

**AIR FORCE**  
**21.2 Small Business Innovation Research (SBIR) Phase I**  
**Proposal Submission Instructions**

**INTRODUCTION**

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

All SBIR Phase I proposals under this solicitation must be submitted through the DoD SBIR/STTR Innovation Portal (DSIP), <https://www.dodsbirsttr.mil/submissions/login>, no later than the date and time published in the DoD 21.2 SBIR BAA.

Questions pertaining to the AF SBIR/STTR program and these proposal preparation instructions should be directed to the AF SBIR/STTR Program Office at [usaf.team@afsbirsttr.us](mailto:usaf.team@afsbirsttr.us). For questions regarding DSIP, contact the DoD SBIR/STTR Help Desk via email at [DoDSBIRSupport@reisystems.com](mailto:DoDSBIRSupport@reisystems.com). For technical questions about the topics during the pre-release period, contact the Topic Authors listed for each topic. To obtain answers to technical questions during the formal announcement open period, visit the Topic Q&A on DSIP at <https://www.dodsbirsttr.mil/submissions/login>.

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](http://www.sba.gov), and the Procurement Technical Assistance Centers, <http://www.aptaacus.us.org>. These centers provide Government contracting assistance and guidance to small businesses, generally at no cost.

**Information at a Glance for Air Force 21.2 SBIR Phase I Topics:**

Topic Number	Performance Period	Max SBIR Funding	Technical Volume Contents
AF212-0001	6 months	\$100,000	White paper NTE 25 pages
AF212-0002	6 months	\$100,000	White paper NTE 25 pages
AF212-0003	6 months	\$100,000	White paper NTE 25 pages
AF212-0004	9 months	\$150,000	White paper NTE 30 pages
AF212-0005	12 months	\$150,000	White paper NTE 25 pages
AF212-0006	9 months	\$150,000	White paper NTE 30 pages
AF212-0007	9 months	\$100,000	White paper NTE 20 pages
AF212-0008	3 months	\$75,000	White paper NTE 25 pages
AF212-0009	6 months	\$100,000	White paper NTE 25 pages
AF212-0010	12 months	\$150,000	White paper NTE 15 pages
AF212-0011	12 months	\$150,000	White paper NTE 15 pages
AF212-0012	9 months	\$150,000	White paper NTE 15 pages
AF212-0013	12 months	\$150,000	White paper NTE 25 pages
AF212-0014	12 months	\$150,000	White paper NTE 25 pages
AF212-0015	12 months	\$150,000	White paper NTE 25 pages

## **PHASE I PROPOSAL SUBMISSION**

DoD 21.2 SBIR 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. For the AF, the Phase I contract periods of performance and dollar values are found in the table above.

### **Limitations on Length of Proposal**

**The Phase I Technical Volume page/slide limits as identified in Chart 1 (above) do not include the Cover Sheet, Cost Volume, Cost Volume Itemized Listing (a-j).** 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 considered for review. The documents required for upload into Volume 5, "Other", do not count toward the specified limits.

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

### **Phase I Proposal Format**

**Proposal Cover Sheet:** If selected for funding, the proposal's technical abstract and discussion of anticipated benefits will be publicly released. Therefore, do not include proprietary information in these sections.

**Technical Volume:** The Technical Volume should include all graphics and attachments but should not include the Cover Sheet, which is completed separately. Phase I technical volume (uploaded in Volume 2) shall contain the required elements found in Chart 1. Make sure all graphics are distinguishable in black and white. Once uploaded to DSIP, the completed, uploaded file will be virus checked and converted to a .pdf document within an hour. If it does not appear after an hour, please contact the DoD SBIR/STTR Help Desk via email at [dodsbirsupport@reisystems.com](mailto:dodsbirsupport@reisystems.com)

**Key Personnel:** Identify in the Technical Volume all key personnel who will be involved in this project; include information on directly related education, experience, and citizenship. A technical resume of the principal investigator, including a list of publications, if any, must be part of that information. Concise technical resumes for subcontractors and consultants, if any, are also useful. 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. You may be asked to provide additional information during negotiations in order to verify the foreign citizen's eligibility to participate on a contract issued as a result of this announcement.

### **Phase I Work Plan Outline**

<p><b><u>NOTE: THE AF USES THE WORK PLAN OUTLINE AS THE INITIAL DRAFT OF THE PHASE I STATEMENT OF WORK (SOW). THEREFORE, DO NOT INCLUDE PROPRIETARY INFORMATION IN THE WORK PLAN OUTLINE. TO DO SO WILL NECESSITATE A REQUEST FOR REVISION AND MAY DELAY CONTRACT AWARD.</u></b></p>
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Include an outline of the work plan in the following format:

Scope: List the major requirements and specifications of the effort.

Task Outline: Provide a brief outline of the work to be accomplished over the span of the Phase I effort.

Milestone

Schedule

Deliverables

Progress reports

Final report with SF 298

Cost Volume: 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-j below) regarding funds use if an award is received. The DSIP Cost Volume and Itemized Cost Volume Information will not count against the specified page limit. The itemized listing may be submitted in Volume 5 under the "Other" dropdown option.

a. Special Tooling/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 test equipment purchases must, in the Contracting Officer's opinion, be advantageous to the Government and relate directly to the effort. It may include such items as innovative instrumentation and/or automatic test equipment.

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

c. 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 vs. purchase justification.

d. 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.

e. 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.

f. 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, unless otherwise approved in writing by the Contracting Officer. 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.

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

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

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

NOTE: 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, 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. **If you have concerns about any of these contractors, you should contact the AF SBIR/STTR Contracting Officer, Kris Croake at [kristina.croake@us.af.mil](mailto:kristina.croake@us.af.mil).**

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

### **PHASE I PROPOSAL SUBMISSION CHECKLIST**

NOTE: If you are not registered in the System for Award Management, <https://www.sam.gov/>, at the time of proposal submission, you will not be eligible for award. Additionally, verify you are registered to receive contracts (not just grants) and the addresses in the proposal and SAM are consistent.

- 1) Air Force Phase I proposals should meet the specific topic's period of performance and cost limitations located on page 1 of these Air Force Instructions.
- 2) The Air Force will accept only those proposals, including all required volumes, submitted electronically via DSIP, <https://www.dodsbirsttr.mil/submissions/>. Hard copies or email copies sent outside the system will not be accepted.

Please note the Fraud, Waste and Abuse Training must be completed prior to proposal submission. When training is complete and certified, the DoD Submission Website will indicate completion of the Volume 6 requirement. The proposal cannot be submitted until the training is complete.

The AF recommends completing submission early, as computer traffic is heavy prior to solicitation close, causing system lag. **Do not wait until the last minute.** The AF will not be responsible for proposals not completely submitted prior to the deadline due to system inaccessibility unless advised by DoD. Please ensure the e-mail addresses listed in the proposal is current and accurate. The AF is not responsible for ensuring notifications are received by firms changing mailing address/e-mail address/company points of contact after proposal submission without proper notification to the AF. 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 at [usaf.team@afsbirsttr.us](mailto:usaf.team@afsbirsttr.us). The message shall include the subject line, "21.2 Address Change".

### **AIR FORCE PROPOSAL EVALUATIONS**

The AF will utilize the Phase I proposal evaluation criteria in section 6.0 of the 21.2 SBIR DoD announcement in descending order of importance with technical merit being most important, followed by principal investigator's (and team's) qualification, followed by the potential for commercialization as detailed in the Commercialization Plan.

The AF will utilize the Phase II proposal evaluation criteria in section 8.0 of the 21.2 SBIR DoD announcement in descending order of importance with technical merit being most important, followed by the potential for commercialization as detailed in the Commercialization Plan, followed by the qualifications of the principal investigator (and team).

### **Proposal Status and Feedback**

The Principal Investigator (PI) and Corporate Official (CO) indicated on the Proposal Cover Sheet will be notified by e-mail regarding proposal selection or non-selection. Small businesses will receive a notification for each proposal submitted. Please read each notification carefully and note the Proposal Number and Topic Number referenced. If changes occur to the company mail or email addresses or company points of contact after proposal submission, the information shall be provided to the AF at [usaf.team@afsbirsttr.us](mailto:usaf.team@afsbirsttr.us). The message shall include the subject line, "21.2 Address Change".

Feedback will not be provided for Phase I proposals determined Not Selectable. Feedback will be provided only for Phase II proposals determined Not Selectable.

**IMPORTANT: IMPORTANT:** Proposals submitted to the AF are received and evaluated by different organizations, handled topic 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.

It is anticipated all the proposals will be evaluated and selections finalized within approximately 90 calendar days of solicitation close. Please refrain from contacting the BAA Contracting Officer for proposal status before that time.

### **PHASE II PROPOSAL SUBMISSIONS**

AF organizations may request Phase II proposals while technical performance is on-going. This decision will be based on the contractor's technical progress, as determined by an AF TPOC's review using the DoD 21.2 SBIR BAA Section 8.0 Phase I review criteria. All Phase I awardees will be provided an opportunity to submit a Phase II proposal unless the Phase I purchase order has been terminated for

default or due to non-performance by the Phase I company.

NOTE: Air Force primarily awards Phase I and II contracts as Firm Fixed Price. However, Phase II 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. Please address questions to the Phase II Contracting Officer, if selected for award.

**All proposals must be submitted electronically at <https://www.dodsbirsttr.mil/submissions/login> by the date indicated in the Phase II request for proposal. Note: Only ONE Phase II proposal may be submitted for each Phase I award.**

### **AIR FORCE SBIR PROGRAM MANAGEMENT IMPROVEMENTS**

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

### **AIR FORCE SUBMISSION OF FINAL REPORTS**

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

## **AIR FORCE 21.2 SBIR Phase I Topic Index**

AF212-0001	Man-Packable NAV-AID
AF212-0002	Artificial Intelligence Tool for Background Database Generation
AF212-0003	Advances in Infrared Target Scene Projection for Munition Testing
AF212-0004	Thermal Management of V-band Transmit Arrays
AF212-0005	Munition Development for Petroleum, Oil, and Lubricant (POL) Targets
AF212-0006	W-Band Anti-Jam Receiver
AF212-0007	Algorithms for MIMO Techniques to Enable a Coherent Distributed Array from Multiple Airborne Platforms
AF212-0008	Next Generation Weapons Mission Planning
AF212-0009	Design Tool for Multiple Electromagnetic Radome Problems
AF212-0010	Innovative Engines for Small Unmanned Aerial Systems (SUAS)
AF212-0011	ASCENT Based Thruster Component and System Characterization and Optimization for Lifetime Extension
AF212-0012	Rocket Landing on Irregular Surfaces
AF212-0013	Mid-IR Satellite Communications
AF212-0014	Simultaneous Harvesting of Incoming Solar and Outgoing Thermal Radiation in a Space Environment
AF212-0015	Meta-lens Filtering and Beam Forming for Mid-Wave and Long-Wave Infrared LEDs and Photodiodes

## **AF212-0001** Man-Packable NAV-AID

**TECH FOCUS AREAS:** General Warfighting Requirements (GWR)

**TECHNOLOGY AREAS:** Sensors; Electronics; Battlespace

**OBJECTIVE:** Develop a two man-packable, man-portable, air-deliverable (parachute), covert tactical aircraft navigational aid system. RF emissions should be very low, designed to be Low Probability of Intercept/ Low Probability of Detection (LPI/LPD). The solution should be lighter and smaller than an airfield mobile Tactical Air Navigation (TACAN) AN/TRN-47v2. The proposed solution should provide the user with bearing and distance (slant-range) to a ground or ship-borne station at a range of at least 20 nm. The Navigation Aid should be capable of meeting Instrument Flight Rules (IFR) certification standards similar to existing portable TACANs.

**DESCRIPTION:** The desired near-covert Navigational System should provide the user with bearing and distance (slant-range) to a ground or ship-borne beacon at a range of at least 20 nm from altitudes up to 30,000', performing similar to VHF Omni-Directional Range/Distance Measuring Equipment (VOR/DME). Units should be lighter and smaller than the current MM-7000 MP TACAN (Moog Industries) for harsh environments. The system should be capable of tracking up to 50 airborne targets concurrently. The ability to track ground personnel and vehicular traffic at close range would also be beneficial. The proposed solution should be capable of being Instrument Flight Rules (IFR) certifiable per Federal Aviation Administration (FAA) guidelines and standards (ref. AC 00-31A). The system must provide an all-weather non-precision navigational aid for use at remote landing sites, assault landing zones, and unprepared or dissuaded runways. The system should enable rapid setup and tear-down by a two-man team to keep pace with the maneuver elements, yet provide the same accuracy as a TACAN AN/TRN-47v2 or MM-7000MP TACAN. The system should include an on-demand mode where it will only transmit when interrogated by an aircraft on-channel.

The proposed solution must be interoperable with all models of current TACAN/VOR/DME receivers already installed on US Military aircraft and interface with those receiver controls. The covert Navigational Aide should be able to be powered in the man-packable configuration by 5590 B/U 12V/24V 15Ah Primary Lithium Sulfur Dioxide (LiSO<sub>2</sub>) Dual-Voltage Military radio batteries (multiple batteries is permissible). It should also have the option of being powered by a small generator when in-place for longer durations.

The system must be hardened and packaged to withstand parachute operations when loaded in an individual soldier's rucksack on a lowering line below him and hitting the ground first. Utilizing a para-container for the system is not preferred; however, if Size Weight and Power (SWAP) requirements would require a large para-container, that would be considered. The design should be able to be assembled and brought into service by a two-man crew within 15 minutes. The system must meet all applicable TACAN Standards; STANAG 5034, MIL-HDBK-217, MIL-STD-461-F, MIL-STD-291C, MIL-STD-810G, ICAO Annex 10.

**PHASE I:** Establish feasibility of the proposed solution. Perform sufficient modeling and experimentation to determine high risk components are attainable. Perform tradeoffs to establish a preliminary design leading up to Phase II. Define a Phase II program plan. Identify potential transition partners. Provide a thorough understanding of the solution to the Government to enable a timely Phase II decision.

**PHASE II:** Finalize design of a demonstration prototype. Procure, develop, and integrate the solution prototype. Plan and coordinate one or more demonstrations to provide proof of concept determination. Perform experiments and analyze results to establish the adequacy of the solution approach and



minimize transition risk. Contact potential customers and transition partners to support Phase III activities. Provide regular communication to the government sponsor to ensure understanding and risk mitigation.

**PHASE III DUAL USE APPLICATIONS:** Demonstrate this prototype Man-Portable Aircraft Navigation Aid.

NOTE: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Contracting Officer, Ms. Kris Croake, [kristina.croake@us.af.mil](mailto:kristina.croake@us.af.mil).

**REFERENCES:**

1. Department of Transportation and Department of Defense (March 25, 2002). "2001 Federal Radionavigation Plan" (PDF).
2. "GRAVITY GRADIOMETRY AND MAP MATCHING: AN AID TO AIRCRAFT INERTIAL NAVIGATION SYSTEMS", USAF AFIT Thesis, Maj. Anthony DeGregooria
3. "AC 00-31A - United States (U.S.) National Aviation Standard for the Very High Frequency Omnidirectional Radio Range (VOR)/Distance Measuring Equipment (DME)/Tactical Air Navigation (TACAN) Systems", 30 Sep. 1982 4. 9840.1 - U.S. National Aviation Handbook for the VOR/DME/TACAN Systems

## **AF212-0002** Artificial Intelligence Tool for Background Database Generation

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

**TECHNOLOGY AREAS:** Sensors; Space Platform; Air Platform; Battlespace

**OBJECTIVE:** Scene Generation tools are used to create synthetic image data representative of what a sensor on a weapon system would measure. Creating synthetic data is limited by lack of available models or lack of measured databases to capture the radiometric characteristics of the scene required. The objective of this topic is to develop a robust capability to approximate backgrounds at the resolution required in closed-loop simulations using a combination of geo-spatial information, required time of day and year, measured databases and trained artificial intelligence algorithms for image feature identification and construction.

**DESCRIPTION:** Scene generation tools provide in-band models of sensor output and input to simulators, allowing for the research and development of new weapon systems. These tools drive scene projectors during hardware-in-the-loop testing and provide synthetic output for software-in-the-loop testing and algorithm development for new sensor concepts. Scientists developing new munition seeker concepts and those responsible for executing test programs are limited to a small subset of geographic locations and environmental conditions. An example would be the limited ability to capture the scene changes due to weather, time of year, and time of day.

Another issue is the ability to create data at the resolution of a weapon seeker that is rapidly approaching the ground; the databases currently used are at a fixed resolution, which may be significantly coarser than the seeker resolution. This intent of this topic is to establish an automated process that can generate an approximation of scene background data using topographical maps, transportation maps, maps of watershed features, knowledge of area vegetation, geographic features, weather and timeframe. All data available, including data from the public domain such as google earth should be considered. Real-data from high resolution assets should be used as a part of the scene construction process when appropriate to establish realism and to train the system in the sense of Deep Learning.

The goal is to create a capability that is global and multi-spectral, representing a user specified sensor waveband. The capability must be repeatable to allow duplication to the extent possible of test results. While the capability might be used in part as a preprocessor, the final stage must operate as a plug in to standard scene generation tools, such as FLITES, in order to integrate into the scene targets, people, moving vehicles, or other objects and perform the final radiometric discretization and image modeling.

**PHASE I:** Perform a preliminary demonstration creating background data from commonly available resources and knowledge of a given geographic region. The demonstration should provide the feasibility of a range of resolutions characteristic of a sensor moving from high-altitude to the ground. Narrowing scope to an IR band is acceptable to provide a proof of concept. A plan for Phase II development, and the role of artificial intelligence in that process, shall be established. Limitations of the planned capability shall be documented.

**PHASE II:** Finalize design of a demonstration prototype. Develop, integrate, and train the solution prototype. Establish and document relevant use-cases. Plan and coordinate one or more demonstrations to provide proof of concept determination. Perform experiments and analyze results to establish the adequacy of the solution approach and minimize transition risk. Contact potential customers and transition partners to support Phase III activities. Provide regular communication to the

government sponsor to ensure understanding and risk mitigation. Deliver a prototype to AFRL/RWWG compatible with the FLITES simulation tool.

PHASE III DUAL USE APPLICATIONS: Add additional classified data sources and work with multiple end-users to provide additional specific capabilities required.

NOTE: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Contracting Officer, Ms. Kris Croake, [kristina.croake@us.af.mil](mailto:kristina.croake@us.af.mil).

#### REFERENCES:

1. Crow, Dennis & Coker, Charles & Keen, Wayne. (2006), "Fast Line-of-Sight Imagery for Target and Exhaust-plume Signatures (FLITES) scene generation program," art. no. 62080J, Proceedings of SPIE, 10.1117/12.669306
2. Savage, James & Coker, Charles & Thai, Bea & Aboutalib, Omar & Pau, John. (2007), "Irma 5.2 multi-sensor signature prediction model," Proc SPIE, 6965, 10.1117/12.778000
3. Bruce A. Wilcoxon and Harry M. Heckathorn "Synthetic scene generation model (SSGM R7.0)", Proc. SPIE 2742, Targets and Backgrounds: Characterization and Representation II," (17 June 1996); 10.1117/12.243028
4. Jeevan Devaranjan, Amlan Kar, Sanja Fidler, "Meta-Sim2: Unsupervised Learning of Scene Structure for Synthetic Data Generation," arXiv

KEYWORDS: FLITES; synthetic scene generation; hardware-in-the-loop; simulation; munitions; sensor; seeker

**AF212-0003** Advances in Infrared Target Scene Projection for Munition Testing

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

**TECHNOLOGY AREAS:** Sensors; Electronics; Battlespace

**OBJECTIVE:** Scene projectors are used in military test facilities to provide stimulus to seekers/sensors used by flight control and surveillance systems. The objective of this topic is to advance scene projection capabilities within government test facilities to achieve necessary accuracy and compatibility relative to advances in sensor technology requirements.

**DESCRIPTION:** Current scene projection technologies, e.g., resistor arrays, infrared LEDs, and liquid crystal arrays, have significant limitations. Resistor arrays are limited in temperature achievable and manufacturability in large formats, LED arrays have yet to be demonstrated with adequate efficiency and calibration characteristics, and liquid crystal arrays have been prone to degradation and lack of image quality. TI DMD's have also been used successfully in many applications, but there are inherent diffraction limits at longer wavelengths. Sensor technology is significantly outpacing projector technology in terms of pixel format and framerate, to the point that full field-of-view projector solutions may never catch up. In the future, hybrid scene injection/projection solutions or pure scene injection solutions may become necessary that are very application specific. Even then, high-quality IR projectors will still be required, but they will be used in either unconventional ways or primarily as a means of validating a scene injection sensor model. Alternative solutions are sought that effectively mitigate the limitations of current technology. Solutions that improve the efficiency of emitters, thermal management solutions that maintain a stable predictable pixel temperature, and calibration methods that achieve requisite calibration accuracy are of interest. Technologies that are realizable, cost-effectively, over a range of wavebands are desired. Infrared scene projection systems typically include analog interface electronics, digital control systems, and real-time scene generation computers. Advancement of projection technology also requires advancement of the associated system components. Solutions that advance or leverage existing proven capabilities to achieve robust solutions compatible with leading edge Air Force system requirements are desired. The result of the proposed effort should be a product with a direct transition path to multiple end use applications or facilities. The solutions prototyped and provided are expected to be compatible with typical use cases associated with munition hardware-in-the-loop testing. If a projector technology is proposed, there should not be outstanding characteristics that would limit use on the target gimbal of a flight motion simulator or in configurations necessary for multi-mode or multi-band scene simulation. It is also desired that the technology be compatible with cryogenic space simulation chamber implementations. If an enabling control system or scene generation solution is proposed, they should be modular and readily upgradeable to enhance longevity and flexibility. Projector technologies proposed should be targeted for 2048 x 2048 at 200 Hz, with an NEDT of approximately 50 mK at ambient conditions.

**PHASE I:** Establish feasibility of the proposed solution. Perform sufficient modeling and experimentation to determine that high-risk components are attainable. Perform tradeoffs to establish a preliminary design leading for Phase II. Define a Phase II program plan. Identify and document endorsement from potential transition partners. Provide a thorough understanding of the solution to government in time to make a Phase II decision.

**PHASE II:** Finalize design of a demonstration prototype. Procure, develop, and integrate the solution prototype. Plan and coordinate one or more demonstrations to provide proof of concept determination. Perform experiments and analyze results to establish the adequacy of the solution approach and minimize transition risk. Contact potential customers and establish a transition plan with partners supporting Phase

III activities. Provide regular communication to the government sponsor to ensure understanding and risk mitigation.

PHASE III DUAL USE APPLICATIONS: Demonstrate an integrated scene projection system for a specific application, including a functional projector control system and image generation capability.

NOTE: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Contracting Officer, Ms. Kris Croake, [kristina.croake@us.af.mil](mailto:kristina.croake@us.af.mil).

#### REFERENCES:

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2. Rodney McGee, Fouad Kiamilev, et al., "512x512, 100Hz Mid-wave Infrared LED Scene Projector," GOMAC Tech Conference, P-50 (2015)
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KEYWORDS: Resistor Array; IRLED; Infrared LED; DMD; Hardware-in-the-Loop; HWIL; Seeker; Sensor

**AF212-0004** Thermal Management of V-band Transmit Arrays

TECH FOCUS AREAS: Network Command, Control and Communications; General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Space Platform

OBJECTIVE: Develop and demonstrate thermal management techniques for a V-band multi-element transmit subarray. The developed subarray should address wafer-scale antennas and front-end components for high-power SATCOM downlinks.

DESCRIPTION: Future military SATCOM concepts include V-band (71-76 GHz) downlinks and W-band (81-86 GHz) uplinks to support next-generation high-data-rate communications systems. While single-point RF power sources with gimbaled antennas address a potential V-band transmitter architecture, phased array architectures are also viable for these satellite communications concepts. Currently demonstrated array front-end components at V-band have relatively low output power. As higher transmit array power is demonstrated utilizing high-power density, high-power dissipation power transistor technologies and within the size constraints of array elements, greater thermal management challenges result. This Phase I SBIR focuses on the definition of a thermal management approach for an overall V-band downlink transmit array architecture, as well as the wafer-scale antennas and front-end components for a Phase II proof-of-concept multi-element demonstration vehicle. At a minimum, the array components/functions should include power amplification and beam steering. Due to high atmospheric attenuation at these frequencies, EIRP >75 dBW and per element power output >400 mW should be considered for the full transmit array architecture. Operating environment goals include a temperature range of -40 degrees to +85 degrees Celsius.

PHASE I: Conduct a feasibility study to determine thermal management and V-band phased array architecture definition, including the definition of the multi-element demonstration vehicle for Phase II.

PHASE II: Development of the thermally-managed wafer-scale antenna and front-end components in a multi-element V-band transmit subarray demonstrator.

PHASE III DUAL USE APPLICATIONS: Military millimeter-wave phased array applications include V-band satellite communications downlink electronics for future high-data-rate communications systems. Commercial: Commercial V-band phased array applications potentially include commercial satellite communications services. Technologies under this effort will further benefit applications in nearby frequency bands.

NOTE: The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Contracting Officer, Ms. Kris Croake, [kristina.croake@us.af.mil](mailto:kristina.croake@us.af.mil).

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KEYWORDS: E-band; V-band; phased arrays; thermal management; satellite communications

**AF212-0005** Munition Development for Petroleum, Oil, and Lubricant (POL) Targets

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Ground Sea; Battlespace

OBJECTIVE: Develop an ordnance concept for the catastrophic defeat of Petroleum, Oil and Lubricant (POL) targets.

DESCRIPTION: The goal is to catastrophically defeat large petroleum, oil, and lubricant (POL) targets with small weapons by exploiting the flammability of the POL (References 1-3). Ideally, a single weapon would perform two events -- spill the fuel and ignite the fuel. Fire starting in POL targets is challenging for two reasons: (a) the time to spill and start a fire is quite long relative to the duration of a typical explosive event; and (b) POL fuels are fire resistant (i.e., low vapor pressures, narrow flammability limits) for safety reasons, and are difficult to ignite. A two weapon concept (i.e., strike and restrike) would be acceptable, but a single weapon concept is greatly preferred. The contractor should develop an air-delivered weapon concept that is robust against a wide variety of fuel types – including commercial fuels (e.g., diesel fuel) and military fuels (e.g., JP-8). The weapon concept should not be solely applicable to POL targets; it should also function as a general-purpose bomb against blast-frag susceptible targets.

PHASE I: The contractor will develop a weapon concept and modeling capabilities for weapon initiation and target response. Small-scale testing is encouraged to (a) demonstrate proof-of-concept (feasibility), (b) validate the models, and (c) demonstrate fabrication and manufacturing techniques. Failure to start a fire in these tests is not disqualifying; their primary purpose is to identify critical issues early in the program and to show the contractor's capability to execute the Phase II program.

PHASE II: In Phase II, the contractor will refine the designs, develop additional modeling capability as needed, develop larger scale warhead prototypes, and demonstrate fire starting capability in a mid-scale tests (e.g., a 55-gallon drum). Targets of interest are commercial and military fuels.

PHASE III DUAL USE APPLICATIONS: In Phase III, the contractor will develop a full-scale prototype, and characterize weapon performance and effectiveness in large-scale arena tests. The contractor will also deliver an engineering-level code that simulates performance against POL targets.

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KEYWORDS: warhead; weapon; combustion; explosive; petroleum; oil; lubricant; POL; flammable; fire

**AF212-0006** W-Band Anti-Jam Receiver

TECH FOCUS AREAS: Network Command, Control and Communications

TECHNOLOGY AREAS: Sensors; Electronics; Space Platform; Information Systems

OBJECTIVE: Develop anti-jam receiver operating from 81 to 86 GHz suitable for future wideband satellite communications (SATCOM) satellite applications.

DESCRIPTION: Expanding the availability of battlefield information for better situational awareness to the warfighter will require increased satellite communications (SATCOM) capacity. Due to the present frequency allocation restrictions in existing SATCOM bands, there is a continually increasing need to exploit frequency spectrum available in nontraditional bands such as 81 to 86 GHz for uplinks and 71 to 76 GHz for downlinks.

In order to access this spectrum, a new generation of transmitter and receiver microelectronics, will be required. The Air Force is interested in sponsoring research to develop anti-jamming 81 to 86 GHz block down converter receiver. Would support multiple high data rate channels using advanced signal modulation waveforms. Develop a low noise block down converter receiver with high dynamic range and high resistance to interfering signals. Investigate filtering or other techniques for Jammer mitigation. Demonstrate low noise, high linearity and Conversion gain to significantly improve the overall sensitivity of receiver.

PHASE I: Develop innovative 81-86 GHz block down converter receiver designs that are resistant to jamming. Validate design feasibility through modeling and simulation.

PHASE II: Fabricate one or more prototypes and characterize performance in areas of jamming resistance, NF, gain, bandwidth, operating frequency, and operating temperature range.

PHASE III DUAL USE APPLICATIONS: Next generation of Wideband High data rate satellite communications. Commercial applications include high speed wireless communications for backhaul for 5G and internet.

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KEYWORDS: jammer; low noise amplifier; W-band; noise figure; satellite communications

**AF212-0007** Algorithms for MIMO Techniques to Enable a Coherent Distributed Array from Multiple Airborne Platforms

TECH FOCUS AREAS: Microelectronics; Autonomy; General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Sensors; Electronics; Air Platform; Battlespace

OBJECTIVE: Develop a set of algorithms to use sub-wavelength time and phase synchronization to increase performance of multiple, cooperating airborne sensors for multi-function RF applications.

DESCRIPTION: The ability to use Precision Navigation and Timing (PNT) on the order of picosecond and nanosecond accuracy can provide the needed phase synchronization to enable multiple airborne platforms to achieve phase coherence on receive and transmit. This phase coherence theoretically enables a constellation of UASs to perform as a large distributed aperture and provide performance gains to radar, jamming, and communications which have been up to this point unattainable. There are many efforts to provide the hardware architecture to enable the synchronization of time and phase across multiple channels and platforms. This effort will concentrate on developing the algorithms and methods necessary to process both the transmitted and received pulses of multiple platforms and aggregate them into a single radar detection or jamming waveform at the target location. After the algorithms are developed, a simulation that considers the sensitivity of algorithm performance due to both timing errors that can be modeled as a statistical mean and standard deviation of the clock delay and errors from an onboard INS/IMU that will provide position and velocity estimates of each source. Finally, the model should be improved to consider the traditional errors in a radar system that may include but are not limited to possible clutter effects, radar noise, and any propagation effects.

PHASE I: Demonstrate and model algorithms to prove the feasibility of using phase coherence to establish increased detection or jamming performance at a single STATIONARY point target from multiple platforms in flight.

PHASE II: Demonstrate and model algorithms that can use phase coherence to establish increased detection or jamming performance at multiple STATIONARY point target from multiple platforms in flight.

PHASE III DUAL USE APPLICATIONS: Demonstrate and model algorithms that can use phase coherence to establish increased detection or jamming performance at multiple MOVING point targets from multiple platforms in flight.

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**KEYWORDS:** MIMO; Cohere on Receive; Cohere on Transmit; Distributed Apertures; Distributed Coherent Array; Cooperative Radar; Cooperative Electronic Attack

## **AF212-0008** Next Generation Weapons Mission Planning

**TECH FOCUS AREAS:** AI/Machine Learning; General Warfighting Requirements (GWR)

**TECHNOLOGY AREAS:** Information Systems; Air Platform; Battlespace

**OBJECTIVE:** Demonstrate next generation Weapons Mission Planning software working in the Next-Generation Open Mission Systems (NOMS) architecture.

**DESCRIPTION:** Today's aircrews face increasingly complex and capable threat systems. Next generation weapons and tactics are in development to overcome and defeat these threats. These highly sophisticated systems of systems require large quantities of data seamlessly coordinated across multiple platforms at different classification levels. Due to this, workloads are placed on the planners that are orders of magnitude greater than past weapon systems, yet the planners have less time than ever to complete the work. To overcome these challenges; new mission planning capabilities with seamless data sharing, automated processes, and artificial Intelligence must be deployed faster than our adversaries can adapt to them.

Currently, the majority of the Air Force uses the Joint Mission Planning System (JMPS) to plan their flights. JMPS enables mission planners to create a flight plan based on multiple inputs including threats, targets, terrain, weather, aircraft performance capability and configuration. JMPS has been in the field for nearly 20 years, and is becoming increasingly outdated. The antiquated software architecture results in less than ideal planning times. To prepare for the future, the Air Force and Navy are jointly developing a next generation software architecture called Next-generation Open Mission Systems (NOMS). NOMS is a cloud-based architecture, in which Mission Planning software capabilities will be developed and fielded as microservices. As the Air Force transitions to this new architecture, the Mission Planning Program Office is seeking innovative solutions to improve weapons planning in NOMS. Areas include:

- Development of core weapons planning capabilities in microservices architecture to decouple dependencies of Mission Planning features resulting in a more robust and reliable planning experience that can be quickly updated when required
- Integrating machine learning and artificial intelligence to weapons delivery and threat avoidance, continuously improving and enhancing the planning workflow allowing for faster, more efficient, and better results
- Increasing process automation to eliminate manual weapons planning where possible in order to decrease planning times while improving quality of results
- Development of a next generation fly-out model (FOM) service enabling multiple planning microservices to share common weapon models in order to provide a common interface and architecture that enables quick and easy extension for new weapons
- Enhancing weapons planning user experience, including workflows and user interface improvements to provide intuitive and easy to use Mission Planning tools
- Seamless integration of weapon delivery planning, modeling and simulation, and weaponeering to include collateral damage assessment in order to provide greater fidelity and success rates when preparing a strike mission
- Develop tools to provide communication line of sight (LOS) analysis for network enabled weapons (NEW) ensuring controllers can communicate with the weapons when required throughout a mission
- Augmented reality/virtual reality (AR/VR) implementation for weapons planning to provide planners increased visibility for complex integrated 4D strike package planning
- Enhanced seamless cloud services linking target, weather, threat and other essential mission data from multiple sources to facilitate automated weapon planning processes

PHASE I: Investigate feasibility of one or multiple topic areas and provide innovative ideas to efficiently improve Mission Planning execution. The Phase I effort should also conclude with a sound understanding of the architectural approach required for development.

PHASE II: Phase I study will be leveraged to develop prototype software that can be integrated into the NOMS architecture providing enhanced weapons planning capability. The software should accomplish one or multiple goals that are addressed in the topic areas and be stable enough to show basic functionality.

PHASE III DUAL USE APPLICATIONS: Phase II prototype will be refined and developed into fully working, robust software. Phase III will also look to include additional functionality not present in the Phase II prototype.

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KEYWORDS: Mission Planning; Artificial Intelligence; Machine Learning; Automation; Weapons; Virtual Reality; Augmented Reality; cloud; microservices; weaponeering

## **AF212-0009** Design Tool for Multiple Electromagnetic Radome Problems

**TECH FOCUS AREAS:** Microelectronics; General Warfighting Requirements (GWR)

**TECHNOLOGY AREAS:** Sensors; Materials; Information Systems

**OBJECTIVE:** Develop a software tool for designing next generation military radomes that accounts for all aspects of the radome performance.

**DESCRIPTION:** Modern military radomes have many electromagnetic requirements. A holistic approach must be taken when designing radomes to meet the various performance requirements. The transmissivity and reflectivity of the radome is impacted by the materials used in the radome including frequency dependent, anisotropic, and metamaterials. Very thin coatings of anti-static material are often applied to the exterior surfaces of radomes to bleed off static electricity. Lightning diverter strips are used to protect the radome structure from physical damage due to lightning strikes, which are especially common for nosecone radomes. Structures behind the radome such as antenna arrays, electronic units, cable harnesses, and bulkhead geometries must also be considered. Reflections internal to the radome from high power radars can couple into cable harnesses under the radome and cause interference to electronic devices or cause physical damage to the cables. Current commercial simulation tools address aspects of the radome design problem but no single tool exists that can be used to assess the performance of the radome with regards to transmissivity/reflectivity, precipitation static, direct and indirect effects of lightning strikes, and cable coupling. A solution is needed that can address the vast scale of the problem (ranging from nanometers to meters), complex material properties including frequency dependent and anisotropic materials, tapered layer thicknesses, complex cable harnesses composed of multiple conductors and multiple branches, and complex antennas/radars located behind the radome. The simulation tool also needs to be able to efficiently generate data for many frequencies as the phenomena to be studied cover a wide range of frequencies (lightning to high frequency radars). The tool must also be able to work with many different CAD formats and include capabilities for efficiently healing CAD models. Very often, CAD healing requires more engineering time than setting up and running the electromagnetic simulation.

**PHASE I:** Demonstrate a simulation tool that is capable of simulating lightning strikes, precipitation static, cable coupling, and transmissivity/reflectivity of a complex radome structure. The tool should employ the same simulation framework and CAD model for all types of simulations performed. Develop a product roadmap for additional features to improve the accuracy, speed, and usability of the tool to be implemented during the Phase II.

**PHASE II:** Implement the product roadmap features identified during the Phase I. Validate the performance of the simulation tool through comparisons with measured data collected for military radomes. Explore hybridization with other simulation tools to account for radome/platform interactions. Document the software design and validation results in a final report. Provide intensive training to Air Force personnel for the simulation tool.

**PHASE III DUAL USE APPLICATIONS:** Radomes are used for many commercial applications including aerospace, naval, and land applications. For example, the performance of autonomous radars for self-driving vehicles is an extremely important application area where such a tool would find widespread commercial application.

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KEYWORDS: radome; lightning; precipitation static; cable harness

**AF212-0010** Innovative Engines for Small Unmanned Aerial Systems (SUAS)

TECH FOCUS AREAS: Autonomy

TECHNOLOGY AREAS: Air Platform

**OBJECTIVE:** This topic is for innovative propulsion for SUAS (Group 2 thru small Group 4 UAS) that supports Global ISR missions such as: long range – persistent ISR, air launch – extended reach ISR, and time critical – responsive ISR. The topic shall address how innovative propulsion will allow for improved UAS capabilities, the use of UAS in mass, and consider air launch and performance at altitude (25,000 ft AGL). Objective: A concept design for innovative propulsion of GR2 (2 to 7 hp), GR 3 UAS (10 to 100 hp), and small GR 4 UAS (500 to 700hp). Small engines are defined as less than 1000 lbs thrust and under 1000 HP.

**DESCRIPTION:** To keep ahead of the changing global environment, improved capabilities for UAS systems for Global ISR are needed. The USAF 2030 Science and Technology Strategy seeks to: Develop and Deliver Transformational Strategic Capabilities: thru Global Persistent Awareness and Complexity, Unpredictability, and Mass. This objective can be achieved thru increased capabilities from SUAS with improved propulsion. Present day GR2 thru GR4 propulsion systems are slow, noisy, inefficient, and lose performance at altitude. These SUAS use piston and rotary engines which are gasoline operated and have limited life of approximately 200 hours and fly at 100 knots or less. Piston engines in this class have low thermal efficiencies, less than 20% and low specific power of approximately 0.5 hp/lb. What is needed is innovation in the UAS propulsion for quiet operation, performance at altitude, light weight, improved efficiency, and high power to weight.

**PHASE I:** The proposals should expand the technical enterprise upon teaming with “non-traditional experts” for propulsion innovations for GR 2 SUAS (less than 50 lbs GTOW), GR3 SUAS (less than 1350 lbs. GTOW), and GR4 UAS (less than 5000lbs). Non-traditional experts are those of authority/study that are outside of the UAS community/industry, but have novel concepts to meet the future S&T demands. Concepts in innovative propulsion are sought which include: internal combustion, detonation, and nuclear; which are more efficient, have higher specific power and more durable. The concept shall demonstrate the feasibility of the design, development and integration activities required for an operational SUAS. Small Propulsion are engines less than 1000 HP/1000 lbs thrust. Key design attributes are; Specific Power > 1.0 HP/lb; SFC < 0.5 lbs/hp-hr; and +500 hr life.

**PHASE II:** Builds off of the PH I effort and consists of the development of a prototype and takes the prototype to a ground test to demonstrate its power, efficiency, acoustics and durability. This phase shall have a design review prior to fabrication and identify risks with risk reduction tests completed before the final engine demonstration. Further, teaming with operational users should be established to show how the new UAS capabilities will improve Global ISR thru improved SUAS propulsion.

**PHASE III DUAL USE APPLICATIONS:** Integrate the innovative engine to a candidate UAS for flight testing. The innovative engine can be developed for commercial application for aviation, marine, and land-based power generation; hence being dual use in nature.

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**KEYWORDS:** Internal Combustion Engine; Combustion Strategies; specific power; variable cycle; hybrid propulsion; efficiency; thermal efficiency

**AF212-0011** ASCENT Based Thruster Component and System Characterization and Optimization for Lifetime Extension

TECH FOCUS AREAS: Network Command, Control and Communications

TECHNOLOGY AREAS: Space Platform

OBJECTIVE: Mature advanced spacecraft energetic non-toxic (ASCENT), formerly referred to as AF-M315E, technology to meet or exceed the performance of state of the art chemical propulsion systems for air and space platforms requiring thrust levels from 1 N through 44.5 kN.

DESCRIPTION: The intent of this topic is to accelerate the proliferation of ASCENT monopropellant technology to be available to meet present and emerging mission needs. Current state of the art chemical propulsion for spacecraft, kick and upper stage platform applications rely upon extremely hazardous and sensitive propulsion technologies such as hypergolic or cryogenic bipropellants, granular catalytic reactors in the case of monopropellants, or sensitive solid rocket motors. ASCENT monopropellant provides a significant reduction in operational hazards due to its reduced vapor pressure contact hazard relative to hypergols, and electrostatic discharge sensitivity. Areas of technology maturation of interest are:

- Reactor or ignition approaches that reduce environmental control needs such as pre-heat and have flexibility to scale across the thrust levels of interest
- Reactor or ignition approaches that mitigate duty cycle and life limiting attrition mechanisms
- Long term compatibility and consistent operability of storage, feed, and flow control components for extended mission life applications
- Characterization and understanding of the impact of aging and extended exposure to state of the art propulsion component materials to ASCENT hazard and delivered performance
- Modeling and simulation tools capturing component behavior with ASCENT, reactive and non-reactive flow models, optimized catalytic or energy deposition ignition device characteristics such as pore size and density, dominant decomposition and combustion reaction paths to support design of increased life and thrust delivery
- Diagnostic approaches that support delivered performance and thruster state of health assessment that can provide accurate information from the high temperature and oxidation environment ASCENT produces under decomposition and combustion
- Thermal management approaches to decrease required pre-heat power for a given reactor configuration and propellant feed line stand-off distances in propulsion systems.

In regards to component optimization and long term compatibility, responsive manufacturing methods such as those that fall under additive manufacture techniques or coatings to impart desired characteristics are also of interest. Igniter or reactor configurations of interest are not limited to state of the art structure and composition. Approaches to maturation should include sufficient engineering analyses to provide confidence of feasibility and pathway to flight qualification. Supporting analyses should also consider limitations in the physical architecture so that the approach could satisfy current state of the art mission duty cycles and life as defined by propellant throughput associated with required delivered impulse across the thrust range of 1 N through 44.5 kN.

PHASE I: Demonstrate at minimum empirically via bench level heavyweight configuration for measured data feasibility of maturation approach for target platform application mission duty cycles and the critical aspects of the physical architecture that drive the requirements. Industrial base considerations should be included in the analysis. Lab bench validation to the extent feasible is also desired.

PHASE II: Demonstrate the viability of the Phase I concept performance and manufacturability of the architecture to a TRL 5/6 level with supporting empirical data and analysis.

PHASE III DUAL USE APPLICATIONS: Transition of Phase II technology to a flight demonstration program. This effort will include all necessary activities for flight qualification as well as support for on-orbit flight demonstration activities.

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KEYWORDS: ignition; energy; deposition; decomposition; injection; pressurization; catalyst; monopropellant; reaction; sinter; reactor; igniter

## **AF212-012** Rocket Landing on Irregular Surfaces

**TECH FOCUS AREAS:** Autonomy; General Warfighting Requirements (GWR)

**TECHNOLOGY AREAS:** Space Platform; Air Platform

**OBJECTIVE:** Both Tactically Responsive Space Access as well as Rocket Cargo have the need to lift-off from and/or land on a non-improved, irregular surface. This could be anything from a parking lot to an irregular farm field. However, little work has been conducted in landing a rocket on flat, improved surfaces, let alone these types of surfaces. This topic seeks to develop strategies that can be used to enable landing on these surfaces as well as mitigations that can be potentially implemented to enable this capability. Mitigations can either be lightweight structures that can be placed on the landing surface or structures, strategies placed on the rocket, nozzle technologies that address the plume impaction, smart landing structures, and landing software.

**DESCRIPTION:** Although vertically landing a rocket on an improved, flat surface has been achieved by multiple launch vehicle companies (Masten Space, SpaceX, Blue Origin), landing a rocket vehicle on an irregular, unimproved surface has a number of challenges including, but not limited to the rocket sinking in the surface, the plume kicking up dust and creating an observable event, and the uneven footing causing the rocket to fall over. The terrain that the rocket vehicle may land in is also unpredictable and not known a priori. Any solution needs to be broad enough to handle multiple potential landing challenges and to be able to adjust to the situation seen at landing. This topic seeks to address these and other challenges at sub-scale levels in phase I and phase II and transition those technologies to a full-scale vehicle in Phase III.

The intent of this topic is to accelerate the development of technologies to vertically land a rocket on an irregular, un-improved surface. It is recognized that a number of different technologies are possible to achieve the overall objective. This can include (but is not limited to) sensor technology on the lander, nozzle technology to mitigate plume impingement, venting of gases and liquids from the vehicle as it is landing, as well as mitigating ground structures that can easily and quickly be applied to a surface. It should be noted that it is necessary to balance precision in the landing location, speed of access to vehicle after landing with terrain avoidance, and minimizing potential observability issues such as the creation of dust cloud which can cause damage to nearby structures as well as allow for viewing of the landing site from a distance.

Approaches to maturation to full-scale should include sufficient engineering analyses to provide confidence of feasibility and pathway to feasibility at full scale. Supporting analyses should also consider limitations in the physical architecture of both the sub-scale and the potential full-scale systems.

**PHASE I:** Perform analysis and/or demonstrations of vertically landing a rocket on an irregular, non-improved surface in order to identify critical technical challenges and explore feasibility of the proposed concept.

**PHASE II:** Perform sub-scale testing to demonstrate feasibility of vertically landing a sub-scale rocket on an irregular, non-improved surface. Achieve TRL 6 for a sub-scale test article.

**PHASE III DUAL USE APPLICATIONS:** Transition of Phase II technology to a full-scale demonstration program. This effort will include all necessary activities for flight qualification as well as support for a full-scale test landing on an irregular, non-improved surface.

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

services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign

nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Contracting Officer, Ms. Kris Croake, [kristina.croake@us.af.mil](mailto:kristina.croake@us.af.mil).

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KEYWORDS: liquid rocket engine; vertical landing; plume impingement; high temperature materials

**AF212-0013** Mid-IR Satellite Communications

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

**TECHNOLOGY AREAS:** Space Platform

**OBJECTIVE:** The goal is to develop a high-speed infrared laser transmitter for ground-to-satellite and satellite-to-ground communications that is highly directional and covert.

**DESCRIPTION:** Military and often commercial satellites require high-speed ground-to-satellite and satellite-to-ground communications that are also covert. While radio frequencies are often used, they are easily intercepted since beam footprints are large. Thus, additional steps such as strong encryption are required. But even then, an adversary can tell when a transmission is taking place and is free to record the transmission and attempt to decrypt it later. Laser wavelengths offer a satellite communications solution where the beam footprint can be made much smaller thus preventing nearby signal interception. However, visible and near-IR laser wavelengths are undesirable for eye safety reasons. Also scattering of such wavelengths can be easily noticed by the human eye or night-vision type devices severely mitigating the desire to be covert. In contrast, a mid-infrared wavelength has many advantages. First of all, it is an eye-safe wavelength (light is absorbed by ocular media and not focused on the retina). Secondly, it is not detectable by the human eye nor by night-vision devices. And finally, wavelengths near 4 microns have optimum atmospheric transmission, avoiding aerosol scattering at shorter wavelengths and absorption at longer wavelengths. The topic would seek to develop a mid-IR laser transmitter with carrier wavelength of nominally 4 microns, > 1 Gbit/s data rate modulation, M2 5 W. The laser source should be space qualifiable. Beam quality and long-term operation shall be demonstrated as well as long-distance atmospheric transmission.

**PHASE I:** In Phase I one would design, fabricate and demonstrate a breadboard laser transmitter operating near 4-micron wavelength with modulation or pulse rate of 1 GHz. This would explore the feasibility of novel structural, laser material, and fabrication approaches via proof-of-principle experiments.

**PHASE II:** In Phase II, fabricate and demonstrate a prototype laser transmitter/receiver system operating near 4-micron wavelength with modulation or pulse rate of 1 GHz and average output power > 5 W.

**PHASE III DUAL USE APPLICATIONS:** The fundamental nature of AFOSR programs reflect the broad opportunity to commercialize science to both commercial and defense markets. Awardees will have the opportunity to integrate with prospective follow-on transition partners. The contractor will transition the solution to provide expanded mission capability to a broad range of potential Government and civilian users and alternate mission applications.

**NOTES:** The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the proposed tasks intended for accomplishment by the FN(s) in accordance with section 5.4.c.(8) of the Announcement and within the AF Component-specific instructions. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws. Please direct questions to the Air Force SBIR/STTR Contracting Officer, Ms. Kris Croake, [kristina.croake@us.af.mil](mailto:kristina.croake@us.af.mil).



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1. 2018 National Defense Strategy of the United States Summary. Retrieved from: <https://www.Defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>

KEYWORDS: Space, IR, communication, satellite, Command and Control

**AF212-0014** Simultaneous Harvesting of Incoming Solar and Outgoing Thermal Radiation in a Space Environment

TECH FOCUS AREAS: Network Command, Control and Communications

TECHNOLOGY AREAS: Sensors

**OBJECTIVE:** The objective of this topic is to develop technologies that enable harvesting of outgoing thermal radiation to generate useful work. Moreover, the incoming sunlight and outgoing thermal radiation typically occupy different spectral wavelength ranges. The sunlight is in the wavelength range spanning from approximately 2 micron to ultraviolet, whereas the thermal radiation is in the longer wavelength range. Therefore, it is conceivable that both solar and thermal radiation can be harvested using the same device in different operation modes, leading to the capability of simultaneous harvesting. Being able to do so could enhance the power generation capability of a spacecraft without increasing its weight.

**DESCRIPTION:** In a space environment the thermal balance of a spacecraft is dominated by radiations. These radiations include sunlight as well as the thermal radiation. To control the thermal balance of a spacecraft it is therefore of crucial importance to control the solar absorption and the thermal emission properties. Moreover, both the process of the absorption of sunlight and the emission of thermal radiation can be harvested to generate useful work such as electricity. However, while significant work has focused on developing high-efficiency photovoltaic cells for harvesting sunlight, far less work has been devoted to developing device that can harvest the outgoing thermal radiations.

**PHASE I:** Phase I of the project will explore the feasible device concepts and elucidate the theoretical and practical limits of simultaneous energy harvesting

**PHASE II:** Phase II of the project will demonstrate a viable scheme for simultaneous harvesting with generated power density exceeding that of a standard photovoltaic cell for the same physical area.

**PHASE III DUAL USE APPLICATIONS:** The fundamental nature of AFOSR programs reflect the broad opportunity to commercialize science to both commercial and defense markets. Awardees will have the opportunity to integrate with prospective follow-on transition partners. The contractor will transition the solution to provide expanded mission capability to a broad range of potential Government and civilian users and alternate mission applications.

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1. 2018 National Defense Strategy of the United States Summary. Retrieved from: <https://www.Defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>

**KEYWORDS:** solar; thermal radiation; space; temperature mitigation; power conversion; photovoltaic

**AF212-0015** Meta-lens Filtering and Beam Forming for Mid-Wave and Long-Wave Infrared LEDs and Photodiodes

TECH FOCUS AREAS: General Warfighting Requirements (GWR)

TECHNOLOGY AREAS: Sensors

OBJECTIVE: The objective of the topic is to develop meta-lens filtering and beam-forming for LED and PD packaging using novel materials such as chalcogenide as windows materials for patterning into meta-lenses.

DESCRIPTION: Compared to commercial visible optical packaging technology for LEDs and PDs, the mid-IR technology base is decades behind. This is because the transmissive and diffractive lenses and encapsulation materials for visible wavelengths are too absorptive or even opaque at mid-IR wavelengths. The objective of the topic is to develop meta-lens filtering and beam-forming for LED and PD packaging using novel materials such as chalcogenide as windows materials for patterning into meta-lenses. These will require designing and developing layers and structures for converting the Lambertian emission profile of LEDs into suitable narrow beams, estimating the tradeoff between light collection efficiency and beam divergence. Numerous applications are envisioned such as chip-scale on and off communications, bio-sensors, and gas detection of such species as methane and CO<sub>2</sub> by band limiting the emission and reducing the opto-mechanical system requirements for optical gas sensing. One could imagine health and safety gas detection for Air Force systems such as wearable sensors for jet fuel vapor detection and other hazards. The beam-forming capabilities should be especially useful for point-to-point free-space communication links in the MWIR. The low-SWAP properties of such LED-PD paired devices for gas sensing lend themselves to needs in unmanned aerial vehicles. The higher-performance emitter configurations would also be useful for high-stability, on-platform calibration references for satellite-borne and other sensors.

PHASE I: A Phase I effort would determine the feasibility of optimizing the novel films and meta-lens geometries and characterize the transmission.

PHASE II: A Phase II project would adapt these meta-lenses to TO and surface mounted packages for LEDs and PD product prototypes, with the goal to design for additional wavelengths.

PHASE III DUAL USE APPLICATIONS: The fundamental nature of AFOSR programs reflect the broad opportunity to commercialize science to both commercial and defense markets. Awardees will have the opportunity to integrate with prospective follow-on transition partners. The contractor will transition the solution to provide expanded mission capability to a broad range of potential Government and civilian users and alternate mission applications.

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1. 2018 National Defense Strategy of the United States Summary. Retrieved from: <https://www.Defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>

KEYWORDS: optics; lens; sensing; space; satellite