VERSION 5

DEPARTMENT OF THE AIR FORCE
24.1 SMALL BUSINESS INNOVATION RESEARCH (SBIR) PHASE I
PROPOSAL SUBMISSION INSTRUCTIONS

The Air Force intends these Phase I proposal submission instructions to clarify the Department of Defense (DoD) Broad Agency Announcement (BAA) as it applies to the topics solicited herein. **Offerors must ensure proposals meet all requirements of the SBIR 24.1 BAA posted on the Defense SBIR/STTR Innovation Portal (DSIP) at the proposal submission deadline date/time.**

Applicants are encouraged to thoroughly review the DoD Program BAA and register for the DSIP Listserv to remain apprised of important programmatic and contractual changes.

- The DoD Program BAA is located at: https://www.defensesbirsttr.mil/SBIR-STTR/Opportunities/#announcements. Be sure to select the tab for the appropriate BAA cycle.
- Register for the DSIP Listserv at: https://www.dodsbirsttr.mil/submissions/login.

Complete proposals **must** be prepared and submitted via https://www.dodsbirsttr.mil/submissions/ (DSIP) on or before the date published in the DoD SBIR 24.1 BAA. Applicants are responsible for ensuring proposals comply with the requirements in the most current version of this instruction at the proposal submission deadline date/time.

The DAF 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 DAF 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 DAF 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.

Please ensure all e-mail addresses listed in the proposal are current and accurate. The DAF 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 DAF. **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, "24.1 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 SBIR 24.1 BAA.
- Air Force SBIR/STTR Contracting Officer (CO):
    - Mr. Daniel J. Brewer, Daniel.Brewer.13@us.af.mil

General information related to the AF Small Business Program can be found at the AF Small Business website, http://www.airforcesmallbiz.af.mil/. The site contains information related to contracting opportunities within the AF, as well as business information and upcoming outreach events. Other informative sites include those for the Small Business Administration (SBA), www.sba.gov, and the Procurement Technical Assistance Centers (PTACs), http://www.aptacus.us.org. These centers provide

Government contracting assistance and guidance to small businesses, generally at no cost.

PHASE I PROPOSAL SUBMISSION

The DoD SBIR 24.1 Broad Agency Announcement, https://www.dodsbirsttr.mil/submissions/login, includes all program requirements. Phase I efforts should address the feasibility of a solution to the selected topic's requirements.

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.**

The System for Award Management (SAM) allows proposing small business concerns interested in conducting business with the Federal Government to provide basic information on business structure and capabilities as well as financial and payment information. Proposing small business concerns must be registered in SAM. To register, visit www.sam.gov. A proposing small business concern that is already registered in SAM should login to SAM and ensure its registration is active and its representations and certifications are up-to-date to avoid delay in award.

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

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

PHASE I PROPOSAL FORMAT

Complete proposals must include all of the following:
Volume 1: DoD Proposal Cover Sheet
Note: If selected for funding, the proposal's technical abstract and discussion of anticipated benefits will be publicly released. Therefore, do not include proprietary information in this section.
Volume 2: Technical Volume
Volume 3: Cost Volume
Volume 4: Company Commercialization Report
Volume 5: Supporting Documents
Volume 6: Fraud, Waste, and Abuse Training

DoD PROPOSAL COVER SHEET (VOLUME 1)

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.

TECHNICAL VOLUME (VOLUME 2):

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

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

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

- A technical resume of the principal investigator, including a list of publications, if any, must be included
- Concise technical resumes for subcontractors and consultants, if any, are also useful.
- Identify all U.S. permanent residents to be involved in the project as direct employees, subcontractors, or consultants.
- Identify all non-U.S. citizens expected to be involved in the project as direct employees, subcontractors, or consultants. For all non-U.S. citizens, in addition to technical resumes, please provide countries of origin, the type of visa or work permit under which they are performing and an explanation of their anticipated level of involvement on this project, as appropriate. Additional information may be requested during negotiations in order to verify the foreign citizen's eligibility to participate on a contract issued as a result of this announcement. **Note:** Do not upload information such as Permanent Resident Cards (Green Cards), birth certificates, Social Security Numbers, or other PII to the DSIP system.

Phase I Work Plan Outline

NOTE: The DAF uses the work plan outline as the initial draft of the Phase I Statement of Work (SOW). Therefore, **do not include proprietary information in the work plan outline**. To do so will necessitate a request for revision, if selected, and may delay contract award.

Include a work plan outline in the following format:
Scope: List the effort's major requirements and specifications.
Task Outline: Provide a brief outline of the work to be accomplished during the Phase I effort.
Milestone Schedule
Deliverables
Progress reports
Final report with SF 298

COST VOLUME (VOLUME 3)

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

a. **Direct Cost Materials**: Justify costs for materials, parts, and supplies with an itemized list containing types, quantities, prices and where appropriate, purpose. Material costs may include the costs of such items as raw materials, parts, subassemblies, components, and manufacturing supplies.

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

c. **Direct Labor**: Identify key personnel by name, if possible, or by labor category, if not. Direct labor hours, labor overhead and/or fringe benefits, and actual hourly rates for each individual are also necessary for the CO to determine whether these hours, fringe rates, and hourly rates are fair and reasonable.

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

e. **Subcontracts**: Involvement of university or other consultants in the project's planning and/or research stages may be appropriate. If so, describe in detail and include information in the Cost Volume. The proposed total of consultant fees, facility lease/usage fees, and other subcontract or purchase agreements may not exceed **one-third of the total contract price** or cost (do not include profit in the calculation), unless otherwise approved in writing by the CO. The SBIR funded work percentage calculation considers both direct and indirect costs after removal of the SBC's proposed profit. Support subcontract costs with copies of executed agreements. The documents must adequately describe the work to be performed. At a minimum, include a Statement of Work (SOW) with a corresponding detailed Cost Volume for each planned subcontract.

f. **Special Tooling, Special Test Equipment, and Material**: The inclusion of equipment and materials will be carefully reviewed relative to need and appropriateness to the work proposed. Special tooling and special test equipment purchases must, in the CO's opinion, be advantageous to the Government and relate directly to the effort. These toolings or equipment should not be of a type that an offeror would otherwise possess in the normal course of business. These may include items such as innovative instrumentation and/or automatic test equipment.

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

NOTE: If no exceptions are taken to an offeror's proposal, the Government may award a contract without negotiations. Therefore, the offeror's initial proposal should contain the offeror's best terms from a cost or price and technical standpoint. If there are questions regarding the award document, contact the Phase I CO identified on the cover page. The Government reserves the right to reopen negotiations later if the CO determines doing so to be necessary.

COMPANY COMMERCIALIZATION REPORT (VOLUME 4)

Completion of the CCR as Volume 4 of the proposal submission in DSIP is required. Please refer to the DoD SBIR 24.1 BAA for full details on this requirement. Information contained in the CCR will not be considered by the Air Force during proposal evaluations.

SUPPORTING DOCUMENTS VOLUME (VOLUME 5)

The following documents are required for all proposal submissions:

1. Contractor Certification Regarding Provision of Prohibition on Contracting for Certain Telecommunications and Video Surveillance Services or Equipment (Attachment 1 to the DOD SBIR 24.1 BAA)
2. Disclosures of Foreign Affiliations or Relationships to Foreign Countries (Attachment 2 to the DOD SBIR 24.1 BAA)
3. Disclosure of Funding Sources (Attachment 4 to the DOD SBIR 24.1 BAA)

The following documents may be required if applicable to your proposal:

1. DD Form 2345: For proposals submitted under export-controlled topics, either International Traffic in Arms or Export Administration Regulations (ITAR/EAR), a copy of the certified DD Form 2345, Militarily Critical Technical Data Agreement, or evidence of application submission must be included. The form, instructions, and FAQs may be found at the United States/Canada Joint Certification Program website, http://www.dla.mil/HQ/InformationOperations/Offers/Products/LogisticsApplications/JCP/DD2345Ins tructions.aspx. DD Form 2345 approval will be required if proposal if selected for award.
2. Verification of Eligibility of Small Business Joint Ventures (Attachment 3 to the DOD SBIR 24.1 BAA)
3. Technical Data Rights Assertions (if asserting data rights restrictions)

FRAUD, WASTE, AND ABUSE TRAINING (VOLUME 6)

Note that the FWA Training must be completed prior to proposal submission. When training is complete and certified, DSIP will indicate completion of the Volume 6 requirement. The proposal cannot be submitted until the training is complete.

DISCRETIONARY TECHNICAL AND BUSINESS ASSISTANCE (TABA)

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

AIR FORCE PROPOSAL EVALUATIONS

Proposals will be evaluated for overall merit in accordance with the criteria discussed in the 24.1 BAA. DAF is seeking varying technical/scientific approaches and/or varying and new technologies that would be responsive to the problem statement(s) and area(s) of interest in the topic. Multiple procurements are planned and anticipated to be awarded as a result of the topic, each proposal is considered a separate procurement and will be evaluated on its own merit, and that the Government may award all, some, or none of the proposals. Any per-award or per-topic funding caps are budgetary estimates only, and more or less funding may become available. Funding decisions are made with complete disregard to the other awards under the same topic.

In accordance with Section 4 of the SBIR and STTR Extension Act of 2022, the DAF will review all proposals submitted in response to this BAA to assess security risks presented by small business concerns seeking a Federally funded award. The DAF will use information provided by the small business concern in response to the Disclosure of Foreign Affiliations or Relationships to Foreign Countries and the proposal to conduct a risk-based due diligence review on the cybersecurity practices, patent analysis, employee analysis, and foreign ownership of a small business concern, including the small business concern and employees of the small business concern to a foreign country, foreign person, foreign affiliation, or foreign entity. The DAF will also assess proposals utilizing open-source analysis and analytical tools, for the nondisclosures of the information set forth in 15 U.S.C. 638(g)(13). If DAF assesses that a small business concern has security risk(s), DAF will review the proposal, the evaluation, and the security risks and may decide not to select the proposal for award based upon a totality of the review.

DAF USE OF SUPPORT CONTRACTORS

Restrictive notices notwithstanding, proposals may be handled for administrative purposes only, by support contractors TEC Solutions, Inc., APEX, Oasis Systems, Riverside Research, Peerless Technologies, HPC-COM, Mile Two, Montech, Wright Brothers Institute, and MacB (an Alion Company). In addition, only Government employees and technical personnel from Federally Funded Research and Development Centers (FFRDCs) MITRE and Aerospace Corporations working under contract to provide technical support to AF Life Cycle Management Center and Space and Missiles Centers may evaluate proposals. All support contractors are bound by appropriate non-disclosure agreements. Contact the AF SBIR/STTR CO Daniel J. Brewer (Daniel.Brewer.13@us.af.mil) with concerns.

PROPOSAL STATUS AND FEEDBACK

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

Automated feedback will be provided for Phase I proposals designated Not Selected. Additional feedback may be provided at the sole discretion of the DAF.

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

The Air Force anticipates that all proposals will be evaluated and selections finalized within approximately 90 calendar days of solicitation close. Please refrain from contacting the BAA CO for proposal status before that time.

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 Officer Daniel J. Brewer, Daniel.Brewer.13@us.af.mil.

AIR FORCE SUBMISSION OF FINAL REPORTS

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

PHASE II PROPOSAL SUBMISSIONS

DAF organizations may request Phase II proposals while technical performance is ongoing. This decision will be based on the contractor’s technical progress, as determined by an DAF Technical Point of Contact review using the Phase II review criteria outlined above.

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

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

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

AIR FORCE SBIR/STTR PROGRAM MANAGEMENT IMPROVEMENTS

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

Air Force SBIR 24.1 Phase I Topic Index

Topic Number	Topic Name	Maximum Value*	Maximum Duration**	Technical Volume Page Limit***
AF241-0001	Wargaming and AI for All	$180,000	6	20
AF241-0002	Real-time magnetic field generator for hardware-in-the-loop testing	$180,000	6	20
AF241-0003	Operational Arctic Aerospace Warning & Control to Enhance Information Dominance & Domain Awareness for Rapid Decision Making	$180,000	6	20
AF241-0004	Context-Aware RF Electromagnetic Surveying for Exploiting Signals of Opportunity	$180,000	6	20
AF241-0005	SUU-67/A Pylon Modification for Advanced Weapons	$180,000	6	20
AF241-0006	Mobile Target Tracking	$180,000	6	20
AF241-0007	Advanced Battery Development and Integration for Airborne Platforms	$180,000	6	20
AF241-0008	Additive Manufacturing & Repair of 7075 Aluminum for Weapon Systems	$180,000	6	20
AF241-0009	Spectroradiometric Suite	$180,000	6	20
AF241-0010	Improved Digital Engineering Techniques for Test Data Leveraging	$180,000	6	20
AF241-0011	Enhanced Timing-Programming System	$180,000	6	20
AF241-0012	High Temperature Mach number or Static Pressure Probes for Vitiated Flows	$180,000	6	20
SF241-0013	Planar Hyperspectral Imager	$180,000	6	20
SF241-0014	MUOS SATCOM Simulator Connectivity Over IP	$180,000	6	20
SF241-0015	Securely Operating Through 5G for Enterprise Space Data Transport Applications	$180,000	6	20
SF241-0016	Numerical Simulation of VLF Antennas in Space Plasma	$180,000	6	20
SF241-0017	Satellite Cyber Immune Response to Evolving Threats	$180,000	6	20
SF241-0018	Mitigating Negative Effects of Polysulfide Dissolution in 18650 Lithium Sulfur Battery	$180,000	6	20
SF241-0019	Resonator Laser Gyro	$180,000	6	20
SF241-0020	Trusted Automated Satellite Operations for Mission Life	$180,000	6	20
SF241-0021	Optical Interconnects for High-Speed High-Efficiency Intra-satellite Data Transfer in the Space Environment	$180,000	6	20

SF241-0022	Ultra-Broadband High-Definition High-Frame Rate NIR-MWIR Imager	$180,000	6	20
SF241-0023	Low Latency Space Object Maneuver Detection	$180,000	6	20
SF241-0024	Evaluating Data Strategies in Training AI Solutions for Space C2	$180,000	6	20
SF241-0025	Modernizing USSF BMT	$180,000	6	20

***Proposals that exceed this amount will be disqualified**
**** Proposals that exceed this duration will be disqualified**
*****Pages in excess of this count will not be considered during evaluations**

AF241-0001 TITLE: Wargaming and AI for All

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Trusted AI and Autonomy; Advanced Computing and Software

OBJECTIVE: Implement a game server capable of engaging significant portions of allied warfighters in operationally relevant, enjoyable, and analyzable joint operation wargames. This “wargaming cloud” will harness the American democratic and competitive ethos to both train our service members in the operational warfighting “family business” and crowdsource the development of potentially disruptive operational strategies. The dataset created through this effort will enable both traditional data analysis methods and more modern approaches based on machine learning and artificial intelligence. SBIR phases will seek a warfighting game that balances playability, DoD relevance, and data extraction capability.

