that results from combining the small spatial and temporal scales described above with the high energy densities required for melting the powder, which makes it difficult to reliably predict the process trajectory in the multi-parameter process space before the build process starts and virtually impossible to control it in real time.
5. The large number of process parameters (in some cases over 100) that can affect the outcome of the AM process and make it almost impossible to model with physics-based models.
6. The non-symmetric deposition of the processing energy that results from rastering a single laser beam over the powder bed which leads to non-uniform heating/cooling rates, thermal gradients, residual stresses and part defects and distortion.

Most of these challenges can be alleviated by better controlling and distributing the laser energy at and around the melt pool area and/or the processing part surface area combined with real-time monitoring of the same area or beyond and by intelligently linking the laser energy control parameters with the process monitoring sensors to learn and adapt to the continuously evolving environment. Distributing the process energy intelligently at and around the melt pool would help reduce the process variability, the powder bed physical property variability, the heating/cooling rates and the thermal gradients. For example, it might be desirable to pre-heat the powder ahead of the melt-pool without melting it, to reduce the heating rates and thermal gradients later during melting. Doing so might allow processing the powder faster and reducing the build time while at the same time reducing evaporative recoils, ejecta and denudation effects (which induce defects in the final part). Monitoring the temperature profile around the melt-pool area could be used to adjust the distributed laser energy control parameters (power levels and distribution) in real time in a system where the temperature profile is directly linked to the heating source control parameters via an AI processor. Similar improvements could be achieved by intelligently distributing the laser processing energy over the entire part surface while monitoring the temperature evolution over the same area.

AI is starting to be used in several aspects of the AM process. For example, similar to combinatorial chemistry, ML is being used to develop and test new AM alloy systems to quickly identify those alloys with optimal properties for specific application. ML is also being used to correlate AM layer features with computed tomography inspection images to learn how to predict problem areas. In another application, various forms of microstructure data are correlated to process parameters to predict the optimum strategy to build AM parts. All these approaches and others

are important contributions to make quality AM parts.

In contrast with the above-mentioned approaches, this STTR topic seeks innovative solutions that link the actuators controlling the laser energy distribution over the powder bed with the sensors that monitor the temperature distribution and/or other relevant process parameters over the powder bed using a real-time AI controller (ML, deep neural network, neuromorphic processor) for purposes of making better AM parts.

Since only a limited number of sensors will be installed in the intelligent AM system, human assistance will be indispensable during the training period by providing the necessary digital maps of the part microstructure, defect and residual stress distributions as well as performance parameters such as surface roughness, strength, stiffness, fatigue life or any other relevant training data set.

PHASE I: Define, design and develop a concept for an intelligent AM (IAM) system for laser metal powder bed fusion or modify a conventional one to make it intelligent. The IAM system design will include subsystems to: (1) distribute the laser energy over the powder bed and provide a list of the control parameters; (2) monitor the response of the powder bed and provide a list of the sensed parameters (temperature being the main preferred monitored parameter); (3) generate auxiliary digital training data and a list of the different physical measurands; and (4) link the control parameters to the monitoring sensors values and auxiliary digital data via an artificial intelligent processor for training and operation purposes. Finally, the performer will start acquiring parts of the IAM system, developing the software and graphical user interface (GUI) and will provide a validation plan with a list of planned coupons and tests. Due to the limited funds available in a Phase I STTR contract, the performer will limit the validation tests to just those subsystems, coupons, and tests consistent with the resources available. For the Phase I Option, the performer will continue progress towards IAM system parts and refining the design of the system based on validation test results. Develop a Phase II plan.

PHASE II: Complete the purchase of all the components necessary for the development of the IAM system or for modification of a commercial one. Start assembling the unit and developing the controls software and GUI. Perform validation tests after completing all the training exercises required for the IAM system to learn how to make quality coupons. To further validate the performance of the system, identify a challenge part between the performer and the Navy team and demonstrate that the IAM system can fabricate two of them, one for destructive microstructural analysis and another for mechanical testing. The success criteria consists in making coupons or parts with less defects or distortions and/or better control of the microstructure than the same coupon or part made by a state of the art AM platform but without AI.

PHASE III DUAL USE APPLICATIONS: Support the Navy in transitioning the IAM system for Navy use. Working with the Navy, integrate the IAM system into a Navy platform for evaluation to determine its effectiveness. Define the IAM system integration strategy and test plan for qualification.

Commercial applications of IAM include almost all commerce sectors such as: aerospace, shipping, transportation, rail, automobile and medical. Applications include almost all technology areas such as: engine parts, structural parts, mechanical or electrical parts, medical prosthetics, and tooth implants. Finally, material applications focus is on metals.

REFERENCES:
1. Alhart, Todd. "3D Printing: Just Press Print: GE Is Building A 3D-Printing Vending Machine For The Jetsons." GE Reports, Apr 10, 2017. https://www.ge.com/reports/just-press-print-ge-building-3d-printing-vending-machine-jetsons/

2. Zhua, Z., Anwer, N., Huang, Q., and Mathieu, L. "Machine learning in tolerancing for additive manufacturing." CIRP Annals, Vol 67, Issue 1, 2018, pp. 157-160. https://www.sciencedirect.com/science/article/pii/S0007850618301434#!

3. Scime, L. and Beuth, J. "Anomaly detection and classification in a laser powder bed additive manufacturing process using a trained computer vision algorithm." Additive Manufacturing, Vol 19, Jan 2018, pp. 114-126.

https://www.sciencedirect.com/science/article/pii/S221486041730180X

4. Scime, L. and Beuth, J. “Using machine learning to identify in-situ melt pool signatures indicative of flaw formation in a laser powder bed fusion additive manufacturing process.” Additive Manufacturing, Vol 25, Jan 2019, pp. 151-165. https://www.sciencedirect.com/science/article/pii/S2214860418306869

5. Zielinski, Peter (ed). How Machine Learning Is Moving AM Beyond Trial and Error (Originally titled 'Where AM Meets AI'). Additive Manufacturing. https://www.additivemanufacturing.media/articles/how-machine-learning-is-moving-am-beyond-trial-and-error

6. Hu, D. and Kovacevic,R. “Sensing, modeling and control for laser-based additive manufacturing.” International Journal of Machine Tools & Manufacture, 43 (2003), pp. 51–60. http://www.sciencedirect.com/science/article/pii/S0890695502001633

7. Everton, S.K., Hirsch, M. Stravroulakis, P, Leach, R.K., and Clare, A.T. “Review of in-situ process monitoring and in-situ metrology for metal additive manufacturing.” Materials and Design, 95 (2016), pp. 431–445. http://www.sciencedirect.com/science/article/pii/S0264127516300995

8. Spears, T.G. and Gold, S.A. “In-process sensing in selective laser melting (SLM) additive manufacturing.” Integrating Materials and Manufacturing Innovation 2016 (a Springer Open Journal). DOI 10.1186/s40192-016-0045-4. https://link.springer.com/article/10.1186/s40192-016-0045-4

KEYWORDS: Artificial Intelligence; AI; Machine Learning; ML; Neural Networks; Additive Manufacturing; Laser Based Powder Bed Fusion; Process Monitoring Sensors

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T019 TITLE: Employing Machine Learning to Accelerate High Temperature Corrosion-Resistant Materials Design

TECHNOLOGY AREA(S): Battlespace, Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: Shipboard Gas Turbine Marinization Package for Higher Temperature, Higher Pressure Operations

OBJECTIVE: Utilize literature materials data and research data to develop models/algorithms for machine learning (ML) that will detect data patterns and characteristic trends, learn from the accumulated data, and evolve distinguishing characteristics between calcium-magnesium-alumino-silicate attack (CMAS) and calcium sulfate hot corrosion with and without the influence of sea salt in order to develop resistant coatings to CMAS and calcium sulfate hot corrosion.

DESCRIPTION: Calcium oxide is known to react with chromium contained in MCrAlY (M=Ni, Co) alloys and nickel-based superalloys to form a low-melting (1,100°C) calcium chromate. The reactivity of gamma-NiAl and gamma-Ni-based NiCoCrAlY alloys with CaO at 1,100°C produced multi-layer scales of Al_2O_3 and calcium aluminates ($xCaO–yAl_2O_3$). Increasing alloy chromium content only enhances corrosion severity. The reaction of two-phase beta-gamma MCrAlY alloys with CaO progressed according to two distinct mechanisms. During the initial stage, formation of a liquid calcium chromate led to the rapid consumption of the Cr-rich gamma-phase. The extent of degradation was particularly important for a single-phase gamma-composition, and was significantly reduced by increasing the alloy beta fraction. In the subsequent stage, a continuous Al_2O_3 layer was established at the base of the scale, which led to a much lower oxidation rate. Additions of Al_2O_3 or SiO_2 decreased the CaO

reactivity due to the formation of aluminates or silicates. CMAS degradation is both thermochemical and thermomechanical to thermal barrier coatings (TBCs). Molten CMAS (1,150-1,240°C) penetrates the TBC pores and freezes a given depthwithin the TBC. Early research also showed that CaSO4 attacked yttria, destabilizing zirconia-based TBCs. Upon cooling, the glass and reaction product phases solidify and the void structure that is utilized to reduce thermal conductivity and provide the strain compliance is lost leading to TBC delamination. Recent advances in computer power, coupled with materials databases and informatics, modeling and simulation, and experimental validation of models will enable accelerated discovery and discrimination of degradation mechanisms leading to the creation and development of new materials for mitigation corrosion. These informatic tools will facilitate Integrated Computational Materials (Science and Engineering) (ICMSE/ICME)) to reliably predict the composition and behavior of new materials. This STTR topic seeks to develop the tools that will allow usage of various open and closed materials data sources to provide more conclusive outcomes for mitigation of degradation of propulsion components. This research would develop algorithms from research of both mechanisms and utilize ML to detect chemical patterns that distinguish between the two corrosion mechanisms and lead to efforts to develop corrosion-resistant coatings.

PHASE I: Search and secure literature that pertains to calcium sulfate hot corrosion and CMAS attack in propulsion systems. Identify key attributes/conditions, variables of each corrosion mechanisms and material (alloy or coating), material system that will help distinguish differences in the two mechanisms, which will help develop experiments to validate and/or modify the models. Insert the literature databases and experimental results into a data analytical program to incorporate ML. Boundary conditions and variables that need to be considered for entry: include the alloy/materials type, the chemical composition of the alloy, materials, and/or coatings, corrosion and/or oxidation activity, fatigue, interdiffusion resistance, creep resistance to phase transitions, the coefficient of thermal expansion compatibility, durability, stress, temperature stability, etc. Assemble and assess a suite of modeling tools to predict processing outcomes and desirable materials properties. Ensure that the selected modeling tools have a history that the modeling results represent gas turbine field (ship and/or aero) conditions, and provide an accurate mathematical representation of the engineering principles and relationships that predict materials' behavior in Navy ship or aero gas turbines. Create an informatics-based framework that will be able to assess the type and quality of the databases required by ICME and other computational programs that can also work with materials modeling and simulation tools. Develop a Phase II plan.

PHASE II: Using the outline of a framework created in Phase I, expand the informatics-based program to determine the quality of different database sources calcium sulfate hot corrosion and CMAS attack in propulsion systems. Continue experiments performed under the range of field conditions identified during Phase I to further populate the data inputs to the ML framework. Validate or modify models as needed to summarize general mechanistic trends and incorporate the complexity in data using, for example, linear regression and logistic regression focus on attribute relationships. Ensure that the discriminating database program is able to perform nonparametric statistical tests for a rapid section-wise comparison of two or more massive data sets, and repair errors in databases. Ensure that the program provides a means for capturing, sharing, and transforming materials data into a structured format that is amenable to transformation to other formats for use by ICME and other computational programs and modeling and simulation methods. Demonstrate the functionality of this framework to distinguish between calcium sulfate hot corrosion and CMAS attack in propulsion systems with or without the presence of sea salt. Ensure that the framework is able to assist in determining materials resistant to CMAS attack (including overlay/diffusion and thermal barrier coatings (TBCs)). The small business should be working with an engine original equipment manufacturer (OEM) to assist in determining discriminating variables for hot corrosion and CMAS.

PHASE III DUAL USE APPLICATIONS: Engage with the Government and/or public, commercial, company, or professional technical societies that retain materials databases. Interface with a software company that promotes and delivers materials computational programs to explore and develop an integration pathway for the database discriminating program with their software. The outcome of this technology development program will be a commercial suite of informatics-derived tools that can will be able to reliably analyze and discriminate various sources of materials databases to optimize the capability for materials prediction. Transition the material production methodology to a suitable industrial material producer. The ICME code needs to be transitioned to the commercial entity for potential incorporation of a more comprehensive ICME code. Commercialize the material for use in DoD and commercial markets. The commercial aviation industry would benefit from this technology when flying in sand-ingested areas such as the Middle East and would provide some added protection for aircraft against the effects of

volcanic ash as there are similarities chemically with CMAS, volcanic ash, and calcium sulfate-induced hot corrosion.

REFERENCES:
1. Cowles, B. Backman, D. and Dutton, R. "Verification and Validation of ICME Methods and Models for Aerospace Applications." Integrating Materials and Manufacturing Innovation, 1, 16 (2012Verification_and_validation_of_ICME_methods_and_models_for_aerospace_applications/fulltext/027a24e00cf2195fcb29fdd0/Verification-and-validation-of-ICME-methods-and-models-for-aerospace-applications.pdf

2. Shifler, D,A, "The Increasing Complexity of Corrosion in Gas Turbines." 2019 Turbomachinery Technical Conference & Exposition, June 17-21, 2019, Phoenix, AZ. Paper GT2019-90111. https://gasturbinespower.asmedigitalcollection.asme.org/article.aspx?articleid=2656598

3. Shifler, D.A. and Choi, S.R. "CMAS Effects on Ship Gas-Turbine Components/Materials." 2018 Turbomachinery Technical Conference & Exposition, June 11-15, 2018, Lillestrøm, Norway. Paper GT2018-75865. https://proceedings.asmedigitalcollection.asme.org/proceeding.aspx?articleid=2700469

4. Krämer, S., Faulhaber, S., Chambers, M., Clarke, D.R., Levi, C.G., Hutchinson, J.W. and Evans, A.G,." Mechanisms of cracking and delamination within thick thermal barrier systems in aero-engines subject to calcium-magnesium-alumino-silicate (CMAS) penetration" Mater. Sci. Engr. A, 490 (2008). "

KEYWORDS: CMAS; Hot Corrosion; Calcium Sulfate; Propulsion Materials; Informatics; Machine Learning; Material Databases

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T020 TITLE: Non-intrusive Diagnostics to Quantify Interactions between High-speed Flows and Hydrometeors

TECHNOLOGY AREA(S): Air Platform, Sensors, Weapons

ACQUISITION PROGRAM: ONR Hypersonics D&I Program

OBJECTIVE: Develop and demonstrate non-intrusive diagnostics to: (1) quantify the spatiotemporal evolution of raindrops, ice crystals (clouds), and snow during high-speed aerobreakup; and (2) simultaneously quantify aerobreakup effects on the surrounding gas parameters such as velocity, composition, and thermodynamic state variables.

