NASA SBIR 2025-I Solicitation

Proposal Details

Proposal Number: A1.02-1004
Subtopic Title: Quiet Performance - Airframe Noise
Proposal Title: Accurate Airframe Noise Predictions Using Large Eddy Simulations

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Airframe noise generated by the undercarriage (landing gear, cavities) and high-lift devices is by far the most dominant source of noise during approach conditions and has been known to cause adverse health effects in communities residing near airports. There is a desperate need for computational tools that can rapidly and accurately predict this noise in order to integrate acoustic analysis in the design design process and to meet the regulatory goals around noise reduction. The current industry standard appears to be a single Lattice Boltzmann hybrid RANS/LES solver; the work proposed in this Phase-I research is intended to remedy this by mitigating several known limitations in the current state-of-the-art. Volcano ScaLES, an immersed boundary wall-modeled Large Eddy Simulation (WMLES) will be utilized to demonstrate accurate broadband noise predictions on a variety of test cases such as the PDCC-NLG landing gear model, the 30p30n multi-element airfoil and a the 10% scaled high-lift common research model in landing configuration. We intend to demonstrate that these cases can be completed with overnight turnaround (<16 hours of walltime) using single server/node resources with up to 8 general purpose computing GPUs (such as the Nvidia L40S). Furthermore, highly automated and rapid mesh generation capable of representing un-simplified complex geometries will be utilized along with entirely in-situ post-processing for farfield acoustics propagation and flow visualization. Beyond the 3 demonstration problems, additional code enhancements targeting the Ffowcs Williams-Hawkings (FHW) formulation to address the method's well-known drawbacks (such as need for quadrupole corrections) will be also be considered in Phase-I. If successfully achieved, the goals outlined in the work would represent a major advancement computational predictions of airframe noise, and we anticipate significant interest from both airframe developers and government agencies.

Duration: 6

Proposal Details

Proposal Number: A1.02-1009
Subtopic Title: Quiet Performance - Airframe Noise
Proposal Title: Machine Learning-Augmented Far-Field Noise Prediction for Distributed Electric Propulsion Aircraft

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

The growing adoption of Distributed Electric Propulsion (DEP) aircraft presents new challenges in aeroacoustic modeling, as multi-propeller interactions, airframe effects, and noise certification requirements become critical barriers to large-scale deployment. Current low-fidelity noise models fail to capture complex noise sources, while high-fidelity CFD-based simulations are computationally prohibitive for rapid design iteration. To address this, we propose a machine learning-driven surrogate modeling framework that enables real-time, high-accuracy noise prediction for DEP aircraft. This framework integrates Graph Neural Networks (GNNs) and Fourier Neural Operators (FNOs) to predict full flow-fields and far-field noise signatures, rather than relying solely on empirical regression of noise metrics. Compared to traditional scale-resolving CFD, this approach achieves 1,000x faster computations while maintaining high accuracy (5% MSE with a few hundred simulations). By leveraging multi-fidelity aeroacoustic data sources (FW-H, VPM, CFD) and embedding physics constraints, the model can generalize across various DEP configurations, enabling faster aircraft design, optimization, and certification. Phase I funding will be used to develop and validate the FNO-GNN prediction methodology, starting with single-propeller and wing interactions before expanding to multi-propeller DEP configurations in Phase II. The technology targets NASA aeronautics programs, OEMs (Airbus, Boeing, Joby, Archer, Lilium), defense contractors (Lockheed Martin, Northrop Grumman), and regulatory agencies (FAA, ICAO, EASA), supporting urban air mobility (UAM), hybrid-electric regional aircraft, and UAV applications. By accelerating DEP aircraft noise prediction and mitigation, this innovation directly supports NASA’s Sustainable Aviation and Advanced Air Mobility (AAM) initiatives, providing a scalable, high-impact solution for future electric aviation.

Duration: 6

Proposal Details

Proposal Number: A1.03-1009
Subtopic Title: Propulsion Efficiency - Propulsion Materials and Structures
Proposal Title: Enabling Material Design within System-Level Optimization via Machine Learning

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 6

Technical Abstract (Limit 2000 characters):

The focus of the proposed work is on new tools, primarily enabled with machine learning, to establish a stronger link between composite material selection, and design of materials, and vehicle-level design. This will be especially beneficial where extensive material test data is not readily available, such as novel materials for applications with extreme environments in propulsion structures. The effort outlined in this proposal starts with the structural analyst/designer viewpoint and would use machine learning to develop tools to build a bridge to materials scientists/engineers. The HyperX software, a tool for performing structural analysis and optimization at the vehicle/system level, will be used as the foundation of this approach. Structural optimization at a vehicle/system level can require between 1,000 to 100,000 candidate evaluations per component, repeated over 100s or 1,000s of components in a structure. Therefore, it is not practical to run something such as a micromechanics simulation during the evaluation of each candidate. However, advancements made in machine learning in the last decade creates the opportunity to embed surrogates of these multiscale material models within vehicle-level optimization while using significantly less computational resources. Machine learning has been successfully applied within each of those two domains; the work outlined in this proposal would be the first use of machine learning in a commercial software to link these two domains. Machine learning would be used to develop surrogates of the HyperX analysis and optimization, with composite lamina properties as inputs to the models. This would enable rapid design exploration and optimization with tailored material systems by providing accurate component performance and vehicle/system masses for each material candidate considered.

Duration: 6

Proposal Details

Proposal Number: A1.03-1010
Subtopic Title: Propulsion Efficiency - Propulsion Materials and Structures
Proposal Title: Digital Twin and Thread Ecosystem for Automated ICME and Modeling Workflow Optimization

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 5
Technical Abstract (Limit 2000 characters):

MDMi Modeling Hub (MMH) aims to integrate modeling, testing, design, and manufacturing data into a digital ecosystem, accelerating the transition from ideation to implementation. By leveraging a robust and automated data management strategy, MMH will advance ICME and Digital Twin concepts, enabling experimental and virtual data to seamlessly drive model optimization and accuracy. In industries where production costs are high and performance is critical, benefits of modeling can be seen over the entire product lifecycle, reducing development costs and time-to-market. The value of modeling is irrefutable and capable of broad organizational impact, yet challenges in standardizing usage and understanding limitations have hindered effective implementation and widespread adoption. Further, in the absence of data management, the full potential of modeling is never realized. Some large organizations have developed tools to meet limited, highly specialized needs, the complex and resource-intensive nature of modeling creates a high barrier of entry that deters many organizations. There is a gap in commercial software that can simplify and automate multistep modeling and data storage processes. MMH has been designed to fill this gap. In Phase 1, a prototype software framework will demonstrate a scalable, interoperable, and traceable modeling solution that allows the creation of simplified and standardized workflows that integrate diverse user-developed models (ranging from physics to ML-based models, supporting numerical, text, and traceability data). MMH's cloud-compatible approach will offer a holistic solution that can be configured to accelerate innovation throughout an organization. MMH forwards NASA goals of improving accessibility of data and analysis tools to drive collaboration to advance modeling. MMH will directly augment research within NASA's Materials and Structures Division and significantly further NASA's 2040 Vision.

