AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Direct to Phase II (D2P2)
Proposal Submission Instructions
AMENDMENT 4
22 December 2021

The purpose of this amendment is to remove Air Force Direct to Phase II Topic AF221-D012, "Multiphysics Modeling Software for Directed Energy Bioeffects", from the DoD 22.1 SBIR Broad Agency Announcement and associated Air Force-specific instructions. Proposals **will not** be accepted under this topic.

All other content, as previously amended, remains unchanged and in full effect.

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Direct to Phase II (D2P2)
Proposal Submission Instructions
AMENDMENT 3
20 December 2021

This amendment changes the following:

1. Chart 1: Air Force 22.1 SBIR Direct to Phase II Topic Information at a Glance, Technical Volume Content column information for each topic to read, "White Paper NTE XX **Pages**". The maximum number of pages specified for each individual topic **is unchanged**.

2. Section III, Proposal Preparation Instructions and Requirements, last sentence, is changed to read, "There is no set format requirement for **white papers**."

All other content, as previously amended, remains unchanged and in full effect.

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Direct to Phase II (D2P2)
Proposal Submission Instructions
AMENDMENT 1
2 December 2021

This amendment implements the following changes to **Topic AF221-D002, Multi-Role Radio Frequency Sensing for GPS-degraded Navigation**:

Phase I Summary section, current content is changed to read, "This is a Direct to Phase II topic; Phase I proposals will not be accepted in response to this topic. Direct to Phase II topics require detail regarding a "Phase I-like" feasibility study. This study would include initial hardware system design with suggested procurement/implantation plan and schedule and/or an initial algorithm development, with documentation of the algorithmic steps, associated hardware assumptions/requirements for RF sensor and signal processing, and expected run-time performance analysis."

Phase II Summary section, "Proposers with relevant hardware prototypes, existing "classic" RF/SAR sensors and processing, i.e., GPS-enabled, and already developed non-GPS algorithms on real, or representative simulated, RF data are encouraged to propose," **is added as the first sentence**.

All other content, as previously amended, remains unchanged and in full effect.

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Direct to Phase II (D2P2)
Proposal Submission Instructions
AMENDMENT 1
2 December 2021

The purpose of this amendment is to correct the following:

1. Chart 1: Air Force 22.1 SBIR Direct to Phase II Topic Information at a Glance**,** Max SBIR Funding column, the amounts for Topics AF221-D013 and AF221-D015 are changed from **$830,000** to **$1,250,000**.

2. Air Force 22.1 SBIR Direct to Phase II Topic Index, all Topic numbers are changed to reflect the following:

AF221-D001 - Development of Adaptive Mesh Refinement for Hypersonic Reacting Flow Solvers
AF221-D002 - Multi-Role Radio Frequency Sensing for GPS-degraded Navigation
AF221-D003 - High Speed Particulate Erosion Capability
AF221-D004 - RF Analog Imaging for Dual Multi-static Radar and Radar Warning Receivers
AF221-D005 - Extremely High Temperature Aperture Materials Maturation and Manufacturing Development for High-Speed Systems
AF221-D006 - Composite Laser Ablation for Surface Preparation (CLASP) Manufacturing Scale-Up
AF221-D007 - NDE of Thick Scarf Repaired Composites and Related As-Manufactured Structures
AF221-D008 - Self-Healing Fuel Tank Bladders for Reduced Aircraft Maintainability
AF221-D009 - Material Advances for Aerospace Cognitive Monitoring
AF221-D010 - AI for the Depot: Using ETAR for Digital Health Records
AF221-D011 - Spatial Registration of Nondestructive Evaluation (NDE) Sensors in Enclosed or Constrained Access Locations
AF221-D012 - Multiphysics Modeling Software for Directed Energy Bioeffects
AF221-D013 - Innovations in Distributed Collaboration for Tactical Environments
AF221-D014 - Peer-based Information Distribution in Contested Environments
AF221-D015 - Mission Relevant ML Artifact Registry
AF221-D016 - Digital Engineering at the Tactical Edge
AF221-D017 - Imaging System for Real Time Observation of High Energy Laser Effects
AF221-D018 - Multiple Sensor Platform for High Power Microwave Field Mapping
AF221-D019 - Digital QuickStart
AF221-D020 - Space-Based Sensing at the Tactical Edge
AF221-D021 - Communications via Beat-Wave Excitation of ELF/VLF Waves in the Ionosphere
AF221-D022 - High Sensitivity Tracking for Event Based LEO Moving Target Indication

3. All corresponding topics, i.e., **AF212-D001** through **AF212-D022**, are renumbered to **AF221-D001** through **AF221-D022**.

4. Government Technical Point of Contact (TPOC) information is changed as follows for **Topics AF221-D013**, **D015**, and **D016**:

    a. AF221-D013, Innovations in Distributed Collaboration for Tactical Environments, TPOC is changed from **Landon Tomcho** to **Jack Eberhardt, (315) 330-2284**, **john.eberhardt.4@us.af.mil**.
    b. AF221-D015, Mission Relevant ML Artifact Registry, is changed from **Edward Verenich** to **Milvio Franco**, **(315) 330-4541**, **milvio.franco@us.af.mil**.
    c. AF221-D016, Digital Engineering at the Tactical Edge, is changed from **Michael Mayhew** to **Milvio Franco**, **(315) 330-4541**, **milvio.franco@us.af.mil**.

5. Topic AF221-D012, Multiphysics Modeling Software for Directed Energy Bioeffects, "Description" section, last paragraph, last sentence, is corrected to read, "Examples of such mechanisms include but are not limited to light transport in turbid media coupled to thermal and acoustic solutions as well as sub-surface vaporization of materials in an elastic media **with the capacity for adaptive and dynamic meshing to account for highly variable and complex geometries."**

All other content remains unchanged and in full effect.

AIR FORCE (AF)
22.1 Small Business Innovation Research (SBIR) Direct to Phase II (D2P2)
Proposal Submission Instructions

AF Phase I proposal submission instructions are intended to clarify the Department of Defense (DoD) Broad Agency Announcement (BAA) as it applies to the topics solicited herein. **Firms must ensure proposals meet all requirements of the 22.1 SBIR BAA posted on the DoD SBIR/STTR Innovation Portal (DSIP) at the proposal submission deadline date/time.**

Complete proposals **must** be prepared and submitted via https://www.dodsbirsttr.mil/submissions/ (DSIP) on or before the date published in the DoD 22.1 SBIR BAA. Offerors are responsible for ensuring proposals comply with the requirements in the most current version of this instruction at the proposal submission deadline date/time.

Please ensure all e-mail addresses listed in the proposal are current and accurate. The AF is not responsible for ensuring notifications are received by firms changing mailing address/e-mail address/company points of contact after proposal submission without proper notification to the AF. **If changes occur to the company mail or email addresses or points of contact after proposal submission, the information must be provided to the AF SBIR/STTR One Help Desk.** The message shall include the subject line, "22.1 Address Change".

Points of Contact:

- General information related to the AF SBIR/STTR program and proposal preparation instructions, contact the AF SBIR/STTR One Help Desk at usaf.team@afsbirsttr.us.
- Questions regarding the DSIP electronic submission system, contact the DoD SBIR/STTR Help Desk at dodsbirsupport@reisystems.com.
- For technical questions about the topics during the pre-announcement and open period, please reference the DoD 22.1 SBIR BAA.
- Air Force SBIR/STTR Contracting Officers (CO):
    - Ms. Kristina Croake, kristina.croake@us.af.mil
    - Mr. James Helmick, james.helmick.2@us.af.mil

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

Chart 1: Air Force 22.1 SBIR Direct to Phase II Topic Information at a Glance

Topic Number	Performance Period	Max SBIR Funding	Technical Volume Contents
AF221-D001	18 months	$1,250,000	White Paper NTE 20 Pages
AF221-D002	24 months	$1,250,000	White Paper NTE 7 Pages
AF221-D003	27 months	$1,500,000	White Paper NTE 15 Pages
AF221-D004	27 months	$1,500,000	White Paper NTE 15 Pages
AF221-D005	27 months	$1,250,000	White Paper NTE 15 Pages
AF221-D006	27 months	$1,500,000	White Paper NTE 15 Pages
AF221-D007	27 months	$1,250,000	White Paper NTE 15 Pages
AF221-D008	27 months	$1,250,000	White Paper NTE 15 Pages
AF221-D009	27 months	$1,500,000	White Paper NTE 15 Pages
AF221-D010	27 months	$1,500,000	White Paper NTE 15 Pages
AF221-D011	27 months	$1,500,000	White Paper NTE 15 Pages
~~AF221-D012~~	~~27 months~~	~~$750,000~~	~~White Paper NTE 25 Pages~~
AF221-D013	27 months	$1,250,000	White Paper NTE 25 Pages
AF221-D014	27 months	$1,250,000	White Paper NTE 25 Pages
AF221-D015	27 months	$1,250,000	White Paper NTE 25 Pages
AF221-D016	27 months	$1,250,000	White Paper NTE 25 Pages
AF221-D017	27 months	$750,000	White Paper NTE 25 Pages
AF221-D018	27 months	$750,000	White Paper NTE 25 Pages
AF221-D019	27 months	$1,500,000	White Paper NTE 15 Pages
AF221-D020	27 months	$1,250,000	White Paper NTE 25 Pages
AF221-D021	27 months	$1,250,000	White Paper NTE 20 Pages
AF221-D022	27 months	$1,250,000	White Paper NTE 10 Pages

The AF recommends early submission, as computer traffic gets heavy near the proposal submission date/time and could slow down the system. **Do not wait until the last minute.** The AF is not responsible for incomplete proposal submission due to system lag or inaccessibility. Please ensure contact information, i.e., names/phone numbers/email addresses, in the proposal is current and accurate. The AF is not responsible for ensuring notifications are received by firms for which this information changes after proposal submission without proper notification. Changes of this nature shall be sent to the Air Force SBIR/STTR One Help Desk.

I. **DIRECT TO PHASE II**

15 U.S.C. §638 (cc), as amended by NDAA FY2012, Sec. 5106, and further amended by NDAA FY2019, Sec. 854, PILOT TO ALLOW PHASE FLEXIBILITY, allows DoD to make a SBIR Phase II award to a small business concern with respect to a project, without regard to whether the small business concern was provided an award under Phase I of an SBIR program with respect to such project. AF is conducting a "Direct to Phase II" implementation of this authority for these 22.1 SBIR topics and does not guarantee D2P2 opportunities will be offered in future solicitation. Each eligible topic requires documentation to determine whether the feasibility requirement described in the Phase I section of the topic has been met.

II. **INTRODUCTION**: Direct to Phase II proposals must follow the steps outlined below:

1. Offerors must create a Cover Sheet in DSIP; follow the Cover Sheet instructions provided in the DoD SBIR Program BAA.Offerors must provide documentation satisfying the Phase I feasibility requirement* to be included in the Phase II proposal. Offerors must demonstrate completion of research and development through means other than the SBIR/STTR Programs to establish the feasibility of the proposed Phase II effort based on the criteria outlined in the topic description.
2. Offerors must submit D2P2 proposals using the instructions below.

*NOTE: AF will not consider the offeror's D2P2 proposal if the offeror fails to demonstrate technical merit and feasibility have been established. It will also not be considered if it fails to demonstrate the feasibility effort was substantially performed by the offeror and/or the principal investigator (PI). Refer to the topics' Phase I descriptions for minimum requirements needed to demonstrate feasibility. Feasibility documentation MUST NOT be solely based on work performed under prior or on-going Federally funded SBIR and/or STTR work.

II. PROPOSAL SUBMISSION

The complete proposal must be submitted electronically through DSIP. Ensure the complete technical volume and additional cost volume information is included in this sole submission. The preferred submission format is Portable Document Format (.pdf). Graphics must be distinguishable in black and white. **VIRUS-CHECK ALL SUBMISSIONS.**

Complete proposals must include all of the following:
Volume 1: DoD Proposal Cover Sheet
Volume 2: Technical Volume
Volume 3: Cost Volume
Volume 4: Company Commercialization Report
Volume 5: Supporting Documents, e.g., SBIR/STTR Environment, Safety and Occupational Health (ESOH) Questionnaire; DoD Form 2345, Militarily Critical Data Agreement (if applicable); etc.
Volume 6: Fraud, Waste, and Abuse Training Completion

Phase II proposals require a comprehensive, detailed description of the proposed effort. AF D2P2 efforts are to be proposed in accordance with the information in these instructions and Chart 1 (above). Commercial and military potential of the technology under development is extremely important. Proposals emphasizing dual-use applications and commercial exploitation of resulting technologies are sought.

All D2P2 research or research and development (R/R&D) must be performed by the small business and its team members in the United States, as defined in the DoD SBIR 22.1 BAA. The Principal Investigator's (PI's) primary employment must be with the small business concern at the time of award and during the entire period of performance. Primary employment means more than one-half the PI's time is spent in the small business' employ. This precludes full-time employment with another entity.

Knowingly and willfully making false, fictitious, or fraudulent statements or representations may be a felony under18 U.S.C. Section 1001, punishable by a fine up to $250,000, up to five years in prison, or both.

III. PHASE II PROPOSAL PREPARATION INSTRUCTIONS AND REQUIREMENTS

See Chart 1 (above). Advocacy letters, if any; SBIR/STTR Environment, Safety and Occupational Health (ESOH) Questionnaire; and the additional cost proposal itemized list, 17.a-j, should be included in Volume 5, Supporting Documentation. This documentation and the Cover Sheet will not count toward the technical volume limits. There is no set format requirement for white papers.

Please note the Fraud, Waste and Abuse Training **must** be completed prior to proposal submission. This is accomplished under Volume 6 within DSIP. When the training is complete and certified, DSIP will indicate so in the proposal, completing the Volume 6 requirement. **The proposal cannot be submitted until the training has been completed.** The complete proposal must be submitted via DSIP on or before the date published in the DoD 22.1 SBIR BAA. Submissions outside DSIP including, but not limited to, email, hardcopy, or other media will not be accepted.

Complete the SBIR/STTR Environment, Safety, and Occupational Health (ESOH) Questionnaire found at:https://www.afsbirsttr.af.mil/Portals/60/Pages/Overview/Air%20Force%20SBIR_STTR%20Environment%20Safety%20and%20Occupational%20Health_ESOH_Oct%202021_JSH.pdf . Include the completed document in the proposal under Volume 5, Other Documents.

A. Proposal Requirements. A Phase II proposal shall provide sufficient information to persuade the AF the proposed technology advancement represents an innovative solution to the scientific or engineering problem worthy of support under the stated criteria. All sections below count toward the page limit, unless otherwise specified.

B. Proprietary Information. Information constituting a trade secret, commercial/financial information, confidential personal information, or data affecting National Security must be clearly marked. It shall be treated in confidence to the extent permitted by law. Be advised, in the event of proposal selection, the Work Plan will be incorporated into the resulting contract by reference. Therefore, DO NOT INCLUDE PROPRIETARY INFORMATION in the work plan. See the DoD BAA regarding proprietary information marking.

C. General Content. Proposals should be direct, concise, and informative. Type shall be no smaller than 11-point on standard 8 ½ X 11 paper, with one-inch margins and pages consecutively numbered. Offerors are discouraged from including promotional and non-programmatic items. If included, such material will count toward the page limit.

D. Proposal Format. The technical proposal includes all items listed below in the order provided.

(1) **Proposal Cover Sheet:** Complete the proposal Cover Sheet in accordance with the instructions provided via DSIP. The technical abstract should include a brief description of the program objective(s), a description of the effort, anticipated benefits and commercial applications of the proposed research, and a list of keywords/terms. The technical abstract of each successful proposal will be submitted to the Office of the Secretary of Defense (OSD) for publication and, therefore, must not contain proprietary or classified information. The term "Component" on the Cover Sheet refers to the AF organization requesting the Phase II proposal.

(2) **Table of Contents:** A table of contents should be located immediately after the Cover Sheet.

(3) **Glossary:** Include a glossary of acronyms and abbreviations used in the proposal.

(4) **Milestone Identification:** Include a program schedule with all key milestones identified.

(5) **Identification and Significance of the Problem or Opportunity:** Briefly reference the specific technical problem/opportunity to be pursued under this effort.

(6) **Phase II Technical Objectives:** Detail the specific objectives of the Phase II work and describe the technical approach and methods to be used in meeting these objects. The proposal should also include an assessment of the potential commercial application for each objective.

(7) **Work Plan:** The work plan shall be a separate and distinct part of the proposal package, using a page break to divide it from the technical proposal. It must contain a summary description of the technical methodology and task description in broad enough detail to provide contractual flexibility. The following is the recommended format for the work plan; begin this section on a new page. **DO NOT include proprietary information.**

a) 1.0 – Objective: This section is intended to provide a brief overview of the specialty area. It should explain the purpose and expected outcome.
b) 2.0 – Scope: This section should provide a concise description of the work to be accomplished, including the technology area to be investigated, goals, and major milestones. The key elements of this section are task development and deliverables, i.e., the anticipated end result and/or the effort's product. This section must also be consistent with the information in Section 4.0 below.
c) 3.0 – Background: The offeror shall identify appropriate specifications, standards, and other documents applicable to the effort. This section includes information or explanation for, and/or constraints to, understanding requirements. It may include relationships to previous, current, and/or future operations. It may also include techniques previously determined ineffective.
d) 4.0 – Task/Technical Requirements: The detailed individual task descriptions for accomplishing proposed work are considered to be legally binding on the offeror. Therefore, it must be developed in an orderly progression with sufficient detail to establish overall program requirements and goals. The work effort must be segregated into major tasks and identified in separately numbered paragraphs.

Each numbered major task should delineate the work to be performed by subtask. The work plan MUST contain every task to be accomplished in definite, realistic, and clearly stated terms. Use "shall" whenever the work plan expresses a binding provision. Use "should" or "may" to express a declaration or purpose. Use "will" when no contractor requirement is involved, i.e., "... power will be supplied by the Government."

(8) **Deliverables:** Include a section clearly describing the specific sample/prototype hardware/ software to be delivered, as well as data deliverables, schedules, and quantities. Be aware of the possible requirement for unique item identification IAW DFARS 252.211-7003, Item Identification and Valuation, for hardware. If hardware/ software will be developed but not delivered, provide an explanation. At a minimum, the following reports will be required under ALL Phase II contracts.

a) Scientific and Technical Reports: Rights in technical data, including software, developed under the terms of any contract resulting from a SBIR Announcement generally remain with the contractor. The Government obtains SBIR/STTR data rights in all data developed or generated under the SBIR/STTR contract for a period of 20 years, commencing at contract award. Upon expiration of the 20-year SBIR/STTR license, the Government has Government purpose rights to the SBIR data.

i. Final Report: The draft is due 30 days after Phase II technical effort. The first page of the final report will be a single-page project summary, identifying the work's purpose, providing a brief description of the effort accomplished, and listing potential result applications. The summary may be published by DoD. Therefore, it must not contain any proprietary or classified information. The

remainder of the report should contain details of project objectives met, work completed, results obtained, and technical feasibility estimates.

ii. Status Reports: Status reports are due quarterly at a minimum.

iii. Small Business Online Success Stories: Success Story submissions are due at the end of the technical effort via http://launchstories.org. If selected, refer to the Contract Data Requirements List (CDRL) in the contract for submission instructions.

b) Additional Reporting: AF may require additional reporting documentation including:

i. Software documentation and users' manuals;
ii. Engineering drawings;
iii. Operation and maintenance documentation
iv. Safety hazard analysis when the project will result in partial or total development and delivery of hardware; and
v. Updates to the commercialization results.

(9) **Related Work:** Describe significant activities directly related to the proposed effort, including any previous programs conducted by the Principal Investigator, proposing firm, consultants, or others, and their application to the proposed project. Also list any reviewers providing comments regarding the offeror's knowledge of the state-of-the-art in the specific approach proposed.

(10) Company Commercialization Report (CCR)/Commercialization Potential:

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

b) The DoD requires a commercialization plan be submitted with the Phase II proposal, specifically addressing the following questions:

i. What is the first planned product to incorporate the proposed technology?
ii. Who are the probable customers, and what is the estimated market size?
iii. How much money is needed to bring this technology to market and how will it be raised?
iv. Does your firm have the necessary marketing expertise and, if not, how will your firm compensate?
v. Who are the probable competitors, and what price/quality advantage is anticipated by your firm.

c) The commercialization strategy plan should briefly describe the commercialization potential for the proposed project's anticipated results, as well as plans to exploit it. Commercial potential is evidenced by:

i. The existence of private sector or non-SBIR/STTR Governmental funding sources demonstrating commitment to Phase II efforts/ results.
ii. The existence of Phase III follow-on commitments for the research subject.
iii. The presence of other indicators of commercial technology potential, including the firm's commercialization strategy.

d) If awarded a D2P2, the contractor is required to periodically update the

commercialization results of the project via SBA. These updates will be required at completion of the effort, and subsequently when the contractor submits a new SBIR/STTR proposal to DoD. Firms not submitting a new proposal to DoD will be requested to provide updates annually after the D2P2 completion.

(11)**Military Applications:** Briefly describe the existing/potential military requirement and the military potential of the SBIR/STTR Phase II results. Identify the DoD agency/organization most likely to benefit from the project. State if any DoD agency has expressed interest in, or commitment to, a non-SBIR, Federally funded Phase III effort. This section should include not more than one to two paragraphs. Include agency point of contact names and telephone numbers.

(12)**Relationship with Future R/R&D Efforts**:

i. State the anticipated results of the proposed approach, specifically addressing plans for Phase III, if any.
ii. Discuss the significance of the D2P2 effort in providing a basis for the Phase III R/R&D effort, if planned.

E. **Key Personnel:** In the technical volume, identify all key personnel involved in the project. Include information directly related to education, experience, and citizenship. A technical resume for the Principal Investigator, including publications, if any, must also be included. Concise technical resumes for subcontractors and consultants, if any, are also useful. Identify all non-U.S. citizens expected to be involved in the project as direct employees, subcontractors, or consultants. For these individuals, in addition to technical resumes, please provide countries of origin, type of visas or work permits held, and identify the tasks they are anticipated to perform.

Foreign Nationals (also known as Foreign Persons) means any person who is NOT:

a. a citizen or national of the United States; or
b. a lawful permanent resident; or
c. a protected individual as defined by 8 U.S.C. § 1324b

ALL offerors proposing to use foreign nationals MUST follow the DoD 22.1 BAA and disclose this information regardless of whether the topic is subject to ITAR restrictions.

When the topic area is subject to export control, these individuals, if permitted to participate, are limited to work in the public domain. Further, tasks assigned must not be capable of assimilation into an understanding of the project's overall objectives. This prevents foreign citizens from acting in key positions, such as Principal Investigator, Senior Engineer, etc. Additional information may be requested during negotiations in order to verify foreign citizens' eligibility to perform on a contract awarded under this BAA.

The following will apply to all projects with military or dual-use applications developing beyond fundamental research (basic and applied research ordinarily published and shared broadly within the scientific community):

(1) The Contractor shall comply with all U. S. export control laws and regulations, including the International Traffic in Arms Regulations (ITAR), 22 CFR Parts 120 through 130, and the Export Administration Regulations (EAR), 15 CFR Parts 730 through 799, in the performance of this contract. In the absence of available license exemptions/exceptions, the Contractor shall be responsible for obtaining the appropriate licenses or other approvals, if required, for exports of (including deemed exports) hardware, technical data, and software, or for the provision of technical assistance.

(2) The Contractor shall be responsible for obtaining export licenses, if required, before utilizing foreign persons in the performance of this contract, including instances where the work is to be performed on-site at any Government installation (whether in or outside the United States), where the foreign person will have access to export-controlled technologies, including technical data or software.
(3) The Contractor shall be responsible for all regulatory record keeping requirements associated with the use of licenses and license exemptions/exceptions.
(4) The Contractor shall be responsible for ensuring that these provisions apply to its subcontractors.

F. **Facilities/Equipment:** Describe instrumentation and physical facilities necessary and available to carry out the D2P2 effort. Justify equipment to be purchased (detail in cost proposal). State whether proposed performance locations meet environmental laws and regulations of Federal, state, and local Governments for, but not limited to, airborne emissions, waterborne effluents, external radiation levels, outdoor noise, solid and bulk waste disposal practices, and handling and storage of toxic and hazardous materials.

G. **Consultants/Subcontractors**: Private companies, consultants, or universities may be involved in the project. All should be described in detail and included in the cost proposal. In accordance with the Small Business Administration (SBA) SBIR Policy Directive, a minimum of 50% of the R/R&D must be performed by the proposing firm, unless otherwise approved in writing by the Contracting Officer. Signed copies of all consultant or subcontractor letters of intent must be attached to the proposal. These letters should briefly state the contribution or expertise being provided. Include statements of work and detailed cost proposals. Include information regarding consultant or subcontractor unique qualifications. Subcontract copies and supporting documents do not count against the Phase II page limit. Identify any subcontract/consultant foreign citizens per E above.

H. Prior, Current, or Pending Support of Similar Proposals or Awards:
WARNING: While it is permissible, with proper notification, to submit identical proposals or proposals containing a significant amount of essentially equivalent work for consideration under numerous Federal program solicitations, it is unlawful to enter into contracts or grants requiring essentially equivalent effort. Any potential for this situation must be disclosed to the solicitation agency(ies) before award. If a proposal submitted in response to BAA is substantially the same as another proposal previously, currently, or in process of being funded by another Federal agency/DoD Component or the same DoD Component, the company must so indicate on the Cover Sheet and provide the following:

a) The name and address of the Federal agency(ies) or DoD Component(s) to which proposals were or will be submitted, or from which an awarded is expected or has been received;
b) The proposal submission or award dates;
c) The proposal title;
d) The PI's name and title for each proposal submitted or award received; and
e) Solicitation(s) title, number, and date under which the proposal was or will be submitted, or under which an award is expected or has been received.
f) If award was received, provide the contract number.
g) Specify the applicable topics for each SBIR proposal submitted or award received.

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

I. **Cost Proposal:** A detailed cost proposal must be submitted. Cost proposal information will be treated as proprietary. Proposed costs must be provided by both individual cost element and contractor fiscal year (FY) in sufficient detail to determine the basis for estimates, as well as the purpose, necessity, and reasonableness of each. This information will expedite award if the proposal is selected. Generally, firm fixed price contracts are appropriate for Phase II awards. In accordance with the SBA SBIR/STTR Policy Directive, Phase II contracts must include profit or fee.

Cost proposal attachments do not count toward proposal page limitations. The cost proposal includes:

a) **Direct Labor:** Identify key personnel by labor category. Number of hours, actual hourly rates, labor overhead, and/or fringe benefits per contractor FY is also required.

b) **Direct Materials:** Costs for materials, parts, and supplies must be justified and supported. Provide an itemized list of types, quantities, prices, and, where appropriate, purpose. If computer or software purchases are planned, detailed information such as manufacturer, price quotes, proposed use, and support for the need will be required.

c) **Other Direct Costs:** This includes specialized services such as machining or milling, special test/analysis, and costs for temporary use/lease of specialized facilities/ equipment. Provide usage (hours) expected, rates, and sources, as well as brief discussion concerning the purpose and justification. Proposals including leased hardware must include an adequate lease versus purchase rationale. Special tooling/test equipment/material costs are acceptable but will be carefully reviewed to determine the need/appropriateness of the work proposed. The Contracting Officer must decide whether these purchases are advantageous to the Government and are directly related to the proposed effort. Title to property furnished by the Government will be vested with the AF unless determined to be more cost-effective for transfer to the contractor. The Government's intention is not to directly fund purchase of general-purpose equipment.

d) **Subcontracts:** Subcontract costs must be supported with copies of subcontract agreements. Agreement documents must adequately describe the work to be performed and cost bases. The agreement document should include a SOW, assigned personnel, hours and rates, materials (if any), and proposed travel (if any). A letter from the subcontractor agreeing to perform a task or tasks at a fixed price is not considered sufficient. The proposed total of all consultant fees, facility leases or usage fees, and other subcontract or purchase agreements may not exceed one-third of the total contract price, unless otherwise approved in writing by the Contracting Officer.

The prime contractor must accomplish price analysis, including reasonableness, of the proposed subcontractor costs. If based on comparison with prior efforts, identify the basis upon which the prior prices were determined reasonable. If price analysis techniques are inadequate or the FAR requires subcontractor cost or pricing data submission, provide a cost analysis. Cost analysis includes but is not limited to, consideration of materials, labor, travel, other direct costs, and proposed profit rates.

e) **Consultants:** For each consultant, provide a separate agreement letter briefly stating the service to be provided, hours required, and hourly rate, as well as a short, concise resume.

f) **Travel:** Each effort should include, at a minimum, a kickoff or interim meeting. Travel costs must be justified as required for the effort. Include destinations, number of trips, number of travelers per trip, airfare, per diem, lodging, ground transportation, etc. Per Diem and lodging rates may be found in the Joint Travel Regulation (JTR), Volume 2, www.defensetravel.dod.mil.

g) **Indirect Costs:** Indicate proposed rates' bases, e.g., budgeted/actual rates per FY, etc. The proposal should identify the specific rates used and allocation bases to which they are applied. Do not propose composite rates; proposed rates and applications per FY throughout the anticipated performance period are required.

h) **Non-SBIR Governmental/Private Investment:** Non-SBIR Governmental and/or private investment is allowed. However, it is not required, nor will it be a proposal evaluation factor.

i) **DD Form 2345:** For proposals submitted under export-controlled topics (either ITAR or EAR), a certified DD Form 2345, Militarily Critical Technical Data Agreement, or evidence of application submission, must be included. The form, instructions, and FAQs may be found at the US/Canada Joint Certification Program website, http://www.dlis.dla.mil/jcp/. DD Form 2345 approval will be verified if the proposal is selected for award.