DESCRIPTION: The effect of adverse weather on hypersonic flight conditions is not well understood. Hydrometeors such as rain, hail, snow, and ice disrupt the flow field and impinge on the vehicle surface. Because the impact forces approximately scale as the velocity squared, hypersonic vehicles are at greater risk of damage [Ref 1]. The modeling and understanding of weather encounters are challenging because the vehicle flow field alters the impact boundary conditions as a function of time. Since existing computational models cannot capture these complex, multiscale finite-rate processes, weather effects are currently estimated via component testing and empirically derived correlations.

At altitudes below 4 km, rain is the most prevalent weather encounter. When raindrops are suddenly exposed to a high-speed gas flow, they deform and shatter due to shear-induced entrainment and/or interfacial flow instabilities. This phenomenon, known as aerobreakup, increases in intensity with Weber number. Aerobreakup experiments have typically been performed in shock tubes at moderate supersonic Mach numbers, $M < 2$. With the exception of recent laser-induced florescence (LIF) measurements [Ref 2], aerobreakup measurements strictly use path-integrated

visualization techniques that have led to erroneous physical interpretations [Ref 3]. Weather effects are not limited to low-altitude flight since clouds such as cumulonimbus can reach altitudes exceeding 20 km. Prolonged exposure to high-altitude solid hydrometeors can produce surface roughness that initiate the flow instabilities responsible for laminar-turbulent boundary layer transition.

The development of improved numerical tools requires validation against high-quality experimental data that captures both the spatiotemporal evolution of the hydrometeors during aerobreakup and the effect of the aerobreakup on the surrounding flow field. Such measurements are currently unavailable in ground-test facilities due to the lack of advanced non-intrusive diagnostics. Recent advances in instrumentation and measurement techniques such as high-speed intensified camera, tunable pulsed-burst lasers, and tomographic reconstruction algorithms [Refs 4-7] can be leveraged to develop improved instrumentation for quantitative assessment of weather effects on high-speed flows. Four-Dimensional X-ray imaging [Ref 8] recently used to study an optically complex spray seems promising to provide measurements of droplet structures and liquid density in the near field.

KEY REQUIREMENTS OF THE INSTRUMENTATION SUITE AND PARAMETERS:
• The non-intrusive instrument (or suite of instruments) needs to provide three-dimensional, time-resolved measurements of the aerobreakup process including the atomization of small droplets.
• The non-intrusive instrument (or suite of instruments) needs to provide gas phase measurements (velocity, state variables and composition) for freestream Mach numbers above 3 and conditions corresponding to altitudes below 4 km for raindrops and up to 20 km for ice crystals (present in clouds).
• Primary droplet diameters of approximately 0.3 to 3 mm and secondary droplet diameters of 0.03 to 0.2 mm need to be resolved by the instruments. Ice crystals can be significantly smaller (1 to 50 microns). Therefore, the instrument suites must provide an adequate range of magnifications and spatial resolutions to resolve the wide range of relevant spatial scales.
• Ideally, the instrument must be suitable for measurements with solid particles used as surrogates for hydrometeors (with diameters between 0.03 and 3 mm).
• The non-intrusive instrument (or suite of instruments) needs to operate in various types of large-scale ground-test facilities such as shock tubes, ballistic ranges (light-gas gun), and wind tunnels.
• Ideally, the non-intrusive instrument (or suite of instruments) must be portable (on a cart or set of carts) for usage in multiple facilities.

PHASE I: Design a non-intrusive instrument or a suite of non-intrusive instruments to quantify the spatiotemporal evolution (three-dimensional, time-resolved measurements) of raindrops, ice crystals (clouds), and snow during high-speed aerobreakup, and concurrently quantify aerobreakup effects on the surrounding gas. (Note: Preferably, benchtop demonstrations of the instrument concepts shall occur in a shock tube or other facilities producing a relevant environment.) Develop a Phase II plan.

PHASE II: Refine and optimize the instrument and/or suite to produce a viable prototype. Demonstrate the performance of the prototype in a relevant ground test facility such as a ballistic range (light-gas gun), wind tunnel, or shock tube. Produce relevant data to quantify the spatiotemporal evolution of raindrops, ice crystals (clouds), and snow during high-speed aerobreakup and the effect of the aerobreakup on the surrounding gas. Assess interactions with single and multiple droplets (corresponding to relevant precipitation rates).

PHASE III DUAL USE APPLICATIONS: Private companies have demonstrated interest in commercial hypersonic flight. It will be important to assess the impact of weather effects on commercial systems. The developed instrumentation suite could be used in high-speed ground test facilities operated by the commercial sector.

REFERENCES:
1. Moylan, B., Landrum, B. and Russell, G. "Investigation of the Physical Phenomena Associated with Rain Impacts on Supersonic and Hypersonic Flight Vehicles.", Procedia Engineering, 2013, pp. 223-231. https://www.sciencedirect.com/science/article/pii/S1877705813009326/pdf?md5=068388223a25f6b1823be3307a1b8d06&pid=1-s2.0-S1877705813009326-main.pdf

2. Theofanous, T.G., Mitkin, V.V., Ng, C.L., Chang, C.H., Deng, X. and Sushchikh, S. "The physics of aerobreakup. II. Viscous liquids", , Physics of Fluids, 2012. https://aip.scitation.org/doi/full/10.1063/1.3680867

3. Moylan, B. “Raindrop Demise in a High-Speed Projectile Flowfield: A Dissertation.” University of Alabama in Huntsville, 2010. https://www.worldcat.org/title/raindrop-demise-in-a-high-speed-projectile-flowfield-a-dissertation/oclc/673870343

4. Thurow, B., Jiang, N. and Lempert, W. "Review of ultra-high repetition rate laser diagnostics for fluid dynamic measurements.", Measurement Science and Technology, 2013. https://iopscience.iop.org/article/10.1088/0957-0233/24/1/012002/meta

5. Wellander, R., Richter, M. and Alden, M. "Time-resolved (kHz) 3D imaging of OH PLIF in a flame.", Experiments in Fluids, 2014. https://link.springer.com/article/10.1007/s00348-014-1764-y

6. Roy, S., Jiang, N., Hsu, P., Slipchenko, M., Felver, J., Estevadeordal, J. and J. Gord. "Development of a three-legged, high-speed, burst-mode laser system for simultaneous measurements of velocity and scalars in reacting flows." Optics Letters, 2018. https://www.osapublishing.org/ol/viewmedia.cfm?uri=ol-43-11-2704&seq=0

7. Halls, B., Hsu, P., Jiang, N., Legge, E., Felver, J., Slipchenko, M., Roy, S., Meyer, T. and Gord. J. "kHz-rate four-dimensional fluorescence tomography using an ultraviolet-tunable narrowband burst-mode optical parametric oscillator.", Optica, 2017. https://www.osapublishing.org/optica/abstract.cfm?uri=optica-4-8-897

8. Halls, B.R., Rahman, N., Meyer, T.R., Lightfoot, M.D.A., Slipchenko, M.N, Roy, S. and Gord, J.R. "Four-Dimensional X-ray Imaging of Multiphase Flows." Imaging and Applied Optics, 2018. https://www.osapublishing.org/abstract.cfm?uri=LACSEA-2018-LM3C.2

KEYWORDS: Weather Effects; Multiphase Flows; Laser Diagnostics; Tomography; Hypersonics; High-speed Flows; Ground Test

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T021 TITLE: Hybrid Packaging of Cryogenic Electronics and Photonic Technologies

TECHNOLOGY AREA(S): Electronics, Information Systems, Sensors

ACQUISITION PROGRAM: IARPA Super Cables and ongoing Darpa MTO whole wafer Multichip modules programs, and CSTG4

OBJECTIVE: The objective of this effort is to originate and begin to mature a scalable heterogeneous packaging plan which results in extreme energy efficiency information transfer at high clock rates and low bit error rate of digital data between superconducting and photonic technologies, each at 4K, in a mechanically robust package that withstands repeated thermal cycling from 300K without performance degradation.

DESCRIPTION: Photonic interconnect has become the dominant technology for long-haul data networks, due to its unmatched distance bandwidth product. As data rates continue to increase, photonic interconnect is being incorporated into room temperature data networks within the equipment racks and even into the multi-chip module packages. This success strongly suggests considering using photonics to move the data created by cryogenic digitizers and sensors up to room temperature and into commercial off-the-shelf (COTS) processors. However, in order for photonic interconnects to become the dominant technology for this application, substantial issues must be addressed. These include the requirements for extreme energy efficiency in getting photons on and off the 4K

photonic integrated circuit (PIC) chip and for packaging compatibility with the cryogenic electrically based Very-large-scale integration (VLSI) chips, most of which are based on some form of superconducting device. Most of these superconducting circuits also require magnetic shielding and most shields work by fully encapsulating the circuits, leaving little access for quite rigid and fragile fibers. Moreover, because the power levels required by silicon complementary metal-oxide semiconductor (CMOS) are 4 orders of magnitude larger than needed by niobium digital devices, photonic noise issues that are not problematic at room temperature may have to be addressed when the signal power is drastically reduced, as must occur for low temperature use. Moreover, high frequency circuit operations are a hallmark advantage of superconducting electronics. Thus the packaging that allows transfer of such high speed signals to the PIC requires intimate contact in the photonic to electrical bump bonds to be developed.

Today at 4K isothermal electrical data transport is fully reliable at serial rates above 100 Gbps when the signal path stays on the same chip or moves to an adjacent one through bump bonds and wiring on a Si multi-chip module. The energy cost of such transfer is measured in the aJ/bit. However, electrical data connections between a cryogenic (4K) receiver or processor and one at room temperature introduce significant parasitic heat loads (up to 30mW for 3 bit 40Gps, low BER data flow) given the 4 to 300K thermal gradient and the fundamental physics that connects thermal and electrical conductivity. Thus, the Office of Naval Research (ONR) and the Intelligence Advanced Research Projects Activity (IARPA) are working on high energy efficiency electro-optical modulators/lasers to replace these electrical conductors with optical links. But for them to be successful, the required co-packaging should be considered from the onset, not attempted only at the end. That is the goal of this topic. In future large-scale superconducting circuits, it is already clear the functional blocks will be fabricated on individual chips and those chips pretested. The successful ones will then be flip chip bonded face down on Si multi-chip modules (MCM) which are expected to grow to 300 mm diameter. To function properly, each of the superconducting chips needs to exist where there is a net magnetic field under 4 micro-T in strength. This field will be the sum of the external environmental field (e.g., Earth's) and those generated by currents internal to the vacuum vessel, such as those of the power lines feeding the circuits. To date, that shielding is created passively by closed shields of high permativity magnetic materials around each superconducting processing chip. Thus when providing photonic data links, it is critical to consider the photonic access to the circuits within the magnetic shields as well as to reduce the optical losses in the fiber to waveguide connections. (Any scattered photons will contribute to the parasitic heat load which must be less than the electrical one for photonics to be competitive compared to all electrical data link solutions.)

For small electronics assemblies, it may be feasible to electrically conduct the digital results to the outside edges of the MCM and from there into a specific electro-optical (EO) conversion chip that then launches the light into a fiber. Grating couplers use vertical access for the fiber paths, which may well maximize the chance of breakage in a large area/number of fibers assembly, and currently have about 1 dB of insertion loss. Permanently attached, taped fibers potentially offer lower insertion loss if their movement during epoxy curing, tendency for irreproducible coupling performance, and extreme fragility can be resolved. Both of these methods have problems during cool down with shifting of the alignment of the fiber core with a PIC waveguide. Alignment of arrayed edge couplers after cooling may be more appealing because the planarity of the array can match the array of waveguide inputs. However, no reliable method for optimizing the cold alignment has been invented. Moreover, how this method could scale is totally undefined since the interior superconducting chips currently lack any exposed edges and any mounting areas for attocube-like fiber array aligners.

In all cases, the threshold photonic insertion loss tolerable is 0.2 dB at data rates of 40 Gbps and the goal is to reach below 0.1 dB. The optical alignment and attachment procedures must be robust against thermal cycling (a minimum of 2,000 thermal cycles between 300 to 4K) and vibration of the entire assembly, whether arising from the motion of the deployment platform or created by the periodic motion of a piston within the cryo-cooler compressor. The ability to scale to whole wafer scales and accommodate an arbitrary ratio of superconducting processor area to the numbers of photonic cable leads is desirable. The Navy envisions eventual compatibility with a system geometry where MCM are treated as circuit cards. In this imagination, each MCM is attached on one edge to a thermal bus and staggered about the axis in a deck of card geometry. The perpendicular distance between MCM "cards" must be minimized if the total system density is to be high. How the fibers can attach is then even less clear. Such future enhancements should be compatible with near term choices for the MCM geometry. Phase I proposals must define a plan of attack to demonstrate a packaging strategy for data transmission between a cryogenic superconducting digital integrated circuit (IC) and a room temperature environment. Proposers should clarify the blend of work on total/local magnetic shields versus low loss optical fiber attachment and alignment, all in an MCM context. All

blends ranging from 100/0 to 0/100 are acceptable in Phase I. Both sides of this problem must have been worked by the end of Phase II, possibly via a merger of funded efforts in Phase II. A clear Gannt chart of the proposed Phase I Base and Option tasks is essential and should indicate whether the company or non-profit is responsible for each task. Discussion of test plans is desirable. Any need for government furnished property (GFP) should be carefully noted in the proposal.

PHASE I: The Phase I base effort needs to work the efforts defined in the original proposal so as to significantly lower the risk of success if a follow--on award is offered. The provisional Phase II plan delivered at the end of the Base period will determine whether each performer wins a Phase II. If selected, the Phase I Option will then be awarded. It should provide continuity until the Phase II begins and further reduce technical risk of the proposed overall approach. For performers working only one side of the technology in Phase I, Phase II must contain a plan to add the other.

PHASE II: In the Phase II Base period, design, build, and demonstrate a working assembly consisting of a photonically connected (e.g., to the outside world) superconducting MCM at least 10 x 10 mm (preferably larger) in area and having at least 2 distinct magnetically shielded superconducting chips and 2 photonic input/output (IO) links to the MCM. Some interdependence of the functionality of the 2 technologies needs to be demonstrated (e.g., a fiber provides an activation signal to the superconducting chip and its measurement result is conveyed over fiber to room temperature). The insertion losses and heat loads of the design should be quantified by the end of the Base effort. The first Option, if exercised, should further reduce the technical risk to the system performance of the approach taken.

PHASE III DUAL USE APPLICATIONS: As photonic interconnects become the norm at room temperature in data centers and other computationally dense platforms, they need a way to connect without waveform distortion ("robustly") with electronics chips. Even if the systems are run near room temperature, many of the issues are common with those in this STTR topic. These include the need to fit into 3D packages (with no large empty area over the chips, densely placed face down packaging to attach to bump bonds), discrepant wiring line widths/photonic mode diameters, and differential thermal contraction during thermal cycling. Thus, the work in this effort is expected to have applicability in commercial room temperature settings, e.g., within data centers. At low temperatures, success in programs such as IARPA's Super Cables could make sensor array readout for astro-physics and particle physics, where FDM is already the norm, another possible application area. Within the Government, the interests are primarily centered around high-performance computing and radio frequency (RF) digital signal processing. As a subset of the latter, the ability to do analog signal processing within 4K digital receivers is an attractive possibility. Most of these applications are long term, compatible with the philosophy of the STTR program.