Duration: 6

Proposal Details

Proposal Number: A1.03-1012
Subtopic Title: Propulsion Efficiency - Propulsion Materials and Structures
Proposal Title: Flexible CMC Structures for Propulsion Efficiency

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 5
Technical Abstract (Limit 2000 characters):

Physical Sciences Inc (PSI) will fabricate high temperature spring preloaders for turbomachinery seals from our flexible Carbon fiber-reinforced Silicon Carbide (C/SiC) Ceramic Matrix Composite (CMC) system. The team will fabricate springs of different lengths, thicknesses, and stiffnesses with an accordion fold geometry and variable lengths. PSI will evaluate the springs' mechanical performance at both ambient and elevated temperatures to model their mechanical response based on the different fabrication variables to meet NASA's performance requirements for spring preloaders in turbomachinery sealing systems. Seals have historically been a major area of concern with propulsion systems, both turbines and hypersonics, to prevent leaks and uncontrolled changes in pressure of the flight system. Existing sealing systems for these applications have an upper use temperature of ~2000 °F. Combustors can reach temperatures upwards of 3000 °F in J-class turbine engines, well beyond the upper use temperature of metallic alloys. The High Mach Gas Turbine (HMGT) and Turbine Based Combined Cycle (TBCC) propulsion systems, currently being explored by NASA and AFRL for use in DARPA's NextRS systems, will also require innovative higher temperature materials systems than metallic alloys can provide to reach the desired speeds. PSI's flexible C/SiC CMCs are the most flexible CMCs available with active bend radii as small as 3.5" and tailorable stiffness. The flexible CMCs can be fabricated in complex geometries with bend radii as small as 1/16" for complex structures such as accordion fold spring preloaders. PSI's Flexible CMC material has resilience in extended bend fatigue testing to a 3.5" radius in ambient environments for thousands of cycles. There is no measurable loss in the flexure of the material after the initial few cycles. PSI's flexible CMCs have been tested under continuous actuation in highly aggressive oxidating environments at temperatures up to 5000 °F

Duration: 6

Proposal Details

Proposal Number: A1.03-1013
Subtopic Title: Propulsion Efficiency - Propulsion Materials and Structures
Proposal Title: Novel Environmental Barrier Coatings for Ceramic Matrix Composites in Aero Engines

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

NASA has a significant interest in technologies that can increase the fuel efficiency and power density of gas turbines in aero engines, which dominates purchase decisions. The path for efficiency improvement is through increasing the turbine inlet temperature. Increased use of ceramic matrix composites (CMCs), specifically those based on silicon carbide (SiC), can increase inlet temperatures in excess of 2,700 F (1482 C) and reduce weight. However, SiC-based CMCs are susceptible to significant corrosion in water vapor present in combustion streams at such high temperatures. Therefore, gas turbine components made of these materials require an environmental barrier coating (EBC) to protect them from water vapor. The current state-of-the art EBCs have an operating temperature limit of about 1300 C, above which they themselves experience significant corrosion in water vapor. They are also significantly corroded by calcium magnesium aluminosilicates (CMAS) resulting from dust and volcanic debris. With NASA SBIR funding, a new EBC composition will be developed and demonstrated that is suitable for use at temperatures up to 1482oC. This composition will be selected from a new class of candidate EBC materials that have the potential for excellent matching of the thermal expansion coefficient to the SiC-based composites by altering the chemistry, resulting in improved durability. We will down-select the best candidate from a few thermal expansion matched compositions from this materials family that has sufficient water vapor corrosion resistance and chemical stability against CMAS at 1482 C. A coating of the down-selected composition will be made through a novel plasma spray process. The coating will then be tested in a highly realistic high velocity rig up to the target temperature of 1482 C, to demonstrate improved performance over state-of-the-art EBCs. This novel EBC technology is targeted at aero engines, as well as stationary gas turbines for utility-scale power.

Duration: 6

Proposal Details

Proposal Number: A1.03-1019
Subtopic Title: Propulsion Efficiency - Propulsion Materials and Structures
Proposal Title: Multi-scale location-specific fatigue life prediction for additive propulsion components

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3

Technical Abstract (Limit 2000 characters):

To enable NASA's technology roadmap for robust and efficient modeling and design of advanced propulsion system materials and structures, QuesTek (QT) will develop and demonstrate a multi-scale process-structure-property-performance modeling framework for aero propulsion component lifing. QT will develop a state-of-the-art integrated computational materials engineering toolkit and implement it in the ICMD® software platform to enable NASA, the aerospace industry, and broader materials intensive industries to leverage accurate and predictive component scale lifing in an intuitive and collaborative cloud-based graphical user interface. Additive manufacturing (AM) is key technology enabler for NASA to improve aero propulsion system efficiency, however, components in these systems are exposed to complex fatigue loading conditions, and paired with the inherent complexity of AM microstructures, durability is difficult to predict. This lack of predictive power that currently exists for fatigue of AM aero propulsion components is a barrier to the broader adoption of the technology. QT will enable composition, process history, microstructure, and component geometry/loading conditions to be captured in a multi-scale PSPP framework to provide robust and efficient component lifing predictions. This will enable concurrent engineering of propulsion systems and alloys. The framework will use CALPHAD based modeling to link composition and process history with microstructure evolution, physics-based mean field analytical modeling to link microstructure with tensile properties, crystal plasticity finite element method to link tensile properties and microstructure with fatigue properties, and Ansys' nCode DesignLife, a component scale finite element method software to link fatigue properties with component scale lifing. Machine learning will be used for reduced order surrogate modeling to enable uncertainty quantification and propagation through the model framework.