J. **Feasibility Documentation –** Should be uploaded to Volume 5, Supporting Documents

a. If appropriate, include a reference or works cited list as the last page.
b. Feasibility efforts detailed must have been substantially performed by the offeror and/or the PI. If technology in the feasibility documentation is subject to intellectual property (IP) rights, the offeror must provide IP rights assertions. Provide a good faith representation all other IP utilized in the proposal is owned or possessed. Additionally, proposers shall provide a short summary for each item asserted with less than unlimited rights describing restriction's nature and intellectual property intended for use in the proposed research. Please see DoD SBIR 22.1 BAA for technical data rights information.
c. DO NOT INCLUDE marketing material. Marketing material will NOT be evaluated and WILL be redacted.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

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

IV. METHOD OF SELECTION AND EVALUATION CRITERIA

A. Introduction: D2P2 proposals are evaluated on a competitive basis by subject matter expert (SME) scientists, engineers, or other technical personnel. Throughout evaluation, selection, and award, confidential proposal and evaluation information will be protected to the greatest extent possible. D2P2 proposals will be disqualified and not evaluated if the Phase I equivalency documentation does not establish the proposed technical approach's feasibility and technical merit.

B. Evaluation Criteria: Phase II proposals will be reviewed for overall merit based on the criteria discussed in the DoD 22.1 BAA.

NOTE: Restrictive notices notwithstanding, proposals may be handled for administrative purposes only, by support contractors: APEX, Peerless Technologies, Engineering Services Network, HPC- COM, Mile Two, REI Systems, MacB (an Alion company), and Infinite Management Solutions. In addition, only Government employees and technical personnel from Federally Funded Research and Development Centers (FFRDCs) MITRE and Aerospace Corporations working under contract to provide technical support to AF Life Cycle Management Center and Space Force may evaluate proposals. All support contractors are bound by appropriate non-disclosure agreements. **Contact the AF SBIR/STTR Contracting Officers with concerns about any of these contractors**.

V. CERTIFICATIONS

In addition to the standard Federal and DoD procurement certifications, the SBA SBIR/STTR Policy Directive requires the collection of certain information from firms at the time of award and during the award life cycle. Each firm must provide these certifications at the time of proposal submission, prior to receiving 50% of the total award amount, and prior to final payment.

VI. FEEDBACK

The PI and Corporate Official indicated on the Proposal Cover Sheet will be notified by email regarding proposal selection or non-selection. The small business will receive one notification for each proposal submitted. Please note the referenced proposal number and read each notification carefully. **If changes occur to the company mail or email addresses or points of contact after proposal submission, the information must be provided to the AF via AF SBIR/STTR One Help Desk.**

Feedback requests will be provided to offerors with proposals determined "Not Selectable" ONLY. The notification letter will include instructions for submitting a feedback request. Offerors are entitled to no more than one feedback per proposal. NOTE: Feedback is not the same as a FAR Part 15 debriefing. Acquisitions under this solicitation are awarded via "other competitive procedures." Therefore, offerors are neither entitled to nor will they be provided FAR Part 15 debriefs.

Refer to the DoD SBIR Program BAA for procedures to protest the Announcement.
As further prescribed in FAR 33.106(b), FAR 52.233-3, Protests after Award should be submitted to: Air Force SBIR/STTR Contracting Officers.

AF 22.1 SBIR Direct to Phase II Topic Index

AF221-D001	Development of Adaptive Mesh Refinement for Hypersonic Reacting Flow Solvers
AF221-D002	Multi-Role Radio Frequency Sensing for GPS-degraded Navigation
AF221-D003	High Speed Particulate Erosion Capability
AF221-D004	RF Analog Imaging for Dual Multi-static Radar and Radar Warning Receivers
AF221-D005	Extremely High Temperature Aperture Materials Maturation and Manufacturing Development for High-Speed Systems
AF221-D006	Composite Laser Ablation for Surface Preparation (CLASP) Manufacturing Scale-Up
AF221-D007	NDE of Thick Scarf Repaired Composites and Related As-Manufactured Structures
AF221-D008	Self-Healing Fuel Tank Bladders for Reduced Aircraft Maintainability
AF221-D009	Material Advances for Aerospace Cognitive Monitoring
AF221-D010	AI for the Depot: Using ETAR for Digital Health Records
AF221-D011	Spatial Registration of Nondestructive Evaluation (NDE) Sensors in Enclosed or Constrained Access Locations
~~AF221-D012~~	~~Multiphysics Modeling Software for Directed Energy Bioeffects~~
AF221-D013	Innovations in Distributed Collaboration for Tactical Environments
AF221-D014	Peer-based Information Distribution in Contested Environments
AF221-D015	Mission Relevant ML Artifact Registry
AF221-D016	Digital Engineering at the Tactical Edge
AF221-D017	Imaging System for Real Time Observation of High Energy Laser Effects
AF221-D018	Multiple Sensor Platform for High Power Microwave Field Mapping
AF221-D019	Digital QuickStart
AF2221-D020	Space-Based Sensing at the Tactical Edge
AF221-D021	Communications Via Beat-Wave Excitation of ELF/VLF Waves in the Ionosphere
AF221-D022	High Sensitivity Tracking for Event Based LEO Moving Target Indication

AF221-D001 TITLE: Development of Adaptive Mesh Refinement for Hypersonic Reacting Flow Solvers

TECH FOCUS AREAS: Artificial Intelligence/Machine Learning; General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Battlespace

OBJECTIVE: An unstructured grid based automatic mesh refinement capability is sought for predicting aerodynamic and aero-heating loads on reconfigurable and multi-body vehicles at hypersonic flight conditions.

DESCRIPTION: The accurate prediction of aerodynamic pressure and heating loads in high-speed reacting gas flows are paramount for the advancement of hypersonic vehicle design and analysis. Beyond the development of accurate, stable, and robust numerical schemes for hypersonic flow solvers is the construction of high-quality computational grids. The National Aeronautical and Space Administration computational fluid dynamics (CFD) Vision 2030 Study (Slotnick et al. 2014) identified CFD technology gaps and impediments which included mesh generation and adaptivity stating, "…the generation of suitable meshes for CFD simulations about complex configurations constitutes a principal bottleneck in the simulation workflow process." This statement is especially true in the hypersonic regime where flight conditions and shockwave locations must also be considered, i.e., grid adaptation is necessary to capture the complex shockwave structures around these vehicles leading to accurate boundary layer state, surface pressure, temperature, and heat flux predictions. Furthermore, full vehicle simulations require reconfigurable geometry for aerodynamic database generation dependent on flow conditions (i.e., Mach, Reynolds, angle-of-attack, angle-of-side slip), control surface deflections, and temporary geometric entities such as boosters or shrouds.

An Automatic Mesh Refinement (AMR) capability is sought to be implemented into an existing commercial or government-off-the-shelf (GOTS) unstructured grid flow solver to predict hypersonic vehicle performance. The flow solver chosen must have a proven history of accurate prediction of hypersonic flow fields around reconfigurable and multi-body geometries using monolithic grids. The AMR refinement criteria must be robust to changes in geometry and flight conditions across an entire vehicle trajectory or envelope resolving aeroheating and the high-temperature wake of these vehicles. A focus on scalability (including dynamic node balancing) and accuracy of the AMR methodology to non-axisymmetric 3D configurations and reacting flows is required. The AMR capability must also be compatible with restart/checkpoint capabilities and post-processing workflows of the selected solver. Any third-party library licenses must be compatible with U.S. DoD acquisition.

PHASE I: During Phase I, firms would determine Automatic Mesh Refinement (AMR) methodology and select a commercial or Government-Off-the-Shelf (GOTS) solver for implementation. Extensive literature surveys and prior research highlighting the advantages and limitations of the chosen approach are required.

PHASE II: A successful Phase II efficient and accurate predictions are required using legacy aerodynamic and aero heating databases including comparisons to monolithic grid solutions for the same validation cases. Documentation of the implementation including user manuals, theory manuals, examples, and source code with appropriate data rights is required. Examples must be demonstrated on U.S. Department of Defense High Performance Computing Modernization Program resources.

PHASE III DUAL USE APPLICATIONS: Phase III will consist of transitioning the software module proven in Phase II to existing code bases employed by the DoD and its prime contractors developing next-generation hypersonic vehicles. This transition will focus on user support or consulting to effectively deploy the software in a research & development or test and evaluation.

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

REFERENCES:

1. Slotnick, et al., "CFD Vision 2030 Study: A Path to Revolutionary Computational Aerosciences," NASA/CR-2014-218178, 2014.
2. Nemec, M., Aftosmis, M. J., Murmansk, S. M., Pulliam, T. H., "Adjoint Formulation for an Embedded-Boundary Cartesian Method," AIAA Paper 2005-0877, 43rd AIAA Aerospace Sciences Meeting & Exhibit, 2005.
3. Rodriguez, D. L., Aftosmis, M. J., Nemec, M., "Formulation and Implementation of Inflow/Outflow Boundary Conditions to Simulate Propulsive Effects," AIAA Paper 2018-0334, AIAA SciTech Forum, 2018.
4. Park, M.A., "Adjoint-Based, Three-Dimensional Error Projection and Grid Adaptation," AIAA-Paper 2002-3286, 32nd Fluid Dynamics Conference, 2002.
5. Park, M. A., Krakos, J. A., Michal, T., Loseille, A., Alonso, J. J., "Unstructured Grid Adaption: Status, Potential Impacts, and Recommended Investments Toward CFD Vision 2030," AIAA Paper 2016-3323, AIAA Aviation Forum, 2016.
6. Thompson, K. B., "Aerothermodynamic Design Sensitivities for a Reacting Gas Flow Solver on an Unstructured Mesh Using a Discrete Adjoint Formulation," Ph.D. Thesis, North Carolina State University, Aerospace Engineering, 2017.
7. Basore, K. D., "Reacting Gas Adjoint-Based Grid Adaptation in FUN3D," AIAA Paper 2019-1994, AIAA SciTech Forum, 2019.
8. Schwing, A. M., Nompelis, I., Candler, G. V., "Parallelization of Unsteady Adaptive Mesh Refinement for Unstructured Navier-Stokes Solvers," AIAA Paper 2014-3080, AIAA Aviation Forum, 2014.
9. McDaniel, D., Morton, S.A., "HPCMP CREATE-AV Kestrel Architecture, Capabilities, and Future Directions," AIAA Paper 2018-0025, AIAA SciTech Forum, 2018.

KEYWORDS: computational fluid dynamics; automatic mesh refinement; mesh adaptation; hypersonic; reacting flows

TPOC: Daniel Reasor,
Phone: (850) 882-8221,
Email: daniel.reasor@us.af.mil

AF221-D002 TITLE: Multi-Role Radio Frequency Sensing for GPS-degraded Navigation

TECH FOCUS AREAS: Artificial Intelligence/Machine Learning; General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Air Platform; Battlespace

OBJECTIVE: Develop hardware and/or software for radio frequency (RF)-based navigation aiding on weapon systems. Hardware should be appropriate for both mid-course and terminal sensing, software/algorithm development should be focused on mid-course navigation aiding. Hardware and algorithms should be appropriate for a service-based open architecture approach for both terminal and mid-course applications.

DESCRIPTION: Weapon navigation in contested environments is a critical capability for the Air Force and DoD. Many weapon systems already employ radio frequency (RF) terminal seekers. It is desired to modify or replace these systems with multi-role sensing and processing capabilities. In addition to terminal functionality, these capabilities should also provide for navigation aiding in Global Positioning System (GPS)-denied or degraded scenarios. This effort seeks to develop or modify RF sensor payloads and/or RF signal processing capabilities in support of modular, service-based GPS-denied navigation capabilities.

Hardware: Hardware solutions should target weapon appropriate size, weight, and power (SWaP), provide direct access to in-phase and quadrature components (in-phase and quadrature (IQ) data) and other "raw" data sources, all necessary sensor metadata, act in a GPS-agnostic manner, and be operable with All Source Positioning and Navigation (ASPN) 2.0 or higher compliant interface control documents (ICDs) wherever feasible. Sensor development proposals specifically intended for research and development efforts may be larger SWaP, but should have a clear path to a refined footprint. Specific SWaP goals and details on ASPN ICDs will be provided to perspective proposers in a FAQ document. Proposals where sensor operation requires an inertial navigation solution (INS) input are appropriate; however, if that navigation solution is not GPS disciplined, the sensor must continue to function and the expected degradation of sensor performance as a function of INS uncertainty should be noted. The ability to leverage the sensor for both mid-course and terminal may require a wide field of regard, this may be achieved though digital or mechanical steering, a multi-antenna configuration, or other mechanisms within SWaP constraints. Hardware which provides the broader system with increased flexibility, e.g., frequency band options, multiple receive channels, or other properties that expand possible down-stream algorithm development, will be favored. Hardware focused proposals should also include base-line signal processing capabilities.

Algorithms/Software: Algorithm development should focus on RF signal processing capability aimed at providing explicit navigation feedback to an ASPN compliant navigator, i.e., the processed RF data should provide something akin to a direct measurement (and uncertainties) of position, velocity, or attitude or a bearing to known features in the environment. Other navigation relevant inputs are also acceptable, e.g., nonlinear feedback appropriate for particle filters, or other estimators/optimizers, that provide likelihoods with respect to position or other navigation states. Algorithms are intended to be real-time and appropriate for on-board processing on weapon system processors (no assumed down-link with external processing) and compatible with ASPN ICDs whenever feasible. Algorithms can assume access to high-rate inertial navigation system (INS) input, however, that input should not be assumed to be GPS disciplined. Systems which provide loosely coupled feedback are preferred, however tightly coupled systems, if ASPN compliant, are also acceptable when tight coupling significantly improves efficacy. Algorithm implementations may be "black box" in nature (the specific instantiation), however the algorithms itself must be detailed mathematically as part of the effort. Requirements and assumptions on input data should be explicit, and signal processing capabilities providing broader flexibility in input requirements (e.g., flexibility in band, look angles,

etc.) will be favored.

General: Hardware and software approaches that are agnostic to INS input errors, yet still produce relevant measurement inputs for a navigator, are highly desirable. Specifically, insensitivity to position error and heading error will be most advantageous. Velocities, roll, and pitch will be degraded, but still reasonably well known, however sensitivity to these states should be noted. The following references are an incomplete list example RF-based data products which could likely be leveraged as a navigation aid (with additional development) if they, or something highly similar could be produced without implicit or explicit reliance on GPS. Works of interest include, but are not limited to, multi-angle Synthetic Aperture Radar (SAR) imaging on a unified coordinate system (high-speed platform) [1], interferometric multimode SAR for high quality terrain mapping [2], SAR image retrieval from SAR databases [3], and SAR to EO image matching [4].

Additional, classic hardware and processing capabilities are also desirable. Real-time processing such as synthetic aperture radar image formation or other modalities in situations when GPS is available (or the INS solution is within a specified tolerance) would provide added value to a proposal but is considered secondary to non-GPS disciplined capabilities.

PHASE I: This is a Direct to Phase II topic; Phase I proposals will not be accepted in response to this topic. Direct to Phase II topics require detail regarding a "Phase I-like" feasibility study. This study would include initial hardware system design with suggested procurement/implantation plan and schedule and/or an initial algorithm development, with documentation of the algorithmic steps, associated hardware assumptions/requirements for RF sensor and signal processing, and expected run-time performance analysis.

PHASE II: Proposers with relevant hardware prototypes, existing "classic" RF/SAR sensors and processing, i.e., GPS-enabled, and already developed non-GPS algorithms on real, or representative simulated, RF data are encouraged to propose. A successful Phase II effort will constitute the development of a hardware system or implementation and testing of real-time signal processing. Hardware development efforts will produce prototype hardware systems appropriate for (surrogate unmanned aerial vehicle (UAV)) flight environments and demonstrate data acquisition (and potentially signal processing) on AFRL-lead UAV flights. Algorithm developers will be provided relevant government furnished equipment (GFE) data, but may propose to use their own RF data, and will develop real-time code for signal processing which provides and navigation relevant output appropriate for an ASPN compliant navigator.

PHASE III DUAL USE APPLICATIONS: Phase III will consist of transitioning sensor hardware and software to an operationally approved ASPN compliant navigation system on an operational UAV or weapon system.

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

REFERENCES:

[1] Chang, Wensheng et al. “A Novel Multi-Angle SAR Imaging System and Method Based on an Ultrahigh Speed Platform.” Sensors (Basel, Switzerland) vol. 19,7 1701. 10 Apr. 2019, doi:10.3390/s19071701.
[2] H. Yang, C. Chen, S. Chen, F. Xi and Z. Liu, "Interferometric Phase Retrieval for Multimode InSAR via Sparse Recovery," in IEEE Transactions on Geoscience and Remote Sensing, vol. 59, no. 1, pp. 333-347, Jan. 2021, doi: 10.1109/TGRS.2020.2994197.
[3] L. Jiao, X. Tang, B. Hou and S. Wang, "SAR Images Retrieval Based on Semantic Classification and Region-Based Similarity Measure for Earth Observation," in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 8, no. 8, pp. 3876-3891, Aug. 2015, doi: 10.1109/JSTARS.2015.2429137.
[4] Rostami M, Kolouri S, Eaton E, Kim K. Deep Transfer Learning for Few-Shot SAR Image Classification. Remote Sensing. 2019; 11(11):1374. https://doi.org/10.3390/rs11111374

KEYWORDS: SAR; RF; Navigation; GPS-denied; GPS-Degraded; Open Architecture; ASPN; Modular

TPOC: Kevin Brink,
Phone: (850) 882-4600,
Email: Kevin.brink@us.af.mil

AF221-D003 TITLE: High Speed Particulate Erosion Capability

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: To develop a mobile, high speed, high temperature particulate erosion capability for testing aerospace components and coatings in conjunction with laser heating for the Department of the Air Force (DAF). DAF equipment frequently operates in regions prone to airborne particulates, such as desert sands, volcanic ash, and pollution products. This capability will provide a rapid, low-cost testing capability for flight through atmospheres containing particulates. Applications include electromagnetic windows, leading edge materials, and coatings for supersonic and hypersonic weapon systems.

DESCRIPTION: Develop a new test capability to quantify resistance of aerospace materials to high velocity and high temperature particulate erosion. Existing sand and dust erosion techniques reach a maximum of approximately 225 m/s for continuous testing methods, with single shot testing methods such as gas guns providing a much more limited particulate loading. Long distance flight through dispersed particulate clouds results in high particulate loadings, requiring a new test method capable of similarly high particulate loadings at high speeds. Additionally, fast flight through atmosphere can generate high temperatures. The system should be able to maintain a specimen temperature of 500°C during testing. Further, a replaceable electromagnetic window should be provided which is transparent at 10.6 μm to allow for laser impingement of the specimen surface to generate higher temperatures. This window should be easily replaceable with a low-cost sacrificial window for testing that does not require a laser. The selected acceleration method should not melt the particulate, as angular particulates are required to generate effective surface erosion, and particulates will be solid when encountered during flight. The expected particulates are shattered quartz and volcanic glass, both of which will be highly angular and abrasive. The particulate used should be easily changeable, to allow for each test to use a different particulate mixture. The particulate velocity should be tunable to simulate different flight profiles. The minimum velocity should be 220 m/s or below, to allow comparison to the particle erosion test apparatus located at Wright Patterson Air Force Base. The maximum velocity should be at minimum 800 m/s, with an objective of 1400 m/s. The stream of particulates should be continuous, to allow for buildup to high mass loadings. The target area should be a minimum of 6”x6”, with a target of 18”x18”. This area may be covered by rastering either the nozzle or the specimen, provided that the entire area receives a uniform exposure. An alternative operation mode allowing a changeable exposure path would allow for reduced testing time for leading edges and is a desired feature. The target area should allow for customizable fixturing, to allow for both coupon and component tests. Finally, the test capability should be mobile. This may be as a palletized system utilizing a forklift. Utility water and power may be utilized at each operational site. The origin of this requirement is for movement between specialized laser test facilities and a permanent location for standard operations and storage.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve

product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

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

REFERENCES:
https://www.ues.com/lhmel
MIL-STD-3033, DEPARTMENT OF DEFENSE TEST METHOD STANDARD: PARTICLE / SAND EROSION TESTING OF ROTOR BLADE PROTECTIVE MATERIALS (28-JUL-2010)

KEYWORDS: high temperature particulate erosion capability; testing aerospace components; coatings; laser heating; airborne particulates; desert sands; volcanic ash; pollution products

TPOC: Matthew Hartshorne,
Phone: (937) 255-4108,
Email: matthew.hartshorne.1@us.af.mil

AF221-D004 TITLE: RF Analog Imaging for Dual Multi-static Radar and Radar Warning Receivers

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Sensors; Electronics; Materials

OBJECTIVE: Fabrication of a first generation 32 element radar receiver that images for multi-static and bi-static applications with added functionality as a Signals Intelligence (SIGINT) and communication receiver if feasible within the program. The backend should be software defined and library loaded if in radar warning receiver (RWR) mode, with as large a beam bandwidth possible (within cost constraints, expandable upon enhanced funding and modular to 2-dimensions for further transition) demonstrating maximum bandwidth in at least 1 beam. Multi-static proof of principle demonstrated in laboratory or range, algorithm requirements at least road-mapped if not developed and implemented. Concept of Operations (CONOPS) and scheme.

DESCRIPTION: As use of the radio frequency (RF) spectrum by both red and blue forces continues to expand both to higher frequencies and in producing higher signal density of the environment, the next generation of communications and radar receiver systems will need more capability to route and process signals, and conventional electronic processors will struggle with the data flow especially if receivers are tasked with multiple missions in dense threat environments. Systems have been demonstrated using RF photonic techniques that provide real-time analog spatial and spectral processing of these high frequency signals within dense signal environments. Sorting of signals by analog imaging provides tremendous benefits including instantaneous direction finding and/or carrier frequency information, the relieving of the processors of beamforming thereby freeing up significant digital bandwidth so that processors can function solely as waveform analyzers. New generations of digitizers make extremely wideband receivers possible, putting even more emphasis on analog beam processing as a way to unburden already overstrained data pipelines. These new digitizers offer up to about 35GHz per beam instantaneous bandwidth, giving a huge potential >1TB/s beam-bandwidth product on a 1x32 receiver for instance, and sending that digital data flow to backend processors.

Data bottlenecks would remain; however, the problem is no longer bottlenecked at the same locations and by having data sorted by beam direction at least processors canst threat directions if the instantaneous bandwidth needs to be large. Radar warning receivers in dense environments will probably also have to double as SIGINT receivers in order to deal with the large number of signals and more constrained Size, Weight, and Power (SWaP) environments on today's platforms. RF analog imaging offers avenues for this as again the backend digitizers may feed the same processors, but programmed for a different mission, or even multi-missions. This software defined backend, combined with analog beamforming, will in turn enable a much more agile and capable RF mission set on one phased array. RF Analog imaging is also an enabling technology for future multi-static radar systems as radar returns can come from anywhere in the field of view at any time, making wideband analog imaging extremely useful in that regard. Multi-static radar offers tremendous promise for future warfighting as large emitting radar platforms are increasingly becoming obsolete in high threat environments as expendable low-cost transmitters may be flown in forward of high value receivers. Multiple transmitters illuminate the forward area and therefore a staring imaging receiver is an attractive option for receiving the returns as there may be multiple signals at random directions and time delays. In the past, photonics has offered a way to perform this imaging by modulating received electronic signals onto optical carriers. This conversion is accomplished by means of an electro-optic modulator and the RF signals have been collected within a phased array and then imaged onto high data rate phototransistors. This generation of system can take advantage of advancements in the modulators recently.

PHASE I: This topic is intended for technology proven ready to move directly to Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a "Phase I-like" effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a "Phase I-like" effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

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

REFERENCES:

1. C. A. Schuetz et al., "A Promising Outlook for Imaging Radar Imaging Flash Radar Realized Using Photonic Spatial Beam Processing," IEEE Microwave Magazine, vol. 19, no. 3, pp. 91–101, May 2018, doi: 10.1109/MMM.2018.2801639.

KEYWORDS: First generation 32 element radar receiver; multi-static and bi-static; SIGINT and communication receiver; radar warning receiver (RWR) mode; large a beam bandwidth; Multi-static proof of principle

TPOC: Robert Nelson,
Phone: (937) 255-9907,
Email: robert.nelson.21@us.af.mil

AF221-D005 TITLE: Extremely High Temperature Aperture Materials Maturation and Manufacturing Development for High-Speed Systems

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Sensors; Materials; Air Platform

OBJECTIVE: The objective is to provide material and process options for extremely high temperature aperture applications. Efforts may focus on development of new materials options and approaches, process improvement of existing but immature aperture materials, or manufacturing process development of well-established materials. The candidate material(s) should be validated through a range of mechanical, thermal, and electrical tests, at various times throughout the effort. For a material maturation focused effort, validation should include a demonstration of the ability to fabricate representative sized components (e.g., a 6" x 6" doubly curved panel, or 3" diameter hemisphere) by the end of the effort. The component should then be tested in a relevant environment. For a manufacturing focused effort, manufacturing of a full-scale relevant geometry aperture shall be performed to prove the process.

Testing should also assess the transient aerothermal and electromagnetic performance in a relevant environment. The resulting aperture technology will be validated under these efforts and data and concepts provided for transition to the programs of interest. To be viable, a component must not recess more than 1 mil/min during exposure to high heat flux tests which result in material temperatures well in excess of 1000°C. Electromagnetic properties such as signal transmittance must be measured and shown to be at least 80% of other state-of-the-art options. Ideally the improved manufacturing will also provide improved properties such as strength or erosion resistance as a result of reduction of variability due to controlled manufacturing processes.

DESCRIPTION: The Air Force must be able to operate effectively in anti-access, area-denial environments as well as be able to disseminate "real-time" intelligence, surveillance, and reconnaissance data. This requires current and next generation ground, air, and space platforms to have antenna and aperture systems with improved bandwidth, capability, functionality, selectivity, and performance. This need is accentuated for vehicle platforms that travel at hypersonic speeds due to the additional requirement for the apertures to survive in high temperature and high sheer environments.

Hypersonic platforms represent an extremely challenging combination of design requirements for window and radome materials. Necessary attributes include oxidation resistance, desirable electrical performance over a wide wavelength range, sand and rain erosion resistance, stable performance over a wide temperature range, high strength and toughness, robust processing, reasonable cost, and the ability to be integrated into the vehicle platform. These apertures are most desirably placed at or near the front of the vehicle, where temperature can reach or exceed ~1800°C for short (~20-60 sec) times.

Commercial hypersonic platforms, assuming their successful development and the emergence of a viable business case, will require a range of apertures to meet various communications and sensing needs, but these can be placed in locations where they will experience much less extreme conditions, making extremely high temperature apertures a defense unique requirement. The high temperature composite and monolithic materials that are typical candidates for these types of applications have a long history of being expensive, poorly understood, slow and difficult to manufacture, and exhibiting significant lot-to-lot variability. A goal here is to identify new or improved materials and processes, mature the processing of the candidate material(s), and to increase the manufacturability, producibility, and reliability for current and next generation aperture systems. No single proposal will be able to accomplish all of this, so bidders should discuss the development status of their proposed material(s) and processing and clearly indicate where their focus lies – development of a new material

candidate, maturation of an existing material candidate, or manufacturing and producibility improvement of a well-established material and process.

The proposed aperture system can include Radio Frequency (RF), Electro-Optic (EO), Infrared (IR), or multispectral solutions. New and innovative material solutions may be proposed to provide new options for extreme temperature apertures. Potential candidates include but are not limited to advanced monolithic and composite material variants. Processing approaches could include any of the range of traditional ceramic and composite processing approaches, additive manufacturing, and other innovative and unique techniques. Established but immature aperture materials may be proposed with a focus on addressing outstanding processing issues. The goal here is to identify any process deficiencies (e.g., failure to control all of the key process parameters; failure to ensure the consistency and suitability of all constituents) and seek to remedy them. Tools such as Expert Elicitations and Designed Experiments should be used to solve such problems. Application of an in-process non-destructive evaluation (NDE) technique, or some new measurement may be necessary to gain the understanding needed to resolve such an issue. Well established materials and processes may be proposed with a focus on improving the manufacturability, producibility, and reliability for current and next generation aperture systems. The focus is on reducing cycle time, part count, touch labor, and ultimately reducing the cost of the components while at the same time reducing manufacturing variability.

An integrated manufacturing chain is required to overcome state-of-the-art geometric, material set, and part size limitations. To meet this need, advancements in areas that combine two or more aspects such as multi-material solutions, 3D printing techniques, innovative fiber preforming, engineered and localized property performance, automation, and improved densification techniques are sought. The work should be conducted with consultation or support from a hypersonics Prime vehicle manufacturer that can provide guidance on performance requirements and design considerations such as part size and relevant geometry. The proposal should clearly identify the current state of the art of the aperture system of interest including both technical and manufacturing readiness and how the proposed work will advance readiness for the proposed aperture concept.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/ production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

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

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

REFERENCES:

1. Harris, Daniel C. Materials for infrared windows and domes: properties and performance. Vol. 158. SPIE press, 1999. ISBN 0-8194-3482-5
2. https://multimedia.3m.com/mws/media/1324013O/oxide-oxide-ceramic-matrix-composites.pdf
3. https://www.quartz.saint-gobain.com/news/using-quartz-fiber-aerospace-radomes

KEYWORDS: Extremely high temperature aperture applications; materials; manufacturing process; validated through a range of mechanical, thermal, and electrical tests; fabricate representative sized components (e.g. a 6” x 6” doubly curved panel, or 3” diameter hemisphere); relevant environment; transient aerothermal and electromagnetic performance; exposure to high heat flux; 1000°C; Electromagnetic properties; signal transmittance

TPOC: Carmen Carney,
Phone: (937) 255-9154,
Email: carmen.carney.1@us.af.mil

AF221-D006 TITLE: Composite Laser Ablation for Surface Preparation (CLASP) Manufacturing Scale-up

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: The Composite Laser Ablation for Surface Preparation (CLASP) manufacturing scale-up objective is to take the one-off working handheld prototype and transform it into a set of production ready tools. Since these tools will be utilized on a manufacturing floor, they must be robust, easy to use, meet all governing safety regulations, and perform in a highly efficient and effective manner. They must be adapted for better handheld uses and for higher through put operations such as gantry type of set up where the CLASP tool is stationary and the part needing surface preparation moves under it. In addition, the scale up effort will improve prototype surface preparation time by 25%.

DESCRIPTION: CLASP manufacturing scale-up will refine the prototype handheld unit into a reliable production factory floor set of tools while enhancing its capability and improving its operating efficiency. Proper composite part surface preparation is critical in achieving a strong bond for structural capacity. The current surface preparation method is hand sanding which is extremely time consuming. In addition, the surface preparation is highly variable and thus, introduces structural integrity uncertainties into the bond between the composite parts. CLASP will improve the through put and surface quality for composite part bonding. The scale-up will redesign the handheld prototype into robust high-quality parts for assembly line type manufacture of the tool. The design will be highly ergonomic for handheld operations but also tailored for robotic or gantry type utilization for high output surface preparation. Disposal of ablated surface debris will be 100% contained as to not contaminate the just prepared clean surface. All fiber optic laser cables, debris removal hoses, power lines, user interface display cables and surface offset contact leads will be routed for ease of mobility and safety on the production floor.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

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

REFERENCES:

1. Palmieri, F.L., Ledesma, R. et al., ”Optimized Surface Treatment of Aerospace Composites using a Picosecond Laser,” Composites Part B: Engineering, 2019.
2. Belcher, M.A, Blohowiak, K.Y., Wohl, C.J., Connell, J.W. and Palmieri, F.L., “Laser Ablation Surface Preparation for Adhesive Bonding of Carbon Fiber Reinforced Epoxy,” Int. Journal of Adhesion and Adhesives, 2016.
3. Cargill, R.L. and Wool, M.R., “Surface Preparation of Organic Matrix Composites (OMCs) for Structural Adhesive Bonding,” AFRL-RX-WP-TR-2013-0178, March 2013.
4. AFD 2053 Invention Disclosure “Prepregs and Cured Composites Having Improved Surfaces and Processes of Making and Methods of Using Same” (Adam Hicks, copied here, has patent invention disclosure details)

KEYWORDS: Manufacturing scale-up; handheld unit; production factory floor set of tools; proper composite part surface preparation; tailored for robotic or gantry type utilization;

TPOC: Dean Foster,
Phone: (937) 255-6936,
Email: dean.foster.3@us.af.mil

AF221-D007 TITLE: NDE of Thick Scarf Repaired Composites and Related As-Manufactured Structures

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: Develop novel non-destructive evaluation (NDE) tools and algorithms that facilitate rapid assessment of thick scarf repairs and joints, including those that do not have a plate-like geometry. The NDE tools and/or algorithms should detect delaminations 6 mm in diameter and larger plus porosity equal to and greater than two percent in the vicinity of the scarf. The capability must detect these flaws if the scarf includes multiple layers of composite lamina and should be readily integrated into common non-destructive testing (NDT) inspection equipment. Algorithms to assist in data interpretation and analysis must be prepared to enable easy update and maintenance by organic Air Force resources. The algorithms should not be based on brute force artificial intelligence / machine learning but needs to include the "human in the loop" using the preferred Intelligence Augmentation approach defined by the Air Force.

DESCRIPTION: Future concepts for composite aircraft include the use of bonded scarf joints either as part of the manufacture and assembly of the structure or repairs of manufacturing defects or damage experienced in service. These structures can be relatively thick when compared to current composite aerospace components, exceeding 50mm in total thickness. Typical NDT methods used for thinner composite structures include ultrasonic and thermographic-based techniques, where frequencies and diffusion fields are managed and analyzed by the trained inspector to provide the desired detection capability, nominally delaminations approximately 6 mm in diameter or porosity exceeding two percent of the local volume.

However, these methods are challenged when considering the geometry of a thick scarf repair, especially if multiple layers of composite components are joined together at the location and the scarf penetrates the multiple layers. As the signal becomes quite complex, the signal analysis and interpretation capability can exceed the skill of a typical Level 2 nondestructive inspector. Thus, the Air Force is seeking novel NDE approaches and/or the development of algorithms that assist and augment the inspection via interpretation of the complex signals that result from the interrogation of these types of structures.

It is important to note the Air Force is NOT interested in brute force Artificial Intelligence / Machine Learning approaches as they have been shown to not address the nuanced and outlier nature of the data of interest. The Air Force solution that has been successfully developed and implemented for metallic [ref] and composite [ref] structures use an approach called Intelligence Augmentation [ref] that combines the capabilities of statistical classifiers and other analytical algorithms with the human to optimize the decision-making process to detect features of interest emanating from defects. These algorithms eventually need to be integrated into commercially available NDT equipment to enable them to be supported by major equipment suppliers.

In addition, the NDT tools and algorithms should be developed in such a manner to accommodate changes and/or updates detection criteria and/or types of data being analyzed to enable organic Air Force maintenance of the implemented solution in its final state. Another desired capability is to inspect or facilitate inspection of complex geometry configurations typically found on military aircraft where such scarf repairs will occur. This includes variability in the geometry, lay-up, and substructure to the region of interest. The tools and algorithms must enable the assessment of these highly variable geometric configurations.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II.

Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a "Phase I-like" effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a "Phase I-like" effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

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

REFERENCES:

1. Aldrin, J., C., Forsyth, D. S., and Welter, J. T., "Design and Demonstration of Automated Data Analysis Algorithms for Ultrasonic Inspection of Complex Composite Panels with Bonds," 42nd Annual Review of Progress in QNDE, Incorporating the 6th European-American Workshop on Reliability of NDE, Vol. 1706, p. 120006, AIP Publishing, (2016)
2. Aldrin, J. C., Lindgren, E. A., and Forsyth, D. S., "Intelligence Augmentation in Nondestructive Evaluation," 45th Annual Review of Progress in QNDE, AIP, 2102, p. 020028, (2019).

KEYWORDS: Composite aircraft; repair; manufacture; defects; damage; Structure; detection capability; delaminations; porosity; skill of a typical Level 2 nondestructive inspector; Non-destructive Evaluation; NDE; Artificial Intelligence / Machine Learning; tools and algorithms; highly variable geometric configurations.

TPOC: Charles Buynak,
Phone: (937) 255-9807,
Email: charles.buynak@us.af.mil

AF221-D008 TITLE: Self-Healing Fuel Tank Bladders for Reduced Aircraft Maintainability

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: To develop, produce, and transition a flexible, lightweight self-healing fuel tank bladder for military aircraft that can survive in-service fuel leaks. Fuel leaks from pinholes and seams in aircraft fuel cell bladders are a heavy maintenance burden, particularly for refueling aircraft such as the KC-135. Fuel leaks are a key factor in non-mission readiness for these aircraft. The self-healing function should be integral to the bladders and have weight increase of not greater than 3% (objective) or 10% (threshold). While self-healing materials previously have been developed for saltwater environments, currently there are none for aircraft fuels.

DESCRIPTION: To reduce the maintenance burden and expand the usable life of fuel cells, self-healing bladders are needed to detect and heal minor pinhole leaks and seeps from seams and/or around fittings. Self-healing bladders will reduce costs by reducing the amount of human interaction, system downtime, and the need for part replacement. In turn, the self-healing function will reduce maintainability and extend the mission. Currently there are no commercially available self-healing bladders. Requirements for the self-healing function include:
(1) should be integral to the bladders and not reduce flexibility;
(2) have weight gain of not greater than 3% (objective) or 10% (threshold);
(3) should not alter the capability to contain fuel; and (4) should not hinder the installation nor the removal of the bladders.

The unique shapes and complexity of modern fuel cell bladders should be considered in any proposal, which should address all the requirements of MIL-DTL-6396, Type II. The self-healing capabilities of the bladders should be activated within 2 minutes of fuel leak initiation and be able to permanently seal (objective) or seal for at least 3 years (threshold). Concepts should be able to be readily integrated into the current manufacturing processes of aircraft fuel cell bladders.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR Programs. Under the phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of

the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

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

products and services developed in coordination with the program.

REFERENCES:
1. Davies, J, Shipman, J, Davidson, W. “Self Sealing Fuel Tank Construction”, US Patent 2,446,815.
2. Monk, R.; Ohnstad, T.; Henry, J.; “Projectile Barrier and Method”, US Patent 7,169,452 ;
3. MIL-DTL-6396, Tanks, Fuel, Oil, Cooling Fluids, Internal, Removable Non-Self-Sealing

KEYWORDS: Fuel Bladders; Self-healing

TPOC: Michelle Barga,
Phone: (937) 904-4378,
Email: michelle.barga@us.af.mil

AF221-D009 TITLE: Material Advances for Aerospace Cognitive Monitoring

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: AFRL recently assessed Food and Drug Administration (FDA) approved and/or commercially available products demonstrating reliability and validity for identifying alterations in cognitive ability as a function of various stressors. The assessment's goal was to target the most promising technologies capable of generating human performance metrics for real-time cognitive monitoring which could be compatible with the aerospace environment. Electrophysiological measurements (electro-oculogram (EOG), electromyography (EMG), and Electroencefalography (EEG)) were deemed highly relevant solutions for fatigue detection and potential avenues for rapid prototype development. These prototypes should leverage advances in dry electrode technology for sensor performance and long-term wearability. Additional challenges recording electrophysiological signals in the aerospace environments include:
1) Degradation from electrode instabilities,
2) Impedance mismatch from current electrode materials (must meet impedance levels equal to or better than standard wet electrodes),
3) Existing sensor limitations due to poor form factor/engineering,
4) Degradation due to motion artifacts and sensor decoupling,
5) Human factors challenges, and 6) Mission challenges for maintaining human monitoring in the cockpit.

AFRL seeks to identify solutions that may be low power, manufacturable at scale, wearable, and airworthy. Proposed solutions may include, but are not limited to, wearable, dry electrode EOG prototypes or on-eye contact lenses for fatigue detection with the ability to detect blinking and saccadic velocity metrics. Combined sensing capabilities within one proposed system is also of interest. Finally, proposed solutions may include, in isolation or in combination with a real-time monitoring solution, wearable, airworthy augmentation technology for neuromodulation. A long-term goal for this capability is to inform a closed-loop fatigue mitigation/augmentation capability to increase the long-endurance (>24 hours) operations capability for USAF.

DESCRIPTION: Fatigue is a pervasive problem during high tempo operations in many mission scenarios. The high-performance flight environment imposes unique causes of fatigue on pilots and aeromedical personnel and limits countermeasure capabilities. Flight-related fatigue may be due to consecutive missions, mental exertion, cognitive overload, and/or jetlag and can become chronic leading to reduced health and compounded stress.

Currently, the DoD does not require physiological monitoring of aircrew for the purpose of identifying decrements due to fatigue. However, steady decrements in performance in laboratory settings have been demonstrated (McIntire, et al., 2017) and counter fatigue measures have proven successful, such as transcranial direct current stimulation (tDCS) and noninvasive vagal nerve stimulation (nVNS). In fact, one 30-minute session of tDCS can improve accuracy and reaction times for up to 12 hours and shows this improvement above and beyond the effect of caffeine (McIntire, et al., 2017). In addition, the tDCS condition did not affect subjective mood, whereas performance in the caffeine condition showed a direct relationship (McIntire 2014 & 2017). While advances in cognitive monitoring technology for commercial, R&D, and personal health applications have rapidly advanced, they currently do not exist in flight. Current investigations across several U.S. bases identified 224 lives, $11.6 billion, and 186 aircraft lost due to military aviation mishaps from 2013-2020. While these findings are devastating, the focus of mitigation lies at the investigation of Class C mishaps due to the ability to assess the factors involved. Nonfatal mishaps allow investigation boards to identify causes and establish standards to prevent further fatalities. The National Commission on

Military Aviation Safety (2020) determined that "judgement and decision-making errors" make up a majority of Class C mishaps. With cognitive degradations occurring in 24 hours and a need for optimal decision making to be sustained for multiple days, the unavailability of robust clinical devices for the aerospace environment poses a crucial gap and puts our AF missions at risk. As the Air Force drives towards the capability to sustain mission success in a potentially enduring fight, rapid assessment and augmentation of cognitive readiness and performance becomes crucial to maximize the warfighter's potential and to inform the Joint Area Domain Command and Control (JADC2) network more effectively.

While physiological monitoring capabilities are rapidly being developed to meet the needs of the airborne environment, to date an airworthy, closed-loop, cognitive assessment and augmentation system currently does not exist to ensure medical readiness. This capability gap is largely due to poor signal continuity and reliability of many physiological monitoring technologies in high motion environments. In addition to human movement, the aerospace environment provides additional challenges due to high gravitational acceleration, vibration, ambient noise, and other potential electromagnetic interference. Size, weight, power and form factor become complicating factors. Several methods of detecting fatigue have been validated in a laboratory setting and include EEG/ERP, EOG, EMG, ECG, cerebral oxygenation (Lohani, Payne, & Stayer, 2019), facial recognition, eye tracking (Rozanowski, Bernat, & Kaminska, 2015), cognitive assessment (Basner et al., 2019), standard questionnaires, and various biometrics such as heart rate variability and blood pressure (Lohani, Payne, & Stayer, 2019). In a recent review to assess these validated metrics and their feasibility in a dynamic driving environment, it was recommended that ECG and thermal imaging yielded the most promise in terms of applicability to dynamic environments; however, oculomotion/pupilometry and electromyography can provide insight into user state if luminance can be controlled and measured (Lohani, Payne, & Stayer, 2019).

An additional review by the driving/trucking industry suggested that, among physiological signals, EOG is most suitable because of its simplicity, driver [user] friendliness and robustness against environmental factors such as ambient light and driver movement (Papadelis et al., 2007). Papadelis and colleagues presented clear evidence that eye-blinking statistics are sensitive to the driver's sleepiness and should be considered in the design of an efficient and driver-friendly sleepiness detection countermeasure device. In addition, several studies have demonstrated that saccade "peak" velocity is a sensitive indicator of cognitive fatigue. As time-on-task increases, the slope of saccadic peak velocity as a function of saccadic magnitude decreases. This relationship was validated by Di Stasi and colleagues when comparing air traffic control performance across time-on-task with longer duration times revealing a decreased slope (Di Stasi, et al., 2013b). Finally, in 2016, this relation was validated when comparing a short duration flight to a long duration flight with the longer duration (~2 hours) showing a decreased slope (Di Stasi, 2016). Camera-based eye tracking is widely adopted as a standard way to measure eye movements including saccadic velocity.

Current eye trackers are insufficient in the aerospace environment due to several factors including incompatibility with AFE/helmets, dynamic lighting or sunlight interference, and the requirement to illuminate the eyes with IR sources. In addition, video-based trackers tend to be bulky, slow and often produce a noisy signal. COTS eye trackers are rapidly advancing for aerospace simulation, but operational flight is still a challenge. EOG-based solutions may be more appropriate. In order to close the loop for cognitive monitoring and augmentation in the aerospace environment, such monitoring capabilities need to read into a validated technique for neuromodulation. As mentioned above, transcranial direct current stimulation (tDCS) has been shown to produce significant and sustained performance advantages when compared to a control condition as well as a caffeine condition (McIntire, et al., 2017). In addition, the method of noninvasive vagal nerve stimulation (nVNS) shows the same performance advantages compared to the control condition for multitask performance (McIntire, et al., 2014). These results are backed by significant differences in subjective fatigue. tDCS and nVNS are both highly reliable augmentation methodologies. The ability to administer tDCS

in the aerospace environment is challenging due to need for helmet integration; however, nVNS, which currently requires placement of a device on a specific area of the neck or ear, may prove feasible for the aerospace or austere environment with improvements in form factor for long-term wearability.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a "Phase I-like" effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a "Phase I-like" effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

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

REFERENCES:

1. Basner M., Savitt A., Moore T. M., Port A. M., McGuire S., Ecker A. J., et al. (2015). Development and validation of the cognition test battery. Aerosp. Med. Hum. Perform, 86, 942–952. 10.3357/AMHP.4343.2015
2. Copp, T. (2019). Military Times Crash Database, Fiscal 2011 through 2018. Accessed March 16, 2020: https://www.militarytimes.com/news/your-military/2019/04/09/military-times-crash-database-fiscal-2011-through-2018
3. Di Stasi, L. L., Catena, A., Canas, J. J., Macknik, S. L., & Martinez-Conde, S. (2013a). Saccadic velocity as an arousal index in naturalistic tasks. Neurosci Biobehav Rev, 37(5), 968–75.
4. Di Stasi, L. L., McCamy, M. B., Catena, A., Macknik, S. L., Canas, J. J., Martinez-Conde, S. (2013b). Microsaccade and drift dynamics reflect mental fatigue. Eur J Neurosci, 38(3), 2389–98.
5. Di Stasi, L. L., McCamy, M. B., Martinez-Conde, S., Gayles, E., Hoare, C., Foster, M., et al. (2016). Effects of long and short simulated flights on the saccadic eye movement velocity of aviators. Physiol Behav, 153, 91-96. doi:10.1016/j.physbeh.2015.10.024
6. Lohani, M., Payne, B., & Stayer, D. (2019). A Review of psychophysiological measures to assess cognitive states in real-world driving. Frontiers in Human Neuroscience, 13:57.doi: 10.3389/fnhum.2019.00057.
7. McIntire L. K., McKinley R. A., Goodyear C., Nelson J. (2014). A comparison of the effects of transcranial direct current stimulation and caffeine on vigilance and cognitive performance during extended wakefulness. Brain Stimul., 7, 499–507
8. McIntire L. K., McKinley R. A., Nelson, J., Goodyear C. (2017). Transcranial direct current stimulation versus caffeine as a fatigue countermeasure, Brain Stimul., 10(6), 1070-1078
9. Rozanowski, K., Bernat, M., & Kaminska, A. (2015). Estimation of operators' fatigue using

optical methods for determination. International Journal of Occupational Medicine and Environmental Health, 28(2), 263-281.
10. West, J. B. (2013). A strategy for in-flight measurements of physiology of pilots of high-performance fighter aircraft. Journal of Applied Physiology, 115(1), 145–149. doi:10.1152/japplphysiol.00094.2013

KEYWORDS: Human performance; Aviation; Fatigue; Eye-tracking; Wearables; Pilots; Aeromedical Evacuation

TPOC: Regina Shia,
Phone: (937) 623-0746,
Email: Regina.Shia@us.af.mil

AF221-D010 TITLE: AI for the Depot: Using ETAR for Digital Health Records

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: This effort will deliver a prototype Digital Health Record application to provide all Engineering Technical Assistance Request (or ETAR) information, non-destructive inspection (NDI) results, Airworthiness information and 3D images to determine the health of each aircraft. The Digital health record application will provide an organized and indexed data for Artificial Intelligence & Machine Learning for disposition decisions/actions and contribute to predictive Maintenance.

DESCRIPTION: This project will include: 1. Designing and prototyping a Digital Health Record application to provide all ETAR information, NDI results, Airworthiness information and 3D images to determine the health of KC-135 2. Identify all relevant data sources and connect disparate data to create relationships to expand and operationalize AI/ML and 3. Use machine learning, historical performance data and contextual data to predict maintenance and alert for proactive identification of problem parts. While the data is currently being tracked, it is not analyzed to help make informed planning decisions- and this in this case KC-135 does not use the data to decide when to retire a plane. Engineering dispositions are burdened with repetitive assistance requests and responses, incorrect entry, lack of standards and quality. With increased data standards and quality, trending on historical mx actions it can result in faster/more accurate disposition. With the addition of technology and build out of the aircraft technical baseline (as sustained), the data can begin to be aggregated and analyzed to show predictive results.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

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

REFERENCES:

1. Peixoto, R., Cruz, C., Silva, N. Adaptive learning process for the evolution of ontology-described classification model in big data context (2016) Proceedings of 2016 SAI Computing Conference, SAI 2016, art. no. 7556031, pp. 532-540. Cited 2 times. DOI: 10.1109/SAI.2016.7556031

2. 14th Extended Semantic Web Conference, ESWC 2017 (2017) Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 10250 LNCS, pp. 1-278.
3. Peixoto, R., Cruz, C., Silva, N. Semantic HMC: Ontology-described hierarchy maintenance in big data context (2015) Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 9416, pp. 492-501. Cited 2 times. DOI: 10.1007/978-3-319-26138-6_53
4. Boyles, R.R., Thessen, A.E., Waldrop, A., Haendel, M.A. Ontology-based data integration for advancing toxicological knowledge (2019) Current Opinion in Toxicology, 16, pp. 67-74. Cited 4 times. DOI: 10.1016/j.cotox.2019.05.005
5. ACM International Conference Proceeding Series (2018) ACM International Conference Proceeding Series, 152 p.
6. Conway, M., O'Connor, D. Social media, big data, and mental health: Current advances and ethical implications (2016) Current Opinion in Psychology, 9, pp. 77-82. Cited 47 times. DOI: 10.1016/j.copsyc.2016.01.004
7. Kim, Y., Lee, J., Lee, E.-B., Lee, J.-H. Application of Natural Language Processing (NLP) and Text-Mining of Big-Data to Engineering-Procurement- Construction (EPC) Bid and Contract Documents (2020) Proceedings - 2020 6th Conference on Data Science and Machine Learning Applications, CDMA 2020, art. no. 9044209, pp. 123-128. DOI: 10.1109/CDMA47397.2020.00027

KEYWORDS: Artificial Intelligence (AI); Machine Learning (ML)

TPOC: Elizabeth Loiacono,
Phone: (937) 751-7674,
Email: elizabeth.loiacono@us.af.mil

AF221-D011 TITLE: Spatial Registration of Nondestructive Evaluation (NDE) Sensors in Enclosed or Constrained Access Locations

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: This effort will develop a sensor system to spatially register the location and orientation of non-destructive evaluation (NDE) sensors as an inspection is being accomplished. The sensor system must be sufficiently small to be integrated on current NDE sensors, such as ultrasonic transducers or eddy current pencil probes. The accuracy of the sensor positioning needs to be within 0.5 mm in x and y directions when on a surface and x, y, and z directions when in space. The sensor orientation should be tracked to within 3 degrees. The tracking system must operate inside confined and/or limited access areas where currently commercial systems based on optical, electromagnetic, or ultrasonic methods do not work due to internal reflections and/or interfering structures insides the aircraft. The system should have readily exportable digital data for integration into a display system to be determined and should include some form of software module that can be integrated into the overall display of the inspection process to enable near real-tie feedback to the inspector regarding the area covered by the sensor and the orientation as the data was being collected. This can include both hand-held and robotic-assisted inspection processes.

DESCRIPTION: The Air Force has the desire to spatially track NDE sensors as inspections are performed. This includes spatial tracking accuracy of 0.5 mm in all available dimensions, e.g. x and y when the sensor is on a surface and x, y, and z if the sensor in is the air. In addition, this includes the angular orientation of the NDE sensor to within at least 3 degrees. The tracking capability needs to be provided in a small enough package to not interfere with the performance of an NDE assessment using current commercial sensors, such as hand-held ultrasonic transducers and/or eddy current pencil or specialty probes.

The intent of this tracking capability is to provide an inspector with near real-time feedback regarding the status of the inspection process. This includes ensuring the correct region of the inspection was covered and that the sensor in question was oriented correctly to ensure the inspection was performed in accordance with the intent of the inspection procedure. The feedback would enable the inspector to make any corrective actions before the inspection was marked as complete, greatly reducing the need to revisit and/or re-accomplish a completed inspection. In addition, it will simplify the completion of the inspection in case there are any interruptions as it was being performed to ensure the inspector continued the inspection at the location where the process was interrupted.

The significant challenge for this desired capability is the ability to track sensors inside a confined and/or constrained access location. Thus, current tracking methods, including such approaches as line-of-sight optical methods, electromagnetic positioning methods, and acoustic-based range finders, will not work in these applications due to the lack of access, interference from internal structures such as pipes, fittings, and other structural elements of the aircraft. Initial trials of typical commercial capabilities illustrated that these internal features, typically quite dense even in open bays, inhibit the accuracy and/or resolution of these commercial solutions. In addition to the size and resolution desired, the tracking data must be transmitted form the tracking sensors to a computerized system that will provide feedback to the inspector. Therefore, the data must be near real-time to enable the inspector to correct their processes and monitor their progress as they are accomplishing an inspection.

The preferred option for the display in which this information would be provided to the inspector is using some form of augmented reality or similar type interactive display. It is important that the data

stream from the tracking sensors is provided in a readily defined format to enable its simple integration into any type of display system. In addition to the sensor system, a desired capability is some form of image-based software that can illustrate to the inspector where the probe has been and what was its orientation as it was manipulated. This does not need to be a stand-alone software system but can be a capability that is readily integrated into displays that includes other inspection relevant information.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a "Phase I-like" effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a "Phase I-like" effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

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

REFERENCES:

1. Leveraging Augmented Reality: An NDE Case Study; Eric Lindgren, Charles Buynak; 2020 ASIP; can be accessed at http://meetingdata.utcdayton.com/agenda/Agendas.asp?ID=asip202056080118

KEYWORDS: NDE Spatial Registration; Confined Space; Probe Orientation;

TPOC: Bryce Jolley,
Phone: (937) 255-9053,
Email: bryce.jolley@us.af.mil

AF221-D012 [TOPIC REMOVED]

AF221-D013 TITLE: Innovations in Distributed Collaboration for Tactical Environments

TECH FOCUS AREAS: Network Command, Control and Communications; Autonomy; Artificial Intelligence/Machine Learning; General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Sensors; Electronics; Information Systems; Battlespace

OBJECTIVE: The Air Force Research Laboratory Information Directorate seeks innovation in a collaborative space augmenting the warfighter with tools and technology to safely, efficiently and accurately perform their duties. Examples of emerging technologies which could greatly enhance warfighter capability are voice interface to tactically deployed software systems, such as Android Tactical Assault Kit (ATAK), machine learning and/or artificial intelligence algorithms that leverage both currently deployed hardware and emerging commercial technologies, for revolutionary situational awareness and force collaboration.

DESCRIPTION: This topic seeks innovative technologies for distributed collaboration, using Tactical Assault Kit (TAK), for enhancing warfighter efficiency, safety, and accuracy. As distributed collaboration evolves on the battlefield, so do the possibilities for integration of modern sensors, systems and advanced technologies, including artificial intelligence and machine learning. Use cases for distributed collaboration are tremendously advancing in both the commercially and DOD-wide. Harnessing the power of innovation is often a cumbersome endeavor for the DOD, however the emergence of commonly deployed technology platforms has become exponentially beneficial. Successful development of innovative technologies for tactical collaboration not only benefit the end user of the technology but the larger enterprise, as well. The enhanced situational awareness and fortified software/hardware tool kit used by the tactical operator significantly impact the decision-making capabilities of connect leadership, through the chain of command. Additionally, there is a user community of 350k plus TAK users between commercial and federal users that could benefit from this technology.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study and customer discovery. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Proposals should include development, installation, integration, demonstration and/or test and evaluation of the proposed solution prototype system. This demonstration should evaluate the proposed solution against the proposed objectives; describe how the solution will fulfill the AF’s requirements; identify the technology’s transition path; specify the technology’s integration; and describe the technology’s sustainability. Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will focus on transitioning the developed technology to a working commercial or warfighter solution. If a viable business model for the developed strategy or algorithm(s) is demonstrated, the offeror or identified transition partners would be in a position to supply future processes to the Air Force and other DoD components as this new process is adopted.

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

proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Help Desk: usaf.team@afsbirsttr.us

REFERENCES:

1. tak.gov; https://takmaps.com/
2. https://www.afcea.org/content/army-tactical-assault-kit-always-adapting-new-era
3. https://play.google.com/store/apps/details?id=com.atakmap.app.civ
4. https://github.com/deptofdefense/AndroidTacticalAssaultKit-CIV

KEYWORDS: TAK; ATAK; Artificial Intelligence; System Integration; Systems

TPOC: Jack Eberhardt,
Phone: (315) 330-2284,
Email: john.eberhardt.4@us.af.mil

AF221-D014 TITLE: Peer-based Information Distribution in Contested Environments

TECH FOCUS AREAS: Cybersecurity; Network Command, Control and Communications; 5G

TECHNOLOGY AREAS: Sensors; Information Systems; Battlespace

OBJECTIVE: This topic will assess the ability of existing distributed file sharing protocols and applications to operate in relevant tactical scenarios with Android clients. It will evaluate the ability for selected peer-to-peer applications to support automatic directory synchronization. It will also investigate the feasibility of modifying the existing encryption on those applications to be compatible with DoD standards and the government-owned geospatial and situational awareness platforms. If evaluation proves promising, choose one of those candidates and replace the encryption, file/directory synchronization, and prioritization as appropriate.

DESCRIPTION: Distributed file sharing has broad applicability to the tactical domain, and fully distributed operating systems such as IPFS are likely too heavy weight for such applications. In particular, in an environment where we have large files, such as map imagery in a location with infrastructure (e.g., an Air or Tactical Operations Center (AOC/TOC)) and numerous users who need the information in a disadvantaged environment with low bandwidth to the AOC/TOC, but with substantial bandwidth to one another. This is often the case today with modern Mobile Ad Hoc Networking (MANET) radios, we can leverage a variation of an open-source, distributed, unidirectional file sharing approach to disseminate and store that tactical information in a secure, trusted manner based on prioritization to provide edge users with bandwidth-efficient information in a timely manner.

There are several distributed file replication protocols and applications (e.g. SyncThing, FolderSync, BitTorrent, or a half dozen similar tools) in popular use today. By emulating a disadvantaged tactical environment while concurrently using an existing distributed file client on Android, it's possible to quantify the potential gains that could result from the peer-to-peer architecture described. By modifying the existing open-source application to automatically synchronize files across the architecture, files can be pushed to edge devices whenever an update is available. Integrating such a distributed file distribution protocol with Tactical Assault Kit / Team Awareness Kit (TAK) ecosystem, either using DoD standard certifications in tandem with a Cursor on Target (CoT)-streaming server or using symmetric encryption for strictly peer-to-peer use, will likely make such file distribution exponentially more effective.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a "Phase I-like" effort, including a feasibility study and customer discovery. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Proposals should include development, installation, integration, demonstration and/or test and evaluation of the proposed technology. This demonstration should evaluate the proposed solution against the proposed objectives; describe how the solution will fulfill the AF's requirements; identify the technology's transition path; specify the technology's integration; and describe the technology's sustainability. Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will focus on transitioning the developed technology to a working commercial or warfighter solution. If a viable business model for the

developed solution is demonstrated, the offeror or identified transition partners would be in a position to supply future processes to the Air Force and other DoD components as this new technology is adopted.

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

REFERENCES:

1. https://www.semanticscholar.org/paper/Delay-tolerant-data-sharing-in-tactical-Echeverr%C3%ADa-Lewis/25d1f195acca79d08a7724fde3692eabb4a6d797
2. https://www.semanticscholar.org/paper/An-experimental-evaluation-of-data-distribution-in-Casini-Benincasa/9894fba92d247019ae2ca5a6ad95894d48a2b473
3. https://ieeexplore.ieee.org/abstract/document/4784862

KEYWORDS: ATAK; Torrent; Low bandwidth; TAK

TPOC: Grant Grubbs,
Phone: 484-577-0472,
Email: grant.grubbs@us.af.mil

AF221-D015 TITLE: Mission Relevant ML Artifact Registry

TECH FOCUS AREAS: Artificial Intelligence/Machine Learning

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: The Air Force Research Laboratory Information Directorate seeks the development of a multi-domain, mission relevant ML artifact repository using the StreamlinedML framework developed by AFRL. The effort involves continuous implementation of state-of-the-art ML algorithms and supporting data sets defined by mission relevant use cases. Model development is to be implemented using AFRL's open-source Model Integration Software Toolkit (https://mistkml.github.io/)

DESCRIPTION: This topic seeks to develop mission relevant ML artifact repositories containing state-of-the-art algorithm implementations using StreamlinedML Model Integration Software Toolkit. Data driven AI/ML approaches are emerging as a dominant method for addressing problems too difficult to solve using formal methods. Industry, as well as the academic community, made great strides in successfully solving and demonstrating state-of-the-art solutions to many problems in technical and scientific domains using data driven approaches. In doing so, both of the communities make freely available a large corpus of research and reference implementations of such techniques as they relate to specific problems, such as sentiment analysis, natural language processing, and computer vision. As a result, subsequent research and development of these methods is made easier and less costly by enabling significant reuse and lessons learned of such applications in other domains. A similar approach within the DoD has the potential to bring similar benefits in terms of accelerated research, development, and application of data driven approaches towards a wide range of DoD problems.

Benefits - Successful development of a mission relevant ML artifact repository will provide the DoD with the first of its kind catalog of machine learning models and data sets, providing a number of benefits. It will significantly reduce duplication of work that requires expensive AI/ML expertise. It will allow for rapid experimentation and assessment of various techniques to new and existing problems. It will enable standardized life cycle management of ML artifacts based on a government owned platform. Finally, it will provide a simple method for deploying ML capabilities as stand-alone, self-contained micro-services to cloud-native DoD applications.

PHASE I: In Phase I, awardees will successfully deploy an instance of StreamlinedML into a relevant cloud environment. Conduct a survey of existing ML artifacts, such as models and data sets utilized in DoD applications and create a high-level taxonomy of applicable domains.

PHASE II: For Phase II, the awardee will develop reference implementations of ML models and associated data sets to be ingested into an instance of the StreamlinedML lifecycle management framework for AI/ML artifacts. Development to be done using the Model Integration Software Toolkit (MISTK) provided by StreamlinedML

PHASE III DUAL USE APPLICATIONS: In Phase III, future development of AI/ML capabilities will be significantly accelerated by utilizing the AI/ML artifact repository. This will include automated evaluation of live data against known models, ML workflow templates, and simple ML service deployment from the artifact repository running on StreamlinedML. The MISTK library is open sourced (DIST A) by the AF and is available for potential academic and industry collaborators.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related

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

REFERENCES:

1. https://mistkml.github.io/
2. Page 7 of https://media.defense.gov/2019/Feb/12/2002088963/-1/-1/1/SUMMARY-OF-DOD-AI-STRATEGY.PDF "Delivering AI..."
3. Page 7 of https://media.defense.gov/2019/Feb/12/2002088963/-1/-1/1/SUMMARY-OF-DOD-AI-STRATEGY.PDF "Scaling AI..."

KEYWORDS: Machine Learning; Artificial Intelligence; Data; Model Integration; Natural Language Processing; Computer Vision

TPOC: Milvio Franco,
Phone: (315) 330-4541,
Email: milvio.franco@us.af.mil

,.

AF221-D016 TITLE: Digital Engineering at the Tactical Edge

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

TECHNOLOGY AREAS: Information Systems

OBJECTIVE: This topic's goal is implementation of a server for the Tactical Assault Kit / Team Awareness Kit (TAK) ecosystem supporting low resource usage and easy configuration for more efficient use at the tactical edge, especially where disconnected from the internet

DESCRIPTION: The TAK ecosystem including Android TAK (ATAK), Windows TAK (WinTAK), iOS TAK (iTAK), WebTAK and TAK Server has approximately 350-450,000 users, including Air Force, DoD, other Federal, state, local, international (military & civilian) government users. TAKServer handles enterprise users very well but requires significant resources to administer. Recently, an open source, easy-to-configure/use alternative, future TAKServer has appeared, developed from the ground up using "Digital Engineering" design methodologies has appeared and runs on an android device, Raspberry Pi or other low resource device. Future TAKServer is one of at least six such projects This open-source alternative has the potential to make the TAK ecosystem easily available users by lowering administration costs, however, it has not been fleshed out and developed for that task.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a "Phase I-like" effort, including a feasibility study and customer discovery. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Proposals should include development, installation, integration, demonstration and/or test and evaluation of the proposed technology. This demonstration should evaluate the proposed solution against the proposed objectives; describe how the solution will fulfill the AF's requirements; identify the technology's transition path; specify the technology's integration; and describe the technology's sustainability. Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will focus on transitioning the developed technology to a working commercial, civilian, or warfighter solution. If a viable business model for the developed strategy or software is demonstrated, the offeror or identified transition partners would be in a position to supply future processes to the Air Force and other DoD components as this new process is adopted.

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

REFERENCES:
1. www.theguardian.com/uk-news/2021/mar/19/uk-military-to-unveil-shift-towards-hi-tech-warfare-as-cuts-bite
2. https://github.com/FreeTAKTeam/FreeTakServer
3. https://www.mitre.org/sites/default/files/pdf/09_4937.pdf
4. https://ndiastorage.blob.core.usgovcloudapi.net/ndia/2008/USCG/Wednesday/2NiessenCursorOnTarget.pdf

KEYWORDS: Android; Situational Awareness; ATAK, Servers; Collaboration; Digital Engineering

TPOC: Milvio Franco,
Phone: (315) 330-4541,
Email: milvio.franco@us.af.mil

AF221-D017 TITLE: Imaging System for Real Time Observation of High Energy Laser Effects

TECH FOCUS AREAS: Directed Energy

TECHNOLOGY AREAS: Bio Medical

OBJECTIVE: This topic seeks to model, design, build and install an imaging system enabling high energy laser operators to make real-time damage and hazard assessments during combat, utility and test operations.

DESCRIPTION: The use of high energy lasers (HEL) in military systems has several advantages (line-of-sight targeting, deep magazine, instantaneous engagement), but HEL effects are influenced by multiple factors that are not always predictable. Depending on the conditions, a HEL procedure may take several seconds or completely fail. During extended lasing procedures operators need feedback as to whether the procedure is having the desired effect. If so, the operator can confidently continue the HEL employment; if not, they can make a timely switch to a different course of action.

In addition, the chaotic, uncontrolled battlefield environment requires military HEL operators to make real-time risk determinations. Laser energy reflection modeling can be used to estimate hazard distances and probability of unintended exposure if the surface characteristics of the target are known. Unfortunately targets and their reflection patterns (diffuse, specular collimated, specular divergent) are not always known and are unpredictable. Video imaging of reflection patterns would allow HEL operators to better estimate the effectiveness and the hazards associated with continuing HEL operations. Providing the operator with imagery to support both laser effects and hazard assessments would allow for real-time, high-quality decisions about HEL use on the battlefield and other lasing scenarios including test and laser utility operations.

PHASE I: This topic is intended for technology proven ready to move directly into Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential. The study will have:
1) created imaging models for both HEL damage and hazard assessments;
2) evaluated laser wavelength, power, divergence, lasing distance, target reflectance, ambient illumination, camera sensitivity, aperture, filtering and other factors as potential variables;
3) researched military HEL applications and near-term programs; and
4) design imaging system(s) for real time assessment of HEL operations for one military application.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR/STTR Programs. Build HEL imaging system(s), relevant to one military application. Demonstrate and evaluate the system(s) ability to image HEL performance under variety of operating conditions. Compare measured performance against model(s) predictions. Refine imaging models and redesign imaging system as necessary. Design workstation, including display, graphic user interface and controls, to optimize operator’s decision making.

PHASE III DUAL USE APPLICATIONS: Integrate HEL imaging system into military HEL system. Evaluate HEL operator’s ability to assess HEL effects and hazards.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related

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

REFERENCES:

1. Final Report of Defense Science Board Task Force on Directed Energy Weapon Systems and Technology Applications, Office of the Under Secretary of Defense for Acquisition Technology and Logistics, December 2007http://www.acq.osd.mil/dsb/reports/ADA476320.pdf;
2. Fiorino, S. et al. Effectiveness Assessment of Tactical Laser Engagement Scenarios in the Lower Atmosphere. Journal of Aerospace Information Systems. Vol. 10, No. 1, January 2013;
3. Sawatzky, C. High dynamic range imaging for laser weld monitoring. Industrial Laser Solutions for Manufacturing 09/04/2013
4. Lilley, K. Army, Air Force helps build laser-wielding MRAP to clear bombs. Army Times. July 6, 2015 https://www.armytimes.com/story/military/tech/2015/07/06/rabdo-redstone-arsenal-air-force/29771333/

KEYWORDS: Diffuse Reflection; Specular Reflection

TPOC: Joel Bixler,
Phone: 210-539-8172,
Email: joel.bixler.1@us.af.mil

AF221-D018 TITLE: Multiple Sensor Platform for High Power Microwave Field Mapping

TECH FOCUS AREAS: Directed Energy

TECHNOLOGY AREAS: Sensors

OBJECTIVE: This topic seeks to model, design, build and demonstrate a transportable, passive (non-field perturbing) pulsed Electromagnetic (EM) field measurement device with an array architecture expandable to 100 simultaneous nodes that can measure electric fields as low as 27.5 volts/meter up to air breakdown, magnetic fields as low at 0.0729 Amperes/meter up to air breakdown, a frequency bandwidth of 100 kiloHertz (kHz) to 20 GigaHertz (GHz) and a pulse width resolution as low as 1 nanosecond.

DESCRIPTION: High power electromagnetic field measurements are critical to characterizing transmitter output power, antenna pattern and temporal stability. A sensor system capable of non-perturbing (passive) measurement that can provide more that 100 sensor node spatially distributed measurements while achieving electric field sensitivity from 27.5 volts/meter up to air breakdown and magnetic fields from 0.0729 Amperes/meter up to air breakdown is required for this topic.

Additionally, the device should measure fields over a bandwidth of 100 kHz to 20 GHz with a pulse width resolution of 1 nanosecond. The sensor system should also be reasonably portable for transport to test facilities throughout the world. Previous experience has shown the difficulty of collecting field maps of test systems during routine developmental test activities. Extensive maps are critical to determine risk profiles for electromagnetic interference or bioeffects prediction. Deployment of a large number of simultaneous measurement nodes will allow collection of significant field maps during limited test shots.

PHASE I: This topic is intended for technology proven ready to move directly into Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential. It must have validated the product-market fit between the proposed solution and a potential AF stakeholder. The offeror should have defined a clear, immediately actionable plan with the proposed solution and the AF customer. Offerors should demonstrate they have designed passive (non-perturbing) measurement equipment for use in an industrial or military environments and provide past test or modeling and simulation results as evidence they can meet the requirement of the topic.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR/STTR Programs. Offerors will build, test, and demonstrate a prototype system providing up to 100 measurement channels and meets the sensitivity requirements of the topic, as well as collaborate with the government to prove sensitivity of the measurement equipment in a laboratory environment.

PHASE III DUAL USE APPLICATIONS: Military applications of this technology will include profiling radar and communications emitters in a variety of environments. Commercial applications include mapping fields around Radiofrequency (RF) emitting equipment and mapping of static and gradient magnetic fields in MRI machines.

NOTES: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related

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

REFERENCES:

1. IEEE C95.3™-2002 - Measurements and Computations of Radio Frequency Electromagnetic Fields with Respect to Human Exposure to Such Fields, 100 kHz-300 GHz

KEYWORDS: Electric Field Detection; Magnetic Field Detection; Field Mapping; Electro-optic sensors

TPOC: Ronald Barnes,
Phone: 210-539-8020,
Email: ronald.barnes.10@us.af.mil

AF221-D019 TITLE: Digital QuickStart

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Materials; Air Platform

OBJECTIVE: This topic seeks to establish the infrastructure and environment required for weapon systems and program offices to make digital data visible, accessible, understandable, linked, trustworthy, interoperable, and secure.

DESCRIPTION: B-52 has established the infrastructure and environment at the Engineering Research and Development Center (ERDC) Information Technology Laboratory (ITL) using DoD Defense Research and Engineering Network (DREN) connections to transfer large amounts of data. This provides the user an environment to access and control data. On this project this environment will be connected to DoD Platform One providing the users access from Non-classified Internet Protocol (IP) Router Network (NIPRNet). The implemented solution will be an easy-to-use web-based app so files can be transferred, information extracted, linked, and made available to users. Provide a platform and tools so that data stewards, data custodians and functional data managers are all able to make their data visible to authorized users by identifying, registering and exposing data in a way that makes it easily discoverable. Enable authorized users to obtain the data they need when they need it, including having data automatically pushed to interested and authorized users. This access requires that security controls are in place for credentialed users to ensure that access is permitted.

Understanding data is critical to enable enhanced, more accurate and timely decision-making. The ability to aggregate, compare and truly understand data adversely affects the ability of the Air Force to react and respond. Bringing together business and technology and applying a data-centric approach. Data-driven decisions requires data to be linked such that relationships and dependencies can be uncovered and maintained. Trust is required to deliver the needed value to the sustainment community and stakeholders. Lacking confidence in the data my result in less timely decision-making or consequently, no decision when one is warranted. Property exchanging data between systems and maintaining semantic understanding are critical for successful decision-making and military operations. The Air Force cannot afford to buy licensing from vendors for every document and data type provided as a deliverable to the Air Force. As per the DoD Cyber Risk Reduction Strategy, protected DoD data while at rest, in motion and in use (within applications, with analytics, etc.) is a minimum barrier to entry. Using and developing a data approach, such as attribute-based access control, across the enterprise allows the Air Force to maximize the use of data while, at the same time, employing the most stringent security standards to protect the American people.

PHASE I: This topic is intended for technology proven ready to move directly into a Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR Programs. Under the Phase II effort, the offeror shall sufficiently develop the technical approach, product, or process in order to conduct a small number of advanced manufacturing and/or sustainment relevant demonstrations. Identification of manufacturing/ production issues and or business model modifications required to further improve product or process relevance to improved sustainment costs, availability, or safety, should be documented. Air Force sustainment stakeholder engagement is paramount to successful validation of the technical approach. These Phase II awards are intended to provide a path to commercialization, not the final step for the proposed solution.

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

REFERENCES:

1. Peixoto, R., Cruz, C., Silva, N. Adaptive learning process for the evolution of ontology-described classification model in big data context (2016) Proceedings of 2016 SAI Computing Conference, SAI 2016, art. no. 7556031, pp. 532-540. Cited 2 times. DOI: 10.1109/SAI.2016.7556031
2. 14th Extended Semantic Web Conference, ESWC 2017 (2017) Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 10250 LNCS, pp. 1-278.
3. Peixoto, R., Cruz, C., Silva, N. Semantic HMC: Ontology-described hierarchy maintenance in big data context (2015) Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 9416, pp. 492-501. Cited 2 times. DOI: 10.1007/978-3-319-26138-6_53
4. Boyles, R.R., Thessen, A.E., Waldrop, A., Haendel, M.A. Ontology-based data integration for advancing toxicological knowledge (2019) Current Opinion in Toxicology, 16, pp. 67-74. Cited 4 times. DOI: 10.1016/j.cotox.2019.05.005
5. ACM International Conference Proceeding Series (2018) ACM International Conference Proceeding Series, 152 p.
6. Conway, M., O'Connor, D. Social media, big data, and mental health: Current advances and ethical implications (2016) Current Opinion in Psychology, 9, pp. 77-82. Cited 47 times. DOI: 10.1016/j.copsyc.2016.01.004
7. Kim, Y., Lee, J., Lee, E.-B., Lee, J.-H. Application of Natural Language Processing (NLP) and Text-Mining of Big-Data to Engineering-Procurement- Construction (EPC) Bid and Contract Documents (2020) Proceedings - 2020 6th Conference on Data Science and Machine Learning Applications, CDMA 2020, art. no. 9044209, pp. 123-128. DOI: 10.1109/CDMA47397.2020.00027

KEYWORDS: Artificial Intelligence (AI); Machine Learning (ML)

TPOC: Tamar Boone,
Phone: (443) 850-8359,
Email: tamar.boone@us.af.mil

AF221-D020 TITLE: Space-Based Sensing at the Tactical Edge

TECH FOCUS AREAS: Artificial Intelligence/Machine Learning

TECHNOLOGY AREAS: Space Platform; Information Systems; Battlespace

OBJECTIVE: This topic seeks to build a cloud-based ecosystem continuously pulling multi-INT satellite sensor data, fuses and processes it through artificial intelligence (AI) to track vehicles and distributes actionable intelligence to mobile devices and analysts worldwide.

DESCRIPTION: Through the proliferation of commercial and military satellites populating Low Earth Orbit (LEO), it will soon be possible to perform certain time-critical sensing missions from space. To advance the state of the art, new methods are needed to exploit the increased availability of space imagery, to predict and to track vehicle movement robustly over tactical time scales, and to make this service accessible to a broad set of decision makers. The use of space-based sensors for procuring intelligence, surveillance, and reconnaissance (ISR) on tactically relevant timelines is expected to be a key enabling capability for the Air Force. Potential end-users for such a capability include pilots engaged in mission preparation, special-ops airmen active in the field, intelligence analysts searching for enemy launch sites, and base commanders monitoring threats to facilities. The goal of this effort is to develop an end-to-end software tool that aggregates opportunistic space-based capabilities and enables an efficient and reliable ecosystem for the request and delivery of data products.

The focus is on space-to-ground based tracking of vehicles (cars, trucks, military vehicles, mobile equipment, ships, maritime military assets, etc). The main deliverable will be a cloud based software app that incorporates full satellite tasking and access; builds artificial intelligence (AI) enabled automated target recognition (ATR) and processing, exploitation, and dissemination (PED) tools; extracts patterns and trends; simultaneously tracks multiple targets; merges space based sensor data with tracking tips from other sources; leverages the latest in human-machine interfaces; and an establishes a link to secure data distribution networks.

PHASE I: This topic is intended for technology proven ready to move directly into Phase II. Therefore, a Phase I award is not required. The offeror is required to provide detail and documentation in the Direct to Phase II proposal which demonstrates accomplishment of a “Phase I-like” effort, including a feasibility study. This includes determining, insofar as possible, the scientific and technical merit and feasibility of ideas appearing to have commercial potential. It must have validated the product-market fit between the proposed solution and a potential AF stakeholder. The offeror should have defined a clear, immediately actionable plan with the proposed solution and the AF customer. Relevant areas of demonstrated experience and success include: cloud-based data flows, AI for data curation, parsing and exploiting satellite imagery, effective operator interfaces, systems integration and test, etc.

PHASE II: Eligibility for D2P2 is predicated on the offeror having performed a “Phase I-like” effort predominantly separate from the SBIR/STTR Programs. These efforts will include a working software prototype to include integration of features to aggregate space-based ISR collections, such as satellite tasking, automated target recognition (ATR), and tracking metrics. The prototype should additionally include analytics to recognize Pattern of Life (PoL) behavior, extract patterns and trends, predict vehicle position probabilities, and queue sensor collects. The prototype should feature an intuitive user interface (UI) amenable to use on a web browser or mobile device. The demonstration should use commercial space imagery, while later investments may involve both military and commercial imagery.

PHASE III DUAL USE APPLICATIONS: Phase III should include upgrades to the tool built in

Phase II, accounting for user feedback and results from test and evaluation. This phase should have a strong cyber security focus and allow for the distribution of actionable information from the cloud-based software tool out to the tactical edge for users to navigate, collaborate, and coordinate real-time mission planning and execution. Phase III could also address commercial applications, like global tracking of maritime and overland shipping.

REFERENCES:
[1] A. Savakis, N. Nagananda, J. Kerekes, E. Ientillucci, R. Blue, W. Hicks, T. Rovito and E. Blasch, "Change Detection in Satellite Imagery with Region Proposal Networks," DSIAC Journal, vol. 6, no. 4, pp. 22-28, 2019. ;
[2] E. Blasch, R. Cruise, A. Aved, U. Majumder and T. Rovito, "Methods of AI for Multimodal Sensing and Action for Complex Situations," AI Magazine, vol. 40, no. 4, pp. 50-65, 2019. ;
[3] "The Space Force considers a new mission: tactical satellite imagery," 3 February 2021. [Online]. Available: https://www.c4isrnet.com/battlefield-tech/space/2021/02/03/the-space-force-is-considering-adopting-a-tactical-geoint-mission/?utm_source=Sailthru&utm_medium=email&utm_campaign=EBB%2002.04.21&utm_term=Editorial%20-%20Military%20-%20Early%20Bird%20Brief.

KEYWORDS: space-based sensing; machine learning; automated target recognition; data fusion; tracking

TPOC: Andre Van Rynbach,
Phone: (937) 713-8364,
Email: andre.van_rynbach.1@us.af.mil

AF221-D021 TITLE: Communications Via Beat-Wave Excitation of ELF/VLF Waves in the Ionosphere

TECH FOCUS AREAS: Directed Energy; Network Command, Control and Communications

TECHNOLOGY AREAS: Space Platform; Battlespace

OBJECTIVE: The main objective of the proposed research is to predict optimal conditions for generation of extremely low frequency (ELF) and very low frequency (VLF) waves in the ionosphere F layer due to parametric beat wave interaction of two high frequency (HF) pump waves with different frequencies. The difference in the two HF transmissions should be in the ELF/VLF frequency range. The obtained results should define the necessary amplitudes of injected HF waves in the F-region ionosphere and the dimensions of the excitation region. The theoretical results will define the amplitude range of the excited ELF/VLF beat-waves and spatial localization as a function of the HF pump-wave amplitudes, frequencies, wave numbers, polarization, and incident angles. In particular:
(1) Develop novel analytical models of parametric beat-wave excitation of ELF and VLF waves by HF waves propagating in inhomogeneous ionosphere plasma.
(2) Create numerical code for solution of derived nonlinear equations for HF beat-wave excitation mechanism leveraging with the High-Performance Computers (HPC) capabilities. These models should allow to determine excited ELF/VLF wave amplitudes and spatial localization depending on the HF wave properties, such as frequency, wave number, polarization, amplitude, and incident angle with respect to the plasma density gradient and magnetic field orientation.
(3) Collect unique experimental data on beat-wave excitation of ELF/VLF waves at the High-frequency Active Auroral Research Program (HAARP) facility and compare with theory.
(4) Based on obtained data carry out comprehensive analysis of efficiency of radio frequency (RF) mixing mechanism for excitation of ELF/VLF waves in the F-layer of the ionosphere.
(5) Investigate possibility of creation of frequency modulated and amplitude modulated ELF/VLF waves produced during a beat wave excitation process.
(6) Develop commercialization strategy for developed new techniques and mitigation methods.

DESCRIPTION: Develop a novel comprehensive effort that incorporates theory, computer simulations, and field experiments, to investigate excitation of ELF and VLF waves in the F-region ionosphere and implementation of this method for secure communication on the ground and below sea level. The proposed research aims to explore the efficiency of the beat-wave excitation mechanism for generation of ELF and VLF waves. A beat-wave frequency will be created in the ionosphere due to parametric interaction of two HF pump waves launched from the ground. The proposed theory will be validated by means of controlled experiments. We will predict optimal conditions for the ELF/VLF excitation based on the HF wave characteristics and F-region ionosphere plasma parameters. We are interested in the development of analytical models supported by field experiments to demonstrate possibility of establishing reliable secure communications via ELF/VLF waves generated in the ionosphere F layer in the process of parametric interaction of HF electromagnetic waves from the MHz diapason launched from the ground.

PHASE I: D2P2 proposers should provide documentation that describes their analytic models with examples of numerical analysis for beat wave excitation of ELF/VLF waves by HF waves launched from the split array t the High-frequency Active Auroral Research Program (HAARP) facility. In addition to this, D2P2 proposers must formulate the problem correctly and derive equations that explain beat-wave excitation.

PHASE II: Conduct controlled experiments and collect data on generation of ELF/VLF waves in the F layer of the ionosphere, analyze experimental data and demonstrate that beat wave generation method can efficiently create ELF/VLF waves that can be detected on the ground. Beyond the current

government interest in VLF waves generation, there exists interest in the commercial sector to understand the ability of VLF waves penetrating in deep soil applications such as exploration of tunnels, mining and detection of natural resources. Present efficient commercialization strategy for newly developed techniques.

PHASE III DUAL USE APPLICATIONS: Design compact mobile HF radiation sources for generation of VLF waves for different applications using beat wave technology. Validate novel low-cost beat wave approach for applications such as ionospheric modification, over the horizon radar (OTHR) applications, secure VLF communications, underground structure detection (military or commercial use).

REFERENCES:

1. M. B. Cohen, R. C. Moor, M. Golkowski and N. G. Lehtinen, ELF/VLF wave generation from the beating of two HF ionospheric heating sources, Journal of Geophysical Research, vol. 117, no. A12310, 2012; \
2. V. A. Puchkov, Generation of Plasma Waves in the Ionospheric Plasma by Powerful Nonmonochromatic Microwave Beams, Phys. Scr., vol. 78, no. 1, 2008; D. Main and V. Sotnikov, Parametric interaction between ELF and VLF waves, 3D LSP simulation results, Phys. Plasmas 27, 022304 (2020).

KEYWORDS: Ionosphere; Very low Frequency (VLF) waves; VLF communications; Parametric Wave Interaction

TPOC: Vladimir Sotnikov,
Phone: (937) 713-8946,
Email: vladimir.sotnikov.1@us.af.mil

AF221-D022 TITLE: High Sensitivity Tracking for Event Based LEO Moving Target Indication

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Space Platform

OBJECTIVE: This topic seeks to design and develop an event-based sensing platform specifically optimized to the detection of ground moving targets from a small LEO payload.

DESCRIPTION: The DoD's interest in a proliferated and hybrid constellation architecture to execute intelligence, surveillance and reconnaissance (ISR) missions requires us to rethink traditional sensing modalities and mature those which scale well with large volumes of data, supporting true autonomous sensing development. Space-based EOIR imagery has reached very high spatial resolutions and sensitivities but requires high format sensors which output large unchanging data volumes not useful for the mission. This limits the amount of imagery collected and stored, therefore inhibiting the ability to collect video frames of particular interest in the moving target indication (MTI) field. These problems will be amplified when moving to a hybrid satellite architecture where SWAP C demands are greater but the requirement to process and relay data on the edge puts greater strains on space-borne systems. Event-based sensors rely on asynchronous pixel response which only report information when changes in scene dynamics occur. The result is a sparse stream of high time resolution data where each event is in the format (t, x, y, p) where t is the time of the event, x and y represent the position of the pixel reporting the change, and p is a polarity term indicating positive or negative going changes. This results in inherently sparse data which maintains high time resolution. Event-based sensors, which were first designed for the machine vision applications are then ideal for space-based ISR missions such as MTI. While current state of the art event cameras is improving and well-suited for machine vision applications, they are not optimized for unique space-based remote sensing challenges.

The goal of this research is the design and development of an event-based sensing platform specifically built and optimized to perform ground moving target indication (GMTI) from a small LEO platform ultimately well-suited for integration into a proliferated and hybrid satellite constellation. Successful design will require pixel-level considerations to maximize the trade-off between spatial resolution, field of view, and on pixel photon flux. The platform will also require robust GMTI algorithm development, leveraging the unique event camera dataset to monitor large numbers of targets while looking for anomalous behavior. This will be especially challenging in a constellation architecture, as persistent coverage requires handoff to maintain target tracks for meaningful time periods.

PHASE I: Phase I requires a discovery study to inform the critical design parameters specific to the space-based MTI problem applied to event-based sensors. This includes an examination of pixel design for currently available cameras and improvements to optimize mission specific performance. Phase I will result in a recommended sensor design to be digitally engineered in Phase II.

PHASE II: The Phase II will culminate in delivery of a full payload design including, optics, sensor, readout circuit and algorithms specific to event data for GMTI. Successful solutions will utilize digital engineering to the extent possible for the design process of a GMTI specific event-based sensing payload. Careful attention shall be paid to desired spatial resolution, and FOV required to accomplish the objectives from LEO. Sensor design should be informed by existing state of the art event-based sensors but specifically tailored to the scene dynamics associated with GMTI. Understanding scene background radiances and relevant contrasts for targets of interest will be key to the pixel design, optics selection, and success of developed algorithms. Payload and algorithm performance characterization will require high fidelity synthetic data use. Sensor design and performance will

require all models be validated against physical observables in both the field and laboratory.

PHASE III DUAL USE APPLICATIONS: The Phase III company will work with transition partners to identify mission specific use case. Build sensing payload into field and laboratory testable form factor. Use field and laboratory demonstration to evaluate MTI performance capability. Integrate tested payload into a small satellite form factor for flight demonstration. Further develop EBS exploitation algorithms for detection/tracking/counting of low contrast semi-resolved objects and generalize those methods for commercial applications.

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

REFERENCES:

1. G. Gallego et al., "Event-based Vision: A Survey," in IEEE Transactions on Pattern Analysis and Machine Intelligence, doi: 10.1109/TPAMI.2020.3008413.
2. F. Barranco, C. Fermuller and E. Ros, "Real-Time Clustering and Multi-Target Tracking Using Event-Based Sensors," 2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS), 2018, pp. 5764-5769, doi: 10.1109/IROS.2018.8593380.
3. Afshar S, Ralph N, Xu Y, Tapson J, Schaik Av, Cohen G. Event-Based Feature Extraction Using Adaptive Selection Thresholds. Sensors. 2020; 20(6):1600. https://doi.org/10.3390/s20061600

KEYWORDS: Event Based Sensing; Neuromorphic Vision; Target Tracking

TPOC: Zachry Theis,
Phone: (505) 846-1542,
Email: zachry.theis.1@spaceforce.mil