SF25D-T1201: Adaptive and Intelligent Space (AIS)

ADDITIONAL INFORMATION

N/A

TECHNOLOGY AREAS:

Space Platforms

MODERNIZATION PRIORITIES:

Space Technology

KEYWORDS:

Space Domain Awareness (SDA); Space Control (SC); Space Battle Management (SBM); Passive RF; LIDAR; Radar Detection Technologies; Next-Gen Sensor Solutions; Machine Learning; AI; Radiation-Hardened; Real-Time Data Processing; Rapid response

OBJECTIVE:

The United States Space Force (USSF) is seeking innovative solutions to inform the future of autonomous, resilient, and intelligent space operations through the Futures Series: Adaptive and Intelligent Space (AIS) Challenge—a strategic initiative led by Task Force Futures in partnership with SpaceWERX. This topic invites proposals that investigate the technical and operational feasibility of emerging space concepts and dual-use technologies capable of supporting coordinated satellite operations across Low Earth Orbit (LEO), Geostationary Orbit (GEO), eXtended GEO (XGEO), and the cislunar environment.

In Phase I, offerors should focus on early-stage research activities—including literature reviews, modeling and simulation, trade space analyses, and university or non-profit research collaborations—to lay the groundwork for prototype or proof of concept demonstrations to be developed in a potential future Phase II. This exploration phase is intended to reduce risk, validate feasibility, and refine mission alignment before committing to integrated technology demonstrations. Objectives include:

1. Explore novel concepts and architectures that support enhanced autonomy, survivability, and responsiveness in degraded or adversarial space environments.
2. Assess the feasibility of onboard edge intelligence, predictive threat analytics, and autonomous decision-making systems suitable for bandwidth-limited or contested conditions.
3. Analyze modular, scalable systems—including sensor payloads, computing elements, and spacecraft buses—that can adapt to evolving missions and orbital domains.
4. Develop preliminary Concepts of Operations (CONOPS) aligned with future USSF mission needs and evaluate potential integration paths with Space Force operational constructs.

Proposals should clearly define their Phase I scope, research methods, and collaboration plan with a research institution. While transition and commercialization planning are not the primary focus of Phase I, proposers should briefly articulate how the work could inform a Phase II prototype or proof-of-concept demonstration and support longer-term mission relevance.

ITAR:

The technology within this topic is restricted under the International Traffic in Arms Regulation (ITAR), 22 CFR Parts 120-130, which controls the export and import of defense-related material and services, including export of sensitive technical data, or the Export Administration Regulation (EAR), 15 CFR Parts 730-774, which controls dual use items. Offerors must disclose any proposed use of foreign nationals (FNs), their country(ies) of origin, the type of visa or work permit possessed, and the statement of work (SOW) tasks intended for accomplishment by the FN(s) in accordance with section 3.5 of the Announcement. Offerors are advised foreign nationals proposed to perform on this topic may be restricted due to the technical data under US Export Control Laws.

DESCRIPTION:

This topic seeks to explore emerging technical concepts that could enable a future generation of autonomous, resilient, and networked satellite systems for U.S. Space Force (USSF) missions. The Adaptive and Intelligent Space (AIS) Challenge addresses foundational gaps in how space-based assets are allocated, coordinated, and managed under contested and communication-degraded conditions.

The objective of this Phase I effort is to investigate the scientific, operational, and engineering feasibility of novel technologies supporting space control and battle management, with the goal of improving autonomous behavior, real-time responsiveness, and adaptability in orbital environments including LEO, GEO, XGEO, and cislunar space. Offerors are encouraged to propose early-stage research concepts that address one or more of the following focus areas. All work should include collaboration with a qualified research institution, and clearly define the technical approach, scope of analysis, and expected outcomes of a successful Phase I study:

1. Edge Computing & Algorithms: Investigate edge processing architectures and AI/ML algorithms that can operate onboard spacecraft, enabling autonomous, low-latency decision-making in support of space domain awareness and battle management. This topic area should improve the ability to autonomously manage space activities, and improve the ability to autonomously fuse, process, and filter data from multiple sources and sensors. Desired capabilities may include:
- Technical feasibility of onboard threat analytics
- Architectures for resilient, secure, and radiation-tolerant edge computing
- Methods for reducing kill-chain latency by at least 50% and operator workload by at least 25%
- Potential test environments (digital or orbital) for future validation
- Discrimination in contested environments including resilience to data poisoning, sensor degradation, obfuscation, high noise

Desired technologies may include:
- Predictive threat analytics and orchestrated response
- Thermal management and radiation-hardened solutions for edge and next-gen processing technologies (e.g. neuromorphic)
- Data security
- Agile and assured use of high-partition data
- High-partition data agility and balanced software/AI integration
- Anomaly or maneuver detection AI/ML algorithms and SDA data processing with high throughput
- Tip & Cue capability between SDA and satellite coordination functions
- Memory-safe language applications for autonomy
- Improved ‘do-no-harm’ software for Autonomous Rendezvous and Proximity Operations
- Zero-trust for on-board computation methods
- Data compression algorithms
- Simulation of SDA data to improve training of robust maneuver detection models
- Cislunar simulation and visualization tools

2. Sensors Payloads: Explore modular sensor payload concepts with integrated processing that support multi-modal detection, threat characterization, and real-time insight generation. Emphasis should be placed on adaptability across mission profiles and orbital regimes. This topic area should improve the ability of the USSF to monitor, characterize, and maintain custody of space objects for a comprehensive sight picture. Desired capabilities may consider:
- Integrated sensor-computing packages for persistent tracking
- Techniques for novel SDA collection and data fusion
- Higher fidelity persistent space object custody
- Attribute in-space actions across multiple collection spectra (including visible, IR, RF, LiDAR)
- Solutions for software-defined or reconfigurable payloads
- Techniques for improving satellite change detection and maneuvers

Desired technologies may include:
- Passive RF, LIDAR, radar, IR, hyperspectral sensors
- HPC-S (high-performance computing at the sensor)
- Space-based sensing concepts suitable for GEO, XGEO, and cislunar

3. Bus Design: Assess spacecraft bus concepts that are modular, autonomously managed, and designed for mission flexibility and lifecycle extension. This topic area should enable improved integration of the prior two topics for advanced sensing and computing capabilities. Desired capabilities include:
- Hardware modularity to allow rapid integration of emerging technology
- Software modularity to allow integration of autonomous capabilities
- Reconfigurability across mission profiles and unexpected orbit transfers
- All-of-vehicle (bus and payload) autonomous optimization
- Autonomous load-shedding method to maintain mission operation and payload prioritization under duress
- Autonomous maneuver for collision avoidance

Desired technologies may include:
- Architectures enabling lifecycle extension

- Modular tech, adaptive interfaces
- Bus platforms designed to adapt to technological change without re-architecture
- Integration-ready design for sensors, compute, and maneuver systems
- Highly maneuverable design to include high-delta V, thermal management, and on-board power systems capable of running edge-computing capability

Proposals must emphasize technical feasibility and clearly outline a Phase I research plan that includes modeling, simulation, literature review, or trade studies. While a Phase II transition concept may be outlined, Phase I deliverables are expected to focus on a feasibility study detailing USSF CONOPS and technical viability, as well as analytical findings, and early validation in collaboration with a university or research partner.

ANNEX I: Guidelines for CONOPS development and Feasibility Study
The Concept of Operations (CONOPS) should clearly communicate how the technology is intended to support a military mission within a defined system. The main purpose of the CONOPS is to facilitate a common understanding of a future system to help develop operational and system-level requirements. CONOPS should be written at the system level first and then expanded on how the technology functions enable successful military operations. The CONOPS needs to include, at a minimum:
- The USSF mission and the mission military objectives
- The problem being addressed by the technology in the context of the mission (e.g., existing capability gap)
- (preferred) An operational overview diagram along with supporting text
- (preferred) A system architecture overview diagram with all the elements needed to accomplish the mission to include
- Integration-ready design for sensors, computing, and maneuver systems

Operating Concept to Technology: Space Control and Battle Management are supported through total Space Domain Awareness. The first imperative is achieving persistent, predictive, and precise Space Domain Awareness (SDA). SDA must encompass not only tracking and characterization of objects in orbit, but also attribution of intent, behavioral analysis, and predictive targeting. This requires integration across commercial sensors, alongside AI-driven decision aids and real-time orbital maneuver detection.

Feasibility Study:
A feasibility study is an assessment of the practicality of developing and implementing a new technology within a given concept. The study aims to objectively and rationally uncover the strengths and weaknesses of the new technology, the feasibility of successful development of the technology, and the viability of the success of implementation of the technology in the proposed CONOPS. The study should:
- Identify the benefits of the new technology within the CONOPS over existing solutions (or lack thereof)
- Identify the risks, uncertainties/unknowns, and issues of the proposed CONOPS with mitigation and closure measures
- Identify the critical technology elements (CTEs) of the new technology
- Provide data to support the feasibility of technology development of each CTE to include: literature research supporting technical viability or historical usage, trade studies identifying existing technologies, current developments, and/or feasible development pathways, analysis demonstrating technical solutions, and heritage usage of similar technology with identified differences in operations and/or environment for proposed CONOPS.

PHASE I:

Phase I should focus on developing a feasibility study detailing a technically sound solution to a USSF capability need. This can include evaluating the technical and operational feasibility of a proposed concept within one or more of the specified AIS technology focus areas: edge computing and algorithms, sensor payloads, or bus design. Offerors must develop an initial Concept of Operations (CONOPS) and conduct foundational studies to assess the viability, relevance, and potential impact of the proposed technology in future contested space environments. (See Annex I for guidelines on Feasibility study development and CONOPS in the Topic Description). The Phase I proposal will not exceed 15 pages in length. Efforts under Phase I may include:

- Literature reviews and state-of-the-art assessments
- Modeling, simulation, or analytical studies to explore performance, scalability, and mission relevance
- Preliminary architecture definitions and technology trade space analysis
- Operational use case development, mapped to current or projected Space Force mission needs
- Identification of technical risks and mitigation strategies

Offerors must clearly describe how the effort will:
- Leverage the capabilities and domain expertise of the affiliated research institution
- Advance the small business's internal research and development (IR&D) toward a defensible technical approach
- Inform a future Phase II prototype or proof-of-concept demonstration effort, including early thoughts on transition, testability, and alignment with Space Force capability development priorities

This topic modifies the traditional SBIR/STTR Phase I process, with an event called the Adaptive and Intelligent Space (AIS) Phase I Showcase serving as the basis for Phase II selection.

Phase I Deliverables and Milestones:
Phase I deliverables include an initial report, a documented feasibility assessment, initial CONOPS and architectural framework, a proposed Phase II development plan (including scope, goals, and transition relevance), the final report and the most critical deliverable is the required documentation for the AIS Phase I Showcase. This event will occur near the end of the Phase I Period of Performance (PoP). All Phase I applicants must include the AIS Phase I Showcase in their proposal milestone schedules, and all awards made under this topic will include the AIS Phase I Showcase as a contract deliverable. The following documentation must be submitted at the showcase (not as part of the initial Phase I proposal submission):
- Proposal Cover Sheet (Volume 1)
- Technical Volume (Maximum 5 pages) (Volume 2)
- Cost Volume (Volume 3)
- Company Commercialization Report (Volume 4)
- Fraud, Waste, and Abuse Training (Volume 6)
- Disclosures of Foreign Affiliations (Volume 7)
- Presentation Slide Deck (a maximum of 10 slides that includes summary information from the required volume sections listed above)

Note, the AIS Phase I showcase will constitute the Phase I awardees' Phase II proposal submission. No separate Phase II proposal will be requested. Applicants will be provided more specific submission information as part of their Phase I award instructions.

Travel Considerations:
The AIS Phase I Showcase will take place in El Segundo, CA, near the end of the Phase I PoP. Companies may include the cost of travel for up to two individuals in their Phase I budget to attend this event. The applicant/awardee is responsible for any transportation costs related to any additional individuals that attend this event.
The above-mentioned artifacts and the showcase presentation will constitute the Phase II proposal submission for purposes of the Phase II award decision. Phase II awardees will be determined based on the documentation submitted and the material presented during the AIS Phase I Showcase.

PHASE II:

The Phase II shall focus on the development and demonstration of a functional prototype— or proof-of-concept demonstration-- software, hardware, or integrated systems—based on the feasibility studies and CONOPS defined in Phase I. This work should build on the small business's internal R&D, reduce technology development risk, and support alignment with future Space Force mission concepts. The prototypes or proof-of-concept demonstration should address specific operational challenges identified within the AIS Challenge's three core focus areas: Edge Computing & Algorithms, Sensor Payloads, and Bus Design.

The objective is to deliver and validate technologies that enhance space control, battle management, and space domain awareness capabilities under contested, degraded, or cislunar operational conditions. Potential examples of Phase II capabilities include:

Edge Computing and Algorithms Problems:
- Data Security
- Big Data Processing in Space
- Software/AI Balance, Decision making is slow on orbit, goal is on-orbit self-monitoring and healing
- Training vs. Inference
- Resilience to data/model poisoning
Potential Strategies & Solutions:
- Improved Battle Management, Proactive Predictive Threat Analysis, Collison Avoidance, Rendezvous Proximity Operations
- Spoofing Detection, Robust and Resilient Missions, Agile Multi-Domain Security
- Rapid ID of Anomalies to avoid Operational Surprises, Data filtering, Real Time processing, Sense to Action, Autonomy/Load Sharing Computing and Concurrency, AI technology, High Performance & Assured Data Transport
- AI Based/Real-Time Decision Making, Infusion of New AI/ML Architectures
- Consideration of Human Factors – in/on/out of loop
- Onboard orchestrated Threat Response, Better Space GPU, and processing, RPO System
- Secure Encryption of Trusted Agents, Quantum Encryption, Self-Healing Mesh Networks/Sensors
- Deep Neural Networks for Space, Mesh Network Edge Computing, Data Processing Algorithms, Sharing of data among systems

- Federated AI -Agents across Systems/Payloads
- Standardized Test Regime, Standardized Models for ModSim, Orbital Test Bed, Unclass or CUI Test and Validation

Sensor Payload Problems:
- Size, Weight, and Power (SWaP) too large (Size Weight and Power)
- Phenomenology Restrictions, Focal Plane limitations, Solar Exclusion Angles causing blind spots, Cone of Shame (Blind Spots)
- Enable Distributed Sensor Systems
- Sensitivity Restrictions
- Perform multiple missions and potential Cislunar Space Sensing, Simultaneous multi-object tracking
- Red States (Adversaries) aware of Systems
- Resilience to sensor degradation
- PED; Process, Exploit, Disseminate
- Cost – Future Solutions are expensive
- All Weather sensing – i.e. Can look into Sun, etc.
- Power/Thermal Management

Potential Strategies & Solutions:
- SWaP reduction based on new technologies, materials, or designs
- Advanced approaches to Non-Traditional Methods of improving resolution in all domains, use more advanced versions of current sensors
- Mesh Network, Proliferate Sensor Network in Space, Fusionable Sensor Data capacity
- Re-configurable Sensors, SOI
- Quantum Processing
- Enable Distributed and/or multi-platform Sensing Systems, Real time data fusion from distributed sensor system, high-frame rate, IR Sensors (EO, Hyperspectral), Quantum Sensors, Use of SAR (Radar), Neuromorphic, Integrated LIDAR, Integrated Passive RF, Laser Detection
- Mesh Network Edge Computing, Data Processing Algorithms, Sensor Hardware/SW Adaptability, Autonomous Navigation, XGEO Sensors
- XGEO Sensors

Bus Design Problems:
- Need for more modularity
- Need for more maneuverability
- 10x GEO useability and Communications
- RPO Ability
- Better Thermal management

Potential Strategies & Solutions:
- Longer Mission Life, better SWaP, Improved Delta-V
- Bus is adaptable to more payloads and more solutions
- High Delta V, allow for rapid movements, high position predictability and navigation, better pointing accuracy
- 10x GEO useability and communications, High Delta V, Radiation Hardened, better deep space communication
- Improved Qualification and Validation of RPO Software and Hardware
- Less heat to manage, less power used, better payload performance, longer life, improved heat rejection
- Improved Qualification and Validation of RPO Software and Hardware
- Thermal Scavenging Controls, Generative Design, improved heat rejection methods

PHASE III DUAL USE APPLICATIONS:

Phase III efforts are intended to transition technologies developed under this topic into operational use and/or commercial markets, leveraging non-SBIR/STTR funding. Phase III work may include productization, integration, certification, and large-scale deployment of the capability developed in Phases I and II. Awardees should focus on the following key areas:

1. Commercialization and Scale-Up:
    - Transition the technology developed in Phases I and II into commercial applications, leveraging non-SBIR/STTR funds for scale-up, production, and marketing
    - Identify potential commercial partners, customers, or licensees interested in adopting the technology for commercial use in various industries, including aerospace and defense.
2. Regulatory Compliance and Certification:
    - Obtain necessary government approvals, certifications, and accreditations required for the deployment and operation of the technology in military and commercial settings.
3. Transition Planning and Execution:
    - Develop a comprehensive transition plan outlining the steps, milestones, and resources required to transition the technology from R&D to operational use.
    - Coordinate with relevant stakeholders, including government agencies, industry partners, and end-

users, to ensure seamless integration and adoption of the technology into operational workflows and systems.
4. Additional DAF Customer Opportunities:
    - Explore additional opportunities for technology transition and adoption within the Department of the Air Force (DAF) and other military branches. Engage with DAF customers, such as the Space Force, Air Force Research Laboratory (AFRL), and other organizations, to identify specific mission needs and requirements that can be addressed by the developed technology.
    - Collaborate with DAF customers to tailor the technology to their unique operational contexts and facilitate its adoption for mission-critical applications.

By effectively executing the Phase III effort and transitioning the technology into operational and commercial use, the project aims to maximize the impact and value of the SBIR/STTR-funded R&D efforts, ultimately contributing to national security, economic growth, and technological innovation.

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TECHNICAL POINT OF CONTACT (TPOC):
None