Duration: 6

Proposal Details

Proposal Number: A1.04-1038
Subtopic Title: Novel Aircraft Configurations for Electrified Aircraft Propulsion
Proposal Title: UltraQuiet JetFoil-Enabled V/STOL Multi-Mission UAS

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Whisper Aero has developed unique Electric Ducted Fans that provide scale invariant thrust that has the same high efficiency and thrust to weight ratio characteristics at any size. Because these propulsors are compact with low complexity they can be tightly integrated into emission-less electric aircraft concepts in compelling ways to achieve breakthrough performance, noise, and cost. A battery electric concept will be designed as a manned variant of a DoD hybrid electric cargo drone being developed by Whisper Aero as part of a recent STRATFI/ OECIF award. The proposed effort is a unique design effort with substantially different requirements to meet a General Aviation civil mission definition that can be in production by 2030. A unique characteristic of this design is the ability to perform eVTOL, eSTOL, and eCTOL missions at different gross weights with the same aircraft. This enables a single aircraft product to have varying utility to trade off takeoff performance for added range or payload, depending on user needs. Leveraging the STRATFI drone learnings offers increased probability of achieving a certified aircraft by utilizing identical components arranged in a different configuration and with a different energy source (batteries instead of a hybrid turbogenerator). Achieving dual use across aircraft product families has been a core goal of AFWERX as they've stimulated the eVTOL ecosystem. Commercialization

success is further enhanced by leveraging the Phase II sub-scale test aircraft to align with delivery drone requirements to validate not only the concept feasibility and also yield an operational demonstrator that has additional product potential.

Duration: 6

Proposal Details

Proposal Number: A1.04-1045
Subtopic Title: Novel Aircraft Configurations for Electrified Aircraft Propulsion
Proposal Title: Cost-Effective Electric Cargo Aircraft

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Regional air cargo operations are essential for logistics but face challenges due to high costs and low aircraft utilization. Existing regional cargo aircraft, such as the Cessna 208 Caravan and Beechcraft 99, have high operating costs associated with fuel burn and maintenance of their aging airframes, yet cargo air carriers often rely on depreciated legacy aircraft because of the high acquisition costs of new aircraft. The proposed work focuses on the design of a novel, low-cost, autonomy-ready, electric aircraft optimized for regional air cargo operations. Phase I will include market studies to define aircraft requirements, trade space exploration to evaluate conceptual designs and electric propulsion integration strategies, concepts of operations modeling, cost modeling, and exploration of certification pathways. The target market for the aircraft consists of regional cargo operators, feeder airlines, and government agencies needing affordable air logistics solutions. The proposed work will accelerate the adoption of electrified autonomous cargo aircraft and increase the economic viability of the regional air cargo industry.

Duration: 6

Proposal Details

Proposal Number: A1.04-1052
Subtopic Title: Novel Aircraft Configurations for Electrified Aircraft Propulsion
Proposal Title: The Annular-Wing VTOL Aircraft

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The Annular-Wing VTOL Aircraft introduces a redefinitive aerodynamic configuration built around a circular wing design that addresses critical limitations in existing electric vertical takeoff and landing (eVTOL) platforms. Our innovation integrates a fixed-pitch coaxial lift system within an annular wing architecture, enabling 1,500 lb payload capacity—50% more than competing designs—while achieving exceptional energy efficiency of 2,800 J/lb-mile. Key innovations include: (1) a propeller parking system that eliminates transition drag by aligning lift rotors with airflow during cruise; (2) below-fuselage propulsion that optimizes propwash utilization; (3) streamlined flight mode transitions without complex tilting mechanisms; and (4) hydrogen fuel cell integration capability for extended range operations. Phase I funding will support high-fidelity CFD modeling, propeller parking mechanism development, control system refinement, and scaled prototype flight testing. Our 1-meter subscale prototype has already validated core aerodynamic principles through 50+ successful flight tests. Primary markets include NASA applications (emergency response, scientific deployment), Advanced Air Mobility (4-6 passenger transport), medical evacuation, and defense/security operations. The unique combination of helicopter-class payload with fixed-wing efficiency positions this platform to capture significant market share within the projected $30.8B eVTOL market by 2030.

Duration: 6

Proposal Details

Proposal Number: A1.06-1009
Subtopic Title: Vertical Takeoff and Landing (VTOL) Vehicle Technologies - Vehicle Design Tool & Electric Powertrain Test Capability
Proposal Title: Airfoil Data Analysis Software for Rotorcraft Design

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

NASA is actively working on Vertical Takeoff and Landing (VTOL) Vehicle Technologies such as the Revolutionary Vertical Lift Technology (RVLT) project. For the analysis/design of these types of vehicles, rotorcraft tools require aerodynamic properties of the rotor sections over -180 to +180 degrees of angle of attack and wide range of operating conditions covering all flight situations. This large amount of aerodynamic data is typically provided in the form of C81-formatted airfoil aerodynamic coefficient table files. Thus, there is a need to generate these C81-formatted files using an automated computer tool. AVEC proposes the development of a software package for the generation of airfoil

aerodynamic data using several analysis tools (XFOIL, OVERFLOW, MSES). In addition, the software will also include a database that allows the interactive visualization and manipulation of the data. The software package will be run using a graphic user interface (GUI) with many capabilities to make the process fast, accurate and cost effective. To this end, AVEC will leverage many tools developed over the last 20 years as part of many projects in aerodynamics and acoustics of propulsion systems, e.g. propellers, ducted fans, etc. In fact, using internal funds over the last ~3 years, AVEC has already started developing a GUI operated database for a large number of airfoil profiles and aerodynamic data. Since the existing GUI already contains some of the features and capabilities requested in the solicitation, Phase I work can provide an efficient use of funds while also focusing specifically on addressing NASA's requirements. Based on AVEC's capabilities, experience, and existing tools, a beta version of the software package will be delivered at the end of Phase I.

Duration: 6

Proposal Details

Proposal Number: A1.06-1010
Subtopic Title: Vertical Takeoff and Landing (VTOL) Vehicle Technologies - Vehicle Design Tool & Electric Powertrain Test Capability
Proposal Title: Hierarchical Flexible Toolset for Generating Airfoil Performance Tables for Aircraft Design

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Despite the capabilities and usability improvements of modern computational fluid dynamics software, rotary-wing aircraft design and analysis often uses lower fidelity methods that require pre-computed 2D airfoil data tables because these methods can provide adequate accuracy in a fraction of the setup and computation time. The C81 data format has long been used by rotorcraft sizing, conceptual, and preliminary design tools to define airfoil lift, drag and moment as a function of angle of attack, Mach number, and Reynolds number. Even though C81 tables have a long legacy of use, their generation, especially for new airfoil sections typical of modern Urban Air Mobility configurations, is far from routine given the need to cover 360o angle of attack over a range of Mach and Reynolds numbers – with manual tuning often used to fill-in missing data or remove questionable points. The proposed effort by Continuum Dynamics, Inc., (CDI), seeks to build upon our decades of experience developing and using C81 tables for rotorcraft design and analysis to develop a software toolset tailored to automatically and robustly generating accurate and reliable C81 tables. The toolset will feature a range of methods for automatically predicting single and multi-element airfoil section performance, and assembling the resulting C81 tables. In Phase I, a prototype tool with automatic grid generation, will be developed that launches, monitors, and post-processes airfoil performance predictions. The tool will then assemble the desired C81 table from the database of predictions and experimental data, and provide uncertainty metrics to the user associated with the source of the data used. The tool will be built around CDI’s in-house 2D CFD solver that we use to generate 2D look-up tables, but within a framework flexible enough to support alternate CFD solvers. Phase II will see software enhancement and generalization to support a variety of data and prediction generation sources.

Duration: 6

Proposal Details

Proposal Number: A1.06-1011
Subtopic Title: Vertical Takeoff and Landing (VTOL) Vehicle Technologies - Vehicle Design Tool & Electric Powertrain Test Capability
Proposal Title: PyFoil81: Rotorcraft Design Tool Airfoil Table Generator

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The Revolutionary Vertical Lift Technology (RVLT) Program is exploring an open design space for novel VTOL aircraft configurations. Highly efficient and lightweight electric motors paired with the increasing energy density of batteries are enabling new aircraft concepts such as Distributed Electric Propulsion and eVTOL, which exploit new technologies' advantages to improve existing missions and enable whole new missions such as Urban Air Mobility. Flight for eVTOLs creates new analytical challenges: rotors are designed with small chord and diameter as well as unconventional twist profiles, and with wider operational RPM and advance ratio ranges, can have larger regions of reversed flow. To meet this departure from

traditional rotor aerodynamics in context of the high impact of aeropropulsive efficiency on mission capability, M4 proposes a lightweight Python software, PyFoil81, capable of efficiently analyzing and tabulating airfoil data from a variety of flow regimes. It will efficiently handle user inputs, airfoil rediscretization and modification, API to/from multiple aero solvers, and a data blending tool to create composite C81 airfoil data tables from various data sources.

Duration: 6

Proposal Details

Proposal Number: A1.06-1019
Subtopic Title: Vertical Takeoff and Landing (VTOL) Vehicle Technologies - Vehicle Design Tool & Electric Powertrain Test Capability
Proposal Title: Automated Airfoil Table Generation for VTOL Aircraft

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 5
Technical Abstract (Limit 2000 characters):

The design and development of VTOL air vehicles, especially AAM, is making rapid progress with numerous innovative configurations. The industry is, however, facing serious challenges in achieving its goal toward affordable high performance/ low noise VTOL that can be timely certified for operation. Design and analysis of modern VTOL has been a major hurdle due to extremely high computational demands. Comprehensive rotorcraft analysis tools are widely used for VTOL design and analysis. To manage costs, comprehensive tools use C81 airfoil tables for quick turnaround. Hence, the ability to quickly and accurately generate C81 tables is vital. The proposed work aims at creating a high fidelity airfoil table generator to effectively support VTOL design. The tool to be developed will be versatile in terms of supporting the unique requirements of VTOL design and analysis. The tool will also be streamlined, efficient, automated along with a friendly graphical user interface.

Duration: 6

Proposal Details

Proposal Number: A1.08-1014
Subtopic Title: Aeronautics Ground Test and Measurement Technologies: Diagnostic Systems for High-Speed Flows and Icing
Proposal Title: A Long-wavelength IR Sensor for Water Drop Temperature Measurement

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

This proposed research aims to develop an LWIR imaging sensor to enable real-time, in-situ measurements of temperatures and size distributions of airborne supercooled water droplets. The proposed sensor will use an LWIR camera for 2D imaging of the water droplets. By calibrating temperature and intensity of small water drops in the icing tunnel, the water droplets will be imaged to obtain size distribution information. The temperature of the water droplets will be determined based on the LWIR emission intensity. Phase I will focus on the design, fabrication, and demonstration of the sensor system in a research icing tunnel. Phase II will involve the application and testing of the sensor system in NASA's icing wind tunnel.

Duration: 6

Proposal Details

Proposal Number: A1.09-1008
Subtopic Title: Zero-Emissions Technologies for Aircraft
Proposal Title: HYDRATE: A Zero-Emission Direct Drive Parallel Hybrid Turbofan for Personal Jets

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

HYDRATE represents a transformative leap in zero-emission aviation propulsion, integrating a hydrogen-burning regenerative turbine with MagLev Aero's proprietary maglev rim drive. This parallel hybrid system optimizes fuel efficiency, reducing cruise fuel consumption by over 20%, while increasing bypass ratios and thermal efficiency—key limitations in current small turbofans. Unlike traditional hybridization efforts focused on large commercial aircraft with marginal efficiency gains, HYDRATE targets the underserved Very Light Jet (VLJ) market, where existing propulsion remains outdated. By leveraging magnetic gearing, tip-driven assistance, and regenerative energy use, the system achieves superior throttle

response, reduced complexity, and increased operational flexibility. Quantitatively, the design enables optimized thrust distribution throughout flight, compensating for altitude variations and improving safety. The approach offers a scalable pathway toward zero-emission propulsion with near-term applications in personal jets and potential expansion into larger commercial aviation through NASA's HyTEC initiative, setting a new standard for sustainable, high-performance flight.

Duration: 6

Proposal Details

Proposal Number: A1.11-1010
Subtopic Title: Health Management and Sensing Technologies for Sustainable Aviation Vehicles
Proposal Title: Sustainable Aviation Prognostics and Predictive Health Integrated Reliability Engine

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 6
Technical Abstract (Limit 2000 characters):

As NASA pursues net-zero aviation emissions by 2050, new hybrid-electric, all-electric, and hydrogen aircraft present unique health management challenges. These novel propulsion systems require innovative approaches to detect anomalies in complex integrated architectures. Cybernet proposes SAPPHIRE (Sustainable Aviation Prognostics and Predictive Health Integrated Reliability Engine) to address these needs. SAPPHIRE provides health management specifically for sustainable aviation platforms. Building on Cybernet's predictive maintenance experience with military vehicles, it combines data collection with AI analytics to monitor electric and alternative fuel propulsion components. The system interfaces with aircraft data buses (MIL-STD-1553, ARINC-429, Ethernet) to process high-frequency measurements from electric propulsion systems. SAPPHIRE employs AI algorithms combining dimensionality reduction (PCA, ICA) with deep learning (LSTM networks) to detect degradation in motors, power converters, and hydrogen components. Context-aware analysis distinguishes normal operational variations from genuine anomalies by incorporating mission profiles and environmental conditions. The maintenance support framework translates detected anomalies into actionable recommendations with remaining useful life estimates. Phase I will develop the core architecture, initial AI models, and demonstrate feasibility through simulation. This foundation enables Phase II development of a prototype for integration with sustainable aircraft platforms, progressing from TRL 3 to TRL 6. By enabling early detection of issues and condition-based maintenance, SAPPHIRE enhances safety, reduces costs, and improves efficiency for sustainable aviation vehicles. Its open architecture ensures adaptability across platforms, supporting NASA's transition to environmentally friendly aircraft with the reliability needed for commercial adoption

Duration: 6

Proposal Details

Proposal Number: A1.11-1011
Subtopic Title: Health Management and Sensing Technologies for Sustainable Aviation Vehicles
Proposal Title: Electric Aircraft Health Management Algorithms and Infrastructure

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

The proposed Phase I effort will focus on the development and implementation of component and system-wide failure and degradation detection techniques for electrifiedcal aircraft propulsion (EAP) systems built upon an infrastructure of advanced control devices. Reliable accurate data collection from across the system is necessary to enable system-wide health management and prognostics for predictive maintenance. PCKA's Intelligent, expandable Point-of-Load Electrical System (IPoLES) initiative will provide the infrastructure required for this development. Under the IPoLES effort, PCKA has developed and demonstrated the use of 270V/120A smart solid statesolid-state rectifiers with high-speed sensing and

communication to enable local and coordinated control and protections with improved fault mitigation performance (compared to traditional approaches). The main objectives of the proposed Phase I effort are to 1) determine requirements for electrical noise resilience and sensing, processing, and communication requirements for health management algorithms, 2) develop and implement HMAS algorithms on the IPoLES devices, and finally 3) to demonstrate the HMAS algorithms on IPoLES hardware. PCKA has performed prior work on failure identification in converters and generators under NASA SBIR and STTR programs. The approaches utilize voltage- and power- spectrum metrics to distinguish fault types within the devices, and the selected metrics are well-suited to the sensing and processing capabilities of IPoLES devices. These techniques will likely form the basis for Phase I demonstration, while more expansive analyses of component and system-wide algorithms and their sensing and processing requirements are completed.

Duration: 6

Proposal Details

Proposal Number: A1.11-1015
Subtopic Title: Health Management and Sensing Technologies for Sustainable Aviation Vehicles
Proposal Title: AstraSense: AI-Driven Health Predictions for Sustainable Aviation

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 5
Technical Abstract (Limit 2000 characters):

Purpose: The AstraSense system aims to enhance the reliability and safety of hybrid-electric and all-electric aircraft by providing real-time health monitoring and predictive maintenance. It addresses the challenges of operating in high-voltage, high-noise environments by detecting early-stage degradation and predicting failures before they occur. Technology: AstraSense integrates multi-point sensing, harmonic signature analysis, machine learning-based fault prediction, and noise diagnostics. This combination allows for continuous assessment of system integrity and early warnings, enabling autonomous AI or operators to take corrective action before failures become critical. Intended Use of Funding: The requested funding of $150,000 will be used to develop and validate the AI-driven health monitoring architecture, focusing on: AI-based fault detection and diagnostics. Sensor data processing methods. System performance evaluation in simulated high-voltage conditions. Developing a scalable system architecture for health monitoring and predictive maintenance. Aligning the system with NASA's goals for sustainable aviation. Target Markets: The primary target markets include: NASA and aerospace industry: Enhancing safety and reliability for hybrid-electric aircraft. Commercial eVTOL manufacturers and electric aviation developers: Ensuring safer and more reliable electric propulsion systems. Defense and industrial sectors: Reducing downtime and maintenance costs through predictive maintenance. This innovation supports the transition to sustainable aviation by improving fault detection, system integration, and predictive maintenance, ultimately enhancing flight safety and operational efficiency.

Duration: 5

Proposal Details

Proposal Number: A1.11-1017
Subtopic Title: Health Management and Sensing Technologies for Sustainable Aviation Vehicles
Proposal Title: Real Time Fuel Tank Health Monitoring for Cryogenic Hydrogen Aviation Fuel

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Tech4Imaging (T4I) proposes to develop a real time fuel tank health monitoring system for cryogenic liquid hydrogen (LH2) aviation fuel. This will be accomplished by imaging the fuel distribution in the fuel tank and measuring the total mass of fuel in real time. The measurements will be generated by an Electrical Capacitance Volume Tomography (ECVT) system integrated into a composite vacuum jacketed fuel tank. LH2 fuel tanks pose several challenges to imaging the fuel distribution and measuring the total mass of fuel. While LH2 is extremely cold (20K), highly flammable, prone to boil-off, poses over-pressure hazards, and can

easily leak, the primary difficulty when it comes to mass gauging is the highly unpredictable two-phase nature of the fuel in the tank. ECVT is a non-invasive, non-contact measurement modality that relies on low energy electrical signals to interrogate the permittivity of the two-phase mixture in the tank. This project aims at a sensor that can be designed with a tank in various shapes and sizes and will be sold as an integrated unit for installation into an aircraft. The designs can accommodate many fuel systems such as high Lift/Drag wings, Blended Wing Body, conformal tanks, and distributed/embedded propulsion. The primary customers are cryogenic LH2 manufacturers for aviation, particularly those that create non-conductive composite tanks. Adjacent markets include the growing satellite market. The global space-qualified propellant tank market was $1.95B in 2021 with a projected growth to $3.03B in 2030 (straits research).

Duration: 6

Proposal Details

Proposal Number: A1.11-1021
Subtopic Title: Health Management and Sensing Technologies for Sustainable Aviation Vehicles
Proposal Title: Acoustic Cameras for Health Monitoring of Next-Generation Aircraft

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Persimia proposes to develop a new type of acoustic-based health monitoring system for next-generation aircraft. The system will leverage microphone arrays throughout the aircraft to detect and pinpoint anomalies in the fuel system (for liquid hydrogen-powered aircraft) or electrical or propulsive components (in electric or fuel cell-powered aircraft). The two main components of the system will be the microphones themselves, and a machine learning algorithm that will process the data and identify anomalies. Importantly, the acoustic processing algorithm will leverage data not only from the microphone arrays, but also from the flight computer so that the acoustic background at different thrust settings and flight conditions can be accounted for. The project seeks to develop acoustic fault detection systems for aircraft that can be applied to electrically-driven, fuel cell-driven, and eventually liquid hydrogen-powered aircraft. By mounting microphones in appropriate locations, different components of the system can be monitored, and thus the same overall concepts of acoustic monitoring combined with filtering and anomaly detection can be applied to fault detection for an electric motor, and leak detection for a liquid hydrogen tank. The overall goal, therefore, is to develop acoustic fault detection technology for aircraft so that it can be widely applied as the industry evolves toward new types of sustainable fuel sources. Phase I funding will be used to develop microphone array designs for fault detection in both eVTOL aircraft and liquid hydrogen-powered aircraft. The team will also identify the structure of fault detection algorithms, create simple lab-based experimental case studies, and engage in initial customer outreach. The market for this technology could be aircraft OEMs, the military, NASA, and others interested in implementing fault detection on next-generation aircraft.

Duration: 6

Proposal Details

Proposal Number: A1.11-1022
Subtopic Title: Health Management and Sensing Technologies for Sustainable Aviation Vehicles
Proposal Title: Health monitoring and pre-flight diagnostics for robust electrical machines

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 4
Technical Abstract (Limit 2000 characters):

Electrified powertrains have the potential to enable more economical, efficient, safe, and robust air vehicles. The electrical machine plays a central role in all of these topologies, whether configured as a generator or as a propulsive motor. Hinetics uses fault-tolerant design processes to limit the severity and likelihood of failures. However, once mounted to the vehicle, electrical machines are subjected to extreme environmental conditions and maintenance events with inherent uncertainty. To support the safety goals related to electrical machines, Hinetics proposes developing a health monitoring system and corresponding algorithm using multi-modal

measurement sources, physics-based models, and advanced signal processing and machine learning techniques. The goal is to detect imminent failures and communicate them to the central controller or operator in order to take actions that limit the impact of the failure. In Phase I, Hinetics will: (1) tabulate an exhaustive list of failure modes, sources, and indicators in its slotless permanent magnet machine topology, (2) design and implement a sensor and data acquisition system, (3) characterize nominal and anomalous machine behavior for two key failure modes, and (4) develop and demonstrate the detection algorithm on its HITRACE testbed using one of Hinetics existing megawatt-class machines. Hinetics will also develop a pre-flight diagnostic routine to complete during taxi to detect failures prior to take-off. This work directly supports Hinetics' commercialization plans by addressing key compliance requirements imposed by a potential airframer customer.

Duration: 6

Proposal Details

Proposal Number: A2.01-1005
Subtopic Title: Flight Test and Measurement Technologies
Proposal Title: Compact UAS Sensor for Distributed Mapping of Wildfire Plumes

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Wildfire frequency and severity is increasing across the US. Simply throwing more resources at the problem while doing things the same way is not a cost-effective solution to the wildfire crisis. Uncrewed Air Systems (UAS) provide the opportunity to conduct operations at night and in degraded visual conditions when firefighting conditions are more favorable but crewed assets are grounded. However, there are many hazards associated with operating UAS around wildfires at night including dangerous wildfire plumes. This research focuses on tackling the problem of detecting, mapping, and avoiding the high energy wildfire plume. Plumes contain extreme temperatures, severe updrafts and windshear to include firenadoes and areas of zero visibility. We propose a novel UAS compatible sensor for real time distributed mapping of plumes using Long Wave Infrared (LWIR) sensing technology. A 3D plume model will be assembled from multiple viewpoints similar to a 3D Radon transform. Onboard “edge” processing will allow local sense and avoid capability to support UAS autonomy. The 3D plume data will support digital twin Common Operating Pictures that facilitate second shift operations from a common fire model. By shrinking the sensor to sUAS size and leveraging low-cost Commercial Off the Shelf (COTS) components, the payload will be able to be placed on every crewed and uncrewed asset participating in the firefight. The research also applies to other emergency airspace operations where use of UAS for response to chemical spills, tornadoes, radiological events and volcanic activity will benefit from the capability to sense and avoid plumes. The proposed research can directly support the NASA FireSense and ACERO wildfire projects. In addition, commercial UAS operators are rapidly expanding wildfire services. The proposed plume mapping sensor will enhance revenue streams for these commercial operators.

Duration: 6

Proposal Details

Proposal Number: A2.01-1017
Subtopic Title: Flight Test and Measurement Technologies
Proposal Title: Enhanced Panoptic Imaging for Class 1 UAVs

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Circle Optics proposes the development of a next-generation, low-parallax, 360° multi-camera imaging system optimized for Class 1 UAVs to enhance real-time situational awareness, navigation, and collision avoidance. Our patented optical technology eliminates parallax errors and image stitching requirements, enabling seamless, high-resolution panoramic imaging with minimal computational burden. This system will significantly improve UAV-based sensing in complex urban and extreme environments, advancing NASA's objectives in autonomous flight, vertiport management, and environmental monitoring. Under this Phase I SBIR effort, Circle Optics will design a lightweight (300-400g), low-power (SWaP-optimized) multi-camera array arranged in a visor-like configuration, providing a

full 360° horizontal field of regard with minimal blind spots. The system will support real-time edge computing, integrating AI-based object detection (e.g., YOLO networks) for enhanced airborne detect-and-avoid (DAA) capabilities. This effort builds on Circle Optics' previous work in panoramic imaging solutions for UAV navigation and extends its innovations to smaller drone platforms. Funding from NASA will enable crucial optical and mechanical system development, ensuring the design meets stringent weight, resolution, and environmental robustness requirements. The project will result in preliminary designs for a Phase II project developable prototype optimized for UAV deployment in applications such as airspace safety, autonomous navigation, package delivery, and search and rescue missions. The technology's modular architecture also positions it for broader commercial and defense applications, supporting the expanding UAV ecosystem.

Duration: 6

Proposal Details

Proposal Number: A2.01-1030
Subtopic Title: Flight Test and Measurement Technologies
Proposal Title: All-Weather Airborne mmWave Radar for UAV Lookahead Wind Measurements

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 6
Technical Abstract (Limit 2000 characters):

Uncrewed Aircraft Systems (UAS) face significant challenges in operating safely and efficiently in dynamic weather conditions, particularly in the presence of wind shear and turbulence. Existing weather data sources, including ground-based anemometers and weather models, lack the resolution necessary to provide real-time, localized wind hazard detection for UAS operations. Current solutions, such as telemetry-based wind estimation and onboard anemometers, offer limited capabilities, as they require the aircraft to either enter hazardous conditions or provide only point measurements without predictive capability. This proposal aims to develop a novel lookahead wind radar system capable of detecting wind conditions up to 1,000 meters ahead of a UAS. Leveraging miniaturized millimeter-wave (mmWave) radar technology, the system will enable UAS to dynamically reroute around hazardous wind conditions, enhancing flight safety, efficiency, and operational decision-making. The radar will provide high-resolution wind field data, enabling avoidance of wind shear, turbulence, and gusts, improved takeoff and landing decisions, and optimized flight paths for energy conservation. The effort will focus on miniaturization, power efficiency, and real-time data processing to ensure UAS compatibility. This innovation builds on ground-based wind profiling radar technology, adapting it for airborne integration. The proposed system will have broad applications across commercial, civil, and national security sectors. It will enhance UAS safety and efficiency while enabling monetization of real-time atmospheric data through third-party weather providers such as TruWeather Solutions. Additionally, it aligns with NASA's goals for safe navigation in extreme environments, planetary exploration, and real-time atmospheric hazard detection.

Duration: 6

Proposal Details

Proposal Number: A2.02-1000
Subtopic Title: Enabling Aircraft Autonomy
Proposal Title: A Modular, NDAA Compliant Flight Computer

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 6
Technical Abstract (Limit 2000 characters):

Flight research and validation in a relevant environment is a critical element in the maturation of aeronautics technology. A Research Flight Control System (RFCS) is typically used to conduct this work, which can integrate with additional or higher-quality instrumentation and sensors to facilitate research. Control of the vehicle can fall back to the production system if faults or unexpected behavior occur in the RFCS hardware or software, enabling a more streamlined flight approval process. The RFCS can facilitate rapid development and validation of autonomy and flight control software using a model-based process where algorithms are developed in MATLAB Simulink, validated in Software-In-the-Loop and Hardware-in-The-Loop simulation, automatically compiled to flight code, and uploaded to the RFCS

onboard the vehicle. Bolder Flight Systems Inc. (BFS) and the University of Alabama (UA) propose to research, develop, and commercialize a National Defense Authorization Act (NDAA) compliant RFCS suitable for manned and unmanned aircraft called the Low-cost Infrastructure for Flight Test and Research (LIFTR). The concept is to develop a modular, high-performance, and low Cost, Size, Weight, and Power (C-SWaP) research flight control system comprised of three main components: a high-performance microcontroller, a System on Chip (SOC) autonomy processor, and a Field Programmable Gate Array (FPGA) co-processor. Digital twins will be developed, enabling development and simulation of the entire system. Model reference blocks will enable researchers to develop, autocode, and upload software for each of these processors. Each processor will be implemented on a circuit board with high density connectors, enabling the development of motherboards with different processor configurations, integrated sensors, and ports to external peripherals. LIFTR will enable NASA to efficiently conduct flight research and validation and help usher in a new era of aeronautics technology.

Duration: 6

Proposal Details

Proposal Number: A2.02-1002
Subtopic Title: Enabling Aircraft Autonomy
Proposal Title: Flight Computer for Artificial Intelligence and Autonomy

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

The intended use of the funding is to enhance the single and dual channel computing platforms currently under development by Hover, Inc so they "can be used to offload computationally intensive tasks such as machine learning or be reconfigured to use with a computer vision system." Hover, Inc's technology is adaptable for NASA's CAS/ SWIFT requirements to run Matlab/ Simulink auto-generated code and machine learning software applications and models. Also, Hover, Inc is developing the first FAA and EASA TSO approved artificial intelligence computing platforms capable of running high safety criticality and low safety criticality software applications in parallel whilst preventing them from interfering with each other. They are the only known computing platforms that will support a certifiable Run Time Assurance (RTA) architecture such as NASA's Expandable Variable Autonomy Architecture (EVAA).

Duration: 6

Proposal Details

Proposal Number: A2.02-1017
Subtopic Title: Enabling Aircraft Autonomy
Proposal Title: Adaptive and Secure Autonomy for UAS: A Modular Approach to Flight Control, Machine Learning Integration, and Multi-Vehicle Coordination

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 5 - 7
Technical Abstract (Limit 2000 characters):

This proposal outlines the SwiftCore Flight Management System, a modular avionics solution for uncrewed aircraft systems (UAS) designed for high reliability and rapid adaptability. SwiftCore utilizes a layered architecture with intelligent nodes communicating through a publisher-subscriber messaging system. Its purpose is to provide a flexible and safe platform for advanced UAS functionalities, including multi-vehicle coordination, machine learning-based sensing and control, and adaptive tuning. Phase I funding will be utilized to further develop and validate this modular, layered architecture. Key technical objectives to be achieved with the funding include: -Defining and documenting a modular, multi-layer control and sensing architecture with standardized messaging based on the SwiftCore which already contains many of these characteristics. -Adapting and refining the existing SwiftCore system to meet evolving operational requirements and support multiple aircraft configurations. -Developing a "safe sandbox" environment to allow testing of experimental control modules without compromising overall system safety. -Demonstrating a proof-of-concept for machine learning–enabled, in-flight tuning of control loops. The target markets for the SwiftCore system include government agencies like NASA, NOAA, USGS, and the DoD, as well as commercial customers in aerial surveying, agricultural monitoring, and infrastructure inspection. Uncrewed aircraft original equipment manufacturers (OEMs) and academic research institutions are considered important target market segments.

Duration: 6

Proposal Details

Proposal Number: A2.04-1010
Subtopic Title: Aviation Cybersecurity
Proposal Title: Cyber-agents for Live Onboard Aviation Network Security (CLOANS)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 5

Technical Abstract (Limit 2000 characters):

ATC-NY will develop the Cyber-agents for Live, Onboard Aviation Network Security (CLOANS) software, a distributed cybersecurity monitoring, reporting, and response system. CLOANS employs portable agents that collect and analyze network activities onboard flight systems in near-real-time, reporting Cyber Threat Intelligence to system operators as well as to the centralized CLOANS Service. The CLOANS Service can be deployed on cloud or on-premises computing infrastructure, where it automatically discovers, manages, and processes reports from CLOANS cyber-agents. The CLOANS Service maintains a Common Operating Picture of aviation networks' cybersecurity posture and enables personnel at Cyber Security Operations Centers and flight data centers to coordinate threat mitigation strategies and respond in time to thwart attacks. Using CLOANS, aviation staff, security engineers, and operators can improve safety and security through heightened situational awareness. Early alerts and detailed reports reduce the risk and impact from cyberattacks, particularly manipulation and abuse of multicast protocols.

Duration: 6

Proposal Details

Proposal Number: A2.04-1034
Subtopic Title: Aviation Cybersecurity
Proposal Title: Advanced Threat Analysis and Remediation on Aggregated Air Vehicle ACARS

Small Business Concern

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Principal Investigator

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 4
Technical Abstract (Limit 2000 characters):

The presented solution provides advanced threat analysis using Artificial Intelligence (AI) on aggregated ACARS (Aircraft Communications Addressing and Reporting System) messages. The analysis, performed in near real time (in-time), will identify anomalies across the data set based on deviations from baselined 'normal' operations. The system will provide cross-reference checking across the data set to identify emerging and active threats against single end points (e.g. air vehicles), and system-wide attacks on the National Air Space (NAS). The AI would offer mitigations for the threats/attacks.

Duration: 6

Proposal Details

Proposal Number: A2.04-1040
Subtopic Title: Aviation Cybersecurity
Proposal Title: Mycelial Federated Intrusion Detect System

Small Business Concern

Firm: STEM Resources
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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Modern aircraft are evolving into highly intelligent, interconnected systems, leveraging Electronic Flight Bags (EFBs), Aircraft Interface Devices (AIDs), and real-time data exchange for enhanced operational efficiency. However, this digital transformation expands the attack surface, exposing aviation networks to sophisticated cyber threats that traditional security models—reliant on centralized monitoring and predefined attack signatures—fail to address. The Mycelial Federated Intrusion Detection System (MyFIDES), powered by the AeroShield Federated Learning System (AFLS), introduces a decentralized, AI-driven cybersecurity framework designed to detect and mitigate emerging threats in networked aircraft environments. MyFIDES leverages federated learning (FL) to train machine learning models directly on EFBs and AIDs without transmitting sensitive operational data to a centralized server. This approach preserves data privacy, reduces reliance on continuous cloud connectivity, and enables real-time anomaly detection even in low-bandwidth aviation environments. MyFIDES will integrate a lightweight intrusion detection agent with real-time streaming analytics, utilizing Apache Flink and MQTT-based communication to detect, classify, and respond to threats autonomously. The system will feature tamper-proof event logging, secure aircraft-to-ground (A2G) and aircraft-to-aircraft (A2A) communication, and a user-friendly cybersecurity dashboard for airline security teams. The Phase I project will establish MyFIDES' feasibility through a simulated EFB/AID environment, hosted on DigitalOcean cloud resources and commodity hardware. The system will be evaluated against multiple attack scenarios, including

GPS spoofing, malware injection, and unauthorized access attempts. In collaboration with Jackson State University and industry experts, MyFIDES will demonstrate a scalable, adaptive cybersecurity solution that enhances aviation resilience against next-generation cyber threats

Duration: 6

Proposal Details

Proposal Number: A3.02-1018
Subtopic Title: Advanced Air Traffic Management for Nontraditional Airspace Missions
Proposal Title: A Portable Situational Awareness Toolset for Wildfire Suppression and Team Management

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

A National Oceanic and Atmospheric Administration summary documented 20 wildfire events between 1980 and 2021 that caused $1 billion or more in damages and noted that 16 of those have occurred since 2000. With the increase in damage and physical scope of these fires, larger and more diverse teams are required to address them. Each responding team may have different communication equipment, preventing one team from communicating with another except through a command center that must relay activities and events to each group individually. This limits the operational picture of the fire incident to a select person / few people who must coordinate all elements directly. A team led by Systems Technology, Inc., in collaboration with Bolder Flight Systems Inc., proposes to develop the Firefighter Integrated Reporting System and Transponder (FIRST) system to provide an enhanced wildfire situational awareness (SA) toolset and airspace management capability suitable for both piloted and autonomous air assets. At its core, FIRST will provide the fire incident managers with the ability to track and direct both piloted and autonomous aircraft. Tracking will be facilitated via existing air traffic protocols including ADS-B, the unmanned aircraft system traffic management system, and the newer FAA UAS Remote ID standard. These methods will be augmented via FIRST's hardware element, a low cost, size, weight, and power solution that will provide GPS / INS measurements from each vehicle, direct control of the associated UAS, and will enable the radio mesh network that forms the backbone of the communication architecture for FIRST. The information will be hosted on a smart device display to enable the widest applicability and provide information akin to what a traditional air traffic controller might usually see: aircraft identifying information, speed, altitude, direction, and specific to the firefighting mission, the kind/amount of retardant and or payload available by aircraft.

Duration: 6

Proposal Details

Proposal Number: A3.02-1034
Subtopic Title: Advanced Air Traffic Management for Nontraditional Airspace Missions
Proposal Title: