DEPARTMENT OF THE AIR FORCE
23.3 SMALL BUSINESS INNOVATION RESEARCH (SBIR) PHASE I
PROPOSAL SUBMISSION INSTRUCTIONS
AMENDMENT 2

This Amendment adds language to the **AIR FORCE PROPOSAL EVALUATIONS** section of these Component-specific instructions:

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 choose to either 1) create a plan to mitigate the risk(s) or 2) DAF may decide not to select the proposal for award based upon a totality of the review.

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

DEPARTMENT OF THE AIR FORCE
23.3 SMALL BUSINESS INNOVATION RESEARCH (SBIR) PHASE I PROPOSAL SUBMISSION INSTRUCTIONS
AMENDMENT 1

This Amendment modifies several of the topics associated with the DAF SBIR Phase I offering. Topic numbers that are highlighted have been updated. That includes the following topics:

Topic Number	Topic Name
SF233-0001	Digital Flatsat
AF233-0002	Power Efficient Digital Binocular Night Vision Imaging System (PEDBNVIS)
SF233-0003	Revolutionary SmallSat Power Enhancement
AF233-0004	Hybrid Turbo-Electric Propulsion Design and Optimization
SF233-0005	High Fidelity Sporadic E Model
AF233-0006	Machine Learning Algorithms for Infrared Search and Track Applications
SF233-0007	On-Orbit Intent Estimation of Close-Proximity Space Objects
AF233-0008	Compact Midwave Infrared Hyperspectral Imager for Attritable Platforms
SF233-0009	Sporadic E Predictive Model
AF233-0010	Dual-purpose laser range finder and lidar sensor
SF233-0011	Flexible Satellite Terminals for Multi-Tenancy Applications
AF233-0012	Multi-Spectral Infrared Focal Plane Arrays
SF233-0019	Suborbital Hover Vehicle-Reusable Rocket
AF233-0020	Mapping Mesostructures to Hypersonics for Improved Manufacturability and Performance

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

DEPARTMENT OF THE AIR FORCE
23.3 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 23.3 BAA posted on the Defense SBIR/STTR Innovation Portal (DSIP) at the proposal submission deadline date/time.**

Proposers 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 23.3 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, “23.3 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 23.3 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 23.3 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 exchanges. 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 23.3 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 23.3 BAA)
2. Disclosures of Foreign Affiliations or Relationships to Foreign Countries (Attachment 2 to the DOD SBIR 23.3 BAA)
3. Disclosure of Funding Sources (Attachment 4 to the DOD SBIR 23.3 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/DD2315Ins 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 23.3 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 23.3 BAA.

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 choose to either 1) create a plan to mitigate the risk(s) or 2) DAF 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 23.3 Phase I Topic Index

Topic Number	Topic Name	Maximum Value*	Maximum Duration**	Technical Volume Page Limit***
SF233-0001	Digital Flatsat	$190,000.00	6	20
AF233-0002	Power Efficient Digital Binocular Night Vision Imaging System (PEDBNVIS)	$180,000.00	6	20
SF233-0003	Revolutionary SmallSat Power Enhancement	$190,000.00	6	20
AF233-0004	Hybrid Turbo-Electric Propulsion Design and Optimization	$180,000.00	6	20
SF233-0005	High Fidelity Sporadic E Model	$150,000.00	6	20
AF233-0006	Machine Learning Algorithms for Infrared Search and Track Applications	$180,000.00	6	20
SF233-0007	On-Orbit Intent Estimation of Close-Proximity Space Objects	$150,000.00	6	20
AF233-0008	Compact Midwave Infrared Hyperspectral Imager for Attritable Platforms	$180,000.00	6	20
SF233-0009	Sporadic E Predictive Model	$150,000.00	6	20
AF233-0010	Dual-purpose laser range finder and lidar sensor	$180,000.00	6	20
SF233-0011	Flexible Satellite Terminals for Multi-Tenancy Applications	$150,000.00	6	20
AF233-0012	Multi-Spectral Infrared Focal Plane Arrays	$180,000.00	6	20
AF233-0013	Wafer scale Zinc Selenide (ZnSe) single crystals	$180,000.00	6	20
SF233-0014	Multi-Object Behavior Modeling of Space Systems	$190,000.00	6	20
AF233-0015	Multi-int Multi-look 3D features Image Fusion with Machine Learning	$180,000.00	6	20
SF233-0016	Evaluation of Space-Enabled Kill-Webs	$190,000.00	6	20
AF233-0017	Passively Augmented LiDAR	$180,000.00	6	20
SF233-0018	Mobile RAVEN Observatory	$190,000.00	6	20
SF233-0019	Suborbital Hover Vehicle-Reusable Rocket	$190,000.00	6	20
AF233-0020	Mapping Mesostructures to Hypersonics for Improved Manufacturability and Performance	$180,000.00	6	20
AF233-0021	Operations & Logistics Susceptibility due to Publicly Available Information (PAI)	$180,000.00	6	20

SF233-0022	Rapid ASCENT propellant loading operations	$190,000.00	6	20
AF233-0023	High energy, multi-component, optical isolator for 2 Î¼m fiber lasers	$180,000.00	6	20
AF233-0024	Optical Fiber Combiner for Combining MWIR Quantum Cascade Laser Beams	$180,000.00	6	20
AF233-0025	High bandwidth, low latency wavefront sensing for airborne directed energy applications	$180,000.00	6	20
AF233-0026	Compact High Power Microwave Antenna	$180,000.00	6	20
AF233-0027	Combiner Architectures for Maximum Brightness Fiber Laser Amplifier Pumping	$180,000.00	6	20
AF233-0028	L-Band Buncher/Modulator for X-Band Accelerator	$180,000.00	6	20
AF233-0030	Energy-Aware Autonomy for Air Vehicles	$180,000.00	6	20
AF233-0032	Design AF DCGS Next Gen Enterprise IT systems using 5G Technology for Low to Zero Maintenance	$180,000.00	6	20
AF233-0033	Synthetic Weather Environment Injection	$180,000.00	6	20
AF233-0034	Creating a digital twin of legacy aircraft	$180,000.00	6	20
AF233-0035	Readiness Spares Package (RSP) Optimization	$180,000.00	6	20
AF233-0036	Commercial Technologies for EMP Hardening and Electrical System Protection	$180,000.00	6	20
AF233-0037	Measuring Ground-to-Air Atmospheric Path Transmission	$180,000.00	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**

SF233-0001 TITLE: Digital Flatsat

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

OBJECTIVE: A fully functioning Flatsat via a rapidly produced, easily maintained, cloud-resident Digital Twin model that allows full mission emulation of SDA mission features and allows test of new bus, payload, network and mission commands prior to upload to vehicles on orbit. Solutions should minimize hardware and emphasize massless payload deployment. Resulting flatsats would be expected to fulfill the same mission requirements as traditional hardware/software flatsats – ground test of commands prior to upload, operator training, etc. – but would be instantiated only as cloud-based software solutions.

DESCRIPTION: A fully functioning Flatsat via a rapidly produced, easily maintained, cloud-resident Digital Twin model that allows full mission emulation of SDA mission features and allows test of new bus, payload, network and mission commands prior to upload to vehicles on orbit. Solutions should minimize hardware and emphasize massless payload deployment. Resulting flatsats would be expected to fulfill the same mission requirements as traditional hardware/software flatsats – ground test of commands prior to upload, operator training, etc. – but would be instantiated only as cloud-based software solutions.

PHASE I: Phase 1 feasibility will be demonstrated by a computer model and simulation tool that shows the basic interfaces for a digital FlatSat that supports future system development.

PHASE II: Phase II applicants will be expected to provide a fully operable digital FlatSat that allows the user to create and provide a simulation model that will interface with existing SDA FlatSat hardware, as well as emulate it and allow it to be replicated online.

PHASE III DUAL USE APPLICATIONS: SDA, Space Development Agency is working to provide spiral development of smallsats that allow continue improvement and the ability to add new technology. A Digital FlatSat would provide a model that supports development and integration of new sytems that can be added in with a digital twin model instead of having to build and integrate hardware, allowing for more options to be evaluated and compared. A successful Phase III would be used to evaluate design trades for future SDA tranches and would reduce engineering design time, while increasing the deployment of novel and innovative technology required to keep ahead of near peer competitors in space system design.

REFERENCES:

1. Shangguan, Duansen, A Digital Twin-Based Approach for the Fault Diagnosis and Health Monitoring of a Complex Satellite System, Symmetry 2020

KEYWORDS: Satellite Digital Twin; Satellite Digital Engineering; Computer Aided Design; Satellite Product Lifecycle Management; Satellite Model-Based Systems Engineering; Satellite Digital Thread

AF233-0002 TITLE: Power Efficient Digital Binocular Night Vision Imaging System (PEDBNVIS)

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Microelectronics;Human-Machine Interfaces;Advanced Materials;Advanced Computing and Software

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 digital binocular night vision system having the imaging performance of analog goggles in the reflective infrared bands with power and mass properties consistent with long-term helmet-worn use. System must integrate visual situational awareness

DESCRIPTION: Analog binocular night vision goggle (NVG) sets remain ubiquitously fielded to enable combat operations by aviators and ground operators because an acceptable digital replacement has not emerged over the past 20 years. As a result, higher-performance white-phosphor (HPWP) image intensifier (II) tubes are currently being retrofitted into the AN/AVS-9 and other NVG housings as an improvement over lower-performance green-phosphor tubes fielded in the 1990s. Attempts to optically overlay digital information over analog night scenes in aviator binocular NVG sets via a clip-on device to the objective or ocular optics – including a digital eyepiece (DEP) for the AN/AVS-9 and Night Vision Color Display (NVCD) for the AN/AVS-10) – have failed due to their unacceptable human machine interface (HMI) performance, including dramatically and unacceptably increased power, neck-born mass properties (weight, moment-arm), and image latency. Similarly, attempts to completely replace the functionalities performed by analog tubes – which run on 0.50 W while generating visible representations of near infrared (NIR) scenes with 0.6 ms latency at 20/23 Snellen acuity under quarter-moon illumination over a 40° circular field-of-view (FoV) – with various assemblies of digital devices have failed for similar reasons. Pilots and ground special operators need a digital helmet mounted visualization system that enables night/day/adverse weather operations. The currently fielded analog night and digital day vision helmet systems are not integrated. The opportunity now exists to replace these two separate pilot helmet systems—one for night, another for day—with one, hybrid system leveraging emerging technologies including metaoptics, advanced vacuum electronics-based infrared II designs and materials, power efficient algorithms and processors optimized for human foveal visual perception (e.g neuromorphic, neural-net optimized pipeline), and complementary metal oxide semiconductor (CMOS) digital visual-band sensors and microdisplays developed for the ultrahigh definition television (UHD TV) and computer gaming/metaverse industries. The Air Force has a mission need for a digital binocular night vision goggle operating in a reflective band. Reflective bands of interest include near infrared (NIR, 700-1100 nm), shortwave infrared (SWIR, 900-1700 nm), some visible (VIS), 400-700 nm), or a combination (VNIR, NSWIR, VNIRSWIR). Architectures of interest include 1:1 overlapped left/right channels, each inline with eyes, with the high resolution reflective band sensor-processor-display device chain providing a visible representation of the scene sensed in infrared with interfaces for conformal symbol overlay, external video source display, and native helmet-view transmission off-helmet to other battlespace participants. The power, mass properties, and volume must be minimized sufficiently to achieve end-user acceptance, to avoid neck injuries over years of use and minimize probability of head lock during high g maneuvers. The device must be comfortable for wearing under combat conditions for hours and be usable as a vision aid during night (including overcast starlight), day, and all-weather operations. The power efficient digital binocular night vision imaging system (PEDBNVIS) sought must have an organic helmet mounted battery and an interface to off-helmet power and an image generator for symbology/imagery. PEDNVIS housing, helmet mounting system, and controls must be simple, intuitive, operable with gloved hands, and similar to those for AN/AVS-9 sets. Performance metric threshold (objective) levels sought in the Phase II PEDBNVIS prototypes include: reflective band sensor NIR (VNIRSWIR); spatial image resolution 2000x2000 px (7680x4320 px); field-of-view 40x40 deg. (128x72 deg.); acuity 1.3 arcmin (1.0 arcmin) under quarter moon illumination; frame rate 60 Hz (240 Hz); latency from objective-to-eye, 17 ms (1 ms); head-born mass 2 kg (1 kg); head-born moment arm 0.1 kg-m (0.05 kg-m); power 12W (1W); volume 2000 cc (1400 cc); and head-mounted battery time 4 hr (8 hr) at 22°C. Volume and weight metrics include the digital goggle with its helmet mount and conformal battery pack. No government furnished materials, equipment, data, or facilities will be provided.

PHASE I: Design PEDBNVIS having size, weight, and power (SWaP) consistent with helmet-worn implementation. Justify all design performance metrics (listed in Topic Description) via laboratory experiments and analyses. Explain any estimated performance less than the thresholds described in the topic description and state why a warfighter would accept/select it for combat use over their currently fielded analog NVG set. Develop a system architecture for PEDBNVIS integration (a) with standard helmets (e.g. HGU-55/P, USAF Future Fixed Wing Helmet, or special operations) and (b) with aircraft cockpits or special warfare kit. Develop a System Implementation Plan (SIP) for evaluating PEDNVIS operating performance in combat environments, including producibility and supportability. Describe components and fabrication processes required to build prototypes.

PHASE II: Fabricate and deliver Qty(2) PEDBNVIS prototypes at TRL6 whose performance meets or exceeds thresholds for all metrics simultaneously. Incorporate mechanical, electrical, and software interfaces required for integration into fielded cockpit helmet systems or special warfare operations kits. Support operator testing, provide special test equipment, and refine prototype performance based on feedback. Performance metric threshold (objective) levels sought in the Phase II PEDBNVIS prototypes include: reflective band sensor NIR (VNIRSWIR); spatial image resolution 2000x2000 px (7680x4320 px); field-of-view 40x40 deg. (128x72 deg.); acuity 1.3 arcmin (1.0 arcmin) under quarter moon illumination; frame rate 60 Hz (240 Hz); latency from objective-to-eye, 17 ms (1 ms); head-born mass 2 kg (1 kg); head-born moment arm 0.1 kg-m (0.05 kg-m); power 12W (1W); volume 2000 cc (1400 cc); and head-mounted battery time 4 hr (8 hr). Volume and weight metrics include the digital goggle with its helmet mount and conformal battery pack. Deliver prototype optimized for weight, power, HVS compatibility, reliability, and ruggedization consistent combat operations. Develop and deliver prototype user/maintainer/training manuals. Finalize and deliver a Bill of Materials describing each component with details including its vendor, TRL and MRL. Create roadmap to mature technology to TRL8/MRL8.

PHASE III DUAL USE APPLICATIONS: Develop, fabricate, and deliver Qty(6) PEDBNVIS production configuration units at TRL8/MRL8 with interfaces to the fielded cockpit helmets systems or special warfare kits. Support field test and evaluation activities to demonstrate end-user acceptance. Update BoM and establish PEDBNVIS production performance specification with tolerances for each component. By the end of Phase III, the PEDBNVIS should be capable of all-weather operation worldwide. Finalize commercialization plan. Evaluate PEDBNVIS and its subsystems for other USAF, USSF, and DoD operational applications such expeditionary base security police and lunar night space suites. Develop and deliver quantitative estimates of addressable market by industrial segments including defense, non-defense federal and state agencies, civil and commercial aviation, outdoor recreation (e.g. hunting, camping), and consumer electronics (e.g. computer gaming, metaverse).

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Hopper, AFRL alternative night/day imaging technologies (ANIT) program, in Proceedings of SPIE Vol. 10642, Degraded Environments, Sensing, Processing, and Display 2018, 1064208 (14 May 2018) www.spiedigitallibrary.org; David G. Curry, Gary Martinsen, and Darrel G. Hopper, Capability of the human visual system, in Cockpit Displays X, Proceedings of SPIE Vol. 5080, 58-69 (2003);

2. Metalens technology: M. Khorasaninejad, W.T. Chen, R.C. Devlin, J. Oh, A. Y. Zhu, F. Capasso, "Metalenses at visible wavelengths: Diffraction-limited focusing and subwavelength resolution imaging," Science 352 (6290), pp 1190-4 (3 Jun 2016); William A. Schulz, "Staking a Claim on the Next Best Thing Since Glass," Photonic Focus, Jan/Feb 2023, pp26-29; Metalenz, Leadoptik fiber-thin 3D imaging probes, other startups; "Novel liquid crystal metalens offers electric zoom," ScienceDaily (10 Jun 2021) https://www.sciencedaily.com/releases/2021/06/210610162353.htm ; DARPA/DSO ENVision Program, www.darpa.mil/program/envision ;
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4. prior digital night vision development attempts including: (a) Multispectral Adaptive Networked Tactical Imaging System (MANTIS), https://www.afcea.org/signal-media/us-recoups-nighttime-primacy ; (b) Enhanced Visual Acuity (EVA) http://www.collinsaerospace.com/news/news/2020/06/collins-helps-us-navy-marine-corps-pilots-fly-more-safely-new-enhanced-visual-acuity ; (c) Integrated Visual Augmentation System (IVAS) https://www.army.mil/article/264773/ivas_campaign_of_learning_ensures_development_production_and_fielding_remain_on_track ; (d) Wesley Sheridan, Binocular Multispectral Adaptive Imaging System (BMAIS), DTIC AD1033984 (2010), https://apps.dtic.mil/sti/citations/AD1033984 .

KEYWORDS: Power Efficient Digital Binocular Night Vision Imaging System; PEDBNVIS; pilot augmented reality system; PARS; augmented reality; AR; low latency; digital visual interface; human vision system; HVS; nanooptics; image intensifier; CMOS imagers, metaoptics

SF233-0003 TITLE: Revolutionary SmallSat Power Enhancement

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

OBJECTIVE: Using novel technology to dramatically (at least double) increase available on-orbit power in an ESPA or ESPA Grande class vehicle. Considerations could include enhancing on board processing power efficiency, reducing power requirements of significant power consumption devices or improved power generation, all while maintaining overall commoditized size, weight and cost points currently available

DESCRIPTION: Using novel technology to dramatically (at least double) increase available on-orbit power in an ESPA or ESPA Grande class vehicle. Considerations could include enhancing on board processing power efficiency, reducing power requirements of significant power consumption devices or improved power generation, all while maintaining overall commoditized size, weight and cost points currently available

PHASE I: Phase 1 feasibility will demonstrate a product or power management control system that effectiely improves power operation or conserves power use.
A.) Novel systems that includes more effcient batteries, higher yielding solar arrays, or lower power consuming devices show a good way forward and further development will support a lower power system on orbit
B.) Effective power management is essential and power control and power managment systems that have potential to reduce the need for power consumption or that demonstrate a more effective way to manage power use on orbits should be explored

PHASE II: Phase II will demonstrate a more effective power enhancement system, which could be providing more power, reducing power consumption or more effectively managing the existing power systems. A working model, either virtual or that is integrated with several pieces of hardware, will demonstrate power enhancement that either provides more power or reduces power consumption. Demonstration of that will provide the way forward for novel SmallSat power enhancement.

PHASE III DUAL USE APPLICATIONS: As more and more satellites are in orbit, especially in a proliferated LEO constellation, they will have multiple tasks which will require varied and different power consumption. Finding effective SmallSat Power Enhancement will be essential to providing those new technologies and allowing them to either provide more power, or manage the existing power more effectively. Specific topics include effective power management, novel power generation, autonomous power control systems, and power monitoring systems.

REFERENCES:

1. Mostacciuolo, Elisa, Iannelli, Luigi, et al., "Modeling and power management of a LEO small satellite electrical power system,' 2018 European Control Conference (ECC) Tuschida, Kwamato, Kato, et al., "Efficient Power Control for Satellite-Borne Batteries Using Q-Learning in Low-Earth-Orbit Satellite Constellations" IEEE Wireless Communications Letters (Volume: 9, Issue: 6, June 2020)

KEYWORDS: Small Satellite Power Management; On Orbit Power Efficency; Improved Satellite Power Control Systems; Novel Battery systems on orbit; Novel battery satellite systems

AF233-0004 TITLE: Hybrid Turbo-Electric Propulsion Design and Optimization

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

OBJECTIVE: Conventional turbines and hybrid powertrains have been seen to limit the operational parameters of advanced VTOL and CTOL aircraft and there is strong evidence to believe novel hybrid turbine propulsion architecture can provide enhanced capabilities to provide expanded mission sets beyond what is currently possible in the Air Force. The technology space for hybrid turbine propulsion is growing and the Air Force would like to better understand the feasibility of existing models to meet or exceed current industry standards for turbines, conduct trade space analysis to increase performance characteristics, and develop a prototype to demonstrate performance. The purpose of this topic is to demonstrate that a hybrid turbine propulsion architecture can achieve greater mission performance in key critical phases of flight over conventional turbines. The effort will feed requirements generation and future concept evaluation by AFWERX Prime for electrified aircraft by proving the feasibility, maturity, and mission impact of hybrid turbine propulsion architectures while providing mission relevant capability such as enabling vertical take-off of otherwise overly complicated configurations, maintaining power at high altitude or boosting power for dash phases and exporting power for payloads during cruise. The Agility Prime program has seen the benefit of hybrid powertrains that utilize electric motors for propulsion and hypothesizes that this benefit not only transfers to turbines but will be relevant to a number of existing and future aircraft.

DESCRIPTION: Conventional turbines have typical performance designed towards a peak thrust required for takeoff and an efficient cruise for longer range. AFWERX Prime is interested in the performance enhancement potential of hybrid turbine propulsion architectures which directly link electric machines to turbomachinery input/output shafts. These architectures of “turbo-electric” machines are then able to leverage multiple energy sources (electrical and chemical) and aerodynamic work outputs (fan blades) to produce thrust in novel combinations which are better optimized for various phases of flight. This could be leveraged to better optimize for specific mission profiles such as Vertical Take off and Landing, high altitude loft, fuel efficient cruise, high speed dash, or payload power draw. The architectures are not limited in sizing, maturity, or architecture at this stage; however, it is necessary to investigate and produce a report on their design to achieve greater performance than comparable conventional turbines in one or more of the key mission areas above. A key metric for this topic is to collect and analyze performance data from existing physical prototypes (small scale turbo-electric machines) to inform the design trade space of future systems. It is expected that a company will work collaboratively with AFWERX and other invested DoD stakeholders throughout the full period of performance to inform the tradespace and evaluate potentials. Companies should be mindful during their analysis and design efforts, to identify significant changes in required maintenance and or operational burden and cost. While there is a need to enhance performance in the areas mentioned, a cost benefit balance to the overall system should be maintained. Of note, as a SBIR Topic it is required that proposals are received by SBCs, but companies are allowed to collaborate with academia and partners if need be and AFWERX Prime is interested in all relationship dynamics as long as they adhere to SBIR regulations.

PHASE I: The Phase I effort should consist of a feasibility study and analysis showing that a company’s current technology can, currently or with further innovation, exceed the performance characteristics of conventional turbines to achieve one or more of the following use case/mission parameters: 1. Increased endurance 2. VTOL capability 3. Electrical power output to payloads 4. Increased Altitude Ceiling 5. Increased Maximum Speed The feasibility study is expected to be fed from analysis of current models or prototypes and should include, but not be limited to the following content: a) Tradespace analysis conducted by your team to converge on current design(s) b) Limiting factors to reach maximum performance and potential to overcome c) Technical recommendation or prioritization of alternative solutions Deviations in use case and characteristic improvements not mentioned herein may be explored with coordination with AFWERX Prime and its partner Stakeholders. Success criteria for Phase I is an analysis of trade space and a recommended path forward that describes the design's technical feasibility and a description of work required.

PHASE II: Phase II should pick up where the Phase I left off and will focus on the maturation of a Customer approved design. It is expected that, based on the Phase I results one design or development aspect will be chosen for Phase II development and maturation. The effort should focus on refining the astechnology such that the performance characteristics proposed in Phase I can be verified through prototyping or demonstration. Phase II should result in a demonstration or prototype test and report that validates the capabilities proposed out of Phase I. Additional phase II work efforts include, but are not limited to: Improve and refine the digital models developed in phase 1 throughout prototype integration and testing process, explore supplier options for hybrid power and thermal management architectures and key components to identify key technology gaps, and quantity technology metric goals, required to enable significant capability improvements.

PHASE III DUAL USE APPLICATIONS: Phase III potential exists both in the commercial sector and within the DAF ecosystem. This work will be transitioned and scaled to support Agility Prime efforts. There are opportunities to flight demo and test within the Prime program construct while also exploring and extending the use cases to additional AF interested parties.

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KEYWORDS: electric; hybrid; turbine; turbo; turbofan; turbojet; turboshaft; turboprop; parallel hybrid; series; electric motor; propulsion

SF233-0005 TITLE: High Fidelity Sporadic E Model

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Advanced Computing and Software;Integrated Network System-of-Systems;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: The objective of this project would be to develop and integrate and high fidelity sporadic E model that is useful to currently accepted and deployed ionospheric modeling and ray tracing tools. High fidelity in the context of this model is one that is spacially and temporally on the order of the development of the key features of sporadic E. This model should be 3 dimensional in nature and capture correctly the features seen by high fidelity measures by Incoherent Scatter Radar. This model would then be used to develop and update ionospheric propagation codes used by the Space Force in modeling and tracking ISR performance and communication performance currently in use by operational user.

DESCRIPTION: This model will be developed using existing 2 dimensional Magneto-Hydro-Dynamic codes coupled to existing neutral atmosphere fluid dynamic codes. These codes are already developed and tested on HPC systems, but would be required to extend to a 3 dimensional code. This code would be run for a variety of 3 dimensional cases exploring relevant ionospheric conditions, both across the globe and through a variety of solar conditions. The output of these code will be an extremely high fidelity electron density map which can be compared and validated against existing ISR coverage of sporadic E to ensure that the code produces qualitatively and quantitatively similar results to the highest fidelity observations available. Once validated, the resulting electron density models would be integrated into existing ionospheric propagation code bases to determine the effects of this phenomena on relevant RF military systems. The code would also provide a validation of the resulting codes at the SSC and operational level.

PHASE I: For this topic a phase I is not necessary as the technology and literature review has been conducted as well as relevant code explored and understood. If required Phase 1 would be used to develop a software framework compatible with expected transition agents as well as doing an evaluation of relevant use cases and their particular requirements.

PHASE II: The goal of the Phase II will be to produce representative magneto-hydro-dynamic output and validate that output against existing incoherent scatter radar data. This will be an iterative process to ensure that the relevant underlying physics in understood and that the magneto-hydro-dynamic code captures all sporadic E phenomena. This will likely be run on High Performance Computing systems, utilizing massively parallelizable code. The end point of the Phase II will be a complete, validated sporadic E model.

PHASE III DUAL USE APPLICATIONS: The Phase III of this project will be to produce sporadic E models for a variety of locations and conditions within the ionosphere. This will provide a baseline through which currently existing RF propagation codes can be used with the determine the appropriate effects that sporadic E has on RF propagation. These effects will then be integrated into operationally relevant RF propagation models, after which the models will be validated against the high fidelity models and ISR data.

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KEYWORDS: For this topic a phase I is not necessary as the technology and literature review has been conducted as well as relevant code explored and understood. If required Phase 1 would be used to develop a software framework compatible with expected transition agents as well as doing an evaluation of relevant use cases and their particular requirements.

AF233-0006 TITLE: Machine Learning Algorithms for Infrared Search and Track Applications

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: Develop machine learning algorithms that can be implemented on low cost, size, weight and power processing hardware to aid detection and tracking processing for infrared search and track (IRST) applications.

DESCRIPTION: The United States Air Force needs an extended range passive air-to-air surveillance capability for contested environments where solutions based on active emissions and/or radar returns may not be available or are ineffective.   Detection and tracking algorithms have demonstrated great capability when paired with IRST sensors. However, common statistically-based detection and tracking algorithms are computationally expensive and require large compute resources to operate real-time, leading to compromises in execution methodologies and performance. In addition, required processing resources limit the ability to deploy such IRST systems on platforms with stringent cost, size, weight and power (C-SWaP) constraints and/or may significantly reduce platform endurance and associated mission effectiveness. As such, alternative algorithms must be developed with similar, if not improved, performance but requiring significantly less computational resources.   Machine learning (ML) algorithms offer a possible solution to this challenge. ML algorithms have been explored and developed for various detection and tracking applications [1 - 5]. However, they have not specifically been developed for use in IRST applications with very low contrast targets imbedded in diverse background clutter including sensor-induced artifacts. In this application, the targets are unresolved with their signatures and motion characteristics differing significantly from other tracking scenarios. Here unresolved does not mean the system generates single-pixel targets, but rather the spatial shape is dictated by the impulse response of the imaging system and sampling at the focal plane array. In addition, the specific type of sensor implementation for IRST may dictate methodologies employed. Ultimately, an optimal algorithm/processing solution might be a combination of a conventional approaches with ML techniques applied to a specific aspect of the problem. In order to be effective, robust and generalizable to a variety of environments and different IRST sensor instances, the ML methods should not rely solely on training data collected by the respective sensors themselves. The effort should not be based on blind application of numerous ML methods and evaluating the results. It should instead focus on the entirety of the detection and tracking process and determine where and how ML should be specifically applied. This effort should explore and demonstrate the ability to train the ML algorithm using properly simulated target signatures and clutter plus noise and interference effects, and achieve comparable detection performance to baseline algorithms. In addition, the ML approach should take into account of limitations of truth data for real world IRST data that could be used for the ML training and should be able to overcome this limitation. For this effort, the government will provide 1) Limited real-world IRST data with relevant targets and truth for testing and validation 2) Modeled target signatures 3) IRST sensor characteristics It is expected the Offeror will incorporate physical phenomenology, radiometry, and realistic focal plane characteristics within the structure of the algorithm. The Offeror must also demonstrate knowledge of conventional IRST algorithms and processing products in order to understand the problem space. Offerors must have the ability to process and store classified data up to Secret//Collateral.

PHASE I: Develop a modular machine learning architecture optimized within a detection and track processing framework for IRST. Clearly identify the areas where ML would apply or integrate into a detection and track processing pipeline.

PHASE II: Develop and refine the architecture in described in Phase 1. Demonstrate the ability to train the ML algorithm using a combination of synthetic and real-world data. Apply the ML-enhanced algorithm to real-world government furnished data with relevant targets and associated truth. Compare detection and false track performance of the ML-enhanced algorithm with baseline algorithms. The ML-enhanced algorithm performance should be evaluated against the truth data and should achieve a specified threshold of False Positive rate (or False Alarm) and False Negative rate. Compare computation time/resources via demonstration and/or timing studies of the ML-enhanced algorithm with baseline algorithms.

PHASE III DUAL USE APPLICATIONS: Implement the ML-enhanced IRST detection and tracking algorithm in a ruggedized low SWaP processor to meet the provided platform requirements including Open Mission Systems (OMS), integrate with IRST system(s), and demonstrate performance and capability through mountaintop and/or flight testing.

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1. Hu, Y, Xiao, M, Zhang, and K, Wang, "Aerial Infrared Target Tracking in Complex Background Based on Combined Tracking and Detecting", Mathematical Problems in Engineering, vol. 2019, Article ID 2419579, 17 pages, 2019;
2. Wang, T, Qin, R, Chen, Y, et al., “A reinforcement learning approach for UAV target searching and tracking.” Multimed Tools Appl, 78, 4347–4364 (2019);
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4. Kim, S and Lee, J, “Small Infrared Target Detection by Region-Adaptive Clutter Rejection for Sea-Based Infrared Search and Track,” Sensors (Special issue Detection and Tracking of Targets in Forward-Looking Infrared Imagery), 14(7), 13210-13242 (2014);
5. Ryu, J and Kim, S, “Small infrared target detection by data-driven proposal and deep learning-based classification,” Proc. SPIE, Vol. 10624, Infrared Technology and Applications XLIV, 106241J (2018).

KEYWORDS: Machine Learning; AI/ML; Infrared Detection and Tracking; Infrared Search and Track; IRST sensor; low SWaP; real-time processing; RT processing; low contrast targets; electro-optical/infrared; EO/IR; passive EO/IR

SF233-0007 TITLE: On-Orbit Intent Estimation of Close-Proximity Space Objects

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: The objective of this work is the development of techniques that will enable the estimation of a space object's behavior/intent in close-proximity scenarios. Space domain awareness (SDA) is often described as the characterization of available information in the space environment in a meaningful way. For instance, measurements of an object in the space environment may yield a ``state estimate" of that object (e.g. some position, velocity, and attitude all with some corresponding uncertainty). The belief state of this object, via orbital dynamics knowledge, can then be further propagated into the future. This actionable knowledge enables decision-making in the space domain, such as a collision-avoidance maneuver or a reorientation of a high-valued asset. Conventionally, these belief states represent the core of SDA. However, it is becoming necessary to analyze the available data in the space domain at a higher level - not only where an object is/going, but why it is there/maneuvering. With the assumption that there is some agency behind the control of a space object, what tools and algorithms can be developed on available data that will enable the precise estimation of that object's intent? The ability to estimate both an object's intent and its state simultaneously will enable more-informed decision-making in the space domain. Furthermore, we seek solutions that enable these methods to be implemented on-board a spacecraft, enhancing its autonomous capabilities.

DESCRIPTION: Although there does not yet exist a collectively-agreed upon definition of autonomy amongst academic circles, the core idea is often some variation on the following: a machine-driven system that (i) receives data, (ii) interprets that data into some form of knowledge representation, and (iii) uses that knowledge representation to make decisions and accomplish some predefined task without human input. As the space domain becomes increasingly contested and congested with a rapidly-growing population of space objects there is a need to improve the on-board autonomous capabilities of high-valued assets. A promising avenue to do this is through informed decision-making based on the state and intent estimates of nearby objects. While state estimation techniques have been studied for decades, intent estimation is a relatively unexplored area. The ultimate aim is to infer the intent of an agent from available data (e.g. sensor observations, process dynamics, historical patterns of behavior). There are many open research questions regarding this topic - what types of uncertainty (aleatory, epistemic) are most applicable to intent characterization? Given that many forms of space-based data offer ambiguous interpretations of intent, i.e. available evidence may point to multiple mutually-exclusive hypotheses simultaneously, how can this be leveraged with current mathematical frameworks, such as Kolmogorov's axioms of modern probability or belief function theory? What information theoretics (e.g. Kullback-Leibler divergence, Mahalanobis distance, etc...) can be utilized to yield intent estimation metrics? Thus, the objective of this SBIR is to investigate these research problems and develop mathematically-rigorous algorithms that supply intent estimates of nearby space objects. Offerers should specify in their proposals what government-furnished property and/or data is required to conduct this effort.

PHASE I: Conduct a comprehensive comparative assessment and trade-off study of various intent estimation approaches. Define metrics that indicate the precision/success of intent estimation techniques and acknowledge the computational complexity of employing investigated techniques on-board space-grade hardware. Investigate the effects of intent estimation for on-board autonomous decision making.

PHASE II: Improve and iterate upon the most promising and effective intent estimation method. Conduct performance analyses on available space asset data and test on-board algorithms on space-grade hardware in the AFRL/RV laboratory environment.

PHASE III DUAL USE APPLICATIONS: Develop flight-ready intent-estimation software that can be employed into future AFRL or government space missions and experiments.

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3. Cramer M., Cramer J., Kellens K., Demeester E., (2018), ``Towards Robust Intention Estimation Based on Object Affordance Enabling Natural Human-Robot Collaboration in Assembly Tasks," Procedia CIRP, Volume 78, Pages 255-260, ISSN 2212-8271

KEYWORDS: Autonomy; Intent Estimation; Statistical Inference; Data-Driven Decision-Making

AF233-0008 TITLE: Compact Midwave Infrared Hyperspectral Imager for Attritable Platforms

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): 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 a midwave infrared (MWIR) hyperspectral imager (HSI) capable of covering a 3-5 um with at least 250 spectral bands.

DESCRIPTION: Hyperspectral imaging (HSI) has demonstrated utility for material classification and target detection/identification as well as gas detection and quantification. [1] Most HSI sensors work in either the visible through shortwave infrared (V-SWIR) or longwave infrared (LWIR.) V-SWIR sensors rely on solar illumination limited their use to daytime applications. LWIR sensors rely on the emitted radiance from targets meaning they can operate during day or night but cameras and often optics must be cooled to cryogenic temperatures to avoid near field radiance swamping any target signal thus increasing cost, size, weight, and power (C-SWaP.) MWIR HSI has traditionally received less attention because both solar reflection and self-emission affect the target signature complicating target detection. As non-linear detection algorithms such as neural networks gain prominence these complications become less of a concern. Largely because of these processing issues development of MWIR HSI sensors over the last 20 years has been extremely limited. As such existing MWIR HSI sensors such as Aerospace's MAHI have SWaPs (>10ft^3 and >100lbs) that far exceed those needed for attritable platforms. [2] Low-SWaP MWIR options such as Telops's MWIR Hypercam [3] rely on long integration times to get sufficient SNR which makes detection of transient events such as gas releases or moving targets extremely difficult. MWIR FPA and other component technologies have continued to advance during this time making it possible to design a sensor that meets the SWaP constraints of attritable platforms. MWIR HSI sensor can also potentially balance the limitations of V-SWIR and LWIR sensors allowing for day-night operation but at reduced C-SWaP compared to LWIR systems. Although the use of MWIR HSI has been limited it has demonstrated success in greenhouse gas detection and quantification, [4] camouflage detection, [5] and explosives detection [6] as well as other applications. As camouflages become more sophisticated in reducing SWIR and LWIR features additional wavebands such as MWIR will become more valuable. Additionally, several combustions products such as CO2, CO, H20, and N2O have strong features in the MWIR that can be used to determine whether an engine is running and/or characterize different types of engines (i.e. diesel vs gas.) These applications would directly support AF Operational Imperative 3 by both detecting critical targets and distinguishing targets from decoys. The proposed system should have at least 250 bands with an objective of 600 bands and cover the full wavelength range from 3-5 um (T) or 2.9-5.5um (O). The sensor should have a GSD of no more than 3m (T), 1.5m (O) from when viewing nadir from an altitude of 20kft. NESR should not exceed 2 u-flicks (T) 1 u-flick (O) averaged across all bands between 4.5 and 5 um when viewing a 300K blackbody. There are no SWaP constraints for Phase I and II design and prototype but a design path forward should be presented for the sensor to fit in a volume of 5ft^3(T)/2ft^3(O), weigh less than 80lbs(T)/20lbs(O), and draw less than 500W(T)/100W(O) power. Prototype designs closer to meeting these specifications will be given preference, but the system performance metrics will take precedence.

PHASE I: Develop plans and concept designs and identify component options to demonstrate viability.

PHASE II: Develop and refine concept outlined in Phase I to include thermal and mechanical modeling, stray light analysis, and optical design tolerancing. Develop breadboard lab prototype (T) or ruggedized ground-based (O) sensor system.

PHASE III DUAL USE APPLICATIONS: Adapt existing design to meet C-SWaP requirements of an attritable platform, exact platform is to-be-determined but should be roughly what is outlined in the description. Ruggedize design for flight environment up to 70kft and conduct flight testing.

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2. Tratt, David M., et al. "MAHI: An airborne mid-infrared imaging spectrometer for industrial emissions monitoring." IEEE Transactions on Geoscience and Remote Sensing 55.8 (2017): 4558-4566.
3. Gagnon, Marc-André, et al. "Standoff midwave infrared hyperspectral imaging of ship plumes." 2015 7th Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing (WHISPERS). IEEE, 2015.
4. Casey I. Honniball, Rob Wright, and Paul G. Lucey "MWIR hyperspectral imaging with the MIDAS instrument", Proc. SPIE 10177, Infrared Technology and Applications XLIII, 101770J (9 May 2017)
5. Kumar, Vinay, and Jayanta Kumar Ghosh. "Camouflage detection using mwir hyperspectral images." Journal of the Indian Society of Remote Sensing 45 (2017): 139-145.
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KEYWORDS: Hyperspectral; Midwave Infrared; Low SWaP

SF233-0009 TITLE: Sporadic E Predictive Model

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: The objective of this project is to deliver a predictive model of sporadic E occurrence. The model would allow the user to see a "weather" forecast for sporadic E statistics for a given time and place. The forecast would run out hours, days, weeks, or even months into the future with uncertainty increasing with forecast length. Sporadic E statistics might include percent of day (or other time unit) with blanketing or sporadic E as a function of frequency. The model could also provide information on the expected peak frequency of Sporadic E. Other parameters, such as a yet to be defined "severity" metric could also be provided. The model should be data-assimilative and global. Possible data sources included ionograms, radio occultation measurements, high altitude wind measurements, and sporadic E seed population data. Other data sources are also possible.

DESCRIPTION: Historically, Earth’s ionosphere is separated into 3 distinct layers, namely the D (50-90 km), E (90 – 150 km), and F (150 – 500 km) layers. It is well known that the plasma in these layers impacts propagation at radio frequencies (RF). When the ionosphere is smoothly and slowly varying, it is generally straight forward to model these impacts. The ionosphere, however, is not always in a behaved and well-defined state. Irregular ionospheric structures severely alter RF propagation or produce scintillation. Numerous mechanisms exist that cause irregular structure in the ionosphere. One such mechanism is Sporadic E, which can be described as an unusually dense E layer that sporadically appears for relatively short periods of time. Sporadic E can sometime be so dense that it completely blocks skywave propagation to and from the F layer. When this blocking occurs, the phenomenon is often referred to as blanketing E. It is generally accepted that Sporadic E forms when long lasting meteoritic ions are pushed into a thin, dense layer due to wind shear interactions and the geomagnetic field. Sporadic E occurrence is modulated on timescales from years to hours. Annually, sporadic E occurs much more frequently in the summer. Daily, it is modulated by the semi-diurnal tides, which trigger a descending horizontalwind shear in the thermosphere twice a day. These descending wind shears have been observed in wind measurements as well in measurements of descending sporadic E layers. Additionally, it has been shown that Sporadic E is modulated by quasi-periodic planetary waves with periods ranging from a few days to a few weeks (Haldoupis and Pancheva 2002). It is not exactly known how the planetary waves produce the sporadic E modulation, but the effects are easy to measure. Ionosondes, which measure the electron density as a function of altitude, are the primary tool used for detecting sporadic E. In fact, the term sporadic E is a descriptive term used to describe ionograms (ionosonde measurements) that are affected by the overly dense E layer phenomenon. Since sporadic E is such a thin layer, the only two measured characteristics are the height and peak plasma frequency. These two parameters could then be input into a RF propagation model to determine the geometric impacts. Based on recent observations, the length scales of dense sporadic E structures are on the order of 10s to 100s of km, depending on the orientation. The goal of this topic, however, is not to characterize the exact morphology of sporadic E, rather we intend to predict the occurrence rate and characteristics of sporadic E at any point on Earth. Since it is difficult to globally monitor the drivers of sporadic E (thermospheric winds and meteoritic seed populations), a physics-based forecast model may be impractical. The impacts of sporadic E, however, are regularly observed by numerous instruments, including ionosonde networks and GNSS radio occultation (RO) capable satellite constellations. Since Sporadic E is subject to global weather patterns, spatial and temporal correlation functions could adequately describe future occurrence. For instance, observations in western US today could predict observations in eastern US tomorrow, and Europe a week later. Existing global sensor networks likely provide the necessary tools to build an empirical, predictive model. Such a model currently does not exist. We seek a global forecast model that leverages existing data sources. Preference is given to publicly available data but exceptions can be made. The model should act like a weather forecast for scattered thunderstorms, where the product is a percent probability of occurrence and overall severity. The model should focus on the characteristics of Sporadic E that impact high frequency (HF; 3-30 MHz) propagation but other aspects (e.g. scintillation) can be considered as well. The model will be validated by the performer and customer by comparing predicted Sporadic E levels at Ionosonde sites or other instrument sites with actual measurements.

PHASE I: Phase I will demonstrate the feasibility of using existing data sources for use in a Sporadic E forecast model. Specifically the demonstration would include a global Sporadic E occurrence/severity study using available Ionosonde data and possibly other data sources. The feasibility of a potential model will be determined by the measured temporal and spatial correlations between stations. If a strong enough correlation exists on planetary wave size scales then the model will likely be deemed feasible by the TPOC.

PHASE II: Develop a data-assimilative forecast model based on the results of phase I. The model should be similar to a weather forecast model where the user can get the percent chance for Sporadic E for a given place. The forecast would stretch out days to weeks depending on how far in advance the information is statistically meaningful. The forecast model should be validated using existing data sources. New data sources through AFRL may also become available for validation. The model will be compared to median climatology estimates to determine its usefulness as a forecast tool.

PHASE III DUAL USE APPLICATIONS: There are a number of government and private organizations that rely on accurate predictions of RF interactions with the space environment. Furthermore, the proposed model has potential use within the US Space Force Space Systems Command as well as Air Combat Command, the US Navy, and other DoD and Title 50 organizations.

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2. Tang, Q., Zhao, J., Yu, Z., et al. (2021) Occurrence and Variations of Middle and Low Latitude Sporadic E Layer Investigated With Longitudinal and Latitudinal Chains of Ionosondes, Space Weather, 19, 2;
3. Shinagawa, H., Tao, C., Jin, H. et al. (2021) Numerical prediction of sporadic E layer occurrence using GAIA, Earth Planets and Space, 73, 28

KEYWORDS: Sporadic E; ionospheric model; ionosonde

AF233-0010 TITLE: Dual-purpose laser range finder and lidar sensor

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Integrated Sensing and Cyber;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: This topic seeks to develop a dual-purpose sensor which can operate as a laser range finder (LRF) at long ranges (defined as range detection of a standard 2.3-m x 2.3-m NATO target; multi-pulse processing is allowed) and secondarily as a lidar system which can generate small-scale, 3D point clouds at ranges within approximately 10 kilometers. The sensor should be able to seamlessly switch between either mode while being suitable for operation from an airborne platform.

DESCRIPTION: Digital range finding technology offers many advantageous capabilities to airborne Intelligence, Surveillance, and Reconnaissance (ISR) missions. Many object tracking applications require precise knowledge of the object location, which can be found in real-time using a precision laser range finder in conjunction with some other cueing sensor [1]. The inclusion of a laser system on a sensor platform also invites the opportunity to perform target identification missions using the laser in conjunction with an optically resolved imaging system to create accurate 3D point clouds of targets [2]. Such a dual-purpose sensor will likely require real-time reconfigurable camera and laser settings to switch between the two missions. The goal of this effort is to demonstrate a product with a compact and lightweight design and with standard interfaces that achieves the basic specifications outlined here. The sensor should operate at an eye-safe wavelength of 1.55 μm or longer. The 3D lidar mode should offer a pixel format and/or scanning solution to provide approximately a 256x256 or larger image providing both angular and range resolution. The pixels can be digitally combined into larger macro-pixels and the laser pulse repetition frequency and pulse duration can all be reconfigurable to facilitate the laser range finding mode. In the LRF mode, the range resolution should be less than 50-m with an accuracy of ±5 m out to maximum ranges. The sensitivity and range can be increased through longer dwell times and multi-pulse processing. The solution should fit within size, weight and power constraints of 1 cu ft, 40lbs, 100W, not including the beam steering mechanism. For both modes, some small angle scanning (±0.5 degrees) to fine tune the pointing towards targets in field of view should be developed to be used conjunction with a larger, coarse steering mechanism such as a gimbal or turning mirror. The end-product for this effort need not include the coarse beam steering mechanism.

PHASE I: In this initial phase, device concepts will be developed, evaluated, and computer modelled. Design challenges and trade-offs will be tabulated and areas in need of additional R&D will be identified. Critical factors for the LRF include the maximum operating range, the range accuracy, and overall volume. For the secondary objective of the lidar, critical factors include the resolution and field of view, and reconfigurability between the two modes.

PHASE II: Prototype devices will be constructed and tested for relevant specifications. Tests will be performed against relevant metrics. A final packaged system will be produced that meets the specifications and is suitable for Technology Readiness Level 4. Preliminary designs will be made for a Phase III device.

PHASE III DUAL USE APPLICATIONS: A flight ready version of the design will be built from a compact and lightweight design and with standard interfaces. Manufacturing process will be evaluated and refined to improve yield while reducing cost.

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2. P. McManamon, LiDAR Technologies and Systems, SPIE Press, Bellingham, WA (2019)

KEYWORDS: lidar; laser range finder; ISR; point clouds

SF233-0011 TITLE: Flexible Satellite Terminals for Multi-Tenancy Applications

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Microelectronics;Integrated Network System-of-Systems;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 proper interfaces, digital Intermediate Frequency (IF) services and virtualized digital IF modem terminals with utilization efficiency, maximum flexibility and full automation needed to support fighting SATCOM's reliability, growth, and cybersecurity

DESCRIPTION: The Air Force has identified digital intermediate frequency (IF) technology as one of the key enablers for the digital transformation of space, satellite and related industries as its interoperability and performance standards offer the advantage of load balancing and mission planning flexibility that could replace analog IF signals and help prevent vendor lock-in. This topic explores the current state-of-the-art related to digital IF groundwork, digital IF dividers and combiners, digital IF multi-carrier modem, and integrated modem and terminal in enhancing controls to service providers (e.g., network service providers, application service providers, etc.) with expected benefits of path resilience, baseband aggregation, and radio frequency (RF) disaggregation. Specifically, there is also much interest in pursuing innovative solutions on how digital IF services and virtual digital IF modems based on software-defined, flexible, and extensible virtual platforms, could potentially enhance future digital IF operations of satellite communication gateway infrastructure and satellite terminals as well as emergent deployments of enterprise-to-site management automation, full failover capacity and automation. In addition, proposed solutions should take into account of other technical challenges, e.g., i) multi-tenancy at satellite terminals so that multiple end-users and customers could be attached to the same satellite terminal but still have customized access network services, ii) elastic provisioning based on the underlying network access resources specifically for multi-tenants to achieve service isolation and offering seamless communications services, and iii) transformation potentials of satellite terminals into virtualization-capable remote head-ends, and thus, serving a wide range of services.

PHASE I: Develop necessary digital IF systems engineering plans and concept designs for on-demand satellite terminals capable of handling satellite broadband access services with end-users and customers to be able to dynamically request and acquire bandwidth, quality of service, and quality of experience in flexible and transparent manners. Conceptualize the support of multi-tenancy in satellite terminals to offer satellite access to multiple customers connected to the same satellite terminal. Develop reference solutions of virtualized baseband subsystems composed of return links for satellite access and transmission that efficiently provide adaptive waveforms virtualized on the fly in conjunction of digital IF services, transient on-demand bandwidth allocation, handover, power control, fading mitigation, etc. without affecting normal operation of other users.

PHASE II: Demonstrate the utility of an engineering development unit for flexibility in the provisioning, configuration and customization of multi-tenant satellite terminals with reduced (if any) intervention by satellite network operators and network access operators owning the satellite ground segment platforms. Evaluate operational and business support services by multi-tenants with considerations of promptly setup times and resource elasticity. By the end of Phase II, a proof of concept for an agile deployment of flexible satellite terminals that keep pace with the rapid growth, cost, virtualization, and Commercial-Off-The-Shelf implementation pertaining to customer density and demand shall be demonstrated.

PHASE III DUAL USE APPLICATIONS:

REFERENCES:

1. FAA, “Concept of Operations v2.0”, https://www.faa.gov/researchdevelopment/trafficmanagement/utm-concept-operations-version-20-utm-conops-v20
2. FAA, https://www.faa.gov/uas

KEYWORDS: Digital Intermediate Frequency (IF); Digital IF Multicarrier Modem; Virtual Digital IF Modem; Multi-Tenant Satellite Terminal; Virtualization on Commercial-Off-The-Shelf (COTS) Implementation; Elastic Provisioning; Virtualized Waveforms

AF233-0012 TITLE: Multi-Spectral Infrared Focal Plane Arrays

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Microelectronics;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 commercial supplier of infrared detector materials, readout integrated circuits (ROICS), and/or focal plane arrays (FPAs) optimized for multi-spectral-band operation. Designs should be constrained to operate through the infrared atmospheric transmission windows, specifically short-wave infrared (SWIR, 1-2.7 um), mid-wave infrared (MWIR, 3-5 um), or long-wave infrared (LWIR, 8-16 um). Materials and ROIC designs should be optimized specifically for multi-band operation (2 - 4 spectral bands in one or more atmospheric windows), with an emphasis on temporally simultaneous and/or spatially co-registered data capture. Additional consideration will be made for approaches that engineer radiation tolerance into the multi-band design to support both Air and Space Force applications. Solutions can include specific spectral-band combinations that serve a well-defined application (e.g. missile warning, target ID, gas sensing), or a modular product that can be adapted to a variety of multi-band applications.

DESCRIPTION: The commercial infrared imaging industry has grown tremendously in recent years, but all of the available commercial off-the-shelf infrared cameras are single band or color. Many industries currently utilizing single-band infrared imaging technology could benefit from a multi-band product that would generally provide improved discrimination and added functionality. For example, industrial manufacturers use single-color MWIR infrared cameras for imaging gas leaks. These cameras can be integrated with an optical filter designed to enhance contrast of a specific gas, but are limited in sensitivity by the environmental clutter of the scene and are blind to other gases. A two-color camera could dramatically improve the minimum detectable concentration of the gas, reduce false leak alarms, and provide improved visual fidelity of the gas by providing both a reference wavelength and gas-tuned wavelength. A three or four color camera could additionally detect and distinguish two or three different gasses all in a single camera. Similar cases can be made for industries such as defense, pharmaceuticals, health care, manufacturing etc. While dual-band FPAs have been demonstrated in the DoD, e.g. MWIR/MWIR and MWIR/LWIR, this was achieved using ROICs with two-color bias polarity switching. This approach utilizes alternating frames of each band and has several limitations: limited to two colors; detector array must be an epitaxial-grown stacked design; data capture is not temporally simultaneous; and generally works for broad-band channels with similar charge-handling requirements. For some applications, high quality identification/discrimination requires relatively narrow spectral bands (e.g. gas sensing), which is not easily realizable with the stacked design. Furthermore, many of these two-color ROICs use an analog pixel input with limited charge handling. This creates issues if bands have disparate charge handling requirements (e.g. SWIR with MWIR, or broad filter with narrow filter). Additionally, the detector designs and materials have not been optimized for multi-band imaging, which would ideally feature high absorption coefficients and sharp band edges to minimize optical cross-talk. Another recent technological growth area is in heterogeneous integration using vias, which have not been adequately explored in the context of multi-band FPAs. Solutions to this objective should be focused on providing a commercial supplier of enabling multi-spectral-band components (e.g. infrared detector materials, ROICs, integrated filter assemblies, or FPAs). The solutions should clearly define the innovation that makes the product particularly suitable for multi-band applications, and should be optimized for this purpose. While the main focus could be on optimizing detector materials or ROICs, for example, later phases of the program should include fabrication of full FPAs and/or cameras for demonstration purposes. Because innovations in multi-band imaging have utility for high-altitude and space-based applications, innovations that include some level of radiation hardness or tolerance will be given extra consideration. For proposals focused on ROIC design, there should be an emphasis on flexibility and functionality. As required, designs should consider the disparity in current handling requirements for both bias switched and/or super-pixel arrangements. This may require bias, integration time, and amplifier gain flexibility at the pixel and/or super-pixel level. Another consideration might be ROIC input layouts that accommodate detector arrays with spatially co-registered and simultaneous capture using via contacts. Solutions focused on back-end processing, such as integrated filter assemblies, must consider the current standard FPA manufacturing procedures and limitations to ensure product integration is effective, feasible, and not cost prohibitive. Because dual-band bias switched FPAs have been previously demonstrated, proposals that utilize this approach should also feature something that improves upon the design in a clearly innovative way.

PHASE I: Develop an innovative enabling component that improves state-of-the-art multi-spectral-band imaging capability. Identify applications for the enabling component, and use these applications to define performance metrics and requirements. Model the expected performance, yield/operability, and assess the commercial viability of the product. Determine expected challenges in fabrication/integration and provide mitigation approaches where appropriate. Start basic fabrication or other feasibility demonstration.

PHASE II: Produce and begin optimization of prototype component(s). Assess the operability and yield at this stage. Integrate with FPA and produce test data. Analyze the key performance metrics as defined in Phase I, and compare with current state-of-the-art. Identify partner(s) to develop a prototype demonstration camera utilizing the component for Phase III.

PHASE III DUAL USE APPLICATIONS: Refine the manufacturing process, optimize performance, and maximize operability/yield of the component. Build a prototype camera to demonstrate the functionality and performance of the component in a demonstration system. Compare performance to similar single color cameras with single optical filter and two-color bias switched designs. Focus on identifying interested FPA manufacturers and/or camera and systems integrators to transition the technology.

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KEYWORDS: Infrared; Focal Plane Array; FPA, Image Sensor; Multi-Spectral; Multi-Band; Photodetector; Radiation Hard; ROIC; Readout Integrated Circuits;

AF233-0013 TITLE: Wafer scale Zinc Selenide (ZnSe) single crystals

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Directed Energy (DE);Advanced Materials

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OBJECTIVE: Develop a commercial single crystal growth process for 50mm diameter zinc selenide (ZnSe) wafers

DESCRIPTION: The need for high-brightness, compact infrared lasers operating in the mid-wave infrared (MWIR) through far infrared has long been established in the Global Strike Operational Imperative to address infrared missile threats. Beyond infrared countermeasures (IRCM), such frequencies have applications in spectroscopy, and imaging, for both military and commercial users. Frequency conversion devices based on quasi-phase matching (QPM) have been very successful with PPLN and the more recent development of orientation patterned (OP) GaAs. However, due to the intrinsic absorption losses in PPLN its usefulness is limited to wavelengths shorter than 4 µm. These limitations combined with the need for MWIR to far IR fueled the development of OP-GaAs. As with PPLN there are intrinsic material properties that limit OP-GaAs as a high brightness source for MWIR to far IR radiation. The two primary limitations are the 1.42 eV direct band gap at room temperature and strong absorption at wavelengths longer than 15 µm. GaAs's band gap leads to strong two photon absorption at wavelengths shorter than 1.75 µm limiting the available pump sources. Zinc Selenide has a wider band gap, a modest nonlinear coefficient, and a wide transparency which are attractive for infrared countermeasure applications. The major obstacle to producing OP-ZnSe has been the lack of high quality wafer scale single crystal substrates, which are required for fabrication of OP-ZnSe templates. To date, single crystals of ZnSe have been grown by vapor phase, melt, and solution growth techniques, but the desired sizes and quality have not been achieved. In order to realize OP-ZnSe IR frequency conversion devices, large single crystals of ZnSe must be produced for fabrication of ZnSe OP-templates. This SBIR call is seeking the development of a crystal growth technique to provide high quality, optically clear ZnSe crystals 50mm in diameter.

PHASE I: Develop a scalable ZnSe growth process and then demonstrate a single crystal of ZnSe with a (100) orientation with at least 10x10x1mm dimensions.

PHASE II: Using the growth process established in Phase I, demonstrate and deliver a single crystal of ZnSe with a (100) orientation with at least 25mm in diameter and a 1mm thickness. Dicing and polishing the 25mm wafers with a scratch dig of 40-20.

PHASE III DUAL USE APPLICATIONS: Demonstrate and deliver a single crystal of ZnSe with a (100) orientation with at least 50mm in diameter and a 1mm thickness. Dicing and polishing the 50mm wafers with a scratch dig of 20-10.

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1. Singh et al., Journal of Crystal Growth 312 (2010) 1142–1145.
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KEYWORDS: Zinc Selenide; Crystal Growth; Infrared; Wafer; Single Crystal

SF233-0014 TITLE: Multi-Object Behavior Modeling of Space Systems

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: Investigate and develop tactical-speed analytical capabilities for space multi-threat, multi-object characterization and assessment.

DESCRIPTION: A fundamental component of ensuring freedom of operation in space is space battle management and command and control (SBMC2), with a core tenet therein being the ability to conduct real-time analysis of the risk to mission. This is necessary to allow action to be taken accurately, knowledgeably, and on appropriate timelines. This concept requires having knowledge. Collected data can be used to provide information to form hypotheses, but these hypotheses must have meaningful and critical context for BMC2 decision-making. Thus, accurate characterization on mission-relevant timelines must determine not only the behavior of a space-based threat but also the potential impact to the mission. In the increasingly complex space domain, analyses should look beyond single-object, single-event occurrences. Traditional approaches to modeling multi-object and/or campaign-level activities is time consuming and labor intensive, carries high levels of bias risk, and does not easily accommodate iteration for comparative and/or “what-if” analysis. Improved and new capabilities must support more complex analyses on tactically-relevant timelines and enable a robust risk assessment to include likelihood and consequence of events. The technology to be developed should consider multiple behavioral and physics inputs, perform threat and impact analysis beyond single object and event actions, and present assessment results in mission-time for critical decision making.

PHASE I: Awardees for Phase I will conduct a feasibility study on candidate technologies and develop an architecture that addresses the needs described in the topic description. This feasibility study should include assessments of computational methods for autonomously processing large amounts of space data. The feasibility study should be supported with preliminary analysis and results to demonstrate the viability of the approach.

PHASE II: Phase II efforts will design, develop, and implement a prototype based on the architecture developed in Phase I, focused on multi-object engagements within a single orbital regime with flexibility and scalability to expand into other regimes. The Phase II prototype shall generate situational awareness and risk to mission calculations using synthetic, representative, data.

PHASE III DUAL USE APPLICATIONS: Phase III efforts would involve enhanced performance capabilities of the prototype architecture implementation. They will demonstrate autonomous assessment capabilities as part of military exercises and other representative operational environments. Working with transition partners, they will identify and evaluate opportunities for implementation/integration in DoD and/or civilian applications requiring timely data for situational awareness.

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3. DeMars, K., Frueh, C., Jah, M, Erwin, R., Multiple-Object Space Surveillance Tracking Using Finite-Set Statistics. Journal of Guidance, Control, and Dynamics, 2020, doi:10.2514/1.G000987.

KEYWORDS: Space domain awareness; machine learning; AI, space command control

AF233-0015 TITLE: Multi-int Multi-look 3D features Image Fusion with Machine Learning

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

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: To develop novel, more computationally efficient multi-int and multi-look fusion algorithms to improve detection, classification, and recognition of uncooperative low resolution and occluded objects in urban and other complex terrains using advantages and capabilities of modern sensors and machine learning algorithms.

DESCRIPTION: To develop novel, more computationally efficient multi-int and multi-look fusion algorithms to improve detection, classification, and recognition of uncooperative low resolution and occluded objects in urban and other complex terrains using advantages and capabilities of modern sensors and machine learning algorithms.

PHASE I: Investigate state of the art solutions in simple feature extraction and object level probability of Detection/identification methods that reduce the need for human oversight and the computational complexities of the fusion methods. Develop an architecture design concept of the Phase II detection/classification algorithms. The Phase I report should provide a complete description of the proposed algorithms that includes demonstration of electro-optic, infrared, or radar data processing and low level feature fusion from image data. It is desirable that algorithms be computationally efficient to provide near real-time capabilities. Any data needs and assumptions required by the concept should be clearly outlined and explained. Source code of the final demo is a required deliverable.

PHASE II: Develop and demonstrate a functional algorithmic suite and operator interface using realistic electro-optic, infrared, or radar imagery sensor data. Validate measures of performance established in Phase I. Other tasks include documenting and delivering a report, interim and final source code, including all users’ needs assessments, methodologies, algorithms, and any data structures or software products necessary to support transition of the work to Air Force applications. Imagery and other multi-int data may be provided to the awardees. Extend Phase I approach to include additional sensor modalities and operating conditions. Sensor operating constraints shall also be addressed. The final report should document progress made and include requirements to sensors (range, spectra, timing, minimal amount of multi-look angles/images, and other operational constraints). Final delivery should include source code and data sets for all techniques developed under the contract. To streamline transition of the Phase II products to AF applications, a business model for compensation of the developers’ SBIR data rights must be provided.

PHASE III DUAL USE APPLICATIONS: This system could be used in a broad range of military and civilian security applications where real-time information fusion and target detection/recognition is required: for example, in military operations in urban and complex terrain, in search and rescue, firefighting, drug interdiction, law enforcement, counter terrorism operations in urban structures, border tunnels, industrial facilities, etc. Commercial Application: Technologies developed under this effort can be applied to remote sensing, industrial development and operations, traffic analysis, and environmental monitoring.

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3. I.V. Ternovskiy, T.P. Jannson, "Rotational invariant visual object extraction and understanding," Proc. SPIE, Signal Processing, Sensor Fusion, and Target Recognition IX, I. Kadar (Ed.), Vol. 4052, pp. 85-93, August 2000.
4. T.P. Jannson, I.V. Ternovskiy, "Data reduction for multispectral and hyperspectral imagery based on application of catastrophe theory," Proc. SPIE, Applications and Science of Neural Networks, Fuzzy Systems, and Evolutionary Computation III, B. Bosacchi, D.B. Fogel, J.C. Bezdek (Eds.), Vol. 4120, pp. 110-119, October 2000.

KEYWORDS: Machine Learning; electro-optic, infrared, radar sensors; multi-phenomenology fusion; ISR; multi-look

SF233-0016 TITLE: Evaluation of Space-Enabled Kill-Webs

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 modeling and simulation capabilities which highlight the interaction between space systems and aggregations of terrestrial (air, land, sea) systems coordinating to deliver effects in multi-domain operations scenarios.

DESCRIPTION: The USSF Commander's Campaign Support Plan (CSP) outlines the United States Space Force (USSF) will support Geographic Combatant Commands (GCCs) by organizing, training, equipping, and presenting a ready Space Force with an eye towards collaborative partnerships that yield decisive operational capabilities. Modern force design is moving towards concepts of "Mosaic Warfare" and distributed and connected groups of force components collaborating in new ways. As these force designs evolve terrestrially, so too will the way in which they are supported by space services. Enabling modeling and simulation engines to explore the multi-dimensional graphs structures which arise when analyzing connected and collaborating groups of agents (aka digital twins) while evaluating the utility of the delivered effects is an area of ongoing and rapidly evolving research. This topic explores the integration of model-based systems engineering (MBSE) system representation in systems modeling language (SysML) with agent-based modeling and simulation frameworks to enable high fidelity analytical representations of the connections between system design decisions, and the impact of the increase in space service performance on the utility of the service-dependent platforms in the fight.

PHASE I: Define and develop a concept for a workable prototype or design to address at a minimum the basic capabilities of the stated objective. Define uses cases and specific application for a new capability. Demonstrate technical feasibility to meet the capabilities of the stated objective for one use case.

PHASE II: The solution for this topic will employ multiple modeling and simulation frameworks for the representation of systems in their respective domains and integrate methods for the representation of these systems in SysML such that responsive models may be generated by the system representations as input. Further, multi-dimensional graph visualization and processing tools will be integrated to enable means to explain the complex relationships between interacting and collaborating agents in multi-domain scenarios. Evaluation of the kill-webs will be carried out to a point where, via the use of concrete performance metrics or measures of expected capability equivalent across domains, space-enabled kill-webs can be meaningfully compared to kill-webs that are not space-enabled.

PHASE III DUAL USE APPLICATIONS: Develop a strategy to transition prototype residual capabilities and incremental proliferation based on USAF/USSF requirements.

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3. Fernandez, Nicolas F., Gregory W. Gundersen, Adeeb Rahman, Mark L. Grimes, Klarisa Rikova, Peter Hornbeck, and Avi Ma'ayan. "Clustergrammer, a web-based heatmap visualization and analysis tool for high-dimensional biological data." Scientific data 4 (2017)

KEYWORDS: model-based systems engineering (MBSE); agent-based modeling and simulation; digital twin engineering; Advanced Framework for Simulation

AF233-0017 TITLE: Passively Augmented LiDAR

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: Investigate and prototype passive imager and laser beam scanners for a Passively Augmented LiDAR (PAL) architecture that can be used for autonomously detecting, recognizing, and identifying objects that may be obscured by background clutter. The USAF needs improved munitions and other airborne system sensing and target discrimination capabilities to perform against contested landscapes and deception techniques. Using this imaging architecture, USAF systems are expected to be able to precisely detect, recognize, and identify hidden targets on the battlefield with high confidence. The PAL architecture is based on a hybrid system consisting of a multi-kilometer range LiDAR and a passive imager. The goal of the hybrid system is for the active and passive sensors to complement one another by producing a sensor having the strengths of both, but not limited by the weaknesses of either individual system. To that end the passive imager provides high frame rate, high resolution, wide Field of Regard (FOR) imaging. The passive imager will be capable of producing image quality sufficient for target ID through shape-based template matching. In the event there are obscured targets, and the system is unable to ID targets, the passive imagery will be used for anomaly detection indicating the potential presence of hidden targets. The anomaly coordinates will be transferred to the LiDAR system for detailed interrogation over a narrow region. Although various types of passive imagers could be employed, we anticipate the initial imager will be a longwave passive polarimetric imager. It will be desirable for the LiDAR system to incorporate advanced material identification modalities including multiple spectral wavelengths and/or optical polarization. The LiDAR may be a conventional 3D imaging LiDAR or a spectropolarimetric LiDAR. In both cases the LiDAR will be capable of providing 3D imagery of the narrow FOR. For the spectropolarimetric LiDAR, the system will also provide the spectropolarimetric properties of objects in the narrow FOR. LiDAR imaging technology does not exist in any current US weapon seeker in inventory. Therefore, state-of-the-art imaging seekers do not include lidar capabilities such as 3D point cloud imaging, foliage penetration, and active spectropolarimetric material classification. The PAL concept overcomes the primary limitation of lidar imaging: scanning large areas in short time durations. However, the PAL concept of quickly scanning small regions within a large FOR is not conventional for lidar systems and requires a novel scanning system to enable lidar on weapon seekers for the first time.

DESCRIPTION: In depth investigation of a PAL system is needed in order to more completely understand the system trade-offs necessary to optimize the ability to detect and identify hidden targets. A compelling PAL system for Air Force applications in remote sensing may utilize a high frame rate passive imager to rapidly scan a large field of view, detect potential regions of interest, and pass location data to a LiDAR imager to obtain spatial, spectral, and/or spectropolarimetric information on the region of interest. Other than target identification in a battlefield, this technology may be useful in geologic, urban, or agricultural aerial surveys. It can also be applied for military or non-military search and rescue missions where hidden targets are commonly involved. In the notional system, the passive imager may be able to detect/ID unobstructed targets as it identifies scene anomalies, then cues the higher resolution foliage penetrating LiDAR to scan small regions at the anomalies and perform more advance material identification. Images from passive systems can contain a mixture of multiple potential surfaces of interest on each image pixel due to finite pixel sizes, finite fields of view, and large imaging distances. This adds to the complexity of target detection and the need for a more sophisticated investigation for a potential passive imager on the PAL system. Therefore, a passive imager may need to employ unique anomaly detection (AD) methods that can include contrast enhancement, global RX detectors, and automatic thresholding to successfully analyze and detect anomalies within a complex heterogenous image. Due to the time constraints in a contested battlefield, the techniques for AD of a passive imager may also need to rank high anomaly regions and flawlessly cue the LiDAR system to scan these regions by priority to quickly enable target identification. Scene anomalies detected by a passive imager may include manmade objects obstructed by natural foliage, which may be missed by an unpolarized or non-multispectral imaging system. Therefore, having both a passive imager and a LiDAR in a system such as PAL is expected to result in higher detection rates of hidden targets. Additionally, the LiDAR system may make use of more advanced operational modes including but not limited to simultaneous operation at multiple wavelengths, and/or sensitivity to optical polarization. Polarization depends on a variety of factors including object geometry, surface material, and observation angles. At one extreme, vegetation tends to have a weak polarization signal compared to manmade objects because of surface roughness and nonuniform composition. On the other hand, manmade objects with flat surfaces and uniform composition can lead to a higher degree of polarization. Polarimetric signatures of numerous materials are described in pBRDF databases.

PHASE I: Investigate literature for background information on a PAL system and perform system design and analysis. This includes Field of View (FOV) steering for the passive imager and LiDAR scanners. It is desired to understand the complex system trade-offs involved in incorporating a passive imaging system with a LiDAR scanner; additionally, understanding the potential performance enhancements enabled by advanced LiDAR including multiple simultaneous spectral wavelengths and/or optical polarization sensitivity is desired. Study should identify scanner designs for phase II.

PHASE II: Procure hardware to build and characterize prototype scanning systems (1-3 from above) for passively augmented LiDAR system. This includes the development and delivery of hardware. It is desirable that the prototype system be capable of operation outdoors to enable field data collection, but it would be acceptable to develop a compelling tabletop system enabling indoor data collection. If the system is limited to indoor operation, then a path to outdoor operation should be clearly defined. Scan imaging frame rate, field of view, and operational range are metrics of interest.

PHASE III DUAL USE APPLICATIONS: Develop full system prototype and demonstrate in relevant field environment. Mature the prototype PAL system to perform real-time LiDAR scanning and data acquisition. The completed system shall locate anomalies and cue the novel LiDAR scanner to interrogate small regions. The system shall consist of government furnished or procured laser, detector, and infrared imaging components, completely integrated with the scanner technology developed in Phase II. The fully integrated PAL system will be tested outdoors for foliage penetration and material classification. System performance metrics include frame rate, laser scan rate, power requirements, maximum range, and processing time.

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2. Detection of Hidden Objects Using Passive Polarimetric Infrared Imaging, J. Brown, D. Card, C. Welsh, C. Saludez, C. Keyser, R. Roberts, " IEEE Transactions on Geoscience and Remote Sensing, submitted Aug. 2019;

3. LADAR System and Algorithm Design for Spectropolarimetric Scene Characterization, Richard K. Martin, Christian Keyser, Luke Ausley, and Michael Steinke, IEEE Transactions on Geoscience and Remote Sensing, vol. 56, no. 7, pp. 3735-3746, July 2018;
4. "Single-Pulse Mueller Matrix LiDAR Polarimeter: Modeling and Demonstration, Christian K. Keyser, Richard K. Martin, P. Khanh Nguyen, and Arielle M. Adams, " IEEE Transactions on Geoscience and Remote Sensing, vol. 57, no. 6, pp. 3296-3307, June 2019;
5. Single-pulse, Kerr-effect Mueller matrix LiDAR polarimeter, C. Keyser, R. Martin, H. Lopez-Aviles, K. Nguyen, A. Adams, and D. Christiodoulides, Opt. Exp. May 2020.

KEYWORDS: LiDAR; passive imagery; autonomy; anomaly detection; material classification; polarimetric imagery; multispectral imagery

SF233-0018 TITLE: Mobile RAVEN Observatory

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Directed Energy (DE)

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 goal is to develop a transportable/mobile optical telescope observatory using a Raven-class telescope (aperture of 0.4 to 1.2 meters in size) that can be relocated to remote locations over paved/gravel/dirt roads. The system will be fully functional and autonomous in remote locations, which includes network access (WiFi/StarLink/etc.) and self-contained power source. The observatory should be easily deployed/set-up (1-2 person crew) and optimized for autonomous observations.

DESCRIPTION: The USSF has a need for a telescope system that can be relocated to support one-time observation events, just-in-time requirements in a specific geographic location, or to fill temporary coverage gaps. As a result, a mobile telescope system could best provide the required observations without a human present for collection. The mobile system must have the same capability as its fixed location counterparts (Raven network). To effectively accomplish its mission, it must consist of a dome/cover, telescope, mount, camera, filter wheel, and various satellite characterization filters. Additionally, it must contain compute resources for observatory control, telescope control, image processing, analysis, and data distribution. It must be transportable using its own power, or using a government standard vehicle such as a car or pickup truck. Lastly, the system should be designed to be easily deployable with minimal crew and capable of autonomous collection capability.

PHASE I: Phase I awardees will develop a mobile Raven Observatory design and perform finite element analysis to demonstrate the system's ability to survive transport over various terrains (asphalt, gravel, and dirt roads). The system should be equipped with a vibration suppression/shock absorption system to protect the telescope and its associated optics. The observatory must also be able to determine its location and perform any self-alignment required by the mount before operating. The observatory must have the ability to operate remotely and autonomously.

PHASE II: In Phase II, awardees will construct a prototype of their Phase 1 design. This prototype will be tested to confirm the finite element analysis performed in Phase 1. The autonomy of the observatory will be demonstrated and validated along with a checkout of the optical system after vibration/shock testing. Additionally, the system will be tested to determine measurement accuracy.

PHASE III DUAL USE APPLICATIONS: In Phase III, the awardee will deliver a fully functional Mobile Raven Observatory that can serve as a functional replacement for any of the in-service, fixed Raven observatories while also providing the option for easy relocation.

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KEYWORDS: mobile optical telescope observatory; raven telescope; commercial off the shelf telescope

SF233-0019 TITLE: Suborbital Hover Vehicle-Reusable Rocket

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

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OBJECTIVE: Develop an innovative concept, manufacturing implementation, and system hardware for a Suborbital Hover Vehicle-Reusable Rocket (SHVRR). Demonstrate multiple tethered vertical hover flights (or equivalent) of delivered propulsion pathfinder airframe using Government Furnished Equipment (GFE) of a flight weight Rotating Detonation Rocket Engine and engine controller. The delivered pathfinder vehicle under this topic consists of structure, propellant tanks, feedlines, pressurant, communications, control, and electrical power systems to test propellant fill/drain, engine ignition, vertical transition to hover, landing, engine shutdown, and safety system operations sufficient at a selected test facility at the completion of a Phase II award.

DESCRIPTION: Rotating Detonation Rocket Engines (RDRE) are a disruptive new rocket engine technology under development by the Air Force Research Laboratory’s Aerospace Systems Directorate Rocket Propulsion Division at Edwards AFB California since 2017. The technology has the potential to significantly improve the size, performance, stability, and unit cost of liquid rocket engines over the existing state of the art constant pressure rocket engine technology in use throughout the space industry. To quickly mature the Technology Readiness Level (TRL) of RDREs, development of an innovative minimally viable propulsion system pathfinder is desired. The pathfinder mitigates propulsion development risk for a follow-on full flight demonstration of RDREs for several DoD applications, including, but no limited to: 1) Tactically Responsive Space Access (TRSA) orbital launch, 2) TRSA small point-to-point delivery, and 3) rocket-powered Hypersonic Testbed Vehicles. Mitigating the key propulsion system risks for this engine technology requires repeated testing of a flight weight RDRE in a representative environment for the range of intended DoD capabilities 1-3 above. Addressing the key technical challenges can best be evaluated at reasonable cost to the government using a tethered propulsion pathfinder capable of physically constrained vertical hover/throttling.
Tasks required include:

- Assess technical merit of hover pathfinder for at ≥ two (2) of three (3) TRSA/Hypersonic Testbed capabilities listed above.
- Report budget/schedule feasibility of completing pathfinder design/manufacture/test under SBIR Phase II constraints.
- Complete workplan/schedule/budget.
- Evaluate candidate DoD/non-DoD hover test sites; Rank top two (2) sites with justification.
- In coordination with customer, perform assessment of all safety/flight test/airworthiness requirements for recommended test sites.
- Complete design of pathfinder systems meeting baseline requirements.
- Manufacture pathfinder.
- Complete pathfinder/engine Interface Control Document (ICD).
- Document Pathfinder Hover Test plan.
- Conduct Pathfinder Hover Tests.
- Complete conceptual/preliminary design of Phase III suborbital RDRE flight test vehicle.

- Complete reporting. Key Performance Parameters (KPP) include Parameter / Threshold Goal / Objective Goal Propellant Feed cycle / Pressure-fed / Pump-fed RDRE Chamber Pressure (Pc) / ≥ 300 psi / ≥ 400 psi Propellant Tank Pressurization / Blowdown / Regulated pressurant RDRE Thrust (F) / ≥ 1000 lbf / ≥ 5000 lbf Thrust Vector Control (ΘTVC) / none / ≥ 5 degrees Fuel / Liquid hydrocarbon / RP-2 Oxidizer /Liquid O2 / Liquid O2 RDRE min operation time (tb) / ≥ 10 seconds / ≥ 10 seconds RDRE min specific impulse (Isp) /≥ 215 seconds / ≥ 215 seconds RDRE min throttle /

PHASE I: Phase I efforts shall document the scientific/technical suitability and merit of a SHVRR propulsion pathfinder for at least 2/3 of the proposed DoD TRSA/Hypersonic Testbed capabilities as well as assess the feasibility of completing the design, manufacture, and testing of SHVRR within the budget/schedule of a SBIR Phase I/II. If completion of the baseline requirements under Phase II constraints is judged as infeasible, then recommendations shall be made on how the customer can modify baseline requirements or provide additional specific pathfinder systems, beyond the RDRE, as Government Furnished Equipment (GFE) to allow completion under a Phase II.
Specific deliverables under a Phase I include:

- Assess technical merit of hover pathfinder for at ≥ two (2) of three (3) TRSA/Hypersonic Testbed capabilities listed above.
- Report budget/schedule feasibility of completing pathfinder design/manufacture/test under SBIR Phase II constraints.
- Complete preliminary workplan/schedule/budget.
- Complete conceptual design of pathfinder systems meeting baseline requirements.
- Evaluate candidate DoD/non-DoD hover test sites; Rank top two (2) sites with justification.
- In coordination with customer, perform assessment of safety/flight test/airworthiness requirements for recommended test sites.
- Finalize propulsion pathfinder Hover Test plan.
- Draft propulsion pathfinder/engine Interface Control Document (ICD).
- Complete conceptual design of Phase III Prototype Flight Mothership-Reusable Rocket and its traceability to SHVRR design.
- Complete reporting/documentation.

PHASE II: Phase II work should include completion of the design, manufacture, test planning, and test operations of the SHVRR pathfinder using the GFE provided RDRE.
Task during Phase II include:

- Complete final workplan/schedule/budget/requirements.
- Complete preliminary/critical design of pathfinder systems meeting final requirements.
- Finalize pathfinder/engine Interface Control Document (ICD).
- Manufacture SHVRR propulsion pathfinder and integrate GFE RDRE systems.
- Complete safety & test requirements for selected test site.
- Finalize propulsion pathfinder Hover Test plan.
- Complete preliminary design of Phase III Prototype Flight Mothership-Reusable Rocket.
- Conduct SHVRR Hover Test operations.
- Complete reporting/documentation.

PHASE III DUAL USE APPLICATIONS: Phase III consists of conducting the military utility analysis, design, manufacture, and testing of an integrated capability Prototype Flight Mothership-Reusable Rocket for one of the specified DoD TRSA or Hypersonic Testbed capabilities discussed in the Topic Description above. Manufacture and flight test of the integrated capability prototype may be executed under a SBIR Phase III, Other Transactional Authority (OTA), AFRL S&T Seedling for Disruptive Capabilities program (SDCP), or other flight funding mechanism. It's expected that RDRE propulsion system will be at a TRL=6 at entry into a Phase III effort. A successful completion of Phase II of this topic is envisioned to allow the technology to be included in the trade space for a follow-on for either a TRSA upper/high energy orbit insertion launch program of record, or a prototype program for hypersonic testbed vehicle or TRSA point-to-point delivery.

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4. https://doi.org/10.2514/6.2021-3682 ;
5. AFRLi-61-601 AFRL Airworthiness;
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7. https://www.nasa.gov/centers/marshall/feature/nasa-validates-revolutionary-propulsion-design-for-deep-space-missions;
8. AFRLi 61-103 vol 1 AFRL Flight Test and Evaluation;
9. AFRLi 61-601 AFRL Airworthiness;
10. AFi 62-601 USAF Airworthiness

KEYWORDS: RDRE; VTVL; Hoveroc; Delta Clipper;

AF233-0020 TITLE: Mapping Mesostructures to Hypersonics for Improved Manufacturability and Performance

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 research is to design hypersonic components and systems using mesostructures to improve manufacturability, maneuverability, speed, and range

DESCRIPTION: With emerging manufacturing technologies, engineering design is no longer limited by traditional component manufacturing processes and intrinsic material properties that arise from crystal microstructures. Rather, complex small structures, i.e., mesostructures, may be produced by additive manufacturing (AM) to reduce weight by up to 90% (Deng), integrate components and functionality, and tune effective material properties. A variety of mesostructures have been created using AM technologies including truss structures, triply periodic minimal surfaces (TPMS), and honeycomb structures. With mesostructures, engineers can tune material properties, essentially creating new materials, metamaterials or engineered materials. The properties of the engineered materials with mesostructures can be described at the macroscale using effective material properties and can vary by orders of magnitude from the base material's properties. Therefore, mesostructures are revolutionizing engineering design and are particularly suitable for weight critical industries including hypersonics. In addition to the weight reduction due to the partial density, system weight is also decreased by component integration, multifunctional materials, and property and topology optimization with mesostructures. Engineered materials and AM technology with mesostructures simultaneously improve munitions readiness and effectiveness. There are many complex challenges in the characterizion and subsequent modeling of mesostructures. Many of the simplifying assumptions used to model the behavior of fully dense materials including isotropy, symmetry, and linearity are no longer valid for materials engineered with mesostructures. For example, most polycrystalline materials are isotropic, meaning they behave the same way in every direction. In contrast, most mesostructures are highly anisotropic. Effective material properties vary by orders of magnitude with rotation of the mesostructure. This anisotropy could result in catastrophic failures if not described in the analysis using advanced material models with tensor properties. Anisotropy is incredibly useful to optimize designs and tune material properties utilizing these advanced material models and tensor properties. For example, layered insulation with anisotropic thermal conductivity allows heat to flow from the leading edge along the outer lamina of hypersonic aeroshells while protecting the internal cavity and underlying sensitive components. Current engineering design and analysis techniques, tools, and software were not developed for multifunctional components and systems with variable, tensor material property fields enabled by mesostructures. In state-of-the-art design and finite element analysis (FEA), intrinsic material properties are assigned to entire components, boundary conditions are applied, the analysis is executed, and the thermomechanical response is output. Often entire systems are reinforced, redesigned, or even rejected because the FEA reveals a point failure at a load concentration. The tools required to navigate the burgeoning design space with mesostructures and advanced composites are in development. To inform this development, we must explore the design space, understand the tradeoffs, identify multi-objective optimization functions, develop advanced material models with effective tensor properties, and ultimately map the mesostructures to the hypersonic systems. Therefore, the current challenge in AFRL/RW is to apply mesostructures to a variety of novel hypersonic designs to improve manufacturability and performance in a parallel approach. Exploration of the design space requires the evaluation of the system for opportunities to integrate functionality, reduce component interfaces, distribute loads, reduce weight, and/or otherwise improve system level designs with the application of mesostructures. In the design process, many different variables should be considered for the trade study including but not limited to: anisotropic and multi-physics effective material properties, various base materials and material combinations, mesostructure refinement and density, manufacturability, deformation and distortion of mesostructures, and various types of mesostructures and transition structures. Finally, mesostructures will be mapped to the hypersonic system using advanced models to create fields of tensor material properties for improved manufacturability or performance of representative hypersonic systems. Effective material properties of particular interest include: stiffness, fracture toughness, thermal conductivity, specific heat, density, impact resistance, surface roughness, maximum service temperature, creep, and strength. Manufacturability of mesostructures continues to challenge the AM community. If the engineered materials are not currently manufacturable, manufacturing limitations and progress will be explored in-depth. If the engineered materials are manufacturable, the materials will be characterized to understand the tensor properties, validate advanced material models, and demonstrate mapping, deformed and transition structures, the variable property fields.

PHASE I: During phase I, awardees will select a commercial or government-of-the-shelf (GOTS) FEA solver for implementation. Extensive literature surveys and prior research highlighting the advantages and limitations of the chosen approach is required. The firm will then select a representative hypersonic system, subsystem, or geometry for redesign with mesostructures. The objective performance and/or manufacturing improvements and trade space will be defined. The technical approach including design optimization scheme, advanced material models, and mapping functions will be identified. Effective tensor properties for the materials engineered with mesostructures will be collected from the literature and supplemented with FEA analysis, as required. Manufacturing limitations and progress will be identified

PHASE II: During phase II, the hypersonic system, subsystem, or geometry redesigned with mesostructures will be completed, modeled using the FEA solver selected in Phase I, and analyzed to demonstrate through modeling and simulation the improved maneuverability, speed, and/or manufacture. Mesostructures and engineered materials will be manufactured and characterized to validate advanced material models and demonstrate tunable tensor properties. Documentation of the implementation including user manuals, theory manuals, validation cases, examples, and source code with U.S. government data rights is required.

PHASE III DUAL USE APPLICATIONS: Following successful and innovative applications of mesostructures into hypersonic systems and design, analysis, and optimization tools within Phase I and II, Phase III funding will be available from 6.2 funding for the Advanced Manufacturing Enabled Technologies for Aerodynamics (Advanced META). The contract vehicle is currently being explored with the transition partner, Boeing BRD&T, for integration into developmental hypersonic, high-speed and weight critical systems using the developmental tools.

REFERENCES:

1. Deng, Biwei. Lightweight Mechanical Metamaterials Based on Hollow Lattices and Triply Periodic Minimal Surfaces. 2019.
2. Purdue University, PhD Dissertation; Yang, Lei. Continuous Graded Gyroid Cellular Structures Fabricated by Selective Laser Melting: Design, Manufacturing and Mechanical Properties. Materials and Design. 162, 2019, p. 394-404;

KEYWORDS: Mesostructures; Metamaterial; Hypersonic; Design Optimization; Maneuverability;

AF233-0021 TITLE: Operations & Logistics Susceptibility due to Publicly Available Information (PAI)

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Advanced Computing and Software;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: Research and identify the Publicly Available Information (PAI) military units leave behind as a result of using commercial entities to support military operations. Assess if a potential adversary could use that information to target military units to delay, disrupt or degrade US military capabilities and intentions. Unclassified data includes locations & details of military assets, capabilities, & plans for upcoming operations. While this information may not be classified, it can still be used by adversaries to gain an advantage, such as by preparing for an attack or developing countermeasures to US military capabilities. PAI as a result of dependencies on contracted commercial entities generates a significant amount of unclassified information.

DESCRIPTION: Since the mid-1990s the US military has become increasing reliant on contracted support from commercial entities with Operation Desert Storm being the last major military operation with a predominance of support from military units. The DoD projects that contractors will provide most of the support to future major military operations. Coordination for this support requires communication and transmission of militarily relevant information on unclassified commercial systems and this represents a potential military vulnerability. Joint doctrine directs planners to consider contractors as “forces available” for military operations and in some cases supplanting military logistics forces. This can relieve the US strategic transportation system of the burden of transporting military logistic units into a theater of operations in lieu of combat forces. If planners can expect to contract for heavy equipment transport trucks in theater, then they can plan to move more combat units into theater earlier in the plan. In addition, contractors are often used to fill gaps in military capabilities, provide additional expertise, or to augment the military's capacity to respond to emerging threats. Contractors provide a wide range of support services, such as logistics, transportation, construction, and maintenance, as well as technical and professional services, such as engineering, IT, and intelligence support. They also provide support for functions such as catering, laundry, and other services that are required to sustain military personnel in an operational environment. These activities occur alongside military personnel executing classified missions. Even if the contractor had no knowledge the actual military mission, their presence, and the signals they generate in the environment could provide a discernable pattern that an innovative adversary could use to derive the capabilities and intentions of the US military. This research intends to determine the feasibility of developing a capability for military units to assess the type of pattern that their Publicly Available Information (PAI) creates and if it represents a risk to military operations.

PHASE I: Period of performance objectives are: 1. Conduct a thorough analysis of the types of Publicly Available Information (PAI) generated by military units in receiving support from commercial entities. Include a review of existing datasets, software solutions and technical requirements. 2. Developing a detailed software design document that outlines the architecture, features, and functionality of a proposed solution. 3. Describe a proof-of-concept prototype of the software, which could include a minimum viable product (MVP) or a demo version of the software. 4. Develop a plan for conducting user testing and gathering feedback on the prototype to evaluate its usability and identify areas for improvement. 5. Develop a plan to conduct market research to assess the potential demand for the software, identify potential customers and competitors, and estimate the size of the target market. USE CASES to analyze feasibility, a proof of concept will eventually be able to demonstrate these capabilities, using real or "realistic" fictitious data.

1. UNIVERSAL INTROSPECTION: a commander with sufficient role-based access, should be able to traverse data in the system to understand time, location, co-location, disposition, etc, of their people & assets … a) Doctrinal: does the adversary know our staging location preferences per a type of, or specific objective? b) Plan: does the adversary know our primary COA for placement of assets? c) Execution: our adversary's able to detect friendly locations in real-time d) Report: our adversary knows our own friendly account of where an asset was e) Lessons Learned: the adversary's perception of our measure of success f) Rewrite: our adversary's estimation on our plans to change based on past

2. OPSEC VISUALIZATION: Military operations are increasingly vulnerable to adversary detection due to exploitation of publicly available and open-source data. Currently the military has very few if any tools to allow military units to "see themselves" in the PAI and OSINT environment, especially as it applies to the use of contracted commercial entities. In 2020 a US Army opposing force (OPFOR) commander gave a US Army Brigade Combat Team (BCT) a visualization of their electronic signature on a simulated battlefield, as shown in "This is What Ground Forces Look Like to an Electronic Warfare System" (https://www.thedrive.com/the-war-zone/33401/this-is-what-ground-forces-look-like-to-an-electronic-warfare-system-and-why-its-a-big-deal) The BCT conducting the training was conducting its operations as intended by US Army doctrine and policy. The unit was camouflaged per standard operating procedure and in a tactical posture to avoid detection from the known means of adversary collection. Even so, the BCT was lit up like a Christmas tree in the electronic spectrum and thereby detectable to an adversary with the capability to collect in that spectrum. The signals from the BCT were attributed to unit equipment with modern features required to survive in the operational environment. They were also attributed to active radars and communications systems required to operate a brigade headquarters. Even so, the very equipment necessary for a decisive battlefield advantage also had a significant and heretofore previously unknown or unappreciated downside. Likewise, and because of the dependency on contracted commercial entities, military units may be emitting a signature in the PAI and OSINT environments that is equally detectable by an innovative adversary. These same military units may not be aware of these signatures even though they are utilizing their contracted commercial support in accordance with doctrine and policy. This research intends to relook OPSEC paradigms and investigate the potential for novel data-system design and operationalize OPSEC by allowing military units to see their signatures in the PAI and OSINT environments.

3. BIG DATA ANALYSIS: This call is for a system that not only looks inward for a rich detailed friendly force picture but provides the full range of user functions surrounding the lifecycle of that data: from doctrinal templates, to plans, execution, reporting, lessons learned, & semi-automatically implementing numerical tweaks to doctrinal templates based on the deficiency findings in lessons learned. This is a functional big data approach to providing streamlining automations on internal data. Big data analysis of external data classically requires faulty human analysis. A corresponding match of all-encompassing consolidated internal data, combined with external data & analytic models, provides widely accessible & interactive OPSEC cueing.

PHASE II: Phase II awardees will develop the proof-of-concept prototype described in the software design document developed during the Phase I. Once the prototype has achieved a minimum viable product (MVP) awardee will begin conducting user testing with warfighters such as planners at Pacific Air Forces (PACAF) or other Major Command (MAJCOM). User testing will include gathering feedback on the prototype to evaluate its usability and identify areas for improvement. MVP will preferably be delivered in the python program language and should be able to demonstrate the USE CASES define in the Phase I; 1. UNIVERSAL INTROSPECTION 2. OPSEC VISUALIZATION 3. BIG DATA

ANALYSIS

PHASE III DUAL USE APPLICATIONS: Phase III awardees will have a proof-of-concept prototype that has completed user testing in an operational warfigher environment such as an exercise held by Pacific Air Forces (PACAF) or other Major Command (MAJCOM) resulting in a TRL 7 at entry. Phase III will focus on transitioning the developed technology to multiple warfighting organizations across the Department of Defense through final refinements required to be accepted into a targeted System of Record (SoR) at TRL 9.

REFERENCES:

1. This is What Ground Forces Look Like to an Electronic Warfare System" (https://www.thedrive.com/the-war-zone/33401/this-is-what-ground-forces-look-like-to-an-electronic-warfare-system-and-why-its-a-big-deal)

KEYWORDS: Contested Logistics; OPSEC; operational contract support (OCS); contractors authorized to accompany the force (CAAF); data centric; data system schema design

SF233-0022 TITLE: Rapid ASCENT propellant loading operations

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): 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: Develop and demonstrate repeatable capability to perform ASCENT propellant loading into spacecraft at launch site in

DESCRIPTION: While commercial launch providers have dramatically enhanced US spacelift capability and decreased cost per pound to orbit, there remains a clear military necessity for responsive space access (as little as 24 hrs from notification to on-orbit capability) to support time-critical activities during contested space operations [1]. There are many challenges to achieving this capability, but two major challenges arise from the current hydrazine-based propellant infrastructure – due to the high risk to personnel, during both spacecraft/launch vehicle integration and fueling operations, all other ground operations must be halted. The development of green monopropellants, including the high-performance ASCENT green monopropellant propulsion systems [2], offers a potential opportunity to avoid the challenges posed by hydrazine toxicity to responsive space timelines. The NASA GPIM mission pioneered the development of new ground equipment and CONOPS for ASCENT [3,4]; however, the hardware developed was not transitioned to industry and CONOPS development did not result in clear, robust, widely accepted ground procedures. This proposal seeks to leverage this experience to build a responsive, robust ASCENT loading capability to support Responsive Space Access. Propellant ground support equipment (PGSE) should be capable of loading up to 200 kg of ASCENT propellant in the timeframe specified. A robust ground CONOPS (including SOPs, Checklists, and other procedures; potentially captured in digital tools) should be developed with stakeholder input from the entire Responsive Space team (launch vehicle, spacecraft – primary and secondary, range and ground safety). Particular range safety documents of concern include, but are not limited, to AFSPC Manual 91-710 [5].

PHASE I: Develop initial CONOPS and tools/communications strategy to satisfy AFSPC Manual 91-710 and other relevant documents. Interact with multiple range equities; range safety, LV provider, potentially primary payload integrators to identify timeline, interfaces, operational requirement to meet refueling timeline. Develop a business plan for potential future commercial applications.

PHASE II: Refine Phase 1 strategy, perform PGSE hardware build, and conduct refueling demonstration on non-operational system (either mockup or GFE provided hardware).

PHASE III DUAL USE APPLICATIONS: Validation with actual mission with rapid refueling of a satellite such as PUMA or TacRS-3.

REFERENCES:

1. Erwin, Sandra. (2002, May 12). Space Force to select small rocket for ‘responsive space’ mission. SpaceNews https://spacenews.com/space-force-to-select-small-rocket-for-responsive-space-mission/;

2. Kilcoin, Mackenzie, et al, "Development of ASCENT propellant thrusters and propulsion systems." Small Satellite Conference, Logan, UT, Aug 2022. ;
3. Leitz, Amanda, et al, “Propellant Loading, Pre-Flight Testing, and Launch Integration of the Green Propellant Infusion Mission” AIAA Propulsion and Energy Forum, Aug 2020, AIAA-2020-3811.;
4. Zuttarelli, Anthony, et al, “Progress in Red vs. Green Propellant Operations: ASCENT Load Operations Lessons Learned” AIAA Propulsion and Energy Forum, Aug 2020, AIAA-2020-3829.;
5. https://static.e-publishing.af.mil/production/1/ssc/publication/sscman91-710v3/sscman91-710v3.pdf (check for https://www.e-publishing.af.mil/ for latest update)

KEYWORDS: ASCENT; propellant loading; launch operations; PGSE; Responsive Space Access

AF233-0023 TITLE: High energy, multi-component, optical isolator for 2 Î¼m fiber lasers

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Directed Energy (DE)

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: Advancements in portable high energy pulsed fiber lasers will have a broad impact on the DOD and for industrial applications including medicine, material processing and remote sensing. Substantial R&D by industry in fiber technologies, thermal management, and nonlinear mitigation techniques has led to advancements in high energy, narrow-linewidth thulium-doped fiber amplifiers operating in the 2 Î¼m regime. These amplifiers continue to show great promise for improved scalability, nonlinear performance, thermal management, and atmospheric transmission. Currently, master oscillator power amplifier (MOPA) architectures using all-fiber designs are being developed and scaled to high average powers and high pulse energies. This architecture consists of multiple amplifier stages, with fiber-coupled isolators separating each stage. To reach commercial use power levels, a fiber amplifier typically consists of multiple pre-amplifier stages, which are spliced together with fiber-coupled isolators. Current isolators either have low isolation or low power handling that is not suitable for high power pulsed fiber amplifiers. Additionally, fiber amplifier designs often include other components (such as tap couplers, mode field adapters, and wavelength division multiplexers) between pre-amplifier stages which can contribute to deleterious nonlinearities such as stimulated Brillouin scattering and modulation instability. The objective will be to develop an innovative fiber-coupled isolator that will handle high average and peak powers found in 2 Î¼m pulsed fiber amplifiers. This high-power isolator should also incorporate multiple common fiber components such as tap couplers and mode field adapters in a single portable package.

DESCRIPTION: Demonstrate a production prototype version of a fiber-to-fiber isolator for pulsed fiber lasers operating from 1.9 to 2.1 Î¼m with the following capabilities: 1. average power handling greater than 100 W, 2. peak power handling greater than 100 kW, 3. pulse energy handling greater than 10 mJ, 4. high optical isolation greater than 35 dB, 5. low insertion loss less than 0.5 dB, 6. a B integral less than 1.5 rad., 7. maintain fundamental mode operation with near diffraction limited beam quality from output fiber (M2 < 1.2), 8. insensitive to input polarization, Additionally, the prototype package for the fiber-coupled isolator should be no larger than 80 mm x 50 mm x 50 mm (excluding fiber pigtails) and the design must support the inclusion of common fiber components such as fiber tap couplers and spectral filters.

PHASE I: The criteria for substantiating the proposer’s technology is at an acceptable stage when a report is provided with a prototype design and sufficient evidence that the design can support the capabilities as outlined in the description. The report will include: 1.) description and design of the multi-component, fiber-coupled isolator, 2.) list of components and fibers selected to build the prototype, 3.) theoretical, experimental or a combination of both, results supporting that the prototype design can meet the desired capabilities listed in the Topic Description. Such results may include: a.) damage threshold calculations and measurements supporting that the components can handle the peak powers and energies, b.) thermal lensing calculations and measurements justifying the selection of the Faraday rotator, c.) calculations and measurements of optical nonlinearities (such as self-focusing, B integral for modulation instability, and stimulated Brillouin scattering) for components and fiber pigtails, d.) calculations and measurements that the prototype package can the heat loads due to high average powers.

PHASE II: The awardee will demonstrate the performance of a prototype, multi-component, fiber-coupled isolator that meets the specifications in the Topic Description. The intent is to deliver the working prototype to AFRL/RDLT for assessment and testing

PHASE III DUAL USE APPLICATIONS: The awardee will work with RDLT and industry partners to make their isolator design available to the DoD customer base as well as DoD industrial partners.

REFERENCES:

1. G. Stevens, A. Robertson, "Fibre laser component technology for 2-micron laser systems," Proc. SPIE 9135, Laser Sources and Applications II, 91350N (1 May 2014).

KEYWORDS: optical isolator; Faraday rotator; fiber laser components

AF233-0024 TITLE: Optical Fiber Combiner for Combining MWIR Quantum Cascade Laser Beams

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Directed Energy (DE)

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: An optical fiber combiner that has demonstrated the ability to receive power from seven or more quantum cascade lasers emitting at a wavelength between 4.5 and 5 micrometers. The total output power from the optical fiber combiner should exceed 80% of the total power input by the combined quantum cascade laser collection as measured at the facets of the lasers without additional optical components, accounting for coupling from laser to fiber, coatings, fiber losses, and other sources of loss systemic to the use of the optical fiber combiner. The optical fiber combiner will be designed in such a way as not to undergo damage or degradation while outputting a sustained average power of up to 60 Watts.

DESCRIPTION: As the commercial availability of quantum cascade lasers grow in the 1-3 Watt class, it becomes possible to project a MWIR signal in a compact fashion over distances on the order of kilometers. Greater distances require greater amounts of combined power. To quickly achieve an order of magnitude increase in signal strength for distance propagation, it s necessary to combine the output of multiple devices. Currently, materials used for MWIR fibers are chalcogenides, tellurites, and hollow cores. The losses included in coupling the highly divergent beam of the quantum cascade laser, reflection, and inherent absorption of the fibers lead to a nontrivial amount of loss of the input signal. To achieve long distance propagation of MWIR signal, it is desirable for a collection of quantum cascade lasers with synchronized inputs to have a combined output delivered by a fiber to a beam director. An optical fiber combiner maintaining a large degree of power would be advantageous for applications lacking a strict beam quality requirement, such as target acquisition and illumination systems. The goal of this topic is to produce a commercially viable optical fiber combiner usable as a component of a larger MWIR beam delivery system for long distance directed energy applications. The work involved should include a demonstration of utilizing seven or more commercially available quantum cascade lasers to effectively combine the power of the collection of lasers at a single output fiber. The power measured at the output should retain at least 80% of the sum of the power of the collection of lasers as measured before integration in the combined system, using the same driving setpoint for both measurements.

PHASE I: Phase I awardees will be expected to provide a study on fiber materials, coatings, coupling of the quantum cascade laser produced beam (of a wavelength between 4.5-5 micrometer) into fiber, and fiber combining scheme projecting the feasibility of the combiner system output to retain 80% of the total power introduced into its inputs.

PHASE II: Phase II awardees will be expected to accomplish fabrication and demonstration of the optical fiber combiner system using commercially available quantum cascade lasers, demonstration and measurement of power at output compared to the sum of the power of the component lasers before combining, and delivery of an optical fiber combiner.

PHASE III DUAL USE APPLICATIONS: Phase III awardees will be expected to engage in commercial production of optical fiber combiners for integration into systems requiring the combined power of multiple MWIR sources.

REFERENCES:

1. Francois Chenard, Oseas Alvarez, Hassan Moawad, "MIR chalcogenide fiber and devices," Proc. SPIE 9317, Optical Fibers and Sensors for Medical Diagnostics and Treatment Applications XV, 93170B (5 March 2015); https://doi.org/10.1117/12.2085056;
2. Dan L. Rhonehouse, Jie Zong, Dan Nguyen, Rajesh Thapa, Kort Wiersma, Chris Smith, Arturo Chavez-Pirson, "Low loss, wide transparency, robust tellurite glass fibers for mid-IR (2-5 Î¼m) applications," Proc. SPIE 8898, Technologies for Optical Countermeasures X; and High-Power Lasers 2013: Technology and Systems, 88980D (15 October 2013); https://doi.org/10.1117/12.2033925;
3. Jason M. Kriesel, Nahum Gat, Bruce E. Bernacki, Rebecca L. Erikson, Bret D. Cannon, Tanya L. Myers, Carlos M. Bledt, James A. Harrington, "Hollow core fiber optics for mid-wave and long-wave infrared spectroscopy," Proc. SPIE 8018, Chemical, Biological, Radiological, Nuclear, and Explosives (CBRNE) Sensing XII, 80180V (3 June 2011); https://doi.org/10.1117/12.882840;
4. Zhili Li, Chao Shi, and Wei Ren, "Mid-infrared multimode fiber-coupled quantum cascade laser for off-beam quartz-enhanced photoacoustic detection," Opt. Lett. 41, 4095-4098 (2016);
5. J. Sanghera, W. Kim, C. Baker, S. Bayya, V. Nguyen, D. Gibson, G. Villalobos, M. Hunt, J. Myers, B. Shaw, R. Gattass, J. Frantz, L. Busse, S. Bowman, J. Friebele, I. Aggarwal, and D. Rhonehouse, "Infrared Materials and Fiber Optics," in 2017 European Conference on Lasers and Electro-Optics and European Quantum Electronics Conference, (Optica Publishing Group, 2017), paper CE_9_1.

KEYWORDS: MWIR; Fiber optics; Optical fiber combiner; QCL

AF233-0025 TITLE: High bandwidth, low latency wavefront sensing for airborne directed energy applications

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Directed Energy (DE)

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 Air Force requires a wavefront sensing technology that has the capability of operating at or above 250 kHz. While operating at 250kHz the wavefront sensor must simultaneously sample at least 20 points in both spatial directions and have suitable dynamic range and sensitivity for airborne applications. The proposed wavefront sensor must be designed to operate in the near infrared. In addition, the wavefront sensor body must occupy a volume no larger than 216 in^3. An additional packaged electronics allocation with a volume no larger than 72 in^3 is permitted. The chosen concept is to be proven by prototype with follow-on build of pilot system and demonstration within the laboratory environment.

DESCRIPTION: The Air Force requires a wavefront sensing technology that has the capability of operating at very high bandwidth. This technology would enable long range airborne high energy laser weapon systems operating in tactical environments. For an aircraft in flight, the turbulent flow around the aircraft creates a complex time dependent density field. This complex time dependent density field changes the index of refraction near the aircraft. The dynamic index of refraction field distorts an outgoing laser and severely limits on target intensity. This reduction in intensity on target degrades system performance. The problem outlined above is the so-called aero-optics problem. One potential solution to the aero-optics problem would be the inclusion of higher order adaptive optics to compensate the phase distortions caused by the turbulent flow field. Unfortunately, It has been demonstrated that latency is a significant performance degrader for adaptive optics in airborne directed energy systems1, 2. Current state-of-the-art technology in wavefront sensing inhibits the use of higher order adaptive optics for the compensation of high frequency (spatial and temporal) content. Traditional approaches are limited to compensating only the pseudo-steady lensing effect caused by the turbulent flow field. This SBIR topic seeks the development of a wavefront sensing technology that meets the challenging performance, size, weight, and power requirements demanded by an airborne integration of a high energy laser system. The minimum operating threshold for the sampling frequency of this wavefront sensor is 250 kHz. If successful, this SBIR could provide an absolutely critical component needed for all airborne directed energy systems into the future. In the wider DoD such a sensor could provide very significant improvements over the state-of-the-art for actively illuminated reconnaissance applications. As for commercial applications, this device could provide unprecedented capabilities for non-invasive flow measurements in the wind tunnel environment. A market exists in the commercial space at research institutions and Universities interested in high speed flow measurement.

PHASE I: Develop a concept for a high bandwidth wavefront sensor with an established path toward meeting frame rate, sensitivity, dynamic range, size, weight, and power requirements. Using appropriate modeling and simulation, establish the technical feasibility of the approach and establish estimates for bandwidth, dynamic range, sensitivity, size, and weight of the device. Furthermore, perform radiometric analysis establishing the feasibility of the wavefront sensor given current state-of-the-art specifications of laser illuminators. A sample of target requirements for this design are as follows: Bandwidth (threshold): 150 kHz Bandwidth (objective): 250 kHz Sensor Volume (threshold): 360 in^3 Sensor Volume (objective): 216 in^3 Electronics Volume(threshold): 108 in^3 Electronics Volume(objective): 72 in^3 Sensor Weight (threshold): 20 lbs Sensor Weight (objective): 15 lbs

PHASE II: Complete the design of a wavefront sensor prototype complete with any required electronics subsystem. The prototype wavefront sensor should present a clear engineering path toward the objective requirements outlined in the topic description if they are not explicitly met by the prototype. The prototype must be packaged in a state that would enable suitable laboratory testing. The wavefront sensor must be delivered to a DoD laboratory where it will be independently tested against a state-of-the-art Shack-Hartmann Wavefront Sensor. This testing will establish any improvement the new technology presents for the Air Force. A sample of target requirements for this prototype are as follows: Bandwidth (threshold): 150 kHz Bandwidth (objective): 250 kHz Sensor Volume (threshold): 360 in^3 Sensor Volume (objective): 216 in^3 Electronics Volume(threshold): 108 in^3 Electronics Volume(objective): 72 in^3 Sensor Weight (threshold): 20 lbs Sensor Weight (objective): 15 lbs

PHASE III DUAL USE APPLICATIONS: Phase III should focus on transitioning the prototype developed in Phase II to a commercial product. As such, the wavefront sensor should be packaged in a robust housing suitable for the flight environment. Any objective requirements not met in Phase II, should be met by the packaged Phase III pilot device. In addition, tooling and manufacturing processes required for commercialization shall be developed. Finally, the Air Force will assist the vendor in transitioning their compact high speed wavefront sensor to DoD wind tunnel facilities interested in performing aero-optic experiments. Additionally, a market exists to transition such high speed cameras to a multitude of University wind tunnel facilities interested in high speed flow dynamics. A sample of target requirements for this prototype are as follows: Bandwidth (threshold): 150 kHz Bandwidth (objective): 250 kHz Sensor Volume (threshold): 360 in^3 Sensor Volume (objective): 216 in^3 Electronics Volume(threshold): 108 in^3 Electronics Volume(objective): 72 in^3 Sensor Weight (threshold): 20 lbs Sensor Weight (objective): 15 lbs

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KEYWORDS: Wavefront Sensor; Aero-Optics; Directed Energy; Adaptive Optics; Beam Control

AF233-0026 TITLE: Compact High Power Microwave Antenna

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Directed Energy (DE)

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 SBIR is to design, build, and test high frequency, high gain antennas for High Power Microwave (HPM) applications. These new antennas would open up a new capability for HPM by allowing the HPM system to use already existing apertures on airborne platforms. This would prevent the need to change the outer mold line of an airborne platform which aids in speeding up the flight certification. There are three main goals for the antenna design from this effort. The first goal is a compact mechanically or electrically phased antenna. At the end of the Phase III, the desired end state would be a full design, to include both electromagnetic simulations and mechanical drawings, as well as hardware that could be tested. The second goal would be for the antenna to be broadband and cover the entire X-band. The desired end state of the Phase III of this effort would be a full design, to include both electromagnetic simulations and mechanical drawings. The third goal would be to reduce antenna sidelobes, maximizing the power of directed energy and reducing collateral damage. The first goal is a compact mechanically or electrically phased antenna. At the end of the Phase III, the desired end state would be a full design, to include both electromagnetic simulations and mechanical drawings, as well as hardware that could be tested. The second goal would be for the antenna to be broadband and cover the entire X-band. The desired end state of the Phase III of this effort would be a full design, to include both electromagnetic simulations and mechanical drawings. The third goal would be to reduce antenna sidelobes, maximizing the power of directed energy and reducing collateral damage.

DESCRIPTION: The goal of this topic is the development of a phased array antenna suitable for HPM sources at GW power levels that are broadband with minimal sidelobes. Phased antennas have the benefit of reduced size, weight and power (SWaP) due to their low profile, potential conformal geometries to meet host platform requirements, and their ability to provide beam steering via phase shifting of their elements rather than bulk antenna movement. Phase shifting may be achieved by means of mechanical actuators (e.g. physical manipulation of individual elements), or by means of controlling the electromagnetic fields at each element (e.g. high power phase shifters). A broadband antenna that can cover the entire X-band (8-12 GHz) with instantaneous full bandwidth is highly desired, but a tunable bandwidth covering this frequency range is acceptable. A wide bandwidth, high gain, steerable antenna will enable the next generation of HPM systems to deliver enhanced effects against a broader selection of targets. Sidelobes on HPM systems waste energy and can produce collateral damage. There are well known techniques to reduce sidelobes, but they often come at the expense of increased local electric fields in the antenna. New antenna designs, new manufacturing techniques, lensing and understanding of the local discharge breakdown systems can be utilized to dramatically reduce these sidelobes. Modeling HPM antennas as a complete system enables the analysis and design of antenna systems to reduce sidelobes while also reducing antenna hotspots. Advanced material design using new 3D metal manufacturing techniques can produce antennas with better wear conditions and focusing abilities and allow for expanded manufacturing design options. Lensing systems can be developed to improve HPM focusing. Better understanding of local discharge breakdown phenomena through modeling can inform the design process to further improve the system.

PHASE I: The awardee must demonstrate through electromagnetic simulation a phased array antenna with a threshold gain of 24 dBi and an objective gain of 30 dBi of gain across the frequencies within the X-band (8-12 GHz). The antenna shall be phase steerable with at least plus or minus 20 degrees in both azimuth and elevation. The antenna must be able to handle a threshold power of 20 megawatts per square meter with an objective power handling of 100 megawatts per square meter. The awardee must create models of the improvement in performance of proposed new antenna designs and systems, analyze the tradeoffs of sidelobe reduction and hotspot generation, and correlate new manufacturing and materials development with the modelling in order to design a system that optimizes power delivery and reduces material wear.

PHASE II: The awardee shall design, build, and demonstrate a single element of the phased array antenna designed in Phase I. The module shall demonstrate all electromagnetic parameters needed in order to satisfy the full array requirements described in Phase I. The awardee shall work on improving the full array design to include customer requirements for platform and source integration, as well as determine the limiting factors and trade-offs as it relates to frequency bandwidths, steerability (precision, slew rates, and angular limits), and power handling. Verify sidelobe reduction, reduction of wear and increase of delivered power.

PHASE III DUAL USE APPLICATIONS: The awardee shall design, build, and demonstrate a module of at least 5 elements suitable for incorporating into the full array designed in Phase I and II. This module shall demonstrate all electromagnetic parameters needed in order to satisfy the full array requirements described in Phase II. The awardeshall provide the cost and schedule to fabricate and demonstrate the full phased array antenna. The awardee shall deliver a complete technical data package for the full array to include all electromagnetic simulations and manufacturing-ready drawings. Explore potential to transfer the technology to military high power electromagnetic and Electronic Warfare systems, as well as civilian communication and radar systems. Work with DoD primes and industry partners to identify other applications for the technology.

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KEYWORDS: HPM; 3D manufacturing; Antenna Design; Discharge Breakdown; Sidelobe Reduction; Antenna Materials; Antenna Lensing; high power microwave

AF233-0027 TITLE: Combiner Architectures for Maximum Brightness Fiber Laser Amplifier Pumping

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Directed Energy (DE)

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: State of the art Yb doped fiber amplifiers (YDFAs) with low size, weight, and power (SWaP) depend heavily on the availability of low SWaP pump diodes to meet their size, weight, and power targets. High power YDFAs have historically used (6+1)x1 fiber taper bundle combiners in a co-pumped configuration, but there is evidence that this area of fiber amplifier power scaling could be refined to bring lower cost and/or higher power. Current topics in combiner design include: (1) counter-pumped combiners to reduce amplified spontaneous emission (ASE), spread the inversion profile of the gain fiber and/or support bidirectional gain fiber pumping. (2) tandem pumped co-pumped and counter-pumped combiner configurations to spread the inversion of the gain fiber across multiple fibers and reduce gain per stage. (2) combiners with higher channel count (e.g. (7+1)x1 and (8+1)x1) to reach record powers. Etendue conservation calculations suggest that channel count might be considerably increased from (6+1)x1 without a significant increase in loss. Both approaches lead to increased power, should be further explored, and are mutually inclusive. Due to the manufacturing challenges and risks of making high power pump diodes with many single emitters, higher channel count means that an amplifier could make use of more inexpensive pump diodes. Such a combiner design may lead to lower overall system cost at state-of-the-art performance. An optimized bidirectional combiner design which is also optimized to maximize brightness conservation is likely to benefit both next generation directed energy weapons at 1.03-1.07 um wavelength as well as the commercial laser material processing industry. Cost per watt and material processing speed are key metrics for commercial systems using high power YDFAs.

DESCRIPTION: Demonstrate a production prototype of a combiner architecture for a fiber laser amplifier for use with existing commercial off the shelf (COTS) pump diodes. The combiner architecture should support an amplifier design with at minimum 50% more pump power in the gain fiber than existing state-of-the-art Yb laser systems (see references) and operate with minimum loss of brightness in the combiner.

PHASE I: The awardees will provide a set of combiner designs, a trade space survey, and simulation justifying a design for a (N+1)x1 combiner architecture in the context of an amplifier which can meet the high power constraint laid out in the Topic Description. The awardees will also provide a plan to produce the (N+1)x1 combiner(s) necessary to employ the architecture.

PHASE II: The awardees will develop manufacturing for and demonstrate a (N+1)x1 combiner handling power consistent with the Topic Description with less than 0.1 dB insertion loss. The performer will also demonstrate combiner handling of 15% of forward power in the reverse direction. The awardees will conduct experiments detailing the forward and backward power handling limitations of the combiner, separating manufacturing challenges from fundamental physical limits. The net loss of brightness will be examined and performance limits will be explicitly discussed. Finally, the awardees will deliver four prototype combiners to AFRL/RDLT.

PHASE III DUAL USE APPLICATIONS: Awardees will commence packaging and development work to refine thermal handling and increase the manufacturability of the (N+1)x1 combiner to commercially viable levels, delivering at least 10 units to AFRL/RDLT.

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KEYWORDS: High Power Combiner; Combiner Architecture; Brightness optimization; Directed Energy; Fiber Optics; Combiner;

AF233-0028 TITLE: L-Band Buncher/Modulator for X-Band Accelerator

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Directed Energy (DE)

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: Deliver a compact (up to 2m), high current, L-band modulator/buncher with broad bandwidth (>20% fractional bandwidth) capability to the Air Force Research Laboratory (AFRL). This capability is beyond the scope of what has traditionally been done with bunchers since providing a broad bandwidth is atypical. The buncher/modulator should be designed such that it is optimized to provide L-band modulated electron beams of arbitrary waveform (given Fourier limitations) to a state-of-the-art X-band accelerator (peak beam current 75-250 mA delivered over a 3 us macropulse with length of ~1m). Designs should provide consistent capture efficiency (>25%) going into the X-band accelerator across a variety of lower frequency (DC through L-band) modulated electron beams. The current to the accelerator should ensure that the accelerator can output 75-250mA. This design should include a transition into X-band cavities such that it is integrable with an X-band accelerator.The design should provide broadband modulation within L-band to an input electron beam with arbitrary amplitude modulation containing frequency content from DC to 1 GHz. Designs can include advances in cathodes - the requirement is that they can be operated such that modulated high frequency electron pulses are possible and integrable with X-band buncher/accelerator cavities.

DESCRIPTION: The performance of this work should include extensive modeling/simulation/theory of modulator/buncher designs and methods for integration with X-band accelerator cavities. This could include use of software such as HFSS and CST for full wave electromagnetic design, Parmela, ASTRA, GPT, and TRACK for particle tracking, and particle-in-cell software such as CST, Hellweg, or MAGIC for self-consistent study of beam dynamics. Those advancing to Phase II will need to fabricate the modulator and integrate it with an X-band accelerator. Final beam acceleration tests can be performed at AFRL's facilities and will include measurements of key performance parameters such as degree of modulation, bandwidth, and capture efficiency. Improvements to design may be required. Those advancing to Phase III will need to refine their designs, scale them from L-band to S-band and integrate the new design with the X-band accelerator. Final beam acceleration tests for Phase III will proceed as in Phase II with emphasis on key performance parameters.

PHASE I: Phase I awardees should design and simulate an L-band modulator/buncher which can effectively produce arbitrary amplitude, L-band modulation on arbitrary input waveforms with frequency from DC to 1 GHz. Designs must be scalable to higher frequency bands. Various approaches can be taken with the design and may include cavities and waveguides (including folded waveguides, tapered bunchers, etc.), or multi-section bunchers incorporating both and other elements such as choppers. Input beams to the modulator should be modulated through gridded or gridless cathodes, modulated photoinjection into accelerator/buncher cavities or any other viable techniques, which can produce distinct and arbitrary on/off cycles from DC to 1 GHz. Required performance parameters will include bandwidth of operation and degree of modulation and should be addressed with modeling/simulation/theory. Other key performance parameters will vary by design choice but should be demonstrated using theory/simulation. Examples of key performance parameters could include shunt impedance, current/current density handling, capture coefficient/efficiency, length of modulator/buncher section and plots of phase space. The modulator/buncher should not exceed 2m in length in order to maintain compactness. A transition between the modulator and X-band accelerator cavities should be designed such that there is minimal loss of electrons/energy. Full-wave, particle-in-cell analysis of electron propagation and electromagnetic fields should be performed showing performance across L-band. Identify commercial off-the-shelf components including electron gun, pulsed power, L-band RF amplifier or oscillators, or design in-house system(s). Provide quarterly reports to AFRL and write a final Phase I report presenting the modulator design and all modeling, simulation, and theory work (including raw data) indicating the device's progress towards meeting Topic Objectives. Provide a plan to carry out Phase II.

PHASE II: Phase II awardees should fabricate modulator designs and purchase/build electron guns, pulsed power supplies, L-band RF sources, or other required equipment to experimentally demonstrate buncher design. Designs can be demonstrated using limited frequency points (e.g. 2 frequencies which represent performance for the full bandwidth). Experiments should demonstrate feasibility of modulator and data for key performance parameters as described in Phase I should be collected and compared to theory/simulation. Designs should be optimized through experimentation to match, as near as possible, the theoretical/computational results. Final integration of modulator with X-band accelerator may be performed in AFRL's facilities. Quarterly reports should be sent to AFRL. A final report should be written to include modulator design, verification of all required/key performance parameters including raw data, standard operating procedures, and analyses of experiments vs. simulation/theory. A plan for Phase III should be provided.

PHASE III DUAL USE APPLICATIONS: Phase III awardees will refine their designs and scale the modulator to S-band. The system may also be integrated onto a ruggedized platform for field testing. Improvements to system performance may be required. Quarterly reports to AFRL should be written discussing design and integration of modulator and accelerator and overall performance of the modulator/accelerator system. A final report will be delivered to AFRL which will include a summary of all work performed in Phase III.

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KEYWORDS: Buncher; Modulator; Linear accelerator; RF Linac; Electron Beams; Directed Energy

AF233-0030 TITLE: Energy-Aware Autonomy for Air Vehicles

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: This topic seeks to develop, mature, apply and advance innovative ideas to control, manage and extend the electrical power and thermal capabilities of an unmanned air vehicle (UAV) through energy aware autonomous algorithms. The effort can focus across a broad range of flight phases or focus on just a few. Flight phases that the proposal could investigate but are not limited to include 1) pre-flight planning, 2) ground operations, 3) terminal area operations, 4) climbing, 5) cruising, 6) mission area, 7) return, or 8) post-flight. Potential energy aware autonomous algorithms may include, but are not limited to, 1) path planning (offline and online), 2) task planning for single vehicle level and/or multi-vehicles, 3) energy contingency management (e.g., causing the electrical system to prioritize actuation energy needs due to sudden wind gusts while landing.), 4) prediction of electrical, thermal, and fuel usage throughout flight phases, 5) optimal formation flying for energy improvements, 6) intelligent electrical startup, and 7) energy run-time assurance. These algorithms could include various artificial intelligent methods, though other methods could be considered.

DESCRIPTION: In the military space, growing mission demands (i.e., electronic warfare, advanced sensing, etc.) along with the practical constraints imposed on the size, weight, and power of the energy subsystems of an autonomous vehicle limit the vehicle executing its mission. In the commercial space, optimization of flight paths and energy usage for long endurance package delivery will be needed. Further, vehicles such as electric vertical take-off and landing air taxis require management of energy resources to ensure passengers can safely get to where they need to go in a climate-controlled environment while minimizing fuel usage. In the current state of the art of vehicle power and thermal management, the energy subsystems have only limited communication with autonomy system/pilot and vehicle systems. As a result of this limited information sharing a strategy should be developed to integrate the capabilities of various electrical power and thermal subsystems of the vehicle with appropriate autonomy algorithms to ensure the vehicle can meet its goals. There are two levels of autonomy that could be investigated within this work. The first is a level of autonomy at the vehicle level in which sharing between the mission systems, the air vehicle systems, the autonomous algorithms, and the energy systems (including electrical, thermal, and engine systems) would occur to improve overall capability of a single vehicle. The second level of autonomy exists at the battlefield or mission space. It will integrate the power and thermal performances of each air vehicle across the fleet of multiple UAVs computing trajectory and task assignments based on a operator’s intent. In so doing, energy is managed across the battlefield allowing the operator to choose the asset most likely to complete the mission. For example, the pre-flight mission task could include planning for a fleet of UAVs that considers the total energy of each vehicle and its capabilities in the fleet for individual task assignment. Similarly, in-flight contingency planning will involve flight paths and alternate landing sites (down range landing or return to launch site landing) suitable for each vehicle. In the commercial realm, choosing an appropriate taxi to fulfill a customer need before depleting its energy capabilities would be important.

PHASE I: Proposals should include description of work previously done in this area along with a description of which portions of the problem the effort will be focused on. The focus of Phase I should be on development of use cases. The use cases should include relevant benefits that will be achieved, the information that will need to be exchanged between other system(s), and generally describe behaviors that will occur. Discussions with various stakeholders should occur to ascertain the feasibility of the use cases.

PHASE II: Proposals should include further development and maturation of Phase I results for the energy aware algorithms. During Phase II, based on the use cases developed in Phase I, algorithms should be developed and implemented to demonstrate the efficacy of the algorithms. Working with AFRL, relevant models of systems could be incorporated with those algorithms to evaluate the benefits outlined in the use cases.

PHASE III DUAL USE APPLICATIONS: Commercial applications could include use of the energy aware autonomy algorithms for a UAV that is assigned delivery package. Flight routes could be computed according to its available electric power and thermal capabilities to ensure delivery success, public safety, and residential restrictions. Other applications include air taxis or electric Vertical Takeoff and Landing (eVTOL) aircraft that will want to optimize energy usage. Phase III military applications could include use of energy aware autonomy algorithms on unmanned vehicles with relatively large payloads to extend mission capabilities.

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KEYWORDS: Air vehicle; autonomy; energy management; thermal management; electrical power management; artificial intelligence; energy aware autonomy

AF233-0032 TITLE: Design AF DCGS Next Gen Enterprise IT systems using 5G Technology for Low to Zero Maintenance

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

OBJECTIVE: Design AF DCGS Next Gen Enterprise IT systems using 5G Technology for Low to Zero Maintenance

DESCRIPTION: The DCGS Next Generation (DCGS Next Gen) delivers a new advantage to the Air Force and its Airmen. Due to the transition from COIN/C-VEO to Great Power Competition, the previous DCGS model no longer offers sufficient capability to produce the needed intelligence and outcomes to counter evolving adversary threats. DCGS Next Gen answers that by enabling analysts to fuse multi-source intelligence and merge into the newest efforts of ABMS and JADC2 to provide decision advantages at all levels. AF DCGS PMO is looking at a breakthrough in 5G Technology and an innovative way to sustain enterprise IT systems beyond existing DOD acquisition strategy today.

PHASE I: Develop a conceptual design for AF DCGS Next Generation (DCGS Next Gen) using 5G Technology and an innovative way to sustain enterprise IT systems. Deliverables include a report or presentation demonstrating the conceptual design and a path forward for Phase II. Develop Modernize AF DCGS 5G Networks to include survivable software mesh topology, prioritized traffic, quality of service (QoS), intelligent routing, flattened converged networks and computing at the tactical edge using SD-WAN. All means of transport, to include commercial 5G cellular/satcom/WIFI will be utilized for maximum resilience while maintaining the security of the data at all classifications. Manage and maintain a new generation of connected devices, wireless networks, and edge computing to ensure the highest standards of mission continuity

PHASE II: Develop and demonstrate a proof-of-concept prototype system based on the preliminary design from Phase 1. Demonstarte proof of concept , Modernize AF DCGS 5G Networks to include survivable software mesh topology, prioritized traffic, quality of service (QoS), intelligent routing, flattened converged networks and computing at the tactical edge using SD-WAN. All means of transport, to include commercial 5G cellular/satcom/WIFI will be utilized for maximum resilience while maintaining the security of the data at all classifications. Manage and maintain a new generation of connected devices, wireless networks, and edge computing to ensure the highest standards of mission continuity.

PHASE III DUAL USE APPLICATIONS: The path for transition is to mature the prototype developed in Phase 2 by delivering phased incremental improvement until fully operational. Delivering phased incremental improvement until fully operational AF DCGS 5G Networks to include survivable software mesh topology, prioritized traffic, quality of service (QoS), intelligent routing, flattened converged networks and computing at the tactical edge using SD-WAN. All means of transport, to include commercial 5G cellular/satcom/WIFI will be utilized for maximum resilience while maintaining the security of the data at all classifications. Manage and maintain a new generation of connected devices, wireless networks, and edge computing to ensure the highest standards of mission continuity

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3. https://www.cto.mil/wp-content/uploads/2020/05/DoD_5G_Strategy_May_2020.pdf

KEYWORDS: 5G; ABMS; JADC2

AF233-0033 TITLE: Synthetic Weather Environment Injection

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

OBJECTIVE: Tailored synthetic weather is required for the purposes of DoD exercises, training, and simulation. As examples, weapon systems Program Offices require synthetic weather to support Digital Engineering to help obtain required performance in the natural operations environment. Also, most live, virtual, and/or constructive military training and exercises require tailored synthetic weather to provide forces and systems the opportunity consider the impacts of the environment in planning and executing mission. Weapon system flight and mission planning systems also have needs for synthetic weather injects. Current AF Weather systems cannot produce or process this synthetic weather.

DESCRIPTION: Tailored synthetic weather is required for the purposes of DoD exercises, training, and simulation. As examples, weapon systems Program Offices require synthetic weather to support Digital Engineering to help obtain required performance in the natural operations environment. Also, most live, virtual, and/or constructive military training and exercises require tailored synthetic weather to provide forces and systems the opportunity consider the impacts of the environment in planning and executing mission. Weapon system flight and mission planning systems also have needs for synthetic weather injects. Current AF Weather systems cannot produce or process this synthetic weather.

PHASE I: Develop a conceptual design for a tool that can generate synthetic weather data and propose means to inject synthetic weather. Identify DoD applications that could utilize synthetic weather to support training, exercises, and/or simulations. Deliverables include a report or presentation demonstrating the conceptual design and a path forward for Phase II.

PHASE II: Develop and demonstrate a proof-of-concept Synthetic Data Generation & Injection prototype system based on the preliminary design from Phase I.

PHASE III DUAL USE APPLICATIONS: Demonstrate the prototype system delivering synthetic weather data to a set if customers utilizing simulations and virtual exercises. Upon successfully supporting external customers, lay out plan to operationalize the prototype.

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KEYWORDS: synthetic weather; Modeling; Simulation; M&S; Live; Virtual; Constructive; LVC; Digital engineering; environment; exercises; training; numerical; prediction; forecast; data; generation

AF233-0034 TITLE: Creating a digital twin of legacy aircraft

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Advanced Computing and Software;Integrated Sensing and Cyber;Trusted AI and Autonomy;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: The topic objective is to develop a faster, more cost-effective way to integrate new equipment at the system design/digital engineering level by creating a digital twin of the B-52H legacy aircraft system. This digital twin will include CAD models and SysML models, and be connectable to various models in different systems. The end state of this project is to have a digital engineering environment that is dynamically connected to an accredited simulation environment, enabling seamless integration of digital engineering models with other systems/products. To achieve this objective, industry players will be asked to propose a solution for creating a digital twin of a legacy system.

DESCRIPTION: The topic objective is to develop a faster, more cost-effective way to integrate new equipment at the system design/digital engineering level by creating a digital twin of the B-52H legacy aircraft system. This digital twin will include CAD models and SysML models, and be connectable to various models in different systems. The end state of this project is to have a digital engineering environment that is dynamically connected to an accredited simulation environment, enabling seamless integration of digital engineering models with other systems/products. To achieve this objective, industry players will be asked to propose a solution for creating a digital twin of a legacy system.

PHASE I: Define a system concept, perform a feasibility study, and propose an solution for creating a digital twin of the B-52 legacy system. 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 the Phase II SBIR project will be to further develop the digital twin of a legacy aircraft for equipment integration and testing 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 aircraft 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 its functionality. Integration of New Equipment The digital twin will be used to simulate the integration of new equipment with the aircraft. The simulation will involve testing the new equipment in different scenarios to identify potential issues and make necessary modifications. Testing The digital twin will undergo rigorous testing to ensure its accuracy and functionality. The testing will involve simulating a wide range of scenarios, including extreme weather conditions, equipment failures, and system malfunctions. Success Criteria The success criteria for this project will be the creation of a well-defined deliverable prototype that accurately simulates the installation of new equipment and changes to the aircraft's systems. The prototype should be able to simulate a wide range of scenarios, including equipment integration and testing, extreme weather conditions, equipment failures, and system malfunctions, and be validated through comparison to the actual aircraft. 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 digital twin prototype will be able to simulate a wide range of scenarios, including equipment integration and testing, extreme weather conditions, equipment failures, and system malfunctions. The prototype will be validated through comparison to the actual aircraft, and its accuracy and functionality will be tested in a wide range of scenarios. The prototype will also be tested to ensure its compatibility with different equipment and systems. Additionally, the prototype will be tested for ease of use and user-friendliness. Conclusion The success of the Phase II project will result in a well-defined deliverable prototype of the digital twin of a legacy aircraft for equipment integration and testing. The prototype will be able to simulate a wide range of scenarios and be validated through comparison to the actual aircraft. The prototype will provide a safer, more efficient, and cost-effective way to test and integrate new equipment with legacy aircraft. Finally, the commercialization potential of this project is significant, with a potential market among aerospace companies, government agencies, and military organizations.

PHASE III DUAL USE APPLICATIONS: The objective of the Phase III/Dual Use SBIR project will be to develop and commercialize the digital twin of a legacy aircraft 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 developing and commercializing the digital twin technology 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 digital twin will have been tested and validated in a wide range of scenarios, and its accuracy and functionality will have been demonstrated through comparison to the actual aircraft. 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

REFERENCES:

1. GAO-23-106453

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

AF233-0035 TITLE: Readiness Spares Package (RSP) Optimization

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

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OBJECTIVE: Develop a software solution for optimizing the packing time of Readiness Spares Packages (RSP) deployment, with maintenance and load planning actions considered. The solution should be agile and incorporate activity tracking for pack-out operations, and should provide detailed level 4 data for each pallet and ISU needed for packout, based on input of NSNs and UTC data from HQ. One goal is to reduce the current 14-day packing time to 3 days from notification. Another goal is to maximize the space needed to be utilized when building packages for deployment

DESCRIPTION: Readiness Spares Packages (RSP) are pre-positioned spares that enable quick response to a crisis or contingency. The RSPs are typically stored in a containerized system, which can be rapidly deployed to a forward location. However, the current process for packing and deploying RSPs is time-consuming and involves manual processes that are prone to error. This topic seeks to develop a software solution that can optimize the packing time of ISU-90s and 463L pallets for deployment, with maintenance and load planning actions considered. The solution should be agile and incorporate activity tracking for pack-out operations, and should provide detailed level 4 data for each pallet and ISU needed for packout. Proposed solutions should include a software solution that can efficiently and accurately manage the packing process of ISU-90s and 463L pallets for deployment. The solution should be capable of taking NSNs (along with their packing dimensions and weight) and UTC data from HQ and generating a detailed plan for each pallet and ISU needed for packout. The solution should also be agile and incorporate activity tracking for pack-out operations, to ensure that the process is efficient and effective. Maintenance and load planning actions should be considered, to ensure that the spares are properly stored and transported, and that maintenance actions are scheduled and completed as needed.

PHASE I: Phase I is used for determining the scientific and technical merit and feasibility of the proposed technology. The Phase I Period of Performance objectives for the RSP Optimization for Efficient Deployment SBIR topic are to develop a concept for a software solution for optimizing the packing time and space of ISU-90s, 463Ls, and custom tire racks for deployment. The concept should include a detailed description of the proposed software solution, including its features and functionality, and a plan for testing and validating the solution. The Phase I objectives also include developing use cases and establishing operating parameters for the proposed software solution. The use cases will be used to determine the effectiveness and efficiency of the solution in various deployment scenarios. The operating parameters will define the inputs, outputs, and conditions under which the software solution will operate, ensuring that it meets the needs and expectations of users. In addition, the Phase I objectives include developing a plan for testing and validating the software solution. This plan should include a detailed description of the testing methodology, including the types of tests to be performed and the metrics used to evaluate the performance of the software solution. The plan should also include a timeline for testing and validating the solution, as well as a description of the resources required to complete the testing and validation process. Phase I deliverables should include a report summarizing the proposed approach and a plan for testing and validating the software solution. The report should provide a detailed description of the proposed software solution, including its features and functionality. It should also include a description of the use cases and operating parameters established during the feasibility analysis. Finally, the report should describe the testing and validation plan, including the methodology, timeline, and required resources. In summary, the Phase I Period of Performance objectives for the RSP Optimization for Efficient Deployment SBIR topic are to develop a concept for a software solution for optimizing the packing time and space of ISU-90s, 463Ls, and custom tire racks for deployment. The objectives include developing use cases and establishing operating parameters for the software solution, as well as a plan for testing and validating the solution. The Phase I deliverables should include a report summarizing the proposed approach and a plan for testing and validating the software solution.

PHASE II: Phase II is used to further develop the first phase, in which awards shall be made on the scientific, technical, and commercial merit of the Phase II proposal. Phase II is the principal research and development effort and is expected to produce a well-defined deliverable prototype. The Phase II Period of Performance objectives for the RSP Optimization for Efficient Deployment SBIR topic are to develop a prototype software solution for optimizing the packing time and maximum utilization of space for RSP deployment, and demonstrate its ability to accurately manage the packing process for deployment. The Phase II objectives also include developing prototyping expectations, including operating parameters, testing requirements, and success criteria. The operating parameters will define the inputs, outputs, and conditions under which the software solution will operate, ensuring that it meets the needs and expectations of users. The testing requirements will include a plan for testing the prototype in a realistic environment, such as a military logistics operation, to validate its effectiveness and efficiency. The success criteria will define the metrics used to evaluate the performance of the prototype and determine its readiness for deployment. The Phase II objectives also include developing a plan for testing and validating the prototype in a realistic environment. This plan should include a detailed description of the testing methodology, including the types of tests to be performed and the metrics used to evaluate the performance of the prototype. The plan should also include a timeline for testing and validating the prototype, as well as a description of the resources required to complete the testing and validation process. The Phase II deliverables should include a well-defined deliverable prototype of the software solution for optimizing the packing time and maximum utilization of space for RSP deployment, and a plan for testing and validating the prototype in a realistic environment. The prototype should be capable of taking National Stock Number (NSN) packing data and weights, as well as Universal Time Code (UTC) data from HQ and generating a detailed plan for each pallet and ISU needed for packout, and should incorporate maintenance and load planning needs. The solution should also be agile and incorporate activity tracking for pack-out operations. In summary, the Phase II Period of Performance objectives for the RSP Optimization for Efficient Deployment SBIR topic are to develop a prototype software solution for optimizing the packing time and maximum utilization of space for RSP deployment, and demonstrate its ability to accurately manage the packing process for deployment. The objectives include developing prototyping expectations, including operating parameters, testing requirements, and success criteria, as well as a plan for testing and validating the prototype in a realistic environment. The Phase II deliverables should include a well-defined deliverable prototype and a plan for testing and validating the prototype in a realistic environment.

PHASE III DUAL USE APPLICATIONS: Per OSD, Phase III is accomplished when the Department of Defense (DoD) and/or commercial applications of SBIR/STTR-funded R&D are developed (using non-SBIR/STTR funds). The expected Phase III effort for the RSP Optimization for Efficient Deployment SBIR topic is to transition the technology from development to full-scale production and commercialization. The developed technology has dual-use applications for both military and commercial logistics operations. Military applications include RSP deployment and other supply chain management operations, as well as maintenance and load planning actions. The technology can help the military optimize its logistics operations, reducing costs and increasing efficiency. Commercial applications include supply chain management and logistics operations for industries such as transportation, manufacturing, and distribution. The technology can help commercial organizations optimize their logistics operations, reducing costs and increasing efficiency. The expected TRL at Phase III entry will be TRL 8 or 9, with a well-defined and validated software solution ready for commercialization. The technology will have been tested and validated in realistic environments, and any necessary modifications or customizations will have been made to ensure that it is compatible with existing systems and workflows. Additional information regarding transition planning includes identifying known government approvals required for deployment and any additional opportunities for deployment of the optimization solution within the government and commercial sectors. The integration plan will involve working closely with government and commercial partners to ensure that the optimization solution is integrated seamlessly into their existing systems and workflows. To facilitate the transition from Phase II to Phase III, a transition plan will be developed that outlines the steps necessary to ensure that the optimization solution is deployed and used effectively by government and commercial partners. The plan will include a timeline for deployment, a plan for identifying potential partners and customers, and a plan for marketing and selling the solution. The plan will also include a detailed description of the integration plan and any necessary modifications or customizations needed to make the solution compatible with existing systems. Overall, the expected Phase III effort for the RSP Optimization for Efficient Deployment SBIR topic is to transition the technology from development to full-scale production and commercialization, with dual-use applications for both military and commercial logistics operations. The expected TRL at Phase III entry will be TRL 8 or 9, and the transition planning will involve working closely with government and commercial partners to ensure seamless integration into existing systems and workflows.

REFERENCES:

1. DAFI 23-101;
2. AFMAN 24-604

KEYWORDS: Readiness Spares Packages (RSP); optimization; packing time; maintenance; load planning; software solution; activity tracking; NSNs; UTC data; level 4 data; pallets; ISUs.; space.

AF233-0036 TITLE: Commercial Technologies for EMP Hardening and Electrical System Protection

OUSD (R&E) CRITICAL TECHNOLOGY AREA(S): Microelectronics;Trusted AI and Autonomy;Advanced Computing and Software;Directed Energy (DE);Integrated Network System-of-Systems;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: The end state of this effort is to create a robust and resilient nation that is well-prepared to face EMP threats, protecting its citizens, critical infrastructure, and military capabilities. AFGSC is interested in commercial solutions that address the following five key areas: 1. Advanced EMP shielding and hardening technologies 2. Resilient power grid and energy infrastructure and including EMP protected Power and HVAC systems remain operable and ensure equipment maintains a certain temperature for optimal function 3. Rapid detection and monitoring of EMP events 4. EMP-protected communication networks and data centers 5. EMP risk assessment and mitigation strategies The successful completion and integration of the projects would lead to the following outcomes: Enhanced EMP protection: Electronic systems and infrastructure across various sectors would be equipped with advanced EMP shielding and hardening technologies, minimizing the potential damage from E1, E2, and E3 EMP components. Resilient power grid and energy infrastructure: The energy infrastructure would be designed and maintained to withstand the effects of EMP events, ensuring uninterrupted power supply and preventing widespread blackouts during EMP incidents. Rapid response capabilities: Advanced sensors and monitoring systems would enable prompt detection and assessment of EMP events, allowing for swift decision-making and coordinated responses to minimize the impact on national security, public safety, and critical infrastructure. Secure communication networks and data centers: EMP-protected communication networks and data centers would ensure the continuity of essential services and military operations during and after an EMP event, reducing the risk of communication disruptions and data loss. Proactive risk management: Advanced tools and methodologies for assessing and mitigating EMP risks would be widely adopted, enabling stakeholders across various sectors to make informed decisions on resource allocation, policy-making, and emergency response planning.

DESCRIPTION: AFGSC is interested in commercial solutions that address one or more of the following five key areas: 1. Advanced EMP shielding and hardening technologies 2. Resilient power grid and energy infrastructure 3. Rapid detection and monitoring of EMP events 4. EMP-protected communication networks and data centers 5. EMP risk assessment and mitigation strategies Advanced EMP shielding and hardening technologies: Topic Description: This research area focuses on the development of innovative materials, methods, and designs to protect electronic systems and infrastructure from the effects of EMP events. Key objectives include identifying and developing new materials with exceptional EMP shielding properties, exploring active shielding systems, and investigating fault-tolerant designs and redundant systems. Examples: a. Research and development of new materials, such as nanocomposites and metamaterials, that demonstrate exceptional EMP shielding properties and can be integrated into electronic devices and infrastructure. b. Exploration of innovative shielding techniques, such as active shielding systems that can detect and neutralize incoming EMP threats. c. Investigation of advanced hardening methods, including fault-tolerant designs and redundant systems, to minimize the impact of

EMP events on critical electronic components and infrastructure. d. Collaboration with industry and academia to accelerate the transition of cutting-edge research findings into practical applications and commercial products. Resilient power grid and energy infrastructure: Topic Description: This research area aims to improve the resilience and reliability of the power grid and energy infrastructure against EMP threats. Research efforts should focus on advanced transformer designs, novel energy storage solutions, adaptive control systems, and best practices for power grid operators and utility companies. Examples: a. Design and development of advanced transformer designs that are resistant to geomagnetically induced currents (GICs) and can maintain their functionality during and after EMP events. b. Research and implementation of novel energy storage solutions, such as grid-scale batteries and supercapacitors, to ensure uninterrupted power supply during EMP incidents. c. Investigation of advanced control systems and strategies that can automatically detect and respond to EMP threats, minimizing the impact on the power grid and energy infrastructure. d. Development of best practices and guidelines for power grid operators and utility companies to enhance their preparedness for EMP events. Rapid detection and monitoring of EMP events: Topic Description: This research area seeks to develop advanced sensors, monitoring systems, and data analytics techniques for the rapid detection, assessment, and response to EMP events. Key objectives include designing highly sensitive sensors, creating real-time data processing algorithms, integrating sensor networks into a centralized platform, and developing early warning systems. Examples: a. Development of highly sensitive sensors and monitoring systems capable of detecting and measuring the characteristics of EMP events in real-time. b. Creation of advanced data analytics techniques and algorithms to process and analyze large volumes of sensor data, providing accurate and actionable information for decision-makers. c. Integration of sensor networks and monitoring systems into a centralized platform, allowing for real-time situational awareness and coordinated response during EMP incidents. EMP-protected communication networks and data centers: Topic Description: This research area focuses on the design and implementation of EMP-protected communication networks and data centers, ensuring the continuity of essential services and military operations during and after EMP events. Research efforts should explore novel communication protocols, architectures, and hardening techniques for existing and emerging communication technologies. Examples: a. Research and development of novel communication protocols and architectures that are inherently resilient to EMP threats. b. Design and implementation of EMP hardening techniques for existing communication networks and data centers, including shielding, grounding, and redundancy measures. c. Investigation of emerging technologies, such as quantum communication and satellite-based systems, that can potentially enhance the resilience of communication networks against EMP events. d. Development of best practices and guidelines for communication service providers and data center operators to enhance their preparedness for EMP incidents. e. Collaboration with international partners to share knowledge and expertise in building EMP-protected communication networks and data centers. EMP risk assessment and mitigation strategies: Topic Description: This research area aims to develop advanced tools, methodologies, and strategies for assessing and mitigating EMP risks across various sectors and critical infrastructure. Key objectives include creating modeling and simulation tools and designing cost-effective and scalable mitigation strategies. Examples: a. Creation of advanced modeling and simulation tools to evaluate the potential impact of EMP events on various sectors and critical infrastructure. b. Development of cost-effective and scalable mitigation strategies that can be implemented across different industries and sectors. c. Design and implementation of training and education programs to raise awareness about EMP risks and promote a culture of preparedness among stakeholders.

PHASE I: Key Area 1: Advanced EMP shielding and hardening technologies Objectives: Determine the feasibility of novel EMP shielding materials and hardening techniques, identify potential materials and methods, and conduct initial laboratory tests.   Expectations: Develop preliminary material properties, design guidelines, and selection criteria for promising materials and techniques, such as nanocomposites, metamaterials, and active shielding systems. Key Area 2: Resilient power grid and energy infrastructure Objectives: Assess the feasibility of advanced transformer designs, energy storage solutions, and adaptive control systems for enhancing power grid resilience against EMP threats. Expectations: Establish design concepts, performance benchmarks, and initial use cases for promising solutions. Key Area 3: Rapid detection and monitoring of EMP events Objectives: Explore the feasibility of advanced sensors, monitoring systems, and data analytics techniques for rapid detection, assessment, and response to EMP events. Expectations: Develop initial sensor designs, monitoring system architectures, and data processing algorithms; identify potential use cases for establishing feasibility. Key Area 4:EMP-protected communication networks and data centers Objectives: Assess the feasibility of novel communication protocols, architectures, and hardening techniques for enhancing the resilience of communication networks and data centers against EMP events. Expectations: Establish design concepts, performance benchmarks, and initial use cases for promising solutions. Key Area 5: EMP risk assessment and mitigation strategies Objectives: Evaluate the feasibility of advanced tools, methodologies, and strategies for assessing and mitigating EMP risks across various sectors and critical infrastructure. Expectations: Develop initial concepts for modeling and simulation tools, mitigation strategies, and training and education programs; identify potential use cases for establishing feasibility.

PHASE II: Phase 2 Key Area 1:Advanced EMP shielding and hardening technologies Objectives: Further develop and optimize selected materials and techniques, design and fabricate prototypes, and perform rigorous testing to evaluate performance. Expectations: Deliver functional prototypes demonstrating effective EMP shielding and hardening, establish operating parameters, and develop testing requirements and success criteria. Key Area 2: Resilient power grid and energy infrastructure Objectives:Develop and optimize the selected designs and solutions, create prototypes, and conduct comprehensive testing to evaluate performance and reliability. Expectations: Deliver prototypes of advanced transformers, energy storage systems, and control systems; define operating parameters, testing requirements, and success criteria. Key Area 3: Rapid detection and monitoring of EMP events Objectives: Further develop and optimize selected sensors, monitoring systems, and data analytics techniques; design and fabricate prototypes; and perform extensive testing. Expectations: Deliver functional prototypes demonstrating real-time detection and monitoring capabilities; establish operating parameters, testing requirements, and success criteria. Key Area 4: EMP-protected communication networks and data centers Objectives: Develop and optimize the selected protocols, architectures, and techniques; create prototypes; and conduct comprehensive testing to evaluate performance and reliability. Expectations: Deliver prototypes of EMP-protected communication networks and data centers; define operating parameters, testing requirements, and success criteria. Key Area 5: EMP risk assessment and mitigation strategies Objectives: Further develop and optimize selected tools, methodologies, and strategies; create prototypes or pilot programs; and perform extensive testing and evaluation. Expectation: Deliver functional prototypes of modeling and simulation tools, implement pilot mitigation strategies, and design comprehensive training and education programs; establish testing requirements and success criteria.

PHASE III DUAL USE APPLICATIONS: Phase III / Dual-Use Objectives: Transition the developed technology into commercial and government applications, refine and scale up production, and pursue certification and standardization. Expected TRL at Phase III entry: 6-7 Transition planning: Obtain necessary government approvals, collaborate with relevant stakeholders, and identify additional government and commercial opportunities for technology adoption.

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1. Glasstone, S., & Dolan, P. J. The Effects of Nuclear Weapons;
2. United States Department of Defense and the Energy Research and Development Administration;
3. NATO Standardization Agency. AECTP 250 - Electromagnetic Environmental Effects Requirementsfor Systems;
4. Radasky, W. A., & Wik, M. W. The Early-Time (E1) High-Altitude Electromagnetic Pulse (HEMP) and Its Impact on the U.S. Power Grid. Metatech Corporation;

5. Kappenman, J. G. Geomagnetic Storms and Their Impacts on the U.S. Power Grid. Metatech Corporation.

KEYWORDS: EMP; shielding; hardening; technologies; materials; active shielding; fault-tolerant; nanocomposites; metamaterials; power grid; energy infrastructure; transformers; energy storage; control systems; resilience; reliability; grid-scale batteries; supercapacitors; geomagnetically induced currents (GICs)

AF233-0037 TITLE: Measuring Ground-to-Air Atmospheric Path Transmission

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

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OBJECTIVE: Design and fabricate a device that can measure the ground-to-air atmospheric transmission path for electromagnetic waves in the wavelength range of 0.2 µm – 14 µm. This device will improve the accuracy and reliability of infrared signature measurements.

DESCRIPTION: It is important to account for the atmospheric conditions when collecting infrared signature data. Infrared radiation is absorbed and scattered by atmospheric gases, water vapor, and aerosols, which can affect the accuracy and reliability of the measurements. To obtain accurate data, it is necessary to account for the atmospheric temperature, pressure, humidity, and aerosol content, and to correct for their effects on infrared radiation. The current method of doing this is to deploy a weather balloon on site and feed that data into a modeling software called MODTRAN (MODerate resolution atmospheric TRANsmission). MODTRAN will generate a transmission path factor, otherwise known as a tpfact. The tpfact is defined as the ratio of the effective path length of the radiation through the atmosphere to the total path length. When acquiring infrared signature data, the tpfact becomes a part of the calculation that converts a raw image into one that displays temperature and radiance. MODTRAN has been a useful tool, but it has its limitations. Simulating the atmospheric transmission path relies on mathematical models and assumptions that may not reflect the actual conditions present during data capture. Direct measurement of the transmission path will result in a more accurate representation of complex interactions and phenomena within the atmosphere. This will serve to significantly improve the quality of infrared signature data. The goal for this project is to measure how radiation from an airborne target is attenuated by atmospheric conditions. To achieve this, a blackbody and a spectrometer would need to be configured so that one is attached to an airborne platform and the other is placed at the collection site. The platform would need to loiter at the same altitude as the target under test. The desired platform altitude is 10,000 feet AGL or more, but a minimum threshold of 1,000 feet AGL is acceptable. The challenge will be to find an airborne platform that can carry the payload and collect/calibrate atmospheric attenuation data.

PHASE I: In Phase l, the awardees will determine the feasibility of attaching a blackbody or spectrometer to an unmanned aircraft. Questions for which answers will be sought include: 1. What types of spectrometers and blackbodies would need to be used for the spectrometer to gather data from multiple miles away? 2. What type of aircraft is suited to carry the proposed blackbody/spectrometer? 3. How will the data from the spectrometer be recorded? 4. What training, certifications, and FAA approvals will be necessary?

PHASE II: The questions answered in Phase l will serve as the foundation for the prototype delivered in Phase ll. The prototype will be some sort of aircraft capable of flying at least 1,000 feet AGL while carrying either a spectrometer or blackbody. The delivered device will be tested to confirm that the spectrometer is pointed at the blackbody, recording data in the wavelength range of 0.2 µm – 14 µm, and that the data can be used to perform an atmospheric correction on infrared signature dat

PHASE III DUAL USE APPLICATIONS: The proposed aircraft can be adapted to fit a wide variety of needs within the DoD. The device will also provide valuable data that could be of interest to various academic institutions and weather organizations. In Phase lll, efforts will be made to identify any other organizations who might be interested in using this device.

REFERENCES:

1. 1. Berk, A., P.K. Acharya, L.S. Bernstein, G.P. Anderson, P. Lewis, J.H. Chetwynd, and M.L. Hoke, "Band Model Method for Modeling Atmospheric Propagation at Arbitrarily Fine Spectral Resolution"

KEYWORDS: Infrared ; Spectrometer ; UAV ; Airborne Platform ; Ultra-violet ; Midwave Infrared ; Longwave Infrared ; MWIR ; LWIR ; UV