DESCRIPTION: Our proposal aims to build an initial repository of operational wargames designed to educate every allied warfighter on the intricacies of the operational level of war while enabling statistical analysis and AI-informed decision-making through significant quantities of game iterations. Leveraging public and popular games, the SBIR awardees will produce a large dataset from their existing online servers from which military planners could derive decision analyses at the appropriate operational level. Further, if not already developed, SBIR funds should develop a Markov Decision Process dataset for reinforcement learning applications.

Additionally, SBIR awardees will provide plug-in capabilities to their games which allow for the DAF to adjust and create novel scenarios and assets. These plug-ins will provide extensibility and adaptability for future in-depth data-driven strategy analysis.

Further, utilizing these gaming platforms, our approach will allow every airman and guardian to test their operational instincts against the best tacticians worldwide, fostering a sense of pride, competition, and ownership while teaching the family business of warfare.

The datasets that are created via these games will populate a gameplay database, which can be used to analyze trends from worldwide player data, develop alternative strategies from that data, and train AI agents.

These trained AI models will enhance the high-level traditional wargaming process in three primary ways. First, it will add fidelity to adjudication by actually simulating tactical level encounters based on moves, rather than the current process of having ‘white cell’ declare an outcome based on a spreadsheet, dice-roll, or rule of thumb.

Second, it will greatly accelerate logistics and laydown planning, which provides re-playability. One initial early finding from the adoption of Command:PE was that human planners only started taking risk and exercising creativity after the ‘conventional’ plan had tried and failed multiple times, but when they did they were able to actually start winning scenarios that were assumed losses. Replayability gets human players into a place where they can produce these valuable outcomes - if the work-hours required to run a traditional wargame only allow for one rep, bold concepts and disruptive approaches may not get a hearing.

Last, AI agents can provide the ability to ‘MoneyBall’ diverse approaches to wargaming and planning. ‘Anti-fragile’ strategies that incorporate both chaos and order is a strong suit for a free society, especially against an authoritarian regime. Since logistics planning is a necessity, this form of modeling would allow for enough branches to make space for mission command at echelon, which will in turn impose costs on an adversary well prior to conflict.

In order to pursue these objectives, three goals must be met by the AI modeling effort:
-1) Tactical modeling. The ability for AI agents to model tactical encounters in a relevant wargaming system, which will provide a rigorous tool for adjudicating operational-level wargaming moves.
-2) Logistical modeling. Given a combat desired force in a scenario, AI agents can model one or ideally several scenarios for basing and logistical support.
-3) Operational modeling. (stretch goal) Given an operational design, complete laydown, tactical encounters, and operational level branching in order to provide a 'strawman' initial analysis of a concept of operations.

This proposal supports the requirement for DAF warfighters to be educated about real operational threats. Further, this will provide the ability for warfighters to better assess strategies, tactics, and procedures against thinking and adaptive opponents. In so doing, this SBIR will help prepare DAF members to be ready to deploy and fight (OI 7) while ensuring an operational understanding of JADC2 (OI 2) and enabling the analysis of alternatives for resilient forward-basing options (OI 5).

Engaged Stakeholders: AFWERX Spark, AFIMSC, Morpheus, Air Force Gaming, Lincoln Labs, DAF, MIT AIA

PHASE I: The objective of Phase I is that projects will demonstrate their game's playability, DoD relevance, and data extraction capability. The team is seeking games that can balance abstraction and realism, sufficiently mimicking the operational level of war for warfighter education and human evaluation while maintaining high levels of engagement and playability. Additionally, games will demonstrate their ability to export gameplay data that fully and efficiently captures in-game experience for a broad gamut of post processing. In this feasibility study, companies will demonstrate their capability of data extraction.

PHASE II: Phase II will focus on game flexibility, scaleability, and capability demonstration with real gameplay. In addition to Phase I goals (playability, relevance, and extraction capability), performers will demonstrate the commercialization potential of their game (more data to capture for AI agent training), their ability to host their game on government servers and provide a continuous stream of data during the PoP from all hosted games. Additionally, performers shall give the USG the ability to extend scenarios with user-defined assets, inject AI agents as players, and permit faster-than-real-time command-line gameplay suitable for agent training.

PHASE III DUAL USE APPLICATIONS: The future of gaming will require extensible, AI-ready games capable of employing cooperative and competitive agents as NPCs. The ability to inform the development of these agents using real gameplay data from experienced users could be invaluable. These capabilities for small game companies improve the reach, enjoyability, and accessibility of their games to the worldwide market. In ensuring their games are AI-ready, games will improve their marketability for future research and development to unique markets.

REFERENCES:

1. Vinyals, Oriol, et al. "Grandmaster level in StarCraft II using multi-agent reinforcement learning."Nature 575.7782 (2019): 350-354.;
2. Meta Fundamental AI Research Diplomacy Team (FAIR)†, et al. "Human-level play in the game of Diplomacy by combining language models with strategic reasoning." Science 378.6624 (2022): 1067-1074.;
3. Siu, Ho Chit, et al. "Evaluation of human-AI teams for learned and rule-based agents in Hanabi. "Advances in Neural Information Processing Systems 34 (2021): 16183-16195.;

4. Lyons, Joseph, et al. "Measuring Perceived Agent Appropriateness in a Live-Flight HumanAutonomy Teaming Scenario." Ergonomics in design (2022): 10648046221129393.;
5. Silver, David, et al. "Mastering the game of Go with deep neural networks and tree search." nature 529.7587 (2016): 484-489.;

KEYWORDS: Wargaming, Data Analysis, Artificial Intelligence, Imitation Learning, Reinforcement Learning

AF241-0002 TITLE: Real-time magnetic field generator for hardware-in-the-loop testing

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Hypersonics

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

OBJECTIVE: The objective of this project is to develop and prototype a magnetic field scenario generation system that can be used to drive software- and hardware-in-the-loop test configurations for magnetic field based alternate navigation systems. The system required will interface with existing magnetic field emulation hardware to provide calibrated phenomenology representative of the vector field induced by the Earth's crust and other dynamic environmental sources as sensed by aerospace platforms performing a wide range of Air Force missions.

DESCRIPTION: An active area of research in AFRL is the use of the Earth's magnetic field variations as a means for navigation. This technique is thought to be used in nature by animals during long migrations and has been explored by AFRL, MIT, and others as a possible alternative to conventional GPS-based guidance. Given the interest in this area, AFRL has also been exploring development of laboratory simulation capabilities for the purpose of testing navigation systems as an integral part of the guidance and control of aircraft, weapons, and other aerospace assets. This type of navigation research and development is enabled by digital simulations and real-time Software-In-the-Loop (SIL) and Hardware-In-the-Loop (HIL) simulation environments. Recently, the Kinetic-kill Hardware-In-the-Loop Simulation (KHILS) facility at Eglin AFB developed a 3-D vector field simulator, the Magnetic field Navigation Integration Testbed (MagNIT) to demonstrate HIL capability for future Guidance, Navigation & Control (GNC) technologies. While much progress has been made, challenges remain in development of the simulator control system, i.e., User Interface for simulator configuration and calibration, Real-Time Simulation Engine for accurate real-time field generation, Run-time Interface development, environment and self-induced Field Contamination Modeling, and Data Logging. Essential to this capability will be review and implementation of magnetic field models to form the basis of simulations. Numerous magnetic field models exist, e.g., the World Magnetic Model, the Enhanced Magnetic Model, International Geomagnetic Reference Field, etc. One challenge for testing will be to establish maturity and robustness of navigation algorithms that are trained on databases that are known to be continuously changing over time. Another challenge is calibration to deal with the laboratory environment and establishing what facility controls and modifications are necessary to provide an accurate test environment. Another is emulation of fields induced by the sensing platform as it dynamically performs a mission, rapidly changing attitude and altitude using electrically driven control systems and actuators. These processes, along with the more fundamental User and Facility interface functionality, must be instantiated and demonstrated under this activity. Validation test cases are required to demonstrate accuracy of the simulator and viability of the simulation process. The described capability must be adaptable to operate in a digital signal injection mode, an analog signal injection mode, and as a driver for the existing KHILS MagNIT HIL simulator. Innovative solutions, based on demonstrated experience in GN&C, HIL Testing, E-M Phenomenology, Calibration processes, and Software Development, are desired to develop and demonstrate effective and efficient processes for validated magnetic field simulation.

PHASE I:

1. Establish simulator functional requirements and modes of operation.
2. Document facility interface requirements and characterize the test facility environment.
3. Research available databases to use to present sufficiently accurate and relevant crust magnetic field data at altitudes of interest.
4. Establish Use Cases and range of vehicle dynamics.
5. Research validation data sets for assessing simulator calibration accuracy.
6. Document range of potential airframe induced interference magnitudes and dynamics and potential modeling strategies to represent dynamic fields resulting from servos, motors, etc.
7. Develop and build a prototype system to demonstrate baseline functional capability at TRL 4.
8. Demonstrate software externally driven with an appropriate flight profile and using playback of canned flight profiles interfaced to the MagNIT, or an appropriate emulation, with data logging.
9. Build a plan to improve performance, fidelity, and integration into simulation frameworks in order to interface with sensors and the AFRL owned MagNIT.

PHASE II:

1. Build improved prototype of the magnetic field generation controller with User Interface and full operational functionality (TRL 7).
2. Demonstrate all calibration functions in connection to the MagNIT to validate facility constraints and/or modifications and upgrades required to meet future test requirements.
3. Demonstrate real-time operation using 6DOF state data from a HIL simulator through an appropriate interface. 1) Demonstrate magnetic field vector sensor emulation for injection into a processing system, as in a software-in-the-loop simulation. 2) Demonstrate driving the AFRL owned magnetic field generation system (MagNIT).
4. Execute validation test cases and document results with all developed procedures and solutions. Establish and document limitations and required improvements for the MagNIT simulator.
5. Demonstrate prototype system in real-world conditions with full range of potential conditions:
   a. Airframe attitude dynamics
   b. Field perturbation dynamics
   c. Velocities
   d. Arbitrary global locations and trajectories
   e. Atmospheric induced anomalies
6. Document software in User Manual, Technical Manual, Programmer's Manual so that source code can be modified by the government for future interface and compatibility upgrades.
7. Establish transition plan for other government agencies and contractors.

PHASE III DUAL USE APPLICATIONS:

1. Develop a commercial capability to deliver software to DoD and contractors to accurately simulate Earth crust magnetic fields that will run at real-time at TRL 8.
2. Software should be portable, flexible, and able to integrate to most hardware-in-the-loop facilities, software-in-the-loop facilities, and for non-real-time software algorithm testing.

REFERENCES:

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2. A. J. Canciani, “Magnetic Navigation on an F-16 Aircraft using Online Calibration,” IEEE Trans. Aerosp. Electron. Syst., pp. 1–15, 2021, doi: 10.1109/TAES.2021.3101567;
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KEYWORDS: Magnetic field in Earth’s crust; Alternative Navigation; Magnetic navigation; Real-time processing; Closed-loop simulation; Hardware-in-the-loop; Hypersonic; Signal injection

AF241-0003 TITLE: Operational Arctic Aerospace Warning & Control to Enhance Information Dominance & Domain Awareness for Rapid Decision Making

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Trusted AI and Autonomy; Advanced Computing and Software; Integrated Sensing and Cyber; Human-Machine Interfaces; Integrated Network System-of-Systems

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

OBJECTIVE: Develop methods to enhance ADA using low-cost existing and emerging technological solutions that can operate all seasons in the Arctic above 70N latitude.

DESCRIPTION: The Arctic has a complex environment to operate in. Geographically, the Arctic region consists of the Arctic Ocean, adjacent seas, and parts of eight nations: the United States, Canada, The Kingdom of Denmark (which includes Greenland), Finland, Iceland, Norway, Russia, and Sweden (AF Arctic Strategy). The area above the 66 degrees North latitude Arctic Circle is almost 2.5 times the size of the continental United States and mostly over ocean. Due to climatological reasons, the North American Arctic hosts a much harsher climate than the European Arctic. The thick, multi-year ice around the coast lines means there is significantly less road and maritime infrastructure compared with the European Arctic. While roads can be made on the snow in the winter, the changing climate removes this stable surface. Melting permafrost and coastal erosion creates a much less stable environment for transportation and infrastructure. When operating any electronic equipment in the Arctic region, the equipment must be able to withstand extremely cold temperatures, corrosive environments, and damage from sea life like Polar Bears and Arctic Foxes who are known to rip apart or play with buoys in the ice (Author’s experience). Because of this, the Alaskan NORAD Region (ANR) is particularly reliant on ground-based line of site systems to provide rapid access, reach, and air domain awareness in the AOR. A solution is required that takes into account the complexities of achieving ADA in the arctic environment for both current and future threats. This Phase 1 SBIR focuses on any emerging or existing technology that can contribute to the ability to perform Aerospace Warning (AW) and Aerospace Control (AC) in the Arctic beyond the line of site ground-based systems as a connected system. It focuses on low-cost passive or active sensors, information, or other novel applications of traditional equipment in a broader electromagnetic spectrum range (RADAR, EO&IR, etc.). The equipment operating environment must be able to operate in temperatures ranges from –40 degrees Celsius to 10 degrees Celsius, where an average of 20-50 cm of snow fall on the sea ice in the winter, average salinity of the ocean from 32 to 37 PSU, and with relative humidities up to 100% (NSIDC).

PHASE I: Demonstrate a method or conduct a feasibility study that is capable of enhancing ADA in the Arctic for operational use. The method should employ existing and emerging sensors, services, techniques, and solutions that integrate into existing programs of record and data lakes within the Air Force and CDAO office.