REFERENCES:
1. Narayana, S., Semenov, V.K., Polyakov, Y.A., Dotsenko, V. and Tolpygo, S.K. "Design and testing of high-speed interconnects for superconducting multi-chip modules." Superconductor Science And Technology, 25 (2012). https://iopscience.iop.org/article/10.1088/0953-2048/25/10/105012

2. Donley, E.A., Hodby, E., Hollberg, L. and Kitching, J. "Demonstration of high-performance compact magnetic shields for chip-scale atomic devices." REVIEW OF SCIENTIFIC INSTRUMENTS 78, 083102, 2007, DOI: 10.1063/1.2767533. https://pdfs.semanticscholar.org/47ac/742de238c0ece5e91ff7d12c515b9173eb60.pdf

3. Bardalen, Eivind, Akram, Muhammad Nadeem, Malmbekk, Helge and Ohlckers, Per. "Review of Devices, Packaging, and Materials for Cryogenic Optoelectronics." Journal of Microelectronics and Electronic Packaging: October 2015, Vol. 12, No. 4, pp. 189-204. https://www.researchgate.net/publication/287973522_Review_of_Devices_Packaging_and_Materials_for_Cryogenic_Optoelectronics

4. Cardenas, Jaime, Poitras, Carl B., Luke, Kevin, Luo, Lain-Wee, Morton, Paul Adrian and Lipson, Michal. "High Coupling Efficiency Etched Facet Tapers in Silicon Waveguides." IEEE Photonics Technology Letters, Vol. 26, No. 23, December 1, 2014. https://ieeexplore.ieee.org/abstract/document/6895281

5. Son, Gyeongho, Han, Seungjun, Park, Jongwoo, Kwon, Kyungmok and Yu, Kyoungsik “High-efficiency broadband light coupling between optical fibers and photonic integrated circuits.” DeGuyter, Vol. 7, Issue 12, October 20, 2018. DOI: https://doi.org/10.1515/nanoph-2018-0075
https://www.degruyter.com/view/j/nanoph.2018.7.issue-12/nanoph-2018-0075/nanoph-2018-0075.xml

KEYWORDS: Magnetic Shielding; Flip Chip Bonding; Minimal Insertion Loss; Multi-chip Modules; Fiber to Photonic Wave Guide Launches; Coefficient of Thermal Expansion

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T022 TITLE: Measurements of Wall-Shear-Stress Distribution in Hypersonic Flows

TECHNOLOGY AREA(S): Air Platform, Sensors, Weapons

ACQUISITION PROGRAM: ONR Hypersonics D&I Program

OBJECTIVE: Develop, calibrate, and demonstrate a non-intrusive method to measure wall-shear-stress distributions in hypersonic ground test facilities.

DESCRIPTION: The ability to accurately predict the state of boundary layers and regions of separated flows is a key consideration for the design of hypersonic vehicles [Ref 1]. The state of the boundary layer affects the surface skin friction, which, when integrated, impacts predictions of flight performance through lift, drag, and moment coefficients [Ref 1]. In addition, flow separation influences the effectiveness of control surfaces and consequently the vehicle control authority. Therefore, accurate measurements of wall-shear-stress are paramount to predicting the characteristics of boundary layers and the performance of hypersonic vehicles. In addition, the availability of wall-shear-stress distribution measurements in hypersonic ground test facilities is highly valuable to improve and validate the computational tools needed to extrapolate ground test measurements to flight conditions.

Reliable sensors suitable for large-scale hypersonic ground test facilities have been developed and demonstrated over recent years for one-[Ref 2] and two-component wall-shear-stress measurements [Ref 3]. However, to obtain two-dimensional surface information using traditional sensors, one must use a large number of point-measurements that are individually attached/machined onto the surface. This process can be time-consuming and expensive. Ultimately, the number of sensors employed limits the spatial resolution of shear stress data, thereby limiting the usefulness of sensor data for complex flow fields. Oil flow visualization [Ref 4] is useful in obtaining near-wall streamlines, but cannot provide quantitative values of the skin-friction distribution. Quantitative methods such as shear-sensitive liquid crystals have been applied in high-speed flows [Ref 5], but its suitability for hypersonic wind tunnels remains uncertain because of spurious inputs due to variations in surface temperatures. This STTR topic is seeking a technique to quantitatively measure the skin friction distribution on the surface of hypersonic wind tunnel test articles.

KEY REQUIREMENTS
• Provides 2D measurements of the skin-friction distribution (magnitude and direction)
• Non-intrusive technique compatible with standard hypersonic wind tunnel test articles such as a sensing coating that can be applied on the surface
• Allows measurement on smooth curved surfaces (such as conical geometries)
• Spatial resolution better than or equal to 5 mm x 5 mm
• Temporal resolution greater than or equal to 1 kHz
• Wide dynamic range and high sensitivity to allow simultaneous measurements in regions of high shear (shear-stress magnitude ~ 250 Pa) and regions of separated flows (zero shear-stress or low magnitude with reversed direction)
• Intrinsic insensitivity to spurious inputs such as surface temperature and pressure or accurate correction of spurious

inputs via calibration and/or input measurements

PHASE I: Develop a methodology for measuring the wall-shear-stress distribution at Mach 5 or above and surface temperatures up to 395K or above. Demonstrate the suitability of the measurement technique via benchtop experiments. Develop concepts for calibration and characterization of sensitivity to spurious inputs such as pressure and temperature. Develop a Phase II plan.

PHASE II: Further develop the methodology for measuring wall-shear-stress distribution globally and instantaneously at Mach 5-7 and surface temperatures up to 493K or above on canonical geometries such as flat plates and cones. Develop and validate a calibration methodology and characterize sensitivity due to extraneous inputs such as temperature and pressure. Validate measurements by comparing results with theory and previously published results. Validate the global measurements with several discrete shear stress sensors situated along the centerline or ray of a flat plate or cone. By the end of Phase II, the technology should be TRL 5.

PHASE III DUAL USE APPLICATIONS: Further refine the measurement technology to increase the accuracy, range of conditions to higher Mach numbers, and dynamic pressures. Develop commercial system that can be marketed and deployed in large-scale ground test facilities operated by commercial space and aviation companies and the Federal Government.

REFERENCES:
1. Bertin, J.J. "Hypersonic aerothermodynamics." Education Series, American Institute of Aeronautics and Astronautics, Inc., Washington, D.C., U.S.A., 1st ed., 1994. https://www.amazon.com/Hypersonic-Aerothermodynamics-AIAA-Education-Bertin/dp/1563470365

2. Meritt, R.J., Schetz, J.A., Marineau, E.C., Lewis, D.R., and Daniel, D.T. "Direct Skin Friction Measurements at Mach 10 in a Hypervelocity Wind Tunnel." Journal of Spacecraft and Rockets, 54(4) 871-882, 2017. https://arc.aiaa.org/doi/full/10.2514/1.A33657

3. Meritt, R.J., Schetz, J.A., Marineau, and Morauru, G. "Direct Skin Friction Measurements at Mach 14 in AEDC Hypervelocity Wind Tunnel 9." AIAA Paper 2017-3982. https://arc.aiaa.org/doi/abs/10.2514/6.2017-3982

4. Leidy, A.N., Neel, I.T., Bowersox, R.B.W. and Schmisseur, J.D. "Influence of Perturbations on 3-D Hypersonic Shock / Laminar Boundary Interactions." AIAA Paper 2017-1685. https://arc.aiaa.org/doi/abs/10.2514/6.2017-1685

5. Zhao, J. "Measurement of Wall Shear Stress in High Speed Air Flow Using Shear-Sensitive Liquid Crystal Coating." Sensors, 18, 1605, 2018. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5981805/

KEYWORDS: Hypersonic Flow; Wall-shear-stress Distribution; Ground Testing; Non-intrusive; Diagnostics; High-speed

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T023 TITLE: Harvesting Thermal Energy for Low Power Arctic Sensors and Data Communications

TECHNOLOGY AREA(S): Battlespace, Sensors

ACQUISITION PROGRAM: Arctic Mobile Observing System (AMOS) Innovative Naval Prototype (INP)

OBJECTIVE: Develop a survivable capability to harness the Arctic Ocean/Air thermal gradient and provide low power for persistent unmanned Arctic sensors and data communications via Arctic Ocean buoys.

DESCRIPTION: The Navy runs environmental models to provide forecasts for operational use in the Arctic region. The Navy continues to invest in improved predictive capabilities for the Arctic region that will enable more skillful forecasts from weeks to months. A key challenge to modeling the Arctic is the lack of meteorological and oceanographic observational data. Improvements in environmental characterization and predicative capabilities will depend on increasing measurements of the region [Ref 1].

As the Navy continues to implement a persistent unmanned presence in the Arctic Ocean to achieve observational goals, new methods to generate power on site are required in order to sense the environment and communicate data for assimilation into operational models. Currently, unmanned Arctic buoys and platforms carry batteries that take up weight and volume. Power generation via solar and wind energy is available but compromised in the Arctic due limited sunlight hours and harsh winds that require large, expensive structures for survivability. Developing an innovative capability that uses the thermal gradient between Arctic Air and Ocean to generate in-situ power will allow the Navy to harvest an existing energy resource and improve persistence of observations in the region.

Thermal gradients between air and ocean surfaces in the Arctic, expressed as temperature differences and heat flow, can be directly converted into electrical energy [Ref 2]. While there are many factors that affect the entire Arctic Energy Budget, air temperature is a measure of the amount of energy held in the air, while ocean surface temperature is a measure of the amount of solar energy absorbed or reflected in the upper surface. Arctic air temperatures vary widely from -50 to 32°C while Arctic Ocean surface temperatures vary less with yearly averages between -1.8 to 3°C [Ref 3]. These thermal gradients are adequate to generate low power levels.

The Navy seeks an innovative prototype solution to harvest Arctic Ocean thermal energy in-situ and provide low power levels to sensors and data communications while integrated onto a free floating or ice-tethered Arctic buoy such as an Autonomous Arctic Ocean Flux Buoy (AFOB) or Ice Tethered Arctic Profiling Buoy. The planned energy persistence level is one year for low power environmental and oceanographic observational sensors as well as gateway buoy data communications. The desired performance is a 500W thermal harvesting system that can be incorporated into a standard Arctic oceanographic buoy and potentially in a configuration that is moored to the ice. The highest performance risk is the survivability of the energy generator in the harsh Arctic environment. The highest known technical risk is addressing the energy efficiency of generating power given the relatively low thermal gradient that exists on a daily average in the Arctic.

PHASE I: Define and develop a concept for a prototype that can meet the performance and technical requirements listed in the Description. Determine optimal locations and approach for integration and deployment of the prototype onto an Arctic buoy platform. Develop a Phase II plan.

Note: An Oceanographic Research Institute can contribute to all phases of this research. Oceanographers familiar with the Arctic can inform the team about ocean circulation, temperature-salinity environments, currents, winds and other environmental factors that the innovative prototype will need to address. Oceanographers can provide specific power loads required from environmental and oceanographic sensors and data communications.

PHASE II: Construct a prototype using the expertise of research institute ocean engineers to inform the team of valuable lessons learned from previous Arctic platforms, which will drive down technical and performance risk.

PHASE III DUAL USE APPLICATIONS: Integrate the Phase II prototype onto an Arctic buoy that will be deployed in September of 2022 as part of the Arctic Mobile Observing System (AMOS) Innovative Naval Prototype program. During Phase III, research institution technicians can provide invaluable insight about deploying a research prototype in the Arctic.

Dual use applications for this system would include commercial and non-DoD maritime needs such as ROV operations for the Oil and Gas Industry and non-DoD navigation and environmental monitoring in remote locations.

REFERENCES:

1. “Strategic Outlook for the Arctic.” Chief of Naval Operations, The United States Navy, January 2019. https://www.navy.mil/strategic/Navy_Strategic_Outlook_Arctic_Jan2019.pdf

2. Piggott, Alfred. “How Thermoelectric Generators Work.” Applied Thermoelectric Solutions LLC, 24 Oct. 2018. https:/ThermoelectricSolutions.com/how-thermoelectric-generators-work

3. Timmermans, M.L. and Proshutinsky, A. “Sea Surface Temperature.” Arctic Essays, November 25, 2015. https://arctic.noaa.gov/Report-Card/Report-Card-2015/ArtMID/5037/ArticleID/220/Sea-Surface-Temperature

KEYWORDS: Thermal Energy Generation; Low Power for Sensors; Arctic Sensors; Arctic Mobile Observing System; Thermoelectric Generator; Persistent Sensing

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T024 TITLE: Scenario Data Solutions for Forward Deployed Live, Virtual, and Constructive Training at Sea

TECHNOLOGY AREA(S): Human Systems

ACQUISITION PROGRAM: Fleet Training Wholeness Continuum (FTWC) and Total Ship’s Training Concept (TSTC)

OBJECTIVE: Develop shore-based capabilities to improve mission warfighter mission readiness against Great Power Competitors (GPC) and to increase warfare proficiency and agility while operating in a degraded and denied environment against GPC.

DESCRIPTION: Currently, the Navy employs large numbers of at sea mentors, assessors, and certifiers, using a “White Cards” technique to inject a description of the degraded or denied effects on command and control (C2) systems. This is done because the actual distributed simulation of the degraded or denied (D2) effects on the at-sea ships and aircraft C2 systems cuts off the two-way communications between the shore distributed training center (DTC) and the mentors, assessors, and certifiers at sea. This “White Card” method of simulation, or lack of actual effects to the C2 systems, provides “Negative Training” and degrades warfighter readiness. Some specific issues that the technologies the Navy is seeking could address include smart/intelligent communication/simulation routing, and communication/simulation compression over existing communication circuits. The additional benefit from these sought technologies might be to daily operational and tactical operations when the Fleet is being challenged by GPC in a real-world command and control, degraded and denied environment (C2D2E).

PHASE I: Create a concept for software/hardware that design an information assured (IA) NSA approved two-way transmission of simulation and mentor information via a single circuit while all other circuits are being degraded and/or denied. Ensure that the D2 environment does not affect the simulation and mentor information path between the simulation distribution site and shore-based replicate at-sea node. The proof of concept should demonstrate a shore site replicating a DTC and a node replicating a shipboard training suite, transmitting simulation and mentor data being passed two-way without any degradation or loss of data. Develop a Phase II plan.

PHASE II: Build and test a usable prototype of the software/hardware to be tested between a shore site replicating a DTC and a ship pierside using actual Navy C2 circuits. Test the prototype in a simulation on the ship that will be of a degraded and denied environment (D2E) that affects major operational/tactical circuits while non-D2 mentor data are transmitted two-ways. The two-way mentor data will not be degraded. The mentor and simulation data will be degraded between “10 to 15 percent”. Naval Simulation Center Pacific (NSCPAC), San Diego, CA with Tactical Training Group Pacific (TTGP) will act as the DTC and a suitable Destroyer will be assigned by the Surface

TYCOM Command Naval Surface Forces – Pacific (CNSF) to execute this test.

PHASE III DUAL USE APPLICATIONS: Refine the prototype as necessary and make the technology available to the Navy. The technology(ies) will be installed at TTGP and onboard an assigned Destroyer at sea during a Live, Virtual, and Constructive (LVC) Composite Training Unit Exercise (COMPTUEX) offshore on the West Coast Tactical Training Range (WCTTR). Use of these technologies will help inform the Navy Fleet Training Program on how to use Operational/Tactical circuits to transport simulation and mentor data while at sea.

Potential commercial uses for securing Commercial/DoD Cloud Storage, improving network data transferring, improving mixed data transmission across low bandwidth networks, strong data security across commercial wireless networks, and real-time reachback support for technicians in the field across low bandwidth networks.

REFERENCES:
1. USFF N72/CPF N7. “Fleet Training LVC Concept of Employment (CONEMP).” February 2016. (Uploaded to SITIS on 12/10/2019)

2. USFF N72/CPF N7. “LVC Report to Congress.” March 2018. (Uploaded to SITIS on 12/10/2019)

3. USFF N72/CPF N7. “Fleet Synthetic Training Instruction.” 21 May 2018. (Uploaded to SITIS on 12/10/2019)

4. USFF N72/CPF N7. “LVC Executive Agent (EA) Letter from the CNO.” February 2017. (Uploaded to SITIS on 12/10/2019)

5. “Fleet Training Wholeness Strategy (FTWS).” 18 October 2018. (Uploaded to SITIS on 12/10/2019)

Questions may also be submitted through DOD SBIR/STTR SITIS website.

N20A-T025 TITLE: Post Digitizer Analog to Digital Converter (ADC) Linearization Using Artificial Intelligence Methods

TECHNOLOGY AREA(S): Electronics, Information Systems, Sensors

ACQUISITION PROGRAM: ESM and SIGINT 6.3a program are target audience

OBJECTIVE: Increase the analog to digital convertor (ADC) Spurious-free Dynamic Range (SFDR) by 10 dB by digitally diminishing the predictable spurs. Wideband Si and SiGe ADCs often incorporate substantial on-chip linearization processing. In contrast, superconducting ADCs are not today linearized and exhibit spurs as large as 15 dB above the inherent quantization noise floor.

DESCRIPTION: This STTR topic requires a deep understanding of the nature of quantization errors in low bit count, high-speed digitizers and the interdependence of time and frequency domain signal representations. However, no details of the exact ADC will be provided and no run-time dynamic adaptation of the circuit will be acceptable. Rather proposers are expected to correct the output data stream in real time using only digital processors. Two types of distortions of the frequency domain output of ADCs are of concern: a) fixed subharmonics of the sampling clock engendered by rapid switching transients in the output drivers weakly (~-30 dB down) coupled to the analog signal inputs; and b) harmonics of the signal fundamentals, some of which reflect the actual quantization errors associated with the limited bit width samples. The topic philosophy is that the clock spurs are at entirely predictable and consistent frequencies. While their relative amplitudes might depend on the signal mix being digitized at any given time, that will change relatively slowly and some form of interference cancellation/background subtraction ought to be applicable. Achieving that should be the first goal of the effort. Then in the 3 bit, 40 GSps ADCs of greatest interest, there is a range of signal amplitudes where a Fourier Transform shows as many as 18 harmonics above the

quantization noise floor, but not any other mixing products (e.g., with the clock). It is for a smaller signal amplitude range such that maybe only 5 harmonics break the noise floor that the second goal applies. Namely, these harmonics in part reflect the inaccuracies of the real quantization levels in comparison to the actual time dependent signal shape and in part systematic errors in the threshold levels compared to their optimal selection. As such, constructively using the harmonic signals observed ought to provide a way of making the signal representation output more accurate. The real thermal noise that is being quantitized must be distinguished from these systematic terms but is expected to be a small contribution to the total spur power. Recorded data of an actual ADC's response to various amplitude and frequency sine waves can be provided as government furnished information (GFI) for software training purposes if the proposer so requests. Artificial intelligence (AI) and machine learning (ML) are assumed to be the sources of potential solutions due to their ability to learn systematic behavior without supervision. However, any other approach capable of keeping up with the ADC results arrival rate may be proposed. Processing latencies of less than 1 millisecond and reduction of the effective spurs by more than 6 dB are sought.

PHASE I: In the Phase I proposal, define a definite plan of attack to be conducted and clarify the balance between proposed tasks. The proposal should also define a mechanism for selecting the more successful one if more than one approach is to be attempted, include a clear Gannt chart of the proposed tasks, and indicate whether the contractor or sub-contractor is responsible for each task. Inclusion of a discussion of test plans is desirable. Any need for GFI and its data ingest format should also be carefully described. The Phase I Base effort needs to work the concepts/tasks defined in the original proposal so as to significantly lower the risk of success if a follow-on award is offered. The preliminary Phase II proposal delivered at the end of the Base effort will be used to select the Phase II winner. The Phase I Option should be structured to further lower the technical risk of Phase II assuming the approach of the Base succeeds. If any approaches prove unworkable, the topic author(s) should be consulted before the approach is changed. The provisional Phase II plan delivered at the end of the base Phase I Base period will determine whether each performer is awarded a Phase II contract. If selected for Phase II, the Phase I Option period will then be exercised. It should provide continuity until the Phase II begins and further reduce technical risk of the proposed overall approach. Phase II is when the claim of real time processing needs to be developed/demonstrated.

PHASE II: Conduct a working experimental demonstration of spectral clean up by the developed signal processing in the labs of the Government or the ADC vendor to demonstrate real-time processing. Quantification of the degree of real-time spur reduction achieved as a function of sampling clock frequency is expected. The Government will help arrange that testing late in the Phase I Base period.

PHASE III DUAL USE APPLICATIONS: By the end of this STTR effort, the ADC in question ought to have transitioned into fielded systems. Hence once this software is proven useful, it can be added into the digital signal processing (DSP) portion of such systems and result in higher accuracy situational awareness reports to the warfighter. Outside the DoD, the resultant software is expected to be the first linearization product that directly addresses frequency domain issues following a time domain digitizer and could be one of the earliest systems to combine AI with ML in a hybrid, directed system architecture. Examples in other application domains, including correcting for amplifier distortion, ought also to be possible. Specific commercial markets could include satellite communications and many band 5G wireless networks in addition to laboratory instrumentation.

REFERENCES:
1. Yang, Y.-, Motafakker-Fard, A. and Jalali, B. "Linearization of ADCs via digital post processing." 2011 IEEE International Symposium on Circuits Systems, May 15-18, 2011, Rio de Janeiro, Brazil. https://ieeexplore.ieee.org/document/5937734

2. Hummels, D. "Performance improvement of all-digital wide-bandwidth receivers by linearization of ADCs and DACs." Science Direct, Measurement, 4th Workshop on ADC Modelling and Testing, Vol. 31, Issue 1, January 2002, pp. 35-45. https://www.sciencedirect.com/science/article/pii/S0263224101000124

3. Zhang, T., Cao, Y., Ye, F. and Ren, J. "Use Multilayer Perceptron in Calibrating Multistage Non-linearity of Split Pipelined-ADC." 2018 IEEE International Symposium on Circuits Systems (ISCAS), May 27-30, 2018, Florence, Italy. https://ieeexplore.ieee.org/document/8350904

4. Tatsumi, K., Matsuoka, T. and Tani, S. "A calibration with an adaptive data selection based on Bayes estimation for a successive stochastic approximation ADC system." 2017 Joint 17th World Congress of International Fuzzy Systems Association and 9th International Conference on Soft Computing and Intelligent Systems (IFSA-SCIS), June 27-30, 2017, Otsu, Japan. https://ieeexplore.ieee.org/document/8023246

5. Danial, L., Wainstein, N., Kraus and Kvatinsky, S. "Breaking Through the Speed-Power-Accuracy Tradeoff in ADCs Using a Memristive Neuromorphic Architecture." IEEE Transactions on Emerging Topics in Computational Intelligence, vol. 2, no. 5, pp. 396-409, Oct. 2018. https://ieeexplore.ieee.org/document/8471014

KEYWORDS: Linearization; Deterministic Phenomena; Cross Talk; Artificial Intelligence; Frequency Domain Learning; Harmonic Expansion; Probabilistic Comparator Behavior; Equalization Error; Machine Learning; ML; AI

Questions may also be submitted through DOD SBIR/STTR SITIS website.

AIR FORCE
20.A SMALL BUSINESS TECHNOLOGY TRANSFER (STTR) PROPOSAL PREPARATION INSTRUCTIONS

The Air Force (AF) proposal submission instructions are intended to clarify the Department of Defense (DoD) instructions as they apply to AF specific requirements. **Firms must ensure their proposal meets all requirements of the Broad Agency Announcement currently posted on the DoD website at the time the solicitation closes.**

The AF Program Manager is Mr. David Shahady. The AF SBIR/STTR Program Office can be contacted at afsbirsttr-info@us.af.mil. For general inquiries or problems with the electronic submission, contact the DoD SBIR/STTR Help Desk via email at DoDSBIRSupport@reisystems.com (9:00 a.m. to 5:00 p.m. ET, Monday through Friday). For technical questions about the topics during the pre-announcement period (10 December through 13 January 2020), contact the Topic Authors listed for each topic on the Web site. For information on obtaining answers to your technical questions during the formal announcement period (January 2020 through 12 February 2020), go to https://sbir.defensebusiness.org. Your complete proposal **must** be submitted via the submissions site at https://www.dodsbirsttr.mil/submissions/login on or before the **8:00 pm ET, 12 February 2020 deadline.**

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

(Continued on next page.)

CHART 1: Consolidated STTR Topic Information

Applicable Topics	Phase I					Phase II			
	Technical Volume (Vol 2)	Additional Info (Vol 5)	Award Amount	*Technical Duration	*Final Reporting Period	Technical Volume (Vol 2)	Additional Info (Vol 5)	Technical & Reporting	Initial Award Amount
All AF 20.A Topics	Not to exceed 5 pages	Attach a pitch deck not to exceed 15 slides	Not to exceed $150,000	6 months	3 months	Not to exceed 15 pages	Attach a pitch deck not to exceed 15 slides	Typically 27 months	Not to exceed $750,000

*The technical duration and final reporting duration must be added together for the total duration of the project.

PHASE I PROPOSAL SUBMISSION

Read the DoD program announcement at https://sbir.defensebusiness.org/ for program requirements. When you prepare your proposal, keep in mind that Phase I should address the feasibility of a solution to the topic. For the AF, the contract period of performance for Phase I shall be nine (9) months, and the award shall not exceed $150,000. We will accept only one Cost Volume per Topic Proposal and it must address the entire nine-month contract period of performance.

The Phase I topic awardees must accomplish the majority of their primary research during the first six months of the contract with the additional three months of effort to be used for generating final reports. Each AF organization may request Phase II proposals prior to the completion of the first six months of the contract based upon an evaluation of the contractor's technical progress and review by the AF technical point of contact utilizing the criteria in section 8.0 of the DoD announcement. The last three months of the nine-month Phase I contract will provide project continuity for all Phase II awardee (see "Phase II Proposal Submissions" below); no modification to the Phase I contract should be necessary.

Limitations on Length of Proposal

The Phase I Technical Volume has a 5-page-limit (excluding the Cover Sheet, Cost Volume, and Cost Volume Itemized Listing (a-j). The Technical Volume must be in type no smaller than 10-point on standard 8-1/2" x 11" paper with one (1) inch margins. Only the Technical Volume and any enclosures or attachments count toward the 5-page limit. In the interest of equity, pages in excess of the 5-page limitation will not be considered for review or award. The documents required for upload into Volume 5 using "Other" category do not count towards the 5-page limit.

NOTE: The Fraud, Waste and Abuse Certificate of Training Completion (Volume 6) is required to be completed prior to proposal submission. More information concerning this requirement is provided below under "**PHASE I PROPOSAL SUBMISSION CHECKLIST".**

Phase I Proposal Format

Proposal Cover Sheet: If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released on the Internet. Therefore, DO NOT include proprietary information in these sections.

Technical Volume: The Technical Volume should include all graphics and attachments but should not include the Cover Sheet as it is completed separately. The Phase I proposals shall include a technical volume (uploaded in Volume 2) that shall not exceed 5 pages and a pitch/slide deck not to exceed 15 slides (uploaded in Volume 5). The technical volume and slide deck will be reviewed holistically and there is no set format requirements for the two documents. It is recommended (but not required) that more detailed information is included in the technical volume and higher level information is included in the pitch deck. Most proposals will be printed out on black and white printers so make sure all graphics are distinguishable in black and white. To verify that your proposal has been received, click on the "Check Upload" icon to view your proposal. Typically, your uploaded file will be virus checked and converted to a .pdf document within the hour. However, if your proposal does not appear after an hour, please contact the DoD SBIR/STTR Help Desk via email at DoDSBIRSupport@reisystems.com (9:00 am to 5:00 pm ET Monday through Friday).

Key Personnel: Identify in the Technical Volume all key personnel who will be involved in this project; include information on directly related education, experience, and citizenship. A technical resume of the principal investigator, including a list of publications, if any, must be part of that information. Concise technical resumes for subcontractors and consultants, if any, are also useful. You must identify all U.S. permanent residents to be involved in the project as direct employees, subcontractors, or consultants. You must also identify all non-U.S. citizens expected to be involved in the project as direct employees, subcontractors, or consultants. For all non-U.S. citizens, in addition to technical resumes, please provide countries of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project, as appropriate. You may be asked to provide additional information during negotiations in order to verify the foreign citizen's eligibility to participate on a contract issued as a result of this announcement.

Phase I Work Plan Outline

NOTE: THE AF USES THE WORK PLAN OUTLINE AS THE INITIAL DRAFT OF THE PHASE I STATEMENT OF WORK (SOW). THEREFORE, DO NOT INCLUDE PROPRIETARY INFORMATION IN THE WORK PLAN OUTLINE. TO DO SO WILL NECESSITATE A REQUEST FOR REVISION AND MAY DELAY CONTRACT AWARD.

At the beginning of your proposal work plan section, include an outline of the work plan in the following format:

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

Cost Volume

Cost Volume information should be provided by completing the on-line Cost Volume and including the Cost Volume Itemized Listing (a-j) specified below. The Cost Volume information must be at a level of detail that would enable Air Force personnel to determine the purpose, necessity and reasonability of each cost element. Provide sufficient information on how funds will be used if the contract is awarded. The on-line Cost Volume and Itemized Cost Volume Information will not count against the 5-page limit. The itemized listing may be placed in the "Explanatory Material" section of the on-line Cost Volume (if enough room) or may be submitted in Volume 5 under the "Other" dropdown option. (Note: Only one file can be uploaded to the DoD Submission Site). Ensure that this file includes your complete Technical Volume and the information below.

a. Special Tooling and Test Equipment and Material: The inclusion of equipment and materials will be carefully reviewed relative to need and appropriateness of the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the government and relate directly to the specific effort. They may include such items as innovative instrumentation and/or automatic test equipment.

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

c. Other Direct Costs: This category of costs includes specialized services such as machining or milling, special testing or analysis, costs incurred in obtaining temporary use of specialized equipment. Proposals which include leased hardware, must provide an adequate lease vs. purchase justification or rational.

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

e. Travel: Travel costs must relate to the needs of the project. Break out travel cost by trip, with the number of travelers, airfare, per diem, lodging, etc. The number of trips required, as well as the destination and purpose of each trip should be reflected. Recommend budgeting at least one (1) trip to the Air Force location managing the contract.

f. Cost Sharing: If proposing cost share arrangements, please note each Phase I contract total value may not exceed $150,000 total, while Phase II contracts shall have an initial Not to Exceed value of $750,000. Please note cost share contracts or portions of contracts do not allow fee. NOTE: Subcontract arrangements involving provision of Independent Research and Development (IR&D) support are prohibited in accordance with Under Secretary of Defense (USD) memorandum "Contractor Cost Share", dated 16 May 2001, as implemented by SAF/AQ memorandum, same title, dated 11 July 2001.

g. Subcontracts: Involvement of a research institution is required in the project. Involvement of other subcontractors or consultants may also be desired. Describe in detail the tasks to be performed in the Technical Volume and include information in the Cost Volume for the research institution and any other subcontractors/consultants. The proposed total of all consultant fees, facility leases or usage fees, and other subcontract or purchase agreements may not exceed 60 percent of the total contract price or cost, unless otherwise approved in writing by the Contracting Officer. The STTR offeror's involvement must equate to not less than 40 percent of the overall effort and the research institutions must equate to not less than 30 percent.

Support subcontract costs with copies of the subcontract agreements. The supporting agreement documents must adequately describe the work to be performed, i.e., Cost Volume. At a minimum, an offeror must include a Statement of Work (SOW) with a corresponding detailed cost proposal for each planned subcontract.

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

i. Any exceptions to the model Phase I purchase order (P.O.) found at http://www.afsbirsttr.af.mil/Program/Overview/ should be discussed with the Phase I Contracting Officer during negotiations.

NOTE: If no exceptions are taken to an offeror's proposal, the Government may award a contract without discussions (except clarifications as described in FAR 15.306(a)). Therefore, the offeror's initial proposal should contain the offeror's best terms from a cost or price and technical standpoint. Full text for the clauses included in the P.O. may be found at http://farsite.hill.af.mil. Please note, the posted P.O. template is for the Small Business Innovation Research (SBIR) Program. While P.O.s for STTR awards are very similar, if selected for award, the contract or P.O. document received by your firm may vary in format/content. If there are questions regarding the award document, contact the Phase I Contracting Officer listed on the selection notification. (See item i under the "Cost Volume" section above) The Government reserves the right to conduct discussions if the Contracting Officer later determines them to be necessary.

j. DD Form 2345: For proposals submitted under export-controlled topics (either International Traffic in Arms (ITAR) or Export Administration Regulations (EAR)), a copy of the certified DD Form 2345, Militarily Critical Technical Data Agreement, or evidence of application submission must be included. The form, instructions, and FAQs may be found at the United States/Canada Joint Certification Program website, http://www.dla.mil/HQ/InformationOperations/Offers/Products/LogisticsApplications/JCP/DD2345Instructions.aspx. Approval of the DD Form 2345 will be verified if proposal is chosen for award.

NOTE: Restrictive notices notwithstanding, proposals may be handled for administrative purposes only, by support contractors U.Group, Peerless Technologies, Engineering Network Services, and/or Infinite Management Solutions, LLC. In addition, only Government employees and technical personnel from Federally Funded Research and Development Centers (FFRDCs) MITRE and Aerospace Corporations working under contract to provide technical support to AF Life Cycle Management Center and Space and Missiles Centers may evaluate proposals. All support contractors are bound by appropriate non-disclosure agreements. If you have concerns about any of these contractors, you should contact the AF SBIR/STTR Contracting Officer, Kris Croake at kristina.croake@us.af.mil.

k. The Air Force does not participate in the Discretionary Technical and Business Assistance program. Contractors should not submit proposals that include Discretionary Technical and Business Assistance.

PHASE I PROPOSAL SUBMISSION CHECKLIST

NOTE: If you are not registered in the System for Award Management, https://www.sam.gov/, you will not be eligible for an award. Additionally, verify that you are registered to receive contracts (not just grants) and that your address matches between your proposal and SAM.

1) The Air Force Phase I proposal shall be a nine-month effort, and the cost shall not exceed $150,000. The Special Topic shall be a three-month effort and the cost shall not exceed $25,000.

2) The Air Force will accept only those proposals submitted electronically via the DoD SBIR Web site (https://www.dodsbirsttr.mil/submissions/login).

It is mandatory that the complete proposal submission -- DoD Proposal Cover Sheet, Technical Volume with any appendices, Cost Volume, Itemized Cost Volume Information, and Fraud, Waste and Abuse Certificate of Training Completion -- be submitted electronically through the DoD SBIR website at https://www.dodsbirsttr.mil/submissions/login. Each of these documents is to be submitted through the Website.

Please note that the Fraud, Waste and Abuse Training shall be completed prior to submission of your proposal. This is accomplished under Volume 6 of the DoD SBIR Web site (https://www.dodsbirsttr.mil/submissions/login). When the training has been completed and certified, the DoD Submission Website will indicate this in the proposal which will complete the Volume 6 requirement. If the training has not been completed, you will receive an error message. Your proposal cannot be submitted until this training has been completed. The Fraud, Waste and Abuse Certificate of Training website can be found under Section 3.6 of the DoD 20.A. STTR BAA Instructions. Your complete proposal **must** be submitted via the submissions site on or before the **8:00 pm ET, 12 February 2020 deadline.** A hardcopy **will not** be accepted.

The AF recommends that you complete your submission early, as computer traffic gets heavy near solicitation close and could slow down the system. **Do not wait until the last minute.** The AF will not be responsible for proposals being denied due to servers being "down" or inaccessible. Please ensure your e-mail address listed in your proposal is current and accurate. **The AF is not responsible for ensuring notifications are received by firms changing mailing address/e-mail address/company points of contact after proposal submission without proper notification to the AF. Changes of this nature that occur after proposal submission or award (if selected) for Phase I and II shall be sent to the Air Force SBIR/STTR site address, afsbirsttr-info@us.af.mil.**

AIR FORCE PROPOSAL EVALUATIONS

The AF will utilize the Phase I proposal evaluation criteria in section 6.0 of the DoD announcement in descending order of importance with technical merit being most important, followed by the qualifications of the principal investigator (and team), and followed by Commercialization Plan.

The AF will utilize Phase II evaluation criteria in section 8.0 of the DoD announcement in descending order of importance with technical merit being most important, followed by the potential for Commercialization Plan, followed by the qualifications of the principal investigator (and team).

The proposer's record of commercializing its prior SBIR and STTR projects will be used as a portion of the Commercialization Plan evaluation. Only firms with four or more Phase II projects that were awarded at least two years prior to a SBIR solicitation will receive a CAI score If the "Commercialization Achievement Index (CAI)", shown on the first page of the report, is at the 20th percentile or below, the proposer will receive no more than half of the evaluation points available under

evaluation criterion (c) in Section 6 of the DoD 19.C STTR instructions. This information supersedes Paragraph 4, Section 5.4e, of the DoD 19.C STTR instructions.

Proposal Status and Feedback

The Principal Investigator (PI) and Corporate Official (CO) indicated on the Proposal Cover Sheet will be notified by e-mail regarding proposal selection or non-selection. Small businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the Proposal Number and Topic Number referenced. **If changes occur to the company mail or email address(es) or company points of contact after proposal submission, the information shall be provided to the AF at afsbirsttr-info@us.af.mil.**

As is consistent with the DoD SBIR/STTR announcement, any feedback requests must be submitted in writing within 30 days after non-selection notification receipt. Written requests for feedback must be submitted via www.afsbirsttr.af.mil through the SBIR system. Feedback requests should include the company name and the telephone number/e-mail address for a primary and alternate point of contact. Include the topic and the proposal number(s). Feedback requests received more than 30 days after non-selection notification receipt will be fulfilled at the Contracting Officers' discretion. Unsuccessful offerors are entitled to no more than one feedback session for each proposal.

IMPORTANT: Proposals submitted to the AF are received and evaluated by different offices within the Air Force and handled on a Topic-by-Topic basis. Each office operates within their own schedule for proposal evaluation and selection**.** Updates and notification timeframes will vary by office and Topic. If your company is contacted regarding a proposal submission, it is not necessary to contact the AF to inquire about additional submissions. Additional notifications regarding your other submissions will be forthcoming.

We anticipate having all the proposals evaluated and our Phase I contract decisions within approximately three months of proposal receipt. All questions concerning the status of a proposal or debriefing should be directed to the local awarding organization SBIR/STTR Program Manager.

PHASE II PROPOSAL SUBMISSIONS

Phase II is the demonstration of the technology found feasible in Phase I. Only Phase I awardees are eligible to submit a Phase II proposal. All Phase I awardees will be sent a notification with the Phase II proposal submittal date and a link to detailed Phase II proposal preparation instructions. If the mail or email address(es) or firm points of contact have changed since submission of the Phase I proposal, correct information shall be sent to the AF at afsbirsttr-info@us.af.mil. Phase II efforts are typically 27 months in duration (24 months technical performance, with 3 additional months for final reporting) with an initial value not to exceed $750,000.

NOTE: Phase II awardees should either have or start working towards having a Defense Contract Audit Agency (DCAA) approved accounting system. It is strongly urged an approved accounting system be in place prior to the AF Phase II award timeframe. If you have questions regarding this matter, please discuss with your Phase I Contracting Officer.

All proposals must be submitted electronically at https://www.dodsbirsttr.mil/submissions/login by the date indicated in the notification. The technical proposal is **limited to 15 pages** unless a different number is specified in the preparation instructions. The Commercialization Report, any advocacy letters, and the additional Cost Volume itemized listing (a-j) will not count against the 15-page limitation and should be

placed as the last pages of the Topic Proposal file uploaded. The Phase II proposals shall also include a pitch/slide deck not to exceed 15 slides (uploaded in Volume 5). The technical volume and slide deck will be reviewed holistically and there is no set format requirements for the two documents. It is recommended (but not required) that more detailed information is included in the technical volume and higher level information is included in the pitch deck Note: For Phase II applications, only one file can be uploaded to the DoD submission site. Ensure this single file includes your complete Technical Volume and the additional Cost Volume information. The preferred format for submission of proposals is Portable Document Format (.pdf). Graphics must be distinguishable in black and white. Please virus-check your submissions.

AIR FORCE STTR PROGRAM MANAGEMENT IMPROVEMENTS

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

AIR FORCE SUBMISSION OF FINAL REPORTS

All Final Reports will be submitted to the awarding AF organization in accordance with the Contract. Companies will not submit Final Reports directly to the Defense Technical Information Center (DTIC).

AIR FORCE STTR 20.A Topic Index

AF20A-T001	Pitch Day for Quantum Enabling Technologies Quantum Timing
AF20A-T002	Pitch Day for Quantum Enabling Technologies Quantum Sensing
AF20A-T003	Pitch Day for Quantum Enabling Technologies Quantum Information Processing and Computing
AF20A-T004	Pitch Day for Quantum Enabling Technologies Quantum Communications and Networking

AIR FORCE STTR 20.ATopic Descriptions

AF20A-T001 TITLE: Pitch Day for Quantum Enabling Technologies Quantum Timing

TECHNOLOGY AREA(S): Information Systems Technology

ACQUISITION PROGRAM: N/A

OBJECTIVE: This is a Pitch Day Topic, please see the above Pitch Day Topic instructions for further details. A Phase I award will be completed over five months with a maximum award of $156,500K and a Phase II may be awarded for a maximum period of eighteen months and up to $1.5 million. The objective of this topic is to explore innovative quantum technologies related to Quantum Information Sciences that will not be covered by any other specific STTR topic and thus to explore options for innovative solutions that may fall outside the Air Force's current fields of focus but that may be useful to the development of advanced quantum information systems. This topic will reach companies that can complete a feasibility study and prototype validated concepts in accelerated Phase I and II schedules. This topic is specifically aimed at later stage development rather than earlier stage basic science and research.

DESCRIPTION: The Air Force Research Laboratory is seeking innovative technologies and/or processes which will advance the development of Quantum Enabling Technologies and applications. Specifically, AFRL is interested in advancing and retaining scientific and military dominance in the application of quantum science to USAF needs and interests. Specific topics of interest relating to this Focus Area include, but are not limited to:

Quantum Timing

- Quantum enabling technologies for applications to support low SwaP Atomic clocks
- Rugged, optical atomic clocks for terrestrial or space applications
- Chip-scale/Low-SWaP atomic optical clocks, frequency combs
- Utra-high precision time dissemination and syncing

PHASE I: Validate the product-market fit between the proposed solution and the proposed topic and define a clear and immediately actionable plan for running a trial with the proposed solution and the proposed AF customer. This feasibility study should directly address:
1. Clearly identify who the prime (and additional) potential AF end user(s) is and articulate how they would use your solution(s) (i.e., the one who is most likely to be an early adopter, first user, and initial transition partner).
2. Deeply explore the problem or benefit area(s), which are to be addressed by the solution(s) - specifically focusing on how this solution will impact the end user of the solution.
3. Define clear objectives and measurable key results for a potential trial of the proposed solution with the identified Air Force end user(s).
4. Clearly identify any additional specific stakeholders beyond the end user(s) who will be critical to the success of any potential trial. This includes, but is not limited to, program offices, contracting offices, finance offices, information security offices and environmental protection offices.
5. Describe the cost and feasibility of integration with current mission-specific products.
6. Describe if and how the demonstration can be used by other DoD or governmental customers.
7. Describe technology related development that is required to successfully field the solution.
The funds obligated on the resulting Phase I STTR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments, laboratory studies, commercial research and interviews. Prototypes may be developed with SBIR funds during Phase I studies to better address the risks and potential payoffs in innovative technologies.

PHASE II: Develop, install, integrate and demonstrate a prototype system determined to be the most feasible solution during the Phase I feasibility study. This demonstration should focus specifically on:
1. Evaluating the proposed solution against the objectives and measurable key results as defined in the Phase I feasibility study.

2. Describing in detail how the solution can be scaled to be adopted widely (i.e. how can it be modified for scale).
3. A clear transition path for the proposed solution that takes into account input from all affected stakeholders including but not limited to: end users, engineering, sustainment, contracting, finance, legal, and cyber security.
4. Specific details about how the solution can integrate with other current and potential future solutions.
5. How the solution can be sustainable (i.e. supportability).
6. Clearly identify other specific DoD or governmental customers who want to use the solution.

PHASE III DUAL USE APPLICATIONS: The Primary goal of STTR is Phase III. The contractor will pursue commercialization of the various technologies developed in Phase II for transitioning expanded mission capability to a broad range of potential government and civilian users and alternate mission applications. Direct access with end users and government customers will be provided with opportunities to receive Phase III awards for providing the government additional research & development, or direct procurement of products and services developed in coordination with the program.
NOTES:
a. Due to the large amount of expected interest in this topic, we will not be answering individual questions through e-mail, except in rare cases. Instead we will be holding a teleconference to address all questions in an efficient manner. This topic will be updated with the final call-in details as soon as the date is finalized. In the meantime, feel free to use the SITIS Q&A system.
b. This STTR is not awarding grants, but contracts. When registering in SAM.gov, be sure to select 'YES' to the question 'Do you wish to bid on contracts?' in order to be able to compete for this SBIR topic. If you are only registered to compete for grants, you will be ineligible for this topic.
c. First payment will be via Government Purchase Card. Therefore, when registering in SAM.gov under Financial Information, be sure to select 'YES' to the question 'Do you accept credit card as a method of payment?'.
d. We are working to move fast, please double check your CAGE codes and DUNS numbers to be sure they line up, if they are not correct at time of submission, you will be ineligible for this topic. In order to ensure this, please include, in your 15-slide deck, a screenshot from SAM.gov as validation of your correct CAGE code, DUNS number and current business address along with the verification that you are registered to compete for All Contracts.
e. Companies must be present at the Pitch Day for Quantum Information Technologies event (May, 2020 in NY, NY) and complete their pitch to evaluators in order to receive an award. Further details will be shared in SITIS

REFERENCES:
1. United States Air Force 2030 Science and Technology Strategy: Strengthening USAF Science and Technology for 2030 and Beyond.
https://www.af.mil/Portals/1/documents/2019%20SAF%20story%20attachments/Air%20Force%20Science%20and%20Technology%20Strategy.pdf

2. National Strategic Overview for Quantum Information Science: Subcommittee on Quantum Information Science under the Committee on Science, National Science and Technology Council (Sep, 2018). https://www.whitehouse.gov/wp-content/uploads/2018/09/National-Strategic-Overview-for-Quantum-Information-Science.pdf

3. Quantum Networks for Open Science Workshop Report: Office of Advanced Scientific Computing Research Department of Energy; 25-26Sep2018. https://info.ornl.gov/sites/publications/Files/Pub124247.pdf

KEYWORDS: Quantum algorithms, Quantum networking, Quantum computation, Superconducting qubits, Photon-based qubits, Trapped ion qubits, Quantum memory, Quantum Transduction and interfaces, Entanglement distribution, Heterogeneous quantum systems.

AF20A-T002 TITLE: Pitch Day for Quantum Enabling Technologies Quantum Sensing

TECHNOLOGY AREA(S): Information Systems Technology

ACQUISITION PROGRAM: N/A

OBJECTIVE: This is a Pitch Day Topic, please see the above Pitch Day Topic instructions for further details. A Phase I award will be completed over five months with a maximum award of $156,500K and a Phase II may be awarded for a maximum period of eighteen months and up to $1.5 million. The objective of this topic is to explore innovative quantum technologies related to Quantum Information Sciences that will not be covered by any other specific STTR topic and thus to explore options for innovative solutions that may fall outside the Air Force's current fields of focus but that may be useful to the development of advanced quantum information systems. This topic will reach companies that can complete a feasibility study and prototype validated concepts in accelerated Phase I and II schedules. This topic is specifically aimed at later stage development rather than earlier stage basic science and research.

DESCRIPTION: The Air Force Research Laboratory is seeking innovative technologies and/or processes which will advance the development of Quantum Enabling Technologies and applications. Specifically, AFRL is interested in advancing and retaining scientific and military dominance in the application of quantum science to USAF needs and interests. Specific topics of interest relating to this Focus Area include, but are not limited to:

Quantum Sensing

- Quantum enabling technologies for applications to support novel sensing devices
- Optical-mechanical, strain, etc. qubit sensors
- Ultra-sensitive quantum electric, magnetic, and gravitational field sensors
- Quantum sensors for GPS-denied navigation
- Concepts and development of coherent transduction between different qubit technologies
- Distributed/broad-baseline quantum sensor concepts

PHASE I: Validate the product-market fit between the proposed solution and the proposed topic and define a clear and immediately actionable plan for running a trial with the proposed solution and the proposed AF customer. This feasibility study should directly address:
1. Clearly identify who the prime (and additional) potential AF end user(s) is and articulate how they would use your solution(s) (i.e., the one who is most likely to be an early adopter, first user, and initial transition partner).
2. Deeply explore the problem or benefit area(s), which are to be addressed by the solution(s) - specifically focusing on how this solution will impact the end user of the solution.
3. Define clear objectives and measurable key results for a potential trial of the proposed solution with the identified Air Force end user(s).
4. Clearly identify any additional specific stakeholders beyond the end user(s) who will be critical to the success of any potential trial. This includes, but is not limited to, program offices, contracting offices, finance offices, information security offices and environmental protection offices.
5. Describe the cost and feasibility of integration with current mission-specific products.
6. Describe if and how the demonstration can be used by other DoD or governmental customers.
7. Describe technology related development that is required to successfully field the solution.
The funds obligated on the resulting Phase I STTR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments, laboratory studies, commercial research and interviews. Prototypes may be developed with SBIR funds during Phase I studies to better address the risks and potential payoffs in innovative technologies.

PHASE II: Develop, install, integrate and demonstrate a prototype system determined to be the most feasible solution during the Phase I feasibility study. This demonstration should focus specifically on:
1. Evaluating the proposed solution against the objectives and measurable key results as defined in the Phase I feasibility study.
2. Describing in detail how the solution can be scaled to be adopted widely (i.e. how can it be modified for scale).

3. A clear transition path for the proposed solution that takes into account input from all affected stakeholders including but not limited to: end users, engineering, sustainment, contracting, finance, legal, and cyber security.
4. Specific details about how the solution can integrate with other current and potential future solutions.
5. How the solution can be sustainable (i.e. supportability).
6. Clearly identify other specific DoD or governmental customers who want to use the solution.

PHASE III DUAL USE APPLICATIONS: The Primary goal of STTR is Phase III. The contractor will pursue commercialization of the various technologies developed in Phase II for transitioning expanded mission capability to a broad range of potential government and civilian users and alternate mission applications. Direct access with end users and government customers will be provided with opportunities to receive Phase III awards for providing the government additional research & development, or direct procurement of products and services developed in coordination with the program.
NOTES:
a. Due to the large amount of expected interest in this topic, we will not be answering individual questions through e-mail, except in rare cases. Instead we will be holding a teleconference to address all questions in an efficient manner. This topic will be updated with the final call-in details as soon as the date is finalized. In the meantime, feel free to use the SITIS Q&A system.
b. This STTR is not awarding grants, but contracts. When registering in SAM.gov, be sure to select 'YES' to the question 'Do you wish to bid on contracts?' in order to be able to compete for this SBIR topic. If you are only registered to compete for grants, you will be ineligible for this topic.
c. First payment will be via Government Purchase Card. Therefore, when registering in SAM.gov under Financial Information, be sure to select 'YES' to the question 'Do you accept credit card as a method of payment?'.
d. We are working to move fast, please double check your CAGE codes and DUNS numbers to be sure they line up, if they are not correct at time of submission, you will be ineligible for this topic. In order to ensure this, please include, in your 15-slide deck, a screenshot from SAM.gov as validation of your correct CAGE code, DUNS number and current business address along with the verification that you are registered to compete for All Contracts.
e. Companies must be present at the Pitch Day for Quantum Information Technologies event (May, 2020 in NY, NY) and complete their pitch to evaluators in order to receive an award. Further details will be shared in SITIS

REFERENCES:
1. United States Air Force 2030 Science and Technology Strategy: Strengthening USAF Science and Technology for 2030 and Beyond.
https://www.af.mil/Portals/1/documents/2019%20SAF%20story%20attachments/Air%20Force%20Science%20and%20Technology%20Strategy.pdf

2. National Strategic Overview for Quantum Information Science: Subcommittee on Quantum Information Science under the Committee on Science, National Science and Technology Council (Sep, 2018). https://www.whitehouse.gov/wp-content/uploads/2018/09/National-Strategic-Overview-for-Quantum-Information-Science.pdf

3. Quantum Networks for Open Science Workshop Report: Office of Advanced Scientific Computing Research Department of Energy; 25-26Sep2018. https://info.ornl.gov/sites/publications/Files/Pub124247.pdf

KEYWORDS: Quantum algorithms, Quantum networking, Quantum computation, Superconducting qubits, Photon-based qubits, Trapped ion qubits, Quantum memory, Quantum Transduction and interfaces, Entanglement distribution, Heterogeneous quantum systems.

AF20A-T003 TITLE: Pitch Day for Quantum Enabling Technologies Quantum Information Processing and Computing

TECHNOLOGY AREA(S): Information Systems Technology

ACQUISITION PROGRAM: N/A

OBJECTIVE: This is a Pitch Day Topic, please see the above Pitch Day Topic instructions for further details. A Phase I award will be completed over five to six months with a maximum award of $156,500K and a Phase II may be awarded for a maximum period of eighteen months and up to $1.5 million. The objective of this topic is to explore innovative quantum technologies related to Quantum Information Sciences that will not be covered by any other specific STTR topic and thus to explore options for innovative solutions that may fall outside the Air Force's current fields of focus but that may be useful to the development of advanced quantum information systems. This topic will reach companies that can complete a feasibility study and prototype validated concepts in accelerated Phase I and II schedules. This topic is specifically aimed at later stage development rather than earlier stage basic science and research.

DESCRIPTION: The Air Force Research Laboratory is seeking innovative technologies and/or processes which will advance the development of Quantum Enabling Technologies and applications. Specifically, AFRL is interested in advancing and retaining scientific and military dominance in the application of quantum science to USAF needs and interests. Specific topics of interest relating to this Focus Area include, but are not limited to:

Quantum Information Processing and Computing

• Quantum enabling technologies for applications to support information Processing and Computing; including increase of qubit coherence, gate fidelities, readouts, 3D qubit designs
• Quantum algorithm development for computationally hard problems in optimization, machine learning, neural networks, risk/decision analysis, logistics, computational chemistry, material discovery
• Strategies for performing large computations on limited qubit machines, including, efficient gate and problem decompositions, logical qubit embeddings
• Novel forms of quantum computing implementations, e.g. all optical, hybrid qubit architectures
• PIC-compatible, at-wavelength optical components (e.g. isolators, shutters, modulators, amplifiers)

PHASE I: Validate the product-market fit between the proposed solution and the proposed topic and define a clear and immediately actionable plan for running a trial with the proposed solution and the proposed AF customer. This feasibility study should directly address:
1. Clearly identify who the prime (and additional) potential AF end user(s) is and articulate how they would use your solution(s) (i.e., the one who is most likely to be an early adopter, first user, and initial transition partner).
2. Deeply explore the problem or benefit area(s), which are to be addressed by the solution(s) - specifically focusing on how this solution will impact the end user of the solution.
3. Define clear objectives and measurable key results for a potential trial of the proposed solution with the identified Air Force end user(s).
4. Clearly identify any additional specific stakeholders beyond the end user(s) who will be critical to the success of any potential trial. This includes, but is not limited to, program offices, contracting offices, finance offices, information security offices and environmental protection offices.
5. Describe the cost and feasibility of integration with current mission-specific products.
6. Describe if and how the demonstration can be used by other DoD or governmental customers.
7. Describe technology related development that is required to successfully field the solution.
The funds obligated on the resulting Phase I SBIR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments, laboratory studies, commercial research and interviews. Prototypes may be developed with SBIR funds during Phase I studies to better address the risks and potential payoffs in innovative technologies.

PHASE II: Develop, install, integrate and demonstrate a prototype system determined to be the most feasible solution during the Phase I feasibility study. This demonstration should focus specifically on:
1. Evaluating the proposed solution against the objectives and measurable key results as defined in the Phase I feasibility study.
2. Describing in detail how the solution can be scaled to be adopted widely (i.e. how can it be modified for scale).
3. A clear transition path for the proposed solution that takes into account input from all affected stakeholders including but not limited to: end users, engineering, sustainment, contracting, finance, legal, and cyber security.
4. Specific details about how the solution can integrate with other current and potential future solutions.
5. How the solution can be sustainable (i.e. supportability).
6. Clearly identify other specific DoD or governmental customers who want to use the solution.

PHASE III DUAL USE APPLICATIONS: The Primary goal of STTR is Phase III. The contractor will pursue commercialization of the various technologies developed in Phase II for transitioning expanded mission capability to a broad range of potential government and civilian users and alternate mission applications. Direct access with end users and government customers will be provided with opportunities to receive Phase III awards for providing the government additional research & development, or direct procurement of products and services developed in coordination with the program.
NOTES:
a. Due to the large amount of expected interest in this topic, we will not be answering individual questions through e-mail, except in rare cases. Instead we will be holding a teleconference to address all questions in an efficient manner. This topic will be updated with the final call-in details as soon as the date is finalized. In the meantime, feel free to use the SITIS Q&A system.
b. This STTR is not awarding grants, but contracts. When registering in SAM.gov, be sure to select 'YES' to the question 'Do you wish to bid on contracts?' in order to be able to compete for this SBIR topic. If you are only registered to compete for grants, you will be ineligible for this topic.
c. First payment will be via Government Purchase Card. Therefore, when registering in SAM.gov under Financial Information, be sure to select 'YES' to the question 'Do you accept credit card as a method of payment?'.
d. We are working to move fast, please double check your CAGE codes and DUNS numbers to be sure they line up, if they are not correct at time of submission, you will be ineligible for this topic. In order to ensure this, please include, in your 15-slide deck, a screenshot from SAM.gov as validation of your correct CAGE code, DUNS number and current business address along with the verification that you are registered to compete for All Contracts.
e. Companies must be present at the Pitch Day for Quantum Information Technologies event (May, 2020 in NY, NY) and complete their pitch to evaluators in order to receive an award. Further details will be shared in SITIS

REFERENCES:
1. United States Air Force 2030 Science and Technology Strategy: Strengthening USAF Science and Technology for 2030 and Beyond.
https://www.af.mil/Portals/1/documents/2019%20SAF%20story%20attachments/Air%20Force%20Science%20and%20Technology%20Strategy.pdf

2. National Strategic Overview for Quantum Information Science: Subcommittee on Quantum Information Science under the Committee on Science, National Science and Technology Council (Sep, 2018).
https://www.whitehouse.gov/wp-content/uploads/2018/09/National-Strategic-Overview-for-Quantum-Information-Science.pdf

3. Quantum Networks for Open Science Workshop Report: Office of Advanced Scientific Computing Research Department of Energy; 25-26Sep2018. https://info.ornl.gov/sites/publications/Files/Pub124247.pdf

KEYWORDS: Quantum algorithms, Quantum networking, Quantum computation, Superconducting qubits, Photon-based qubits, Trapped ion qubits, Quantum memory, Quantum Transduction and interfaces, Entanglement distribution, Heterogeneous quantum systems.

AF20A-T004 TITLE: Pitch Day for Quantum Enabling Technologies Quantum Communication and Networking

TECHNOLOGY AREA(S): Information Systems Technology

ACQUISITION PROGRAM: N/A

OBJECTIVE: This is a Pitch Day Topic, please see the above Pitch Day Topic instructions for further details. A Phase I award will be completed over five months with a maximum award of $156,500K and a Phase II may be awarded for a maximum period of eighteen months and up to $1.5 million. The objective of this topic is to explore innovative quantum technologies related to Quantum Information Sciences that will not be covered by any other specific STTR topic and thus to explore options for innovative solutions that may fall outside the Air Force's current fields of focus but that may be useful to the development of advanced quantum information systems. This topic will reach companies that can complete a feasibility study and prototype validated concepts in accelerated Phase I and II schedules. This topic is specifically aimed at later stage development rather than earlier stage basic science and research.

DESCRIPTION: The Air Force Research Laboratory is seeking innovative technologies and/or processes which will advance the development of Quantum Enabling Technologies and applications. Specifically, AFRL is interested in advancing and retaining scientific and military dominance in the application of quantum science to USAF needs and interests. Specific topics of interest relating to this Focus Area include, but are not limited to:

Quantum Communication and Networking

- Quantum enabling technologies for applications to support communication and networking
- Entanglement distribution in networks larger than two nodes; protocols and implementations
- Quantum communication and networking beyond (potentially building upon) Quantum Key Distribution (QKD)
- Quantum repeater beyond two nodes
- Concepts and development of coherent transduction between different qubit technologies
- Methods to utilize high dimensional entanglement for networking and communication

PHASE I: Validate the product-market fit between the proposed solution and the proposed topic and define a clear and immediately actionable plan for running a trial with the proposed solution and the proposed AF customer. This feasibility study should directly address:
1. Clearly identify who the prime (and additional) potential AF end user(s) is and articulate how they would use your solution(s) (i.e., the one who is most likely to be an early adopter, first user, and initial transition partner).
2. Deeply explore the problem or benefit area(s), which are to be addressed by the solution(s) - specifically focusing on how this solution will impact the end user of the solution.
3. Define clear objectives and measurable key results for a potential trial of the proposed solution with the identified Air Force end user(s).
4. Clearly identify any additional specific stakeholders beyond the end user(s) who will be critical to the success of any potential trial. This includes, but is not limited to, program offices, contracting offices, finance offices, information security offices and environmental protection offices.
5. Describe the cost and feasibility of integration with current mission-specific products.
6. Describe if and how the demonstration can be used by other DoD or governmental customers.
7. Describe technology related development that is required to successfully field the solution.
The funds obligated on the resulting Phase I STTR contracts are to be used for the sole purpose of conducting a thorough feasibility study using scientific experiments, laboratory studies, commercial research and interviews. Prototypes may be developed with SBIR funds during Phase I studies to better address the risks and potential payoffs in innovative technologies.

PHASE II: Develop, install, integrate and demonstrate a prototype system determined to be the most feasible solution during the Phase I feasibility study. This demonstration should focus specifically on:
1. Evaluating the proposed solution against the objectives and measurable key results as defined in the Phase I feasibility study.

2. Describing in detail how the solution can be scaled to be adopted widely (i.e. how can it be modified for scale).
3. A clear transition path for the proposed solution that takes into account input from all affected stakeholders including but not limited to: end users, engineering, sustainment, contracting, finance, legal, and cyber security.
4. Specific details about how the solution can integrate with other current and potential future solutions.
5. How the solution can be sustainable (i.e. supportability).
6. Clearly identify other specific DoD or governmental customers who want to use the solution.

PHASE III DUAL USE APPLICATIONS: The Primary goal of STTR is Phase III. The contractor will pursue commercialization of the various technologies developed in Phase II for transitioning expanded mission capability to a broad range of potential government and civilian users and alternate mission applications. Direct access with end users and government customers will be provided with opportunities to receive Phase III awards for providing the government additional research & development, or direct procurement of products and services developed in coordination with the program.

NOTES:
a. Due to the large amount of expected interest in this topic, we will not be answering individual questions through e-mail, except in rare cases. Instead we will be holding a teleconference to address all questions in an efficient manner. This topic will be updated with the final call-in details as soon as the date is finalized. In the meantime, feel free to use the SITIS Q&A system.
b. This STTR is not awarding grants, but contracts. When registering in SAM.gov, be sure to select 'YES' to the question 'Do you wish to bid on contracts?' in order to be able to compete for this SBIR topic. If you are only registered to compete for grants, you will be ineligible for this topic.
c. First payment will be via Government Purchase Card. Therefore, when registering in SAM.gov under Financial Information, be sure to select 'YES' to the question 'Do you accept credit card as a method of payment?'.
d. We are working to move fast, please double check your CAGE codes and DUNS numbers to be sure they line up, if they are not correct at time of submission, you will be ineligible for this topic. In order to ensure this, please include, in your 15-slide deck, a screenshot from SAM.gov as validation of your correct CAGE code, DUNS number and current business address along with the verification that you are registered to compete for All Contracts.
e. Companies must be present at the Pitch Day for Quantum Information Technologies event (May, 2020 in NY, NY) and complete their pitch to evaluators in order to receive an award. Further details will be shared in SITIS

REFERENCES:
1. United States Air Force 2030 Science and Technology Strategy: Strengthening USAF Science and Technology for 2030 and Beyond.
https://www.af.mil/Portals/1/documents/2019%20SAF%20story%20attachments/Air%20Force%20Science%20and%20Technology%20Strategy.pdf

2. National Strategic Overview for Quantum Information Science: Subcommittee on Quantum Information Science under the Committee on Science, National Science and Technology Council (Sep, 2018).
https://www.whitehouse.gov/wp-content/uploads/2018/09/National-Strategic-Overview-for-Quantum-Information-Science.pdf

3. Quantum Networks for Open Science Workshop Report: Office of Advanced Scientific Computing Research Department of Energy; 25-26Sep2018. https://info.ornl.gov/sites/publications/Files/Pub124247.pdf

KEYWORDS: Quantum algorithms, Quantum networking, Quantum computation, Superconducting qubits, Photon-based qubits, Trapped ion qubits, Quantum memory, Quantum Transduction and interfaces, Entanglement distribution, Heterogeneous quantum systems.

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

The approved FY20.A topic included in the Chemical and Biological Defense (CBD) Small Business Technology Transfer (STTR) Program is listed below. Offerors responding to this Announcement must follow all general instructions provided in the Department of Defense (DoD) Program Announcement. Specific CBD STTR requirements that add to or deviate from the DoD Program Announcement instructions are provided below with references to the appropriate section of the DoD Announcement.

General Information

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

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

The overall objective of the CBD STTR Program is to improve the transition or transfer of innovative Chem-Bio technologies to the end user – the warfighter – in addition to commercializing technologies within the private sector for mutual benefit. The CBD STTR Program targets those technology efforts that maximize a strong defensive posture in a biological or chemical environment using passive and active means as deterrents. These technologies include chemical and biological detection for both point and stand-off capabilities; individual and collective protection; hazard mitigation (decontamination); medical pre-treatments (e.g., vaccine development and delivery); medical therapeutics (chemical countermeasures and biological countermeasures); medical diagnostics; information systems technology to include but not limited to modeling and simulation (e.g., meteorological dispersion), disease surveillance, data fusion, and health & human effects.

Submitting Your Phase I CBD STTR Proposal

Your entire proposal submission (consisting of a Proposal Cover Sheet, the Technical Volume and Cost Volume) must be submitted electronically through the DoD SBIR/STTR Proposal Submission system located at https://www.dodsbirsttr.mil/submissions/. A hardcopy is NOT required and will not be accepted by the Chemical and Biological Defense STTR Program. Hand or electronic signature on the proposal is NOT required.

The Proposal Technical Volume must be 20 pages or less in length. The Cover Sheet and Cost Volume do not count against the 20-page Proposal Technical Volume page limit. Pages in excess of this length will not be evaluated or considered for review. The proposal must not contain any type smaller than 10-point font size (except as legend on reduced drawings, but not tables).

Volume 4, the Company Commercialization Report, will not be available for the 20.A BAA.

If your proposal is selected for award, the technical abstract and discussion of anticipated benefits will be publicly released on the Internet; therefore, do not include proprietary or classified information in these sections. Also note that the DoD website contains timely information on firm, award, and abstract data for all DoD SBIR/STTR Phase I and II awards archived for several years. This information can be viewed on the DoD SBIR/STTR website.

The maximum dollar amount for a Phase I proof-of-concept/feasibility study is $167,500. **The CBD STTR Program will not accept Phase I proposals which exceed $167,500 for the Phase I effort**. The total STTR funding amount available for Phase II activities from a resulting Phase II contract will be $1,100,000.

Companies submitting a Phase I proposal under this Announcement must complete the Cost Volume using the on-line form, within a total cost Not to Exceed (NTE) $167,500 over a period of up to six months.

Selection of Phase I proposals will be based upon the evaluation criteria discussed in Section 6.0 of this Program Announcement. The CBD STTR Program reserves the right to limit awards under any topic, and only those proposals of superior scientific and technical quality in the judgment of the technical evaluation team will be funded. All STTR contract awards are subject to availability of funding.

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

If a small business concern receives an STTR award, the firm must negotiate a written agreement between the small business and their selected Research Institution that allocates intellectual property rights and rights to conduct follow-on research, development, or commercialization.

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

CBD Program Phase II Proposal Guidelines

Phase II is the demonstration of the technology that was found feasible in Phase I. Phase I awardees may submit a Phase II proposal without invitation; however, it is strongly encouraged that a Phase II proposal not be submitted until sufficient Phase I progress can be evaluated and assessed based on results of the Phase I proof-of-concept/feasibility study Work Plan and no sooner than a recommended five months from date of contract award. **All Phase II proposal submissions must be submitted electronically through the DoD SBIR/STTR Proposal Submission system at https://www.dodsbirsttr.mil/submissions/.** At the proposal submission website, Phase II proposals MUST be submitted to '**CBD** STTR' regardless of which DoD contracting office negotiated and awarded the Phase I contract. Additional instructions regarding the Phase II proposal submission process including submission key dates will be provided to Phase I awardees after the Phase I contract is awarded; additional information may also be found at http://www.cbdsbir.net.

All proposers are required to develop and submit a commercialization plan describing feasible approaches for marketing and manufacturing the developed technology. Proposers are required to submit a budget for the entire 24-month Phase II Period of Performance. During contract negotiation, the Contracting Officer may require a Cost Volume for a base year and an option year; thus, proposers are advised to be aware of this possibility. These costs must be submitted using the Cost Volume format (accessible electronically on the DoD SBIR/STTR submission site). The total proposed amount should be indicated on the Proposal Cover Sheet as the Proposed Cost. At the Contracting Officer's discretion, Phase II projects may be evaluated for technical progress prior to the end of the base year, prior to extending funding for the option (second) year.

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

Technical Assistance

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

CBD STTR Projects Requiring Animal and Human Subjects

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

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 U.S. Army Medical Research and Material Command's (USAMRMC), Animal Care and Use Review Office (ACURO). Written authorization to begin research under the applicable protocol(s) proposed as part of the CBD STTR program will be issued after contract award in the form of an approval letter from the USAMRMC ACURO to the recipient. Furthermore, modifications to already approved protocols require approval by ACURO prior to implementation.

Research under CBD STTR awards involving the use of human subjects, to include the use of human anatomical substances or human data, shall not begin until the DTRA Research Oversight Board (ROB) provides authorization that the research protocol may proceed. Written approval to begin research

protocol will be issued from the ROB, under separate notification to the recipient. Written approval from the ROB is also required for any sub-recipient that will use funds obtained from any CBD STTR awards to conduct research involving human subjects.

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

Key Dates

20.A Announcement Pre-Release	10 December 2019 – 13 January 2020
20.A Announcement Open/Close	14 January 2020 – 12 February 2020 (submission deadline: 8:00 pm Eastern Time on closing date)
Phase I Evaluations	February – April 2020
Phase I Selections	No Later Than 11 May 2020
Phase I Awards	August 2020 (see Note 1)
Phase II Proposal Submission	Recommend proposal submission no earlier than approximately five months from date of Phase I contract award. Additional instructions regarding Phase II proposal submission process including key dates will be provided to Phase I awardees after Phase I contract award and also can be found at http://www.cbdsbir.net.

(Note 1) Subject to the Congressional Budget process.

CBD STTR PROPOSAL CHECKLIST

This is a Checklist of Requirements for your proposal. Please review the checklist carefully to ensure that your proposal meets the CBD STTR requirements. **Failure to meet these requirements will result in your proposal not being evaluated or considered for award**.

_____ 1. The Proposal Cover Sheet along with the Technical Volume, and Cost Volume were submitted via the Internet using the DoD's SBIR/STTR Proposal Submission Web site at https://www.dodsbirsttr.mil/submissions/.

_____ 2. The proposal cost adheres to the CBD STTR Program criteria specified.

_____ 3. The proposal is limited to only **ONE** Announcement topic. All required documentation within the proposal references the same topic number.

_____ 4. The Project Abstract and other content provided on the Proposal Cover Sheet does not contain any proprietary or classified information and is limited to the space provided.

_____ 5. The Phase I Proposal Technical Volume must be 20 pages or less in length. The Cover Sheet and Cost Volume do not count against the 20-page Proposal Technical Volume page limit. Pages in excess of this length will not be evaluated and will not be considered for review.

_____ 6. The proposal must not contain any type smaller than 10-point font size (except as legend on reduced drawings, but not tables).

CBD STTR 20.A Topic Index

CDB20A-T001 Opioid Contamination Identification for Military Surfaces

CBD STTR 20.A Topic Descriptions

CDB20A-T001 TITLE: Opioid Contamination Identification for Military Surfaces

TECHNOLOGY AREA(S): Biomedical, Chemical/Biological Defense

RESEARCH & TECHNOLOGY AREA(S):

ADVANCED CAPABILITIES:

ACQUISITION & SUSTAINMENT AOR:

OBJECTIVE: To develop solution based receptors capable of binding trace concentrations of opioid(s) in the environment and providing amplified, visible signal for immediate large area contamination identification.

DESCRIPTION: Currently, there is no technology in the commercial marketspace that is capable of identification of trace quantities of opioids in large contaminated areas (i.e. military vehicles, individual protective equipment, clandestine labs, etc.). Modern lateral flow immunoassays (LFIs) can rapidly detect various opioid analogues in many bio-samples (e.g., blood, saliva, urine) through the use of colorimetric changes or colored-line appearance as the readout, but are not able to be used for gross contamination identification of large areas [1]. Engineered protein binders [2] and mu-opioid receptors [3] have potential to be used as environmental sensors for opioids, but there have not been any advances in commercialization of a solution-based product using these technologies. The current single use environmental opioid sample collection and identification kits can only cover small areas per wipe, and utilizes either a separate detector [DetectaChem Seeker] to identify the sample, or a Mecke reagent that requires strong acid chemistry [Sirchie Nark II] with the opioid compound. These commercial-off-the-shelf (COTS) kits are not suitable for the Concept of Operation (CONOPS) where large areas of contaminated surfaces need to be rapidly mapped for potential trace amounts of contaminants, which can then be rendered safe through decontamination procedures or through avoidance. There is an immediate need for the U.S. Department of Defense to provide a solution of rapid identification technologies to identify areas contaminated by opioids in order to reduce the risk of exposure to military personnel and first responders.

PHASE I: Describe the potential technologies that could be leveraged to discover or engineer molecular probes/receptors that can bind to the current set of opioids and related compounds. These molecular probes must be amenable to a wide range of chemical and biological conditions and susceptible to chemical modification, as they are expected to elicit an amplified, visible response themselves, or be part of a cascade of reactions that result in an amplified, visible response. The molecular probes must also be able to function in a solution, as the final product will be a solution-based spray. There is an immediate need to develop one type of molecular probe or receptor that can bind and recognize a broad spectrum class of opioids, rather than a unique probe per opioid compound. The synthesis of the molecular probes must be scalable. The deliverable in Phase I should be a proof of concept batch scale formulation that can be demonstrated on operationally relevant surfaces (e.g., green or tan Chemical Agent Resistant Coating (CARC), dark colored carpet, military uniforms, stainless steel, etc.) at the laboratory level, using opioid or opioid simulants as contamination.

PHASE II: For one or more of the prototype molecular probes investigated in Phase I, the offeror is to develop and deliver a batch scale formulation to the Government for independent evaluation using actual opioids and related compounds. Iterative feedback and formulation optimization should occur during Phase II between the offeror and the Government to finalize a formulation that produces an eye-readable response with Limit of Detection at 0.1 mg/m2 (milligram per square meter) surface concentration levels within 10-minutes of application, shelf-life stable for 1-year (shorter term accelerated studies are acceptable), and ready for pre-production. A list of interferents and potential false positive compounds should be included in the final formulation as well as cross-reactivity amongst fentanyl analogues. The formulation needs to be able to recognize the target opioids and elicit an eye-visible

response when in the presence of interferents.

PHASE III DUAL USE APPLICATIONS: PHASE III: Offerors will need to explore low rate initial manufacturability and the operability of the final product form factor using the down-selected formulation. The offerors should have facilities available for low rate initial production during Phase III. The offeror should be able to transition to mid-scale production after Phase III. All products produced from mid-scale production should be validated for activity and shelf-life stability.

PHASE III DUAL USE APPLICATIONS: Beyond contamination mapping for military applications, products derived from this topic can be used by homeland defense and first responders when encountering unknown areas that are suspected to be contaminated by opioids and related compounds.

REFERENCES:
1. Angelini DA, Biggs TD, Maughan MN, Feasel MG, Sisco E, Sekowski JW. Evaluation of a lateral flow immunoassay for the detection of the synthetic opioid fentanyl. Forensic Science International. 2019; 300:75-81.

2. Bick MJ, Greisen PJ, Morey KJ, Antunes MS, La D, Sankaran B, Reymond L, Johnsson K, Medford JI, Baker D. Computational design of environmental sensors for the potent opioid fentanyl. eLife. 2017; 6:e28909.

3. Lerner MB, Matsunaga F, Han GH, Hong SJ, Xi J, Crook A, Perez-Aguilar JM, Park YW, Saven JG, Liu R, Johnson ATC. Scalable Production of Highly Sensitive Nanosensors Based on Graphene Functionalized with a Designed G Protein-Coupled Receptor. Nano Letters. 2014, 2709-2714.

KEYWORDS: opioids, molecular probe, hazard mitigation, contamination mapping, receptors

DMEA
STTR 20.A PROPOSAL SUBMISSION INSTRUCTIONS

INTRODUCTION

The Defense Microelectronics Activity (DMEA) SBIR/STTR Program is implemented, administrated, and managed by the DMEA Office of Small Business Programs (OSBP). If you have any questions regarding the administration of the DMEA SBIR/STTR Program, please contact the DMEA SBIR/STTR Program Manager (PM), Mr. Greg Davis, at smbus@dmea.osd.mil.

For general inquiries or problems with electronic submission, contact the DOD SBIR/STTR Help Desk at 703-214-1333 between 9:00 am to 5:00 pm ET. For questions about the topic during the pre-release period (10 December 2019 through 13 January 2020), contact the Technical Point of Contact (TPOC) listed under each topic on the https://www.dodsbirsttr.mil/submissions/ website prior to the Open phase of the DoD STTR Program Broad Agency Announcement (BAA) FY 20.A. The SBIR/STTR Interactive Topic Information System (SITIS) will be open to questions during pre-release and close to new questions two weeks prior to the announcement close date.. Information regarding the DMEA mission and programs can be found at http://www.dmea.osd.mil.

PHASE I GUIDELINES

DMEA intends for Phase I to be only an examination of the merit of the concept or technology that still involves technical risk, with a cost not exceeding $167,500.

A list of the topics currently eligible for proposal submission is included in this section followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics are directly linked to DMEA's core research and development requirements.
\
Please ensure that your e-mail address listed in your proposal is current and accurate. DMEA cannot be responsible for notification to companies that change their mailing address, e-mail address, or company official after proposal submission.

PHASE I PROPOSAL SUBMISSION

Read the DOD STTR Program BAA FY 20.A for detailed instructions on proposal format and program requirements. When you prepare your proposal submission, keep in mind that Phase I should address the feasibility of a solution to the topic. Only UNCLASSIFIED proposals will be entertained.

The technical period of performance for the Phase I effort should be no more than six (6) months. DMEA will evaluate and select Phase I proposals using the evaluation criteria contained in Section 6.0 of the DOD STTR Program BAA FY 20.A Preface Instructions. Due to limited funding, DMEA reserves the right to limit awards under any topic, and only proposals considered to be of superior quality will be funded.

DMEA does not accept Phase I proposals exceeding $167,500. DMEA will conduct a price analysis to determine whether cost proposals, including quantities and prices, are fair and reasonable. Contractors should expect that cost proposals will be negotiated.
\
If you plan to employ NON-U.S. citizens in the performance of a DMEA STTR contract, please identify these individuals in your proposal as specified in Section 5.4.c(8) of the DOD STTR Program BAA FY 20.A.

It is mandatory that the ENTIRE Technical Volume, DOD Proposal Cover Sheet, and Cost Volume are submitted electronically through the DOD SBIR/STTR website at https://www.dodsbirsttr.mil/submissions/. The DOD proposal submission site submission will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents is submitted separately through the website. If you have any questions or problems with the electronic proposal submission, contact the DOD SBIR/STTR Help Desk at 703-214-1333 or email dodsbirsupport@reisystems.com

Your proposal submission must be submitted via the submission site on or before the 8:00 a.m. ET deadline on 12 February 2020.

Proposal submissions that are not complete or that are received after the closing date and time will not be considered for award.

PHASE II GUIDELINES

Phase II is the prototype/demonstration of the technology that was found feasible in Phase I. DMEA encourages, but does not require, partnership and outside investment as part of discussions with DMEA sponsors for potential Phase II efforts.

Phase II proposals may be submitted for an amount not to exceed $1,100,000. The technical period of performance for the Phase II effort should be no more than twenty-four (24) months.

PHASE II PROPOSAL SUBMISSION

Phase I awardees may submit a Phase II proposal without invitation not later than sixty (60) calendar days following the end of the Phase I contract. The Phase II proposal submission instructions are identified in the Phase I contract, Part I – The Schedule, Section H, Special contract requirements, "STTR Phase II Proposal Submission Instructions."

All Phase II proposals must have a complete electronic submission. Complete electronic submission includes the submission of Cover Sheet, Cost Volume, the entire Technical Volume, and any appendices via the DOD submission site (https://www.dodsbirsttr.mil/submissions/). The DOD proposal submission site will lead you through the process for submitting your technical volume and all of the sections electronically. Each of these documents is submitted separately through the website. Your proposal must be submitted via the submission site on or before the DMEA-specified deadline or it will not be considered for award.

The technical period of performance for the Phase II effort should be no more than twenty-four (24) months. DMEA will evaluate Phase II proposals based on the Phase II evaluation criteria listed in Section 8.0 of DOD STTR Program BAA FY 20.A Preface. DMEA does not have an established page limit for Phase II submissions. Please reference the DOD SBIR Submission site FAQs for more information on generating Phase II proposals. Due to limited funding, DMEA's ability to award any Phase II, regardless of proposal quality or merit, is subject to availability of funds. Please ensure that your proposal is valid for 120 days after submission, and any extension to that time period will be requested by the contracting officer.

Any follow-on Phase II proposal (i.e., a second Phase II subsequent to the initial Phase II effort) shall be initiated by the Government Technical Point of Contact for the initial Phase II effort and must be approved by the DMEA SBIR/STTR Program Manager in advance.

COST VOLUME GUIDELINES

The on-line cost volume for Phase I and Phase II proposal submissions must be at a level of detail that would enable DMEA personnel to determine the purpose, necessity, and reasonability of each cost element. Provide sufficient information (a. through h. below) on how funds will be used if the contract is awarded. Include the itemized cost volume information (a. through h. below) as an appendix in your technical proposal. The itemized cost volume information (a. through h. below) will not count against the 20-page limit on Phase I proposal submissions.

a. Special Tooling and Test Equipment and Material: The inclusion of equipment and materials will be carefully reviewed relative to need and appropriateness of the work proposed. The purchase of special tooling and test equipment must, in the opinion of the Contracting Officer, be advantageous to the government and relate directly to the specific effort. They may include such items as innovative instrumentation and/or automatic test equipment. Title to property furnished by the Government or acquired with Government funds will be vested with the DOD Component; unless it is determined that transfer of the title to the contractor would be more cost effective than recovery of the equipment by the DOD Component.
b. Direct Cost Materials: Justify costs for materials, parts, and supplies with an itemized list containing types, quantities, price, and where appropriate, purposes.
c. Other Direct Costs: This category of costs includes specialized services such as machining or milling, special testing or analysis, costs incurred in obtaining temporary use of specialized equipment. Proposals, which include teased hardware, must provide an adequate lease *versus* purchase justification or rationale.
d. Direct Labor: Identify key personnel by name if possible or by labor category if specific names are not available. The number of hours, labor overhead and/or fringe benefits and actual hourly rates for each individual are also necessary.
e. Travel: Travel costs must relate to the needs of the project. Break out travel cost by trip, with the number of travelers, airfare, and per diem. Indicate the destination, duration, and purpose of each trip.
f. Cost Sharing: Cost sharing is permitted. However, cost sharing is not required, nor will it be an evaluation factor in the consideration of a proposal.
g. Subcontracts: Involvement of university or other consultants in the planning and /or research stages of the project may be appropriate. If the offeror intends such involvement, describe the involvement in detail and include information in the cost proposal. The proposed total of all consultant fees, facility leases, or usage fees and other subcontract or purchase agreements may not exceed one-third of the total contract price or cost, unless otherwise approved in writing by the Contracting Officer. Support subcontract costs with copies of the subcontract agreements. The supporting agreement documents must adequately describe the work to be performed (i.e., Cost Volume). At the very least, a statement of work with a corresponding detailed cost volume for each planned subcontract must be provided.
h. Consultants: Provide a separate agreement letter for each consultant. The letter should briefly state what service or assistance will be provided, the number of hours required, and the hourly rate.

DMEA STTR PHASE II ENHANCEMENT PROGRAM

To encourage transition of STTR into DOD systems, DMEA has a Phase II Enhancement policy. DMEA's Phase II Enhancement program requirements include: up to one-year extension of existing Phase II, and up to $550,000 matching STTR funds. Applications are subject to review of the statement of work, the transition plan, and the availability of funding. DMEA will generally provide the additional Phase II Enhancement funds by modifying the Phase II contract.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

DMEA does not provide Discretionary Technical and Business Assistance (TABA).

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

_____1. Your Technical Volume, the DOD Cover Sheet, and the Cost Volume have been submitted electronically through the DOD submission site by 8:00 pm ET on 12 February 2020.

_____2. The Phase I proposal does not exceed $167,500

DMEA STTR 20.A Topic Index

20A-001	Correlation between Nano-scale Material Properties and Macro-scale Electrical Properties of Radiation Hardened Materials

DMEA STTR 20.A Topic Descriptions

20A-001 TITLE: Correlation between Nano-scale Material Properties and Macro-scale Electrical Properties of Radiation Hardened Materials

TECHNOLOGY AREA(S): Electronics, Materials/Processes, Nuclear Technology, Sensors, Space Platforms

RESEARCH & TECHNOLOGY AREA(S):

ADVANCED CAPABILITIES:

ACQUISITION & SUSTAINMENT AOR:

OBJECTIVE: Develop and validate predictive electronic device behavioral models by systematically correlating nano-scale material properties (e.g. through quantitative electron microscopy techniques) with macro-scale electrical properties determined via device electrical testing.

DESCRIPTION: Radiation hardening, the process of making electronic components resistant to damage from ionizing radiation, has been a critical process for various applications ranging from the design of satellites and military aircraft to nuclear reactors. Therefore, to maintain the reliability of Department of Defense (DOD) microelectronics systems, it is essential to systematically make electronic components radiation hardened. There are various sources of ionization radiation such as Van Allen radiation belts, cosmic rays, solar winds, and nuclear reactors. [1] And, there are three main radiation metrics: i) total ionizing dose (TID), ii) displacement dose damage (DDD), and iii) single-event effects (SEE). TID is caused by the creation of electron-hole pairs, which are generated by photons, electrons, or protons. The TID is a primary issue for dielectric layers in complementary metal oxide semiconductor (CMOS) devices, which can lead to threshold voltage (Vth) shifts. [2] DDD occurs when atoms are displaced in the crystal lattice by protons, neutrons, or alpha particles leading to variation in the electrical properties of devices. The impact of single events (SEE) are typically more subtle because they occur when highly-charged particles cause ionization within a device and cause bits to flip. Because of the soft-error nature of these events, characterization of these processes requires careful characterization. [3]

Utilization of the advanced industrial technologies in the military and space missions have gained traction in the past years. Current, leading non-volatile technologies (e.g., flash) are susceptible to ionization effects. Therefore, to understand the abnormalities associated with the electrical properties of failed devices, it is important to characterize the fundamental mechanisms of failures. Transmission Electron Microscopy (TEM) along with spectroscopy techniques such as Electron Energy Loss Spectroscopy (EELS) and Energy Dispersive X-ray Spectroscopy (EDXS) enables defect characterization with atomic spatial and energy resolution, respectively. [4] Systematic defect characterization with a TEM and correlation to macro-scale electrical properties provides a critical avenue to design radiation hardened electronic components efficiently. Hence, the performer is expected to evaluate and develop predictive models to quantitatively correlate nano-scale behavior (defects) to macro-scale electrical properties.

PHASE I: Perform a feasibility study for evaluating and developing methods to build predictive models to enable better design of radiation hardened electronic components. Conduct research on various techniques, such as artificial intelligent (AI) and machine learning, to build models from experimental data. The proposed technique or method should be capable of predicting electronic component electrical properties based on input from material characterization data and potentially material characteristics based on input from electrical properties. It is expected that the performer chooses a specific materials system to conduct the feasibility study. The proposed technique must adhere to the following concepts:

1) High resolution imaging and spectroscopy for physical material characterization
2) Electrical testing data to inspect electrical properties
3) Modeling based techniques, such as AI and machine learning

PHASE II: Phase II will result in building, testing and delivering a technique of the predictive model developed in phase I. Technique demonstration should include multiple testing data encompassing both material characteristics and electrical properties. Additionally, it is expected that at a minimum testing data is provided from two different material systems. Furthermore, as part of technique demonstration, all the programming and mathematical justifications should be delivered.

PHASE III DUAL USE APPLICATIONS: Phase III will result in the expansion of the technique in Phase II into a tested pre-production technology, which entails a method to predict an electronic component electrical behavior based on nano-scale material characteristics. This system can be utilized for evaluating failures of electronic components sensitive to radiation effects both in commercial and government sectors.

REFERENCES:

1. [1] Kelli, Mars (11 June 2018). "Why Space Radiation Matters". National Aeronautics and Space Administration. Retrieved 27 September 2019.

2. [2] Y. Gonzalez-Velo, et al., “Review of Radiation Effects on ReRAM Devices and Technology,” Semiconductor Science and Technology, 32, p. 44, 2017.

3. [3] G.C. Messenger, M. Ash, “Single Event Phenomena, Springer Science & Business Media,” 1997.

4. [4] D. B. Williams, and C. B. Carter. Transmission Electron Microscopy: A Textbook for Materials Science. 1996.

5. [5] D. Gorissen, et al., “A Software Framework for Automated Behavioral Modeling of Electronic Devices,” IEEE Microwave Magazine, 13, 2012.

KEYWORDS: Radiation Hardening, TEM, Modeling, Electrical Testing, Machine Learning, AI, Electronic Devices