PHASE II: Development of an observing network using one or more sensors, services, techniques, and solutions at low-cost that integrate into the operational picture for air domain awareness in the Arctic.

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. Fesler, Peter M., Brigadier General USAF & O'Shaughnessy, Terrence J., General USAF "Hardening the Shield: A Credible Deterrent & Capable Defense for North America" Canada Institute September 2020;
2. Vanherck, Glen D., General USAF, "NORAD and USNORTHCOM Strategy Executive Summary" March 2021;
3. Savitz, Scott, "Strategic Competition in the Arctic- European Security & Defence/Maritime Defence Monitor, Combined Special Issue, pages 36-41 (October 2022)";
4. Tingstad, Abbie and Savitz, Scott, "U.S. Military May Need to Invest More in Arctic Capabilities" the RAND Blog, February 10, 2022;
5. The White House "National Strategy for the Arctic Region" October 2022;
6. Lee, Caitlin, PHD and Poling, Aidan, "Bolstering Arctic Domain Awareness to Deter Air & Missile Threats to the Homeland- MITCHELL INSTITUTE Policy Paper" Vol. 41, June 2023;
7. The Department of the Air Force "The Department of the Air Force Arctic Strategy," 2020;
8. Multiple Authors, National Snow and Ice Data Center (NSIDC) https://nsidc.org/data/explore-data;

KEYWORDS: Arctic Mobile Observing Systems; arctic capability; improved northern acoustic monitoring; northern communication capabilities; arctic communication capabilities; arctic sea ice acoustic monitoring; arctic sea ice ground based sensors

AF241-0004 TITLE: Context-Aware RF Electromagnetic Surveying for Exploiting Signals of Opportunity

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Trusted AI and Autonomy; Integrated Sensing and Cyber

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

OBJECTIVE: Develop a capability to use 3D environment models and RF propagation patterns to develop low-latency CNNs for RF geolocation and signal-type identification that can be run in parallel on low SWaP RF Electronic Spectrum Monitoring (ESM) antenna arrays for Class I and Class II UAS airframes.

DESCRIPTION: Highly realistic and accurate 3D models are available for nearly all locations of our globe. These models often include coarse geometric and visible light (EO) information as textures. This project will develop algorithms that autonomously or semi-autonomously construct detailed 3D RF propagation models using available 3D geometry-and-texture, i.e., skinned, models of real-world locations. The resulting RF models will be used to develop context-specific AI technologies that estimate candidate 3D RF source locations and signal types from a low SWaP Ultra-Wide Band antenna array consisting of 4 antennas or less. Frequency ranges of interest for geolocation include 0.8 GHz - 6 GHz and solutions extending this range without sacrificing SWaP or performance are welcome. Geolocation approaches should be capable of detecting RF sources in complex multi-path environments where the strongest sensed signal may arrive to the sensor via direct-path propagation or propagation paths involving up to 2 bounces.

Geolocation capabilities will be part of a larger Electronic Surveillance Monitoring (ESM) algorithm suite which can be deployed as downstream analysis capabilities for the payload. Algorithm suite capabilities can provide search, intercept, collect, classify, geolocate, monitor, copy, and exploit capabilities.

PHASE I: Performer shall conduct and report on a feasibility study, survey of relevant technologies, and prototype algorithms that demonstrate an ability to deploy context-specific RF geolocation algorithms inside a 16 hour window that outperform competing approaches in terms of either accuracy and computational complexity or the SWaP of the required payload specifications. Applications should be capable of being run in Zynq Ultrascale+ RFSoC hardware in parallel and deployable as a payload to Class I and Class II UAS.

PHASE II: Building upon their Phase I, Performer shall implement a selected algorithm and approach. Deliver a prototype payload that can be integrated with a UAS that demonstrates the conceptual design of Phase I. Evaluate the performance of the prototype for direct-path, single-bounce and double-bounce geolocation contexts and geolocate targets including those that may exist in low-impedance indoor locations, e.g., inside windows.

PHASE III DUAL USE APPLICATIONS: Phase III efforts transition the prototype technology of Phase II to a fully-developed technology for use as a commercial or warfighter solution. A viable business model for the developed technology must be demonstrated through the performer or in partnership with other contractors. Transition partners would be in a position to supply this capability and future realizations to the Air Force and other DoD entities.

REFERENCES:

1. N211-091 Real-time Simulation of Radio Frequency (RF) Signal Returns from Complex Targets and Backgrounds, Phase I, 2021;
2. Willis, A., Hossain, M., Godwin, J, Hardware-accelerated SAR simulation with NVIDIA-RTX technology, SPIE Defense and Commercial Sensing: Algorithms for Synthetic Aperture Radar Imagery XXVII, 2020;
3. Martian, A. Real-time spectrum sensing using software defined radio platforms. Telecommun Syst 64, 749–761, 2017;
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5. E. Kupershtein, M. Wax, and I. Cohen, “Single-site emitter localization via multipath fingerprinting,” IEEE Transactions on Signal Processing, vol. 61, no. 1, pp. 10–21, 2013;
6. B. R. Phelan, Location of GSM transmitters in an urban environment via unique multipath characterizations, The Pennsylvania State University, State College, Pa, USA, 2012.;

KEYWORDS: Geolocation; RF source models; Electronic Surveillance Monitoring; context-specific RF geolocation

AF241-0005 TITLE: SUU-67/A Pylon Modification for Advanced Weapons

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Hypersonics; Integrated Network System-of-Systems; Advanced Materials

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OBJECTIVE: This proposal seeks to study, engineer, and prototype a modified SUU-67/A Pylon with MIL-STD-1760 aircraft interface. AFGSC is developing a new conventional High Speed, Air-breathing cruise missile capable of range >1000 miles. Such a missile carried by the B-52 will likely exceded the capacity of the existing conventional weapons pylon and Heavy Stores Adapter Beam (HSAB). AFGSC is exploring other means of missile carriage on the B-52. One option is repurposing the existing SUU-67/A Aircraft Pylon for conventional use. The SUU-67/A is currently used to carry the AGM-86/B Air Launched Cruise Missile (ALCM).

DESCRIPTION: Without this effort to repourpose the SUU-67/A, AFGSC will likely have diminished carriage cabability to carry cruise missiles on the B-52. Potential andversaries and conflicts in the Pacific region will need dozens of cruise missiles in mass attacks against hostile forces. The B-52 carries eight missiles internal and twelve missiles on external underwing pylons, each pylon carries six missiles. Without a capable external pylon, B-52 carraige is diminished 60%.

PHASE I: Define a system concept, perform a feasibility study, and propose a solution for creating a modified SUU-67/A with MIL-STD-1760 aircraft interface for the B-52. The developed CAD and SysML models developed during this project will be government-owned, and that the government will have unlimited rights to use, modify, reproduce, release, perform, display, or disclose such technical data or computer software.

PHASE II: "The objective of this Phase II SBIR project is to further develop the solution for a modified SUU-67/A with MIL-STD-1760 aircraft interface for the B-52 integration created in Phase I. The project will focus on refining and improving the digital twin, creating a well-defined deliverable prototype that can be used for commercialization.

Approach:
The project will involve the following steps:

Refinement of the 3D Model: The 3D model of the SUU-67/A created in Phase I will be refined and improved to enhance its accuracy and functionality. This will involve further validation of the model to ensure its accuracy and the addition of new components to improve functionality and future sub-system integration.

Integration of New Equipment: The digital twin will be used to integrate new equipment, wiring, and necessary hardware with the SUU-67/A. Integration will involve testing the new equipment in different scenarios to identify potential issues and make necessary modifications.

Testing: The modified SU-67/A will undergo rigorous testing to ensure its integrity, functionality, and connectivity to the aircraft. The testing will involve simulated carriage in a wide range of scenarios, including adverse weather conditions, various payload combinations, equipment failures, and system malfunctions.

Success Criteria: The success criteria for this project will be the delivery of an modified SUU-67/A prototype.

Commercialization Plan: A commercialization plan will be developed to promote the technology and identify potential licensing and partnership opportunities. A marketing strategy will also be developed to reach potential customers and partners. The proposer will have identified potential customers and partners and have a plan to seek additional funding opportunities to continue the development of the digital twin technology and explore other potential applications in the aerospace industry.

Operating Parameters/Prototyping Expectations:
The modified SUU-67/A prototype will be delivered as an ready-to-integrate & ready-to-flight demonstrate asset.

Conclusion:
The success of this Phase II project will result in a well-defined deliverable modified SUU-67/A prototype ready for integration and testing."

PHASE III DUAL USE APPLICATIONS: "The objective of this Phase III/Dual Use SBIR project seeks to study, engineer, and prototype a modified SUU-67/A Pylon with MIL-STD-1760 aircraft interface for equipment integration and testing created in Phase II. The project will focus on transitioning the technology to government and commercial applications and achieving a high technology readiness level (TRL).

Expected Phase III Effort:
The expected Phase III effort will involve prototyping, testing, and commercializing the modified SUU-67/A for government and commercial applications. The technology will be refined and optimized to meet the specific requirements of these applications. The project will involve collaboration with potential customers and partners to identify their specific needs and develop a plan for commercialization. The project will also involve seeking additional funding opportunities to further develop the technology and explore other potential applications in the aerospace industry.

Expected TRL at Phase III Entry:
The expected TRL at Phase III entry is 9, which means the technology is fully developed, tested, and validated in relevant environments. The SUU-67/A prototype will have been tested and validated in a wide range of testing environments, and its functionality will have been demonstrated through an in-flight demonstration. The technology will be ready for commercialization and deployment.

Additional Transition Planning:
The additional transition planning for this Phase III project will involve identifying the government approvals required for the commercialization of the technology. The project team will work closely with the Department of Defense (DoD) to identify any necessary certifications, approvals, or standards that need to be met for the technology to be deployed in military applications. The project team will also work with potential commercial partners to identify any necessary certifications, approvals, or standards required for commercial deployment.

Known Government Approvals Required:

The known government approvals required for this project will vary depending on the specific application and customer. However, potential approvals that may be required include certification by the Federal Aviation Administration (FAA) or the Department of Defense (DoD), compliance with relevant military standards, and approval by the appropriate government agencies.

Additional DAF Customer Opportunities:
The additional DAF customer opportunities for this project include potential applications in military and commercial aviation. The digital twin technology can be used to improve the safety and performance of aircraft, reduce risk, save time and money, and increase efficiency. The technology can also be used for training and maintenance, providing a realistic and accurate representation of the aircraft that can improve safety and reduce errors during actual operations. The project team will work closely with potential customers and partners to identify additional opportunities for deployment and commercialization of the digital twin technology.

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Additional Transition Planning:
The additional transition planning for this Phase III project will involve identifying the government approvals required for the commercialization of the technology. The project team will work closely with the Department of Defense (DoD) to identify any necessary certifications, approvals, or standards that need to be met for the technology to be deployed in military applications. The project team will also work with potential commercial partners to identify any necessary certifications, approvals, or standards required for commercial deployment.

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REFERENCES:

1. MIL-STD-1760;

KEYWORDS: Digital twin; Legacy aircraft; Equipment integration; Testing; Virtual model; Accurate data; Physical dimensions; Risk reduction; Accredited digital simulation; Time and money saving; Realistic representation; Designing CAD; SysML files; B-52; Non Recurring Engineering cost reduction; Digital engineering; Model development

VERSION 5

AF241-0006 TITLE: Mobile Target Tracking

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Integrated Sensing and Cyber

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

OBJECTIVE: Develop a target tracking method that can be utilized to autonomously track targets based on operator selecting a ground target from sensor data . The method will provide feedback to a flight controller carrying an appropriate sensor and allow the vehicle to track and follow the target without further input from an operator. The method should be sized to be integrated on an FAA Group 2 Unmanned Aircraft System and could be utilized for tracking ground targets from a distance or tracking ground targets as part of a loitering munition system and should be capable of provided guidance data for both use cases.

DESCRIPTION: Unmanned air vehicles play an important role in today's military operations. They are invaluable in locating time critical targets, reporting enemy positions and movements to battlefield commanders, and destroying tactical targets.

Projected great power competitions nearly always include the loss of ability to use Global Positioning System (GPS) for guidance. In today's Department of Defense, GPS is used for a multitude of missions including guiding reconnaissance aircraft and munitions. The objective of this topic is to develop a method to autonomously track a selected target that will reduce manpower requirements, dependence on GPS, and system resources in the amount of bandwidth taken up by having to be continuously connected to the aircraft.

The method should have the ability to track and follow one mobile target from a distance as in a reconnaissance mission, as well as track a mobile target and provide data to achieve terminal guidance and successful strike as in the case of a small loitering munition. To fit this mission, any system under consideration should fit inside the normal hardware and software constraints of a Group 2.

Any hardware or software approach is appropriate. However, it is anticipated that some approaches will utilize commercially available hardware, such as gimbled electro-optical/infrared sensors, and implement a software solution to interpret the data gathered and translate it into flight control commands to guide the system.

Some key desired capabilities of the method are:

- Simply integration onto a multitude of small platforms
- Interoperability with different sensor types and/or different brands of the same sensor
- A simple and intuitive user interface
- Process data and provide flight commands fast enough to allow an appropriately capable aircraft to track a mobile target moving at up to 80km/h all the way through impact
- Potential targets could include, but aren't limited to, sedans, small trucks, armored personnel carriers, and dismounted personnel

PHASE I: The contractor shall provide trade studies & engineering design necessary to define the operational system & associated technologies. The contractor shall show evidence that key enabling technologies are adequately mature (e.g. Technology Readiness Level >=6). Key enabling technologies shall include but aren't limited to sensor hardware, sensor software, target tracking software, interface links with flight control surfaces, user interfaces, data processing systems.

PHASE II: The contractor shall develop and test a method that provides the capability to track a mobile target moving at speeds up to 80km/h, selected by an operator. The test program shall culminate in a demonstration, on a government test range, striking a moving target using only guidance provided by the system under development with a surrogate loitering munition platform.

PHASE III DUAL USE APPLICATIONS: The various technologies developed in Phase II are applicable to military and government applications. There are potential commercial applications in a wide range of diverse fields that include crop and traffic monitoring as well as site security and police surveillance.

REFERENCES:

1. 1. Part 107 – Small Unmanned Aircraft Systems https://www.ecfr.gov/current/title-14/chapter-I/subchapter-F/part-107
2. Gettinger, Dan, and Arthur Holland Michel. "Loitering munitions." Center for the Study of the Drone (2017).
3. Zhang, Zhidong, et al. "Research on speed scheme for precise attack of miniature loitering munition." Mathematical Problems in Engineering 2020 (2020): 1-19.;

KEYWORDS: Loitering munition, small UAS, Group 1, Group 2, unmanned, unmanned aerial system, autonomous, mobile target tracking, targeting

AF241-0007 TITLE: Advanced Battery Development and Integration for Airborne Platforms

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Integrated Network System-of-Systems; Advanced Materials; Microelectronics

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

OBJECTIVE: The objective of this topic is to explore, develop, and employ advanced battery technologies with specific attributes, namely high energy density and adaptable power density, while maintaining low Size, Weight, Power Consumption, and Cost (SWaP-C) characteristics. The goal is to create highly versatile, stretchable, and shape-changing batteries suitable for use in Bomber aircraft, externally carried weaponry, and electronic equipment. These batteries must possess unique qualities, such as the ability to withstand extreme temperatures and fit securely into tight or irregular spaces without compromising safety.

DESCRIPTION: AFGSC aims to explore, develop, and employ advanced battery technologies with specific attributes. The focus is on achieving high energy density and adaptable power density while ensuring the batteries have low Size, Weight, Power Consumption and Cost (SWaP-C) characteristics. These batteries are envisioned to be highly versatile, stretchable, and shape-changing to suit their use in Bomber aircraft, as well as for internal and externally carried weaponry and electronic equipment. AFGSC is actively involved in the research and development of various externally carried weapons and an externally carried pod designed to accommodate a diverse range of electronic equipment. Each of these applications demands batteries with unique qualities, as mentioned earlier. Critical features include the ability to withstand extreme temperatures, both hot and cold, and fit securely into tight or irregular spaces without the risk of fire, explosion, or adverse changes that could compromise the safety of the aircraft or the equipment.

PHASE I: The Phase 1 SBIR performance objectives involve a comprehensive evaluation of the scientific and technical feasibility of developing highly versatile, stretchable, and shape-changing batteries with specific characteristics for military applications. Extensive research will be conducted across various key areas to achieve the objectives. Researchers will explore advanced battery technologies, materials, and manufacturing techniques to identify options with high energy density, adaptable power density, and shape-changing capabilities, all while being cost-effective.

The focus will be on developing and optimizing battery components, such as cathodes, anodes, electrolytes, and separators, to enhance overall performance and achieve the desired high energy density and power density. Additionally, research will delve into new energy storage materials, including solid-state electrolytes and advanced nanomaterials, to push the boundaries of energy density and adaptability. Innovative engineering and material science will play a crucial role in designing batteries that can stretch and change shape while maintaining performance and safety. This could involve using flexible substrates, new electrode designs, or stretchable materials to ensure secure fitting into tight or irregular spaces without compromising structural integrity. Furthermore, effective thermal management solutions will be developed to ensure battery performance and safety across a wide temperature range, vital for their use in bomber aircraft and weaponry.

Safety and reliability are of utmost importance, and the batteries will undergo rigorous testing and validation to ensure their ability to withstand harsh environments, shocks, vibrations, and other stresses without compromising overall safety. Additionally, engineers will focus on miniaturization and SWaP-C optimization to reduce weight and size while maintaining high energy density. Collaboration with relevant stakeholders will ensure seamless integration with existing aircraft and weaponry systems. Scalable and cost-effective manufacturing processes will also be explored to achieve mass production without sacrificing performance and cost targets. Compliance with military and aviation regulations and standards will be addressed, ensuring safety and performance requirements are met, and necessary certifications obtained for deployment. The Phase 1 SBIR will lay the foundation for a successful multidisciplinary approach in the development of advanced batteries, paving the way for Phase 2 SBIR and further advancement in military applications.

PHASE II:
Expected Outcomes:
The Phase 2 SBIR project aims to deliver a matured battery technology with demonstrated performance and capabilities. The functional prototypes will showcase the batteries' potential for integration into military aircraft and weaponry systems. The research and testing conducted during this phase will provide essential data to address technical challenges, safety concerns, and regulatory requirements. Additionally, the project will explore pathways for commercialization, increasing the impact of the technology beyond defense applications.

The ultimate goal of this Phase 2 SBIR is to pave the way for the practical deployment of these advanced batteries in military operations, enhancing the capabilities of bomber aircraft, weaponry, and electronic equipment. The successful completion of this project will contribute to strengthening the technological edge of the United States Air Force and furthering innovation in the field of energy storage for military and civilian applications.

Objective:
The Phase 2 SBIR will focus on advancing the research and development efforts initiated in Phase 1, aiming to mature the battery technology to a level where it can be transitioned into practical applications. The objective is to create highly innovative batteries that meet the stringent requirements of bomber aircraft, externally carried weaponry, and electronic equipment in terms of performance, reliability, and adaptability.

Approach:
Technology Refinement: Researchers will refine and optimize battery technologies, which may include battery chemistry, materials, and manufacturing processes, to enhance energy density, power density, and shape-changing capabilities.

Prototype Development: Building upon the research conducted in Phase 1, the team will develop functional prototypes of the batteries to demonstrate their performance and functionality under real-world conditions.

Performance Testing: Rigorous testing and evaluation will be conducted on the prototypes to assess their safety, reliability, and performance across a wide temperature range and in various environmental conditions and physical shapes.

Miniaturization and Integration: Engineers will further optimize the battery designs that may accomplish milestones such as reducing their SWaP-C footprint, ensuring seamless integration into tight spaces in military aircraft and weaponry.

Scalable Manufacturing: When possible, the focus will be on developing scalable and cost-effective manufacturing processes to enable mass production without compromising on performance and cost targets.

Compliance and Certification: Regulatory compliance with military and aviation standards will be ensured, including things such as obtaining necessary certifications for deployment in military equipment.
Collaboration and Funding: Collaboration will continue among the necessary parties such as the research team, government agencies, defense contractors, and academic partners to pool expertise and resources for successful battery development.

Market Analysis and Commercialization: A comprehensive market analysis will be conducted to identify potential applications beyond military use, exploring commercialization opportunities for the developed battery technology.

PHASE III DUAL USE APPLICATIONS: The Phase III effort for this project aims to transition the highly versatile, stretchable, and shape-changing batteries from the SBIR/STTR-funded R&D phase to practical applications in both Department of Defense (DoD) and commercial domains. The primary goal of Phase III is to achieve technology maturation and commercialization, ensuring widespread adoption and integration into various military and civilian platforms.

Expected TRL at Phase III Entry:
At the Phase III entry, the battery technology is expected to be at a Technology Readiness Level (TRL) of 7 or higher. This indicates that the technology has been demonstrated in an operational environment and is ready for integration into relevant systems and platforms.

Transition Planning and Government Approvals:
Transition planning in Phase III will involve close collaboration between partners such as the research team, government agencies, defense contractors, and potential commercial partners. The primary focus will be on the following aspects:

Validation and Certification: The battery technology will undergo rigorous validation and certification processes to meet all requisite standards including the necessary military and aviation standards required for deployment in DoD applications.

Market Analysis and Commercialization: Further market analysis will be conducted to identify additional commercial opportunities and potential applications outside the DoD domain. Commercialization strategies will be developed to maximize the technology's impact in the commercial market and ensure long-term viability.

Intellectual Property (IP) Protection: Appropriate steps will be taken to protect the intellectual property generated during the R&D phase, ensuring that the technology remains secure and proprietary.
Funding and Investment: Secure funding from non-SBIR/STTR sources will be sought to support the scale-up, production, and commercialization of the batteries. This may involve collaborations with venture capitalists, industry partners, and private investors.

Technology Integration: Consideration will be given towards integrating the batteries into various military platforms, such as bomber aircraft, externally carried weaponry, off-board pods, and electronic equipment, through partnerships with relevant defense contractors and DoD agencies.

Additional DAF Customer Opportunities:
Beyond the initial DoD applications, the Phase III effort will explore additional opportunities within the

Defense Acquisition Framework (DAF) customer landscape. This may include engagements with other branches of the U.S. Armed Forces, government agencies, and allied defense organizations that can benefit from the advanced battery technology
.
Overall, the Phase III effort will focus on successfully transitioning the battery technology from the SBIR/STTR-funded R&D phase to commercial applications, further enhancing the capabilities of military platforms and fostering innovation in the energy storage sector. Through effective transition planning and collaboration with industry partners, the technology is poised to have a significant impact on both defense and civilian sectors, contributing to the technological advancement and competitiveness of the United States.

REFERENCES:
1. 1. MIL-STD-1760;

KEYWORDS: Batteries; Stretchable; Shape-changing; Energy Density; Power Density; SWaP-C; Battery Chemistries; Energy Storage; Solid-State Electrolytes; Nanomaterials; Innovative Engineering; Material Science; Thermal Management; Battery Safety; Reliability; Miniaturization; Integration; Manufacturing.

AF241-0008 TITLE: Additive Manufacturing & Repair of 7075 Aluminum for Weapon Systems

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Advanced Materials

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

OBJECTIVE: Develop and demonstrate structural repair of 7075 parts using AM processes. Provide recommendations on material and processes used to achieve structural repairs. Provide test results for tensile strength of repaired test coupons.

DESCRIPTION: High strength aluminum is used in aircraft and air warfighting components throughout the Air Force Inventory. AL 7075 T6 is used to combine high strength and lightweight material. EBW specifically uses AL 7075 T6 in construction of Launcher Rail Bodies. Some of these parts, which have a life limiting wear condition, are prohibitively expensive to manufacture new but could be repaired and put back into service. The Air Force currently spends $2M per year on the manufacture of new rail bodies to replace ones that could be repaired. Also, the use of this technology could be used to support aircraft sustainment, possibly saving 100s of millions. Many new technologies are currently being developed in the world of AM for printing high strength aluminum alloys. This SBIR would focus on testing the strength that would be achieved from a repair, where the new technology and materials are used with preexisting 7075 T6 Al.

PHASE I: Develop high strength alloy aluminum that can be used in Additive Manufacturing and Repair.

PHASE II: Development of repair process and testing of repairs with the AM high strength alloy aluminum to demonstrate that it can attain at least 70% strength of original 7075 tensile strength.

PHASE III DUAL USE APPLICATIONS: Repair capabilities for 7075 could be used by every military branch and manufacturer that maintains aircraft. All aircraft use AL 7075 components.

REFERENCES:

1. Jones A.C, Rhys & Cizek, Jan & Kovářík, Ondřej & Lang, Jeff & Ang, Andrew & Michopoulos, John. (2021). Characterising crack growth in Scalmalloy”. Procedia Structural Integrity. 34. 39-44. 10.1016/j.prostr.2021.12.006.;

KEYWORDS: Additive manufacturing, repair, aluminum

AF241-0009 TITLE: Spectroradiometric Suite

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Integrated Sensing and Cyber

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

OBJECTIVE: The objective is to have an single system that can perform automated spectroradiometric measurements across the ultra-violet, visible and infrared spectrum, 200nm to 14500nm. System will be used to characterize EO/IR imagers (spectral responses) and perform filter and optical window transmittance measurements. System will have the ability for the user to select spectral resolution and bandpasses within operating spectrum.

DESCRIPTION: Design and fabricate a spectroradiometer system that enables the system to make automated measurements from 200nm to 14500nm. System will produce spectral responses for radiometers and imaging sensors and transmittance curves for filters and optical windows. Meeting the requirements below ensures that the spectroradiometer system is capable of accurately characterizing the spectral responses and transmittance of optical systems, allowing for various scientific, industrial, and research applications.

Spectral Range: It should cover the desired wavelength range relevant to the sensor’s application, this should include ultraviolet, visible, and infrared regions. Threshold wavelength range – 200nm to 14500nm

Spectral resolution: The system must have sufficient spectral resolution to distinguish between different wavelengths accurately. Higher resolution allows for more precise analysis of spectral features.
Sensitivity: The spectroradiometer should be able detect and measure low-sensitivity spectral signals, to ensure accurate and reliable data collection.

Calibration: Regular calibration is crucial to maintain accuracy and traceability of the measurements.
Stability: The system should demonstrate stability over time to ensure consistent and repeatable measurements.

Integration with other radiometric systems: The spectroradiometer must be designed to integrate seamlessly with other COTS systems, threshold - GigE Vision Standard interface.

Data Output: The system should provide data in a format suitable for analysis, often in the form of spectral radiance, spectral irradiance, normalized spectral , or transmittance.
User Interface: A user-friendly interface is essential for easy operation, data visualization, and data processing.

Environmental Considerations: The system needs to be designed to operate in a laboratory environment.
Cost and Size: Depending on the application and portability requirements, the spectroradiometer should be affordable and available in a suitable size.

PHASE I: In Phase l, the vendor will determine the ability of creating a single automated system that can make sprectroradiometric measurements from 200nm to 14500nm. Feasability to combine multiple reference detectors in one system to span overlapping regions of UV, visible and IR. And the ability to provide a source with high spectral resolution across the 200nm to 14500nm region.

PHASE II: Phase II will demonstrat a working protype spectroradiometer that operates across the 200nm to 14500nm wavelength range. The system will be able to provide spectral responses for any given sub-band within the threshold wavelength range. Additionally, the system will be capable of measuring the transmittance of filters and optical windows within the threshold wavelength range.

PHASE III DUAL USE APPLICATIONS: For entrance into Phase lll, the complete system shall be TRL 6 or greater. In Phase III the vendor will be capable of producing a fully working automated system with accessories that allow customers to tailor the system to interface with other COTS or custom sensors outside of the original design parameters. Input from other AF agencies and services will be provided to further broaden commercialization requirements.

REFERENCES:

1. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/spectroradiometers;

KEYWORDS: IR; EO/IR; Midwave IR, Visible; Longwave IR; Spectrometer; UV, ultraviolet; monochromator; Spectroradiometer; Filter transmission: Spectral Detector Response; transmittance.

AF241-0010 TITLE: Improved Digital Engineering Techniques for Test Data Leveraging

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Advanced Computing and Software

OBJECTIVE: Develop and demonstrate a data analysis tool methodology to capture relevant test parameters from past data into a usable form and create a digital engineering-level model capable of evaluating variables and providing accurate predictive answers. Models must be able to quickly learn from new data to improve predictions

DESCRIPTION: Aircraft survivability and ballistic test data have been collected for over sixty years. This data needs to be converted to a format to aid in performing data analysis and for extracting answers to assist in new test and evaluation predictions. With current test reports, which are often stored in Portable Document Format (PDF) for later reference, little regard is given to the usefulness of the data beyond the current project and often insufficient background information is documented along with the data to allow useful models to be created and tailored to new applications. In addition, new test data is often difficult to merge with this previous data without a detailed link to caveats associated with the previous testing. This may include future testing which may make use of enhanced instrumentation techniques able to capture higher resolution or details than data captured in previous testing. The lack of clarity on the past testing and the diligence required for finding and extracting the past test report data often results in duplication of effort and/or re-learning of lessons learned. This, in turn, leads to additional cost and time to get vital answers. Even when engineering level models were built upon the past test data, the addition of new test data most often results in the creation of new Monte Carlo inputs that may not properly capture parameters and constraints.

The digital engineering paradigm requires more coupon, subscale, and large-scale testing to be performed earlier to support design and trade study activities before prototypes are built. Much of this test data will need to come from previous test programs and be adapted to new aircraft survivability test objectives. With only static reports available from the past and perhaps no traceability to raw data or no accurate way to interpret that data, there is often no ability to capture all the necessary information from past testing to create useful test data products for the future. In addition, there is certainly no way to improve upon the past data, as additional related test or simulation data become available. This means that digital engineering will be difficult to carry out in practice.

This SBIR Phase I effort will focus on demonstrating a data encapsulation methodology to apply to coupon, sub-scale, and large-scale survivability test data relating to threat/target interactions. Target-related test data may include stress/strain, pressure, temperature, damaged structure, cracking, hydrodynamic ram effects, fuel spurt and more. Threat-related data may include flash/function probability, residual velocity, residual mass, and more. The data encapsulation methodology should include a demonstration of how various forms of data can be preserved, relevant variables are preserved, accurate predictions can be made, how the resulting tool can improve with additional test data, and how previously generated test data can be used for new and novel test programs.

PHASE I: Significant work equivalent to a Phase I effort in demonstrating the feasibility of a data encapsulation methodology applicable to aircraft survivability test data must be documented in the proposal. The methodology must be able to integrate previous survivability test and analysis data along with data from current and future testing and analyses into a comprehensive analytical tool. This analytical tool will aid survivability engineers in developing future survivability test programs and analyses that will produce more reliable test and analysis results

PHASE II: Development of a data encapsulation methodology should be completed and demonstrated in the form of an engineering-level model for a set of ballistic test data related to threat/target interaction.

Demonstration should be conducted for a new test data being incorporated with previous test data.

PHASE III DUAL USE APPLICATIONS: Digital engineering is not limited to aircraft survivability or military development efforts. With custom materials and new technologies commonly being incorporated into new designs, building efficiently on older test data is essential to both military and commercial applications.

REFERENCES:

1. D. Varas, R. Zaera, J. López-Puente, Numerical modelling of the hydrodynamic ram phenomenon, International Journal of Impact Engineering, Volume 36, Issue 3, 2009, Pages 363-374;
2. Peter J. Disimile, Norman Toy, Liquid spurt caused by hydrodynamic ram, International Journal of Impact Engineering, Volume 75, 2015, Pages 65-74;

KEYWORDS: test data; survivability; machine learning

AF241-0011 TITLE: Enhanced Timing-Programming System

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Advanced Computing and Software; Hypersonics; Microelectronics; Integrated Network System-of-Systems; Human-Machine Interfaces

OBJECTIVE: Develop a modernized system to control timing distribution and electronic event capture with nanosecond accuracy along a 10-mile-long high-speed test track. The system should integrate legacy stand-alone systems into a single overarching mission control system.

DESCRIPTION: The Holloman High Speed Test Track carries out rocket sled tests at speeds ranging from subsonic to hypersonic. The track utilizes a diverse array of sensors to control event timing and capture data. For example, sled velocity is captured using continuous wave Doppler radar; sled position is captured using precisely located breakwires that are time-stamped when the sled breaks them as it passes by; meteorological variables such as altitude, temperature, humidity, and wind speed are captured using various sensors located along the track. Additionally, high-speed camera arrays are used to capture sled and test article behavior throughout the test. Test events, such as seat ejections or bomb impacts, must be initiated, tracked, and terminated using accurate common time to align input & output data across multiple sensor platforms. The current Timer-Programmer control system was updated in the 1980s and utilizes a copper cable network that extends from a centralized control facility to utility risers along the 10 miles of track as well as to various bunkers. It does not incorporate all data collection and control systems currently in use.

This SBIR topic focuses on replacement of the legacy Timer-Programmer system. The new system should provide common timing to distributed data collection and event control systems, provide controlled timing of test events, measure event times, and report data. It should use the existing copper cabling infrastructure and integrate other independent data acquisition systems into one overarching mission control system. The system needs to output nanosecond accuracy timing to multiple locations traveling distances as great as eight miles. It must time tag events in the field with nanosecond accuracy and relay back to a base station computer for processing. All data collected must be stored in a centralized data base for post-mission analysis. The system should integrate real-time data from multiple dispersed data collection and control equipment (radars, ultrasonic anemometers, cameras, McQ portable event controllers) into one heads-up display. The system must deliver real time in formats required by various data collection and event control systems, general time, programmable frequencies, and programmable DC level signals which are outputted through balanced and unbalanced line drivers. In addition, these line drivers should be computer controllable for output signal selection, amplitude and on and off times. Standard data collection reports should include sled first motion, velocity window computations, parallel and serial event times, and weather data. The system must passively record mission day land mobile radio communications for post-test display or playback. Data should be downloadable to widely used data formats such as Microsoft Excel or to structured query language server format for post-mission analysis. Other user requirements include the ability to initiate or terminate events on a programmed time schedule; real-time operator ability to stop/start/restart tests for safety reasons; high system reliability; ability to expand the system to incorporate new equipment in the future; low-maintenance need; low upkeep costs; and non-intrusive for existing wireless systems.

PHASE I: Conduct a feasibility study that decomposes user-level timing, event control and data collection requirements into technical requirements, identifies options (equipment and/or infrastructure) that will meet requirements, and provide an approach for developing a replacement Timer-Programmer system.

PHASE II: Develop and demonstrate a functional system that will provide timing and event controls to meet user requirements. Deliver a deployable system ready for immediate integration into Track operations with only the need for technician training.

PHASE III DUAL USE APPLICATIONS: This technology will have applications to other government, university and commercial test facilities involved highly dynamic test events.

REFERENCES:

1. https://www.arnold.af.mil/News/Article-Display/Article/3398244/846th-ts-brings-the-need-for-speed-to-holloman/;
2. https://www.arnold.af.mil/News/Article-Display/Article/3050680/holloman-high-speed-test-track-sets-record-with-fastest-recovery-mission-in-30/;
3. https://www.af.mil/News/Article-Display/Article/3337705/joint-effort-underway-to-power-rocket-sleds-into-the-future/;

KEYWORDS: Timer-Programmer; mission control; event control; data collection

AF241-0012 TITLE: High Temperature Mach number or Static Pressure Probes for Vitiated Flows

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Hypersonics; Integrated Sensing and Cyber; Advanced Materials

OBJECTIVE: Develop and demonstrate a local Mach number or Static Pressure probe technology suitable for hypersonic and high enthalpy flows.

DESCRIPTION: The Aerodynamic and Propulsion Test Unit (APTU) at the Arnold Engineering Development Complex (AEDC) is a high-speed hypersonic (HS/H) test facility capable of producing flight representative conditions (true temperature and pressure) via a combustion air heater (CAH). Understanding of any HS/H system under test requires a thorough understanding of the as-delivered free stream test conditions. The test conditions are typically characterized during dedicated test runs using intrusive diagnostics such as flow-field rakes with multiple discrete probes. Currently, the probes are limited to the assessment of total pressure and temperature with no direct measurement of local static pressure or Mach number. As such several assumptions and iterative techniques are required to assess the flow-field characteristics. With only wall statics along the nozzle inner mold line, analysis is limited to assuming a uniform static pressure across the flow field. Any divergence in the static pressure from this assumption is superimposed on the total pressure and Mach number profiles. A direct measurement of either static pressure or Mach number will negate the need for the assumptions and reduce the overall uncertainty of test results.

PHASE I: Consult with AEDC personnel to understand APTU operations and gain familiarity with current intrusive rake and probe designs. Survey industry to assess potential solutions to the problem, including later commercialization opportunities. Develop the concept and design of the probe technology for the APTU flow-field conditions. Evaluate the achievable measurement uncertainty and illustrate plans for state-of-the-art improvements.

PHASE II: Develop and demonstrate a prototype probe-rake devices in the APTU flow-field conditions early into the Phase II to allow design iterations design as needed to demonstrate robustness and sufficient accuracy.

PHASE III DUAL USE APPLICATIONS: Reduce device complexity and size for use within the facility rake systems. This technology will result in a product easily commercialized to other highspeed and high temperature wind tunnels.

REFERENCES:

1. Porro, R. A. (2001). Pressure Probe Designs for Dynamic Pressure Measurements in a Supersonic Flow Field. NASA Glenn Research Center. Cleveland, OH. Retrieved 12 2, 2022, from https://ntrs.nasa.gov/api/citations/20010093214/downloads/20010093214.pdf;
2. Pinckney, S. Z. (1975). A Short Static-Pressure Probe Design for Supersonic Flow. NASA Langley Research Center. Hampton, VA. Retrieved 12 2, 2022, from https://ntrs.nasa.gov/api/citations/19750019233/downloads/19750019233.pdf;
3. Pinckney, S. Z. (1975). US Patent 3914997;
4. Capone, F. J. (1961). Wind-Tunnel Tests of Seven Static-Pressure Probes at Transonic Speeds. NASA Langley Research Center. Hampton, VA. Retrieved 12 2, 2022, from https://ntrs.nasa.gov/api/citations/19980227993/downloads/19980227993.pdf;

KEYWORDS: High Temperature; High Pressure; Scramjet; Ground Testing; APTU

High Temperature; High Pressure; Scramjet; Ground Testing; APTU

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SF241-0013 TITLE: Planar Hyperspectral Imager

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Space Technology

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

OBJECTIVE: Advances in satellite technology are driving a new space architecture that relies on constellations of small satellites for proliferated systems. This proliferated architecture will require low cost, rapidly produced optical payloads for intelligence, surveillance, and reconnaissance (ISR). Advances in material science, including nanofabrication and computer based design, are bringing in a new era for achieving high functionality in low SWaP-C (size, weight, power, and cost) payloads. This includes novel planar optics that are broadband, can be fabricated on short timelines, and provide higher functionality in a low-SWaP-C system. This solicitation seeks a low-SWaP-C ISR payload that can provide simultaneous multiband imaging over the range of 500-12000 nanometers. This payload must be compatible with integration into an ESPA class satellite. The system must have a common optical path for the visible through the infrared to use wavelength diversity during data fusion. The system from low earth orbit must be able to achieve NIRS 5 or better (https://fas.org/irp/imint/niirs.htm). The anticipated use case of this payload will be to identify features on the ground such as man-made structures, geographical features such as streams, agricultural fields, roadways, and dwellings.

DESCRIPTION: Advances in satellite technology are driving a new space architecture that relies on constellations of small satellites for proliferated systems. This proliferated architecture will require low cost, rapidly produced optical payloads for intelligence, surveillance, and reconnaissance (ISR). Advances in material science, including nanofabrication and computer based design, are bringing in a new era for achieving high functionality in low SWaP-C (size, weight, power, and cost) payloads. This includes novel planar optics that are broadband, can be fabricated on short timelines, and provide higher functionality in a low-SWaP-C system. This solicitation seeks a low-SWaP-C ISR payload that can provide simultaneous multiband imaging over the range of 500-12000 nanometers. This payload must be compatible with integration into an ESPA class satellite. The system must have a common optical path for the visible through the infrared to use wavelength diversity during data fusion. The system from low earth orbit must be able to achieve NIRS 5 or better (https://fas.org/irp/imint/niirs.htm). The anticipated use case of this payload will be to identify features on the ground such as man-made structures, geographical features such as streams, agricultural fields, roadways, and dwellings.

PHASE I: During Phase I, system analysis will be completed to determine the system requirements of the system and conduct a system's requirements review. This will include breadboard validation of components and the production of a 10-cm or greater single primary optical element that transmits light from 500 to 12000 nm that performs on par (efficiency, resolution, Strehl ratio, etc.) with the quality of a traditional optical aperture across those wavelengths. Design and fabrication of the optics must be completed within 30 calendar days using readily available computational and fabrication facilities. The SWaP of the overall system must be 1/10th of a traditional optical train that uses traditional optical materials. A design with minimal optical elements is highly desired. The plan to develop algorithms for wavelength diversity and data fusion that takes advantage of imaging across the visible and the infrared will also be investigated with a viable path forward for Phase II. The use of COTS hardware is encouraged for the more traditional aspects of the payload.

PHASE II: During Phase II a prototype payload will be constructed and tested on the ground by imaging space based targets. Use of COTS hardware is strongly encouraged to reduce the cost of the prototype and future follow-on systems. The only non-COTS component is expected to be the planar optical elements. This system must meet the system requirements identified in Phase I. Phase II will also require development of algorithms identified in Phase I. The payload developed must be robust enough to survive launch into LEO and survive the harsh space environment for at least three years of space operations not including the spacecraft initialization period (this could take up to 1.5 years to conclude). The payload must be designed and built to integrate into an ESPA class satellite for ISR applications from LEO measuring the ground.

PHASE III DUAL USE APPLICATIONS: Phase III is anticipated to identify a satellite vehicle to launch the payload and collect and analyze images collected of the ground from low earth orbit. There are many potential planned R&D systems that may be willing to host the payload for nominal investment. The imager will be designed for ground ISR but this system may also offer ISR potential from many different platforms. Future integration into the Hybrid Architecture Demonstration (HAD) program as well as contribution to a forthcoming multi-nation space-based Hyperspectral Microsatellite constellation Project Agreement (PA) may also be part of Phase III.

REFERENCES:
1. "Patrice Genevet, Federico Capasso, Francesco Aieta, Mohammadreza Khorasaninejad, and Robert Devlin, ""Recent advances in planar optics: from plasmonic to dielectric metasurfaces,"" Optica 4, 139-152 (2017);
2. NIRS Reference System see https://fas.org/irp/imint/niirs.htm;
3. https://www.spaceforce.mil/Portals/1/Space%20Capstone%20Publication_10%20Aug%202020.pdf;
4. S. Banerji & B. Sensale-Rodriguez, “May. 3D-printed diffractive terahertz optical elements through computational design” In Micro-and Nanotechnology Sensors, Systems, and Applications XI (Vol. 10982, p. 109822X). International Society for Optics and Photonics (2019);
5. M. Meem, S. Banerji, A, Majumder, C. Pies, T. Oberbiermann, B. Sensale-Rodriguez and R. Menon, “Inverse-designed flat lens for imaging in the visible & near-infrared with diameter > 3mm and NA=0.3,” Appl. Phys. Lett. 117(4) 041101 (2020).;

KEYWORDS: ISR; Planar Optics; Imaging Payload; Metamaterials; Engineered Materials; Wavelength Diversity; Data Fusion

SF241-0014 TITLE: MUOS SATCOM Simulator Connectivity Over IP

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Integrated Network System-of-Systems; Space Technology

OBJECTIVE: The objective of this topic is to explore the available configurations of MUOS SATCOM simulators to achieve Air Force mission objectives. The USAF requires a mission engineering and testing tool to evaluate the most appropriate combination of software and processing simulation capability to achieve end to end connectivity analysis with the MUOS satellite constellation. These capabilities should be captured and communicated in a SysML or other MBSE model. At minimum, this is for a single simulator configuration, the Mighty MUOOS," but we will give preferred consideration for multi-satellite communications simulators.

DESCRIPTION: The DoD is transferring from legacy SATCOM systems to the MUOS constellation, This transfer will require significant testing to ensure that legacy terminals ae able to work with the MUOS constellation. Currently , this testing can be performed using the MUOOS simulator or by requesting live satellite time. A simulator, the "Mighty MUOOS," was built and deployed by W5 Technologies under contract FA8750-18-C-0198. However, the MUOOS simulator requires a direct connection (hard wire) between the radio under test and the MUOOS. The USAF requires a global capability to test MUOS equipped terminals like the ARC-210 Gen 6 and to do so, must connect MUOS capable radio terminals and the simulator remotely, via the AFIN or another IP-based network, to test and evaluate data and voice payloads top be passed over the MUOS constellation. Currently the simulator may only be used with an ARC-210 radio. In the interest of expanding the usability of the simulator, identify the feasibility of using the simulator with any SATCOM terminal that operates in the MUOS frequency ranges, including as a minimum, the PRC-117G radio set. This SIBR requests that an investigator identify, test and the evaluate the most appropriate combination of software and processing capability to achieve these ends. These capabilities should be captured and communicated in a SysML or other MBSE model. At minimum, this is for a single simulator to terminal configuration, but we will give preferred consideration for multi-platform configurations. This topic is not focused on a specific production simulator, and the expectation is to model connectivity for any SATCOM simulator that connects to a terminal directly for testing. It is expected that in Phase III, the performer will implement an open architecture interface at the physical level on at least the AF NIPRNet Network and, preferably, for a SIPRNet connection as well.

PHASE I: Demonstrate understanding of current capabilities MUOS SATCOM simulators and how those relate to AF testing requirements. Demonstrate understanding of SysML and MBSE tools as well as the understanding of how to represent COMSAT terminals in this format. Demonstrate understanding of AFSIM capabilities and methods to represent complex SATCOM simulators, particularly MUOSbased simulators in this format.

PHASE II: Develop optimal configurations for MUOS simulators mapped to Air Force SATCOM terminals using Interconnectivity, both non-secure and secure. Present hardware-agnostic model of the IP terminal to simulator linkage using SysML or other Model Based Systems Engineering (MBSE) tools and best practices. Develop ways to represent complex, multi-purpose systems in SysML or other MBSE tools for effective analysis. Develop and present an unclassified scenario(s) to demonstrate the network-based simulator to terminal transmission capability and modeling the desired capability to capture effectiveness of remote network based connections compared to traditional approaches. Capture all documentation and results in the model based form that can be shared and re-used by other developers and/or RY divisions.

PHASE III DUAL USE APPLICATIONS: Implement an open architecture interface at the physical level for a specific MUOS simulator to include the hardware, software, processor, modes and algorithms. The interface will be capable of customization to support connectivity of any USAF SATCOM terminal currently in use to the simulator.

REFERENCES:
1. AF171-043;
2. Mobile User Objective System (MUOS) for Moderate Data Rate Communications (MMDR);

KEYWORDS: MUOS, MUOOS, IP connectivity Radio Frequency; ARC-210 Gen 6, PRC-117G

SF241-0015 TITLE: Securely Operating Through 5G for Enterprise Space Data Transport Applications

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): FutureG; Trusted AI and Autonomy; Integrated Sensing and Cyber; Integrated Network System-of-Systems; Space Technology; Human-Machine Interfaces

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

OBJECTIVE: Add-on software modules, hybrid space and terrestrial communications architectures, and enhancements to 5G user equipment, base stations, and/or augmentations to 5G core infrastructures to best support seamless integration of 5G terrestrial and satellite communications technologies and thus, potentially decreasing costs, increasing coverage, and providing added resilience and multi-level security compatibility to critical communication needs.

DESCRIPTION: New standards and technologies, such as Fifth-Generation (5G) that are expected to meet large throughput increase, seamless connectivity, reliability, and connection density, have become important to the fulfillment of the significantly demanding requirements in flexible interconnections of heterogeneous terrestrial assets, timely data dissemination in non-contested radio environments as opposed to those in military-hardened networks and systems. Recently, DoD has made significant efforts to leverage commercial 5G investments in vendors and operators that are untrusted. Those initiatives that rely on commercial 5G products, create emerging security challenges involving in data integrity, confidentiality, and availability. Concerning the Fighting Satellite Communication (SATCOM) vision by US Space Command that requires future military SATCOM capable of multi-band and multi-waveform operations, whenever possible, to support agile, path-agnostic connectivity, reducing vulnerability to interference and jamming, this topic solicitation is to focus on potential cross-cutting areas required to integrate 5G terrestrial networks with military satellite networks. Such a realization of the enterprise satellite and terrestrial data transport capability across all joint-domain mission areas can only be achieved by means of a radical shift in the way both security and resilience of 5G are designed. For instance, a new dimension for security with path-agnostic and location privacy considerations against denial-of-service (DoS) threats would pose severe challenges to the realization of a 5G-based space data transport. Of particular interest includes but is not limited to: space data transport using cooperative and untrusted indigenous 5G networks where the U.S. and its allied spanning military operators, government services, and DoD controlled infrastructure securely operate through untrusted indigenous 5G wireless communications infrastructures whenever possible. Along with such development for novel security architecture and add-on software modules, both 5G core network and user equipment solutions are necessary to aid in evaluation of expected performance for anomaly detection and recovery, network slicing together with zero-trust protocols, integrity guarantees and covert communications.

PHASE I: Develop necessary plans and concept designs for the proposed 5G-based space data transport or capability in order to demonstrate its viability. Conceptualize a secure hybrid 5G terrestrial & SATCOM system design with potential enhancements to full-stack user software solutions for user equipment and leveraging existing infrastructures. Include appropriate initial laboratory demonstrations as required.

PHASE II: Mature the findings in Phase I. Develop a modeling and simulation capability of a family of security solutions along with user-centric and Open Random Access Network (ORAN) that would leverage artificial intelligence and machine learning intrusion detection analytics. Perform trade studies for security and performance at user equipment and ORAN. Demonstrate a proof of concept to evaluate necessary enhancements and augmentations required pertaining to resilience against DoS threats, integrity guarantees, path-agnostic connectivity, and location privacy subject to variability of untrusted indigenous 5G networks and DoD controlled infrastructures.

PHASE III DUAL USE APPLICATIONS: Integrate with prospective follow-on transition partners to provide improved operational capability to a broad range of potential Government and civilian users and alternate mission applications. Government organizations such as Air Force Research Laboratory and Space Systems Command could sponsor a government reference design of secure 5G networks for legitimate DoD and civil users, in collaboration with small business and industry partners. Successful contractor technology demonstrations will inform the technical requirements of future acquisitions by Primes and subcontractors.

REFERENCES:

1. L. You, K. Li, J. Wang, X. Gao, X. Xia, B. Ottersten, “Massive MIMO Transmission for LEO Satellite Communications”, IEEE Journal on Selected Areas in Communications, 2020;
2. R. Dangi, P. Lalwani, G. Choudhary, L. You, and G. Pau, “Study and Investigation on 5G Technology: A Systematic Review”, Sensors (Basel). 2022 Jan;
3. 22(1): 26;
4. L. Bai, L. Zhu, X. Zhang, W. Zhang and Q. Yu, "Multi-Satellite Relay Transmission in 5G: Concepts, Techniques, and Challenges," in IEEE Network, vol. 32, no. 5, pp. 38-44, September/October 2018.;

KEYWORDS: 5G; SATCOM; single hybrid space and terrestrial communications architectures; security; resilience; military, government, or critical infrastructure operator; 5G Radio Access Network; network slices; network virtualization; multi-access edge computing; end devices; end system security; zero trust architectures; system resilience; human factors

SF241-0016 TITLE: Numerical Simulation of VLF Antennas in Space Plasma

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Space Technology

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

OBJECTIVE: Develop a multi-scale 3D numerical Electro-Magnetic (EM) plasma simulation capable of resolving a real electric dipole antenna (cm width and 100 m length) or magnetic loop antenna (cm wire, 20 m diameter) as well as the electromagnetic radiation produced by the antenna with km scale wavelengths.

DESCRIPTION: Energetic electrons (100 - 2000 keV), due to either natural process or a High Altitude Nuclear Explosion, HANE, become trapped in the Earth's magnetic field where they are a threat to satellites in low Earth orbit. One technique for removing these electrons is to mimic nature with electromagnetic (EM) Whistler waves that are known to scatter electrons onto trajectories aligned with the magnetic field, where they are lost into the atmosphere [Starks, 2020]. The recent DSX (Demonstration and Science Experiment) mission [Johnston, 2023] successfully demonstrated transmission by an 80 m dipole antenna and reception by a remote satellite. While DSX was able to measure the dissipated power, it was unable to quantify the efficiency of radiation versus local dissipation i.e., plasma heating. Since follow-on systems must be precision engineered for a required size, weight, and power, this topic calls for a numerical model capable of representing antenna concepts in realistic detail while modeling both the local plasma response and the distant radiation including the wave mode. Whistler waves can exist in a range of modes from electrostatic (ES) to electromagnetic (EM). Current thinking holds that EM waves are more effective at modifying the electron pitch angle since the magnetic interaction consumes no energy; while antennas that are small compared to the free space VLF wavelength (100 km) preferentially excite ES waves due to the high index of refraction that matches the wavelength in plasma to the antenna size. Current antenna concepts include: the electric dipole such as with DSX, the magnetic loop antenna, the magnetic rod antenna; and engineered plasma modification for such (near the antenna) to produce non-linear beat wave interference and conversion from ES to EM radiation [Sotnikov, 2018]. The end product will be a computer plasma model capable of aiding the design of a space-based antenna immersed in the low or near Earth plasma. This model will be capable of simulating the performance of the recent DSX antenna, a 100A 20 m diameter magnetic loop, and a compact magnetic rod producing a similar dipole moment. While the usual SBIR rights will apply to the model, so also will the government's limited right to effectively use the model following conclusion of the SBIR effort.

PHASE I: In Phase I, the contractor will identify and demonstrate the numerical methods to be used, and at conclusion have demonstrated the viability of the approach. This effort is expected to be computationally intensive so a limited demonstration will be acceptable i.e., it will not be necessary to obtain production levels of super-computer access. Never-the-less, since super-computing is an anticipated requirement, such capability must be convincingly demonstrated

PHASE II: During Phase-II, the capability to effectively model one or more antenna concepts is expected, and a fully functional design tool should be delivered at the conclusion of Phase-II.

PHASE III DUAL USE APPLICATIONS: In Phase-III the antenna-plasma design tool will be used to design candidate systems for the radiation of radios waves at Very Low Frequency.

REFERENCES:

1. Starks, M. J., et.al. 2020, J. Geophys. Res. Space Physics, 125, doi: 10.1029/2019JA027029.;
2. Johnston, W. R., et al. (2023). J.Geophys. Res.: Space Physics,128, doi: 10.1029/2022JA030771;
3. Sotnikov V., et al 2018, Plasma Phys. Control. Fusion 60 044014;

KEYWORDS: Radiation Belt Remediation; High Altitude Nuclear Explosion; Particle-In-Cell,

SF241-0017 TITLE: Satellite Cyber Immune Response to Evolving Threats

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Integrated Sensing and Cyber; Space Technology

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OBJECTIVE: Currently, for USSF satellites there are large amounts of telemetry to monitor to ensure the full health of the system. An auto immune response system for cyber events would remove the need for constant monitoring by operators by detecting currently known vulnerabilities and then classifying unknown vulnerabilities. This system follows the operational capabilities of the human immune system to allow for long term and evolving effectiveness of the detect and response capabilities of a space platform. The Objective of the SBIR is to research and develop algorithms and system architectures that can detect a cyber event both known and unknown using bio-inspired computing techniques.

DESCRIPTION: For an operator to be able to respond to a cyber event in a proficient and responsive timeline the event would need to be quickly detected. Classic cyber detection and mitigation systems, such as Firewalls and Intrusion Detection Systems, lack the ability to detect/respond to unknown attack signatures [1]. A bio-inspired immune response system complements the classic system to handle the unknown signatures, much like how the human immune system can react and handle known pathogens [1]. There exists cloud based systems, such as IBM Watson for Cyber Security [2], but those systems tend to have large computational requirements and false positive rates. Therefore future research and work would need to inter operate with existing security systems, detect unknown cyber events with high accuracy and decrease computational resources to fit within a satellites SWAP-C.

PHASE I: Conduct a literature survey of bio-inspired computing and cyber immune response to understand the current state of the art. Using the survey generate a representative software and hardware architecture for use in implementing a cyber immune response system. Using the architecture create an analysis of alternatives for the key aspects of the architecture. Using the architecture and analysis of alternatives generate a list of data source needs to feed into the system to be able to generate a course of action. Given a vignette mission from the technical point of contact generate a set of courses of action that would pertain.

PHASE II: Operating off the phase 1 vignette and proposed architecture implement a proof of concept system that can generate actionable courses of actions in a simulated digital twin of a space platform. Using the simulation demonstrate the ability of the system to learn and respond to known and unknown threats to the platform. Using the proof of concept and simulation determine the optimal location for the response system based on data source and computational needs. Using the simulation and digital twin generate a set of mitigation techniques possible to act on the course of actions coming from the immune response system. Implement the most impactful mitigation techniques and demonstrate the ability for the system to now detect and respond to known and unknown cyber threats. Develop the proof of concept into a space ready prototype that can be tested government test space test range to determine to operational-ability of the prototype.

PHASE III DUAL USE APPLICATIONS: Entering into phase 3 the immune response system should be at Technology Readiness Level 5-6 and should be nearing Technology Readiness Level 7, based on National Aeronautics and Space Administration's Technology Readiness Levels. The performing company should now work towards getting on-board a flight test program, such as AFRL RV's small-sat, Department of Defense Space Test Program or University Nano Satellite Program.

REFERENCES:

1. Wlodarczak, Peter. "Cyber immunity." International Conference on Bioinformatics and Biomedical Engineering. Springer, Cham, 2017.;
2. IBM launches Watson for Cyber security beta program. IBM (2016). https://www.ibm.com/news/ca/en/2016/12/06/v881650s90213z16.html;

KEYWORDS: Cyber-Security; Bio-Inspired Computing; Satellites;

SF241-0018 TITLE: Mitigating Negative Effects of Polysulfide Dissolution in 18650 Lithium Sulfur Battery

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Trusted AI and Autonomy; Microelectronics; Space Technology; Renewable Energy Generation and Storage; Advanced Materials

OBJECTIVE: The objective of this topic is to improve cycle life and capacity retention of Lithium-Sulfur battery chemistry by addressing and resolving negative effects of parasitic polysulfide reactions.

DESCRIPTION: The current state-of-practice specific energy in 18650 Li-ion cells used in space missions is as low as 150 W-h/kg. Lithium-Sulfur, with its 2600 W-h/kg theoretical specific energy, has been identified as a promising chemistry to achieve for the U.S. Space Force's (USSF) short-term 18650 rechargeable battery target of 450 W-h/kg. A higher energy rechargeable power source would have impacts across all areas of the USSF mission to enable spacecraft resilience and survivability. Most practical issues with Lithium-Sulfur chemistry can be attributed to “polysulfide shuttling”, the dissolution of Lithium Polysulfide in liquid electrolyte which results in parasitic reactions and its relatively low volumetric energy density, especially when in a small form factor battery cell such as an 18650. These reactions cause low Sulfur utilization and capacity fade, resulting in poor cycling efficiency. Recent efforts have been focused on either (1) suppressing diffusion of the dissolved polysulfides out of the cathode, or (2) protecting the lithium anode from reacting with the dissolved polysulfides. Li-S modelling is necessary to understand the technology development way-forward. This topic proposes the investigation of these or other methods to mitigate the inhibiting effects of polysulfide dissolution and improve its volumetric energy density. Findings will be incorporated into materials and 18650 cell design that can improve cycle life performance while maintaining a high specific energy intrinsic to the chemistry.

PHASE I: Investigate the feasibility of practical solutions to the polysulfide dissolution problem affecting the lithium-sulfur chemistry while maintaining a high 18650 specific energy and energy density. Using the results of this investigation, synthesize and characterize proof-of-concept anode, cathode, separator, and/or electrolyte materials that will provide a potential for improved cycle life and capacity retention to be used in the 18650 cell form factor. Model proposed Li-S cell-level performance. A small quantity of material and the cell-level model are encouraged Phase I deliverables.

PHASE II: Continue the research efforts initiated in Phase I. Optimize materials and test the impact on the cyclability of resultant Lithium-Sulfur cells using coin cell, pouch cell, and/or other cell methodology. Optimize Li-S cell model. Utilizing the materials developed during Phase I and optimized during Phase II, construct 18650 cells and provide an appropriate number of cell samples to conduct electrochemical performance testing to AIAA S-144-202X. Performance targets for deliverables include specific energy of 450 W-h/kg at the 18650 cell level and 500 cycles of at least 80% capacity retention at 20% DOD.

PHASE III DUAL USE APPLICATIONS: Transition technology to the USSF supply chain by completing AIAA S-144-202X qualification. Lithium-Sulfur battery chemistry is the USSF’s most near-term high specific energy storage solution. Successful Phase I and II development provides opportunities for transition to the USSF's supply chain into programs of record.

REFERENCES:

1. Li, et al. "Status and prospects in sulfur-carbon composites as cathode materials for rechargeable lithium-sulfur batteries." Carbon, 92. 2015;
2. Zhang, Sheng S. "Liquid electrolyte lithium/sulfur battery: Fundamental chemistry, problems, and solutions." Journal of Power Sources, 231. 2013;

3. Cheon, et al. "Rechargeable Lithium Sulfur Battery: Structural Change of Sulfur Cathode During Discharge and Charge." Journal of The Electrochemical Society, 150(6). 2003;
4. Cheon, et al. "Rechargeable Lithium Sulfur Battery: Rate Capability and Cycle Characteristics." Journal of The Electrochemical Society, 150(6). 2003;

KEYWORDS: Rechargeable Battery; Lithium-Sulfur; High Specific Energy; Polysulfide Shuttling

SF241-0019 TITLE: Resonator Laser Gyro

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Space Technology

OBJECTIVE: The U.S. Space Force (USSF) will require high accuracy navigation attitude systems for use in proliferated constellations with smaller space vehicles. Current low mass micro electro-mechanical (MEMS) gyroscopes do not have the required performance to allow precision operation in small space vehicles. A gyroscope with MEMS size weight and power but with high navigation-grade performance would enable precision pointing of small space vehicles. Small high-grade gyros would also have applications in counterspace uses both for offensive and defensive efforts. Laser communication terminals and hosted sensor payloads would benefit from low mass rate sensors on the gimbaled assembly.

DESCRIPTION: There is an ongoing effort to leverage unique advantages in gyro sensitivity versus size when an optical system is operated at what is termed an exceptional point. The exceptional point in a nanophotonic system which occurs when the gain and loss are balanced. The resulting operational singularity radically changes the behavior of the optical system and creates large changes in system response to external stimulus. A macro scale ring laser gyro (RLG) has sensitivity that is highly dependent on the optical ring resonator loss and the enclosed path length that the light travels. Operation of a nano scale RLG at an exceptional point promises to overcome the limitations of the very short optical path length. Utilization of the behavior singularity at the exceptional point is only possible due to recent developments in exploiting gain/loss properties in nano scale waveguides. To develop a nano scale RLG which operates at the exceptional point, you first need a nano scale RLG which operates in the standard regime of parity-time (PT) symmetry. Once that is achieved, the design can be manipulated to reach the point where parity-time symmetry breaks down and operation is at the exceptional point. This effort supports development of the PT-symmetry chip level RLG as well as error modeling for a future RLG operating at the exceptional point. The project will attempt to leverage advances in gyro technology to enable better than navigation grade performance from a single channel gyro with a one cubic inch volume. The final design should target 1 W per active channel for power consumption. The technology employed will need to be radiation hardened in the future. Target ARW is 0.005 deg/rt-hr. Bias stability at constant temperature target is 0.05 deg/hr at 30 minutes. The gyro dynamic range will be up to 10 deg/s. Performance must be maintained through TBD g acceleration in any orientation relative to the gyro sensing axis. Gyro scale factor nonlinearity from 1 deg/sec to 10 deg/sec magnitude will be less than 10 ppm after any compensation. The SF error of between +1 deg/sec and -1 deg/sec will be 0.036 deg/hr. The SF spec is 2-sigma. These performance goals are very challenging for the sensor size and could be reconsidered if the technology demonstrates promise in initial prototypes.

PHASE I: Phase I will produce a design for a chip level phase-time (PT) symmetric ring laser gyro (RLG). Further investigation into what is required to push the design to the exceptional point will be done. While the concept of an RLG operating in the mode is still at an early stage of development, it is desired to assess the practical aspects of operational use of the device. For example, operation at the exceptional point (EP) requires high bandwidth servos to assess where is the EP is and to keep the gyro at that point. Behavior on either side of the EP is drastically different than at the singularity itself. Models should be developed to assess expected instrument output in the presence of EP control loop error. Temperature sensitivity could be quite high. Models should be developed to assess required temperature stability of the nano-optical substrate needed to maintain EP operation. Phase I will design a sensor which demonstrates 50% of the required static environment performance. Brass board electronics without flight representative size are acceptable. The sensor form factor will be flight representative. Meeting the 50% static performance goal with a 1 ci sensor volume is a challenging task and will enable assessment of the technology’s suitability to meet the higher performance goals. Error models of the sensor shall be presented which show a path to the target static and dynamic performance.

PHASE II: Phase II will produce a sensor which satisfies the complete performance requirement. Error models described in Phase I would be enhanced to account for measured characteristics of the functional device. The supporting electronics should be small enough at the end of Phase II to be able to be mounted on a 24” rate table platter to facilitate dynamic testing. Error models should be sufficiently developed to be able to provide a realistic prediction of gyro noise, gyro bias stability, and scale factor non-linearity.

PHASE III DUAL USE APPLICATIONS: The prototype gyro and Phase II electronics will be tested in an actual dynamic environment with DC rate, AC rate, and reasonable temperature diurnal. The data will be used to validate behavioral models from Phase II. Testing of this type can be performed at The Aerospace Corporation if the small business does not have suitable facilities.

REFERENCES:

1. Mercedeh Khajavikhan, Yuzhou (Nathan) Liu & Mohammad Hokmabadi (USC), Alex Schumer (TU Wien), Ardy Winoto & Gloria Hoefler (Infinera), Demetrios Christodoulides (UCF-CREOL), “Parity-Time Symmetric Ring Laser Gyroscopes”;
2. J. Ren, H. Hodaei, G. Harari, A. U. Hassan, W. Chow, M. Soltani, D. Christodoulides, M. Khajavikhan, “Ultrasensitive micro-scale parity-time-symmetric ring laser gyroscope,” Optics Letters, Vol. 42, Issue 8, pp. 1556-1559, (2017), https://doi.org/10.1364/OL.42.001556;

KEYWORDS: ring laser gyro; distributed constellations; nanophotonic system; precision pointing; Gyroscope, GNC (Guidance, Navigation, & Control), RLG (Ring Laser Gyro), MEMS (micro electro-mechanical), gimbal, attitude control, Sagnac effect

SF241-0020 TITLE: Trusted Automated Satellite Operations for Mission Life

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Trusted AI and Autonomy; Advanced Computing and Software; Integrated Sensing and Cyber; Space Technology

OBJECTIVE: Space assets are currently almost completely operated from the ground. In order to ensure operation in an increasingly contested space environment, the spacecraft must make autonomous decisions and take action. The USSF will require trusted autonomous spacecraft to operate throughout their lifetimes under these circumstances. Hence, technology is needed to provide long periods of time without operator intervention, and this need should be extended to the life of the vehicle.

DESCRIPTION: Create an on-orbit autonomous software suite or architecture which can autonomously evaluate and recommend courses of action in combination with information derived off-board, doing so autonomously when needed.

The current state of the art is that many autonomous sub-modules for spacecraft control have been devised. The modules vary in their use from CubeSats up to small refrigerator sized form factor systems and from single spacecraft to clusters/mega constellations. But there has not been an effort to bring together these advances into a lifetime autonomous software suite. The full capability desired for this tech topic is to go beyond single modular autonomy approaches to one of operating through normal pattern of life from launch and early orbit to normal operations, to end of life. While the goal is a fully autonomous on-orbit system, multiple sub-elements are needed to develop a trusted capability and which the effort solution would need to address: 1) Data analytics techniques such as machine intelligence to build statistical understanding of a spacecraft's own normal pattern of life, deviations and course of action (COA) assessment tools 2) Methods for validation and verification of autonomous decision-making 3) Visualization tools focused on interaction between autonomous system and human users 4) A cyber-secure environment for this software suite 5) Electronics capability to enable computation and COA execution on-orbit.

PHASE I: Conduct a comprehensive review of current research in spacecraft autonomy including academic, civil and commercial sources. Investigate and compile the possible requirements for an integrated autonomy suite including key subsystems such as guidance, navigation, and control; thermal; propulsion; communications; and payload maintenance over the three major phases of spacecraft lifetime: Launch and early orbit, normal operations, and end of life. Describe how to merge current work on modular autonomous software and provide a design path to integrate across multiple subsystems software modules and across the life cycle of the spacecraft. The form factor of the spacecraft could range from a CubeSat up to a rideshare class (size of a half refrigerator) which may require different solutions. The deliverable should be a critical design review (CDR) quality engineering artifact and or a demonstration of the qualities of a lifecycle autonomy on a testbed (Software in the loop (SIL)) by the proposer.

PHASE II: Phase II will build and deliver a breadboard (TRL5) or hardware in the loop (HIL) quality solution, to be demonstrated on at least one form factor size, from 6, 12, 27 U CubeSat up to rideshare class (size of half a refrigerator), for vehicles of 3-year, 5-year and 10-year operational lifetimes. The simulation shall take in normal environmental influences, micrometeoroid impacts, radiation events, and maintain the vehicle operations in all three life phases as well as maintain a positive energy balance, pointing stability, and payload operational environments. Payloads can be communications, navigation, and sensing.

PHASE III DUAL USE APPLICATIONS: The prototype lifetime autonomous system from Phase 2 shall be tested by a government sponsored entity (UARC, FFRDC, DoD Lab) to validate the capability of the software and hardware to meet the requirements. Formal documentation will be provided to enable the

proposer to share the architecture verification and validation with others in the supply chain as a direct injection to the DIB.
Evaluate and document transition opportunities for utilization in approved Government and civilian applications.

REFERENCES:

1. Operations for Autonomous Spacecraft, Castano, R, et al. Proceedings of the 2022 IEEE Aerospace Conference, arXiv:2111.10970v1, 16 pgs.;
2. Design and Testing of Autonomous Distributed Space Systems, Cramer, N., et al, Small Satellite Conference 21-1-04.;

KEYWORDS: autonomous spacecraft; spacecraft decision making;

SF241-0021 TITLE: Optical Interconnects for High-Speed High-Efficiency Intra-satellite Data Transfer in the Space Environment

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Microelectronics; Space Technology

OBJECTIVE: Develop and demonstrate a photonics-based optical data transfer capability suitable for use in the space environment for intra-satellite data movement between electronic components.

DESCRIPTION: Advances in digital microelectronics enable critically important capabilities for DoD space systems in the areas of information processing, sensors, and communications. System performance in these domains is now more and more constrained not by the limits of processing speed at individual chips, but rather by the ability to move data between them electrically. Optical interconnects for intra-satellite data transfer is already in use in some commercial space ventures, but for military use these implementations are inadequate in terms of size, mass, and power. Currently, they do not have the reliability and robustness that is required for long-term use in the natural and strategic space environments. The target performance is a minimum data rate of 250 Gb/s with maximum energy loss of 5 pJ/bit. To meet size, weight, and power constraints, the approach should implement an optical transceiver with photonic and electronic integrated circuits in a multi-chip package to enable sending and receiving data via optical fiber. The environmental objectives are as follows: Radiation Environment: ≥300 krad of total ionizing dose (TID) and >75 MeV·cm2/mg linear energy transfer (LET) for single event effects (SEE), Temperature Range: -55 to 135 C.

PHASE I: The resource constraints are 6 months and $150,000. Vendors will evaluate design trades, component selection, packaging options, etc., to select a candidate design to meet system performance and environmental objectives. They will provide a roadmap for Phase II execution.

PHASE II: The resource constraints are 24 months and $1,500,000. Vendors will develop a prototype of the candidate design, leveraging components that will provide a path to environmental qualification. They will demonstrate that the design achieves the data rate and efficiency targets. The vendor will identify qualification risks and propose a qualification test plan.

PHASE III DUAL USE APPLICATIONS: The Phase III effort will be an on-orbit demonstration of intra-satellite data transfer operations. This will be enabled by laboratory demonstration of the capability and TRL 5 at the conclusion of the Phase II. Lower cost to orbit, proliferating commercial activity, and more complex military operations in mission areas that include Space Domain Awareness and autonomy are expected to lead Phase III opportunities to validate the capability.

REFERENCES:

1. International Defense Security & Technology December 12, 2021 "DARPA PIPES developing optical transceiver capabilities into multi-chip modules for high throughput parallel processing". https://idstch.com/technology/electronics/darpa-pipes-developing-integrated-optical-transceiver-capabilities-multi-chip-modules-high-throughput-parallel-processing/;

KEYWORDS: Optical Transceiver; Optical Interconnects; High-speed data comm; Photonics; Radiation hard photonics

SF241-0022 TITLE: Ultra-Broadband High-Definition High-Frame Rate NIR-MWIR Imager

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Integrated Sensing and Cyber

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

OBJECTIVE: Development of an infrared imager with an ultrawide bandpass encompassing the Near Infrared (NIR) to the Mid-Wave Infrared (MWIR) spectrum: 0.7 micrometers to 5.5 micrometers.

DESCRIPTION: Broadband infrared imagers are required to characterize signatures of military targets, both cooperative and hostile. The specific need is the characterization of missile plume and hardbody signatures in static and free flight tests. This threat characterization supports the design and testing of missile warning and countermeasure systems. The combination of a broadband imager with multiple filters allows registered imagery to be acquired in multiple bands, covering a broader spectral range than currently available hyperspectral imagers. The multi-band ultra-broadband data would also be useful in temperature/emissivity determination of hypersonic thermal protection systems during ground tests in arc-heated facilities. The infrared detector material InAsSb is an enabling technology to be considered.

The focal plane of the imager should consist of at least 2040 x 1100 pixels with a pixel pitch no greater than 5 mm. Full-frame frame rate needs to be at least 500 frames/sec. An f# of f/2.4 is preferred. An integral filter wheel with at least 4 positions accommodating both warm bandpass and neutral density filters in each position is required. Special attention is required to ensure the sandwiching of bandpass and neutral density filters does not result in ghosting or other image artifacts. The filter wheel should not only remotely addressable, but should be able to be driven at some rate during a data collection. The acquisition of high-rate multispectral registered imagery in several sub-bands along with the wideband (in a single imager) is the requirement. High sensitivity is also required, with a well depth of at least 1.8 $x10^6$ electron-volts, a noise floor of no greater than 150 mV, and a minimum detectable temperature difference of 35 mK.

PHASE I: The Phase 1 effort should develop and prove the feasibility of the proposed approach through an analysis of alternatives, identification of high-risk technical elements, and generation of a conceptual design matrix that lays out how achievable design parameters impact system requirements – e.g. frame rate achievable as a function of focal plane array size. The system design should be sufficiently detailed to guide the Phase II work with a minimum of risk. The Phase I effort will culminate in a conceptual design that optimally meets system requirements and a detailed plan for development of a prototype system during the Phase II effort.

PHASE II: The conceptual design will be matured into a detailed design. Iterative prototypes will be developed to validate the fundamental approach. The Phase II effort will culminate in the demonstration and delivery of a fully operational prototype imager along with a validated design for future larger scale production.

PHASE III DUAL USE APPLICATIONS: Phase III efforts would include a limited production of a number of imagers for inclusion in existing signature measurement systems, such as the Arnold

Engineering Development Complex Field Measurement Team and the Center for Countermeasures Joint Standard Instrumentation Suite. Broadband infrared imagers of this type would find wide military application for surveillance, night vision, and target detection, identification, and tracking. As mentioned above, applications for non-contact temperature/emissivity measurements for hypersonic systems and other defense applications are also possible. Commercial applications for security, surveillance, and non-contact imaging thermometry for manufacturing should also be pursued. Infrared imagers are now a ubiquitous piece of laboratory hardware. Advances in infrared imagery will find wide application supporting many disciplines.

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KEYWORDS: Near Infrared, NIR, InAsSb, Indium Arsenide Antimonide, focal plane array

SF241-0023 TITLE: Low Latency Space Object Maneuver Detection

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Space Technology

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

OBJECTIVE: Develop methods for reducing the latency in space object maneuver detection, utilizing existing sensor phenomenologies, cadences, and data types, with the objective of identifying and characterizing the maneuver with as few observations and as short of time as possible.

DESCRIPTION: The ability to detect space object maneuvers is fundamental in enabling space domain awareness and space traffic management. When a space object maneuvers, deviations from its previous track can be sufficiently large to prohibit association of the observed object to the track. The result is an uncorrelated track (UCT), a trackable object whose origin has not yet been established. Only upon reconciliation of the UCT to a previously known object's track can the association be made so that a full state history of the track is available. This process, known colloquially as UCT resolution, typically involves the backwards and forward propagation of states to identify possible candidate maneuver times, and is often done well after the maneuver has been performed. This time lag can result in critical information about maneuvering satellites to be delayed in sharing with analysts who monitor the space object population. While the optimal solution involves observing all maneuvering satellites persistently, such a solution is not feasible. The best case is therefore for analysts to detect, characterize, and identify satellite maneuvers as soon as new observation data is collected.

Solutions are sought that enable space object maneuver detection with limited latency once new observational data has been acquired. This will aid in maintaining persistent awareness of on-orbit objects. The problem is further compounded by the various orbital regimes in which important space assets reside, and the various sensor phenomenologies that dominate that regime. Solutions that bridge various orbital regimes, allowing for a comprehensive all-space solution are preferred to regime-specific solutions.

PHASE I: Develop solution methodology. Conduct analysis of alternatives, propose solution, and develop algorithm. Algorithm should be implemented in prototype simulations against synthesized or real data to demonstrate potential for success. Assess computing requirements necessary for Phase II effort.

PHASE II: Fully develop and implement solution methodology as prototype software. Methodology should be tested against real-world data across multiple orbital regimes. Quantify performance across multiple sensor types including variations to noise and sensing cadence. Compare timeliness of detection and characterization performance to legacy methods.

PHASE III DUAL USE APPLICATIONS: Phase III efforts may include integration of solution into operational test environments for evaluation with real-time data feeds, and transition to operational users. Military applications include more timely and accurate conjunction assessment and threat awareness. Expected TRL at Phase III entry is 5.

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KEYWORDS: space domain awareness; space situational awareness; space traffic management; maneuver detection

SF241-0024 TITLE: Evaluating Data Strategies in Training AI Solutions for Space C2

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Trusted AI and Autonomy

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

OBJECTIVE: Evaluate and illustrate the consequences of employing various data strategies in training autonomous systems (Artificial Intelligence and Deep Learning based algorithms). Demonstrate how space superiority may depend on employing AI which is sufficiently trained and how space domain awareness data can be used to support this training.

DESCRIPTION: Autonomous space command and control systems are already being fielded within mega-constellations and are being considered for other space systems in deep space. Today flight dynamics teams are informed by third party space situational awareness products which are derived from different approaches to collecting data on operational spacecraft and debris. As increased activity which is considered to be dual-use becomes more prevalent, we will increasingly see the use of autonomy in addressing various challenges for which human cognition may not scale to or be capable of responding to in time. A key step in the development of AI solutions is the training of the algorithms which will do the decision-making. This effort seeks to evaluate the relative performance of such algorithms when they are trained by space domain awareness data of varying quality, density, geometric diversity, precision, and timeliness.

The past few years have seen successful proximity operations in GEO, a rapid increase in maneuverable traffic in LEO, and more technology options for autonomous systems to perform enhanced services in space including life extension, refueling, inspection, etc. As more interactions between spacecraft are observed, there is an increasingly comprehensive body of data which can be used to train algorithms which enable autonomous space command and control (C2) solutions. We are already seeing evidence of this training possibly being employed today. As digital twins of space systems become available, it will be increasingly possible to model space systems, their onboard logic, and to enable training within a digital environment. As new systems are fielded, their autonomous logic can be further trained on-orbit and it will be desirable to compare on-orbit experience to models used to train within the digital environment. This topic seeks to develop the digital training environment for space C2 algorithms, and to demonstrate how the agents within this environment can be trained using real-world and simulated SDA data.

PHASE I: Design a digital traning environment which can enable modeling and simulation using digital representations of space systems, as well as data-driven reconstructions of real-world operations informed by SDA data.

PHASE II: Develop a prototype digital training environment which can enable modeling and simulation using digital representations of space systems as well as data driven reconstructions of real-world operations informed by SDA data. Using this environment, train AI algorithms for space command and control and demonstrate the relative performance of these agents as the data strategies used for training are varied. Evaluate the impact of training autonomous systems using SDA data of varying quality, density, geometric diversity, precision, and timeliness.

PHASE III DUAL USE APPLICATIONS: Integrate prototype solution into systems available in operational environments for operator and analyst evaluation and feedback. Expected TRL at Phase III entry is 5.

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KEYWORDS: ai/ml; artificial intelligence; space domain awareness; space c2

SF241-0025 TITLE: Modernizing USSF BMT

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Human-Machine Interfaces

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

OBJECTIVE: Technology has revolutionized military training environments in numerous ways, offering significant advantages and enhancing the overall effectiveness of training. This topic seeks to create a distinct Space Force Basic Military Training (BMT) program that integrates innovative technology and training strategies to drive improve training outcomes for Guardians.

DESCRIPTION: This topic seeks to develop a robust, distinctly Space Force basic military training program that leverages innovative technology to foster the development of critical skills, decision-making abilities, and muscle memory necessary for their roles.

Key aspects to be considered:
Cost-Effectiveness: Technology can significantly reduce training costs over time. Simulators, for instance, eliminate the need for live ammunition, fuel, and other expensive resources, making training more affordable and accessible.

Repetitive Practice: Technology permits soldiers to engage in repetitive practice without exhausting resources. This iterative learning approach enables trainees to refine their skills and improve performance over time.

Personalized Training: Different soldiers may have varying skill levels and learning styles. Technology allows for personalized training programs tailored to individual needs, ensuring that each soldier receives optimal instruction.

Immediate Feedback: Training technologies can provide instant feedback, offering insights into performance strengths and weaknesses. Trainees can learn from mistakes quickly and efficiently, improving their abilities in a shorter time.

Remote Training: With technology, soldiers can access training resources remotely, reducing the need to travel to specific locations. This is particularly beneficial for reservists or soldiers stationed in remote areas.

Tactical Communication: Advanced communication systems enhance coordination between units during training exercises. Efficient communication is essential in a military setting, and technology enables real-time information sharing and decision-making.

Data-Driven Analysis: Technology allows for the collection and analysis of vast amounts of training data. This data-driven approach helps identify trends, patterns, and areas for improvement, leading to more effective training methodologies.

Cybersecurity Training: As the importance of cybersecurity grows, technology facilitates realistic cybersecurity training, helping Guardians learn to defend against digital threats and safeguard sensitive information.

Equipment Familiarization: Guardians can use technology to familiarize themselves with complex military equipment before encountering them in real-life scenarios. This reduces the learning curve and enhances overall operational readiness.

Risk Mitigation: High-risk training exercises can be dangerous and potentially life-threatening. By using technology, Guardians can undergo preliminary training in safe environments, reducing the likelihood of accidents and injuries.

Scenario Customization: Technology allows trainers to create various scenarios, adapting training to meet specific objectives or challenges. This flexibility ensures that Guardians are prepared for a wide range of potential situations they may encounter in the field.

In summary, technology in military training environments offers realism, cost-effectiveness, personalized learning, immediate feedback, enhanced communication, and the ability to analyze data. These advantages contribute to better-prepared soldiers, improved operational capabilities, and ultimately, increased mission success rates.

PHASE I: The Phase I will be a collaborative effort with the Space Force BMT team to identify requirements and outline the curriculum for a 7 week basic military training program.

PHASE II: During Phase II, the curriculum generated during Phase I will be further refined and implemented, with a goal of having this new distinct Space Force curriculum ready for implementation.

PHASE III DUAL USE APPLICATIONS: Phase III efforts will consist of continued refinement and improvement. As operations, culture, and weapons systems change over time, so will the Space Force BMT program. Phase III efforts will ensure the Space Force's BMT program is always current.

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KEYWORDS: U.S. Space Force; USSF; BMT; Basic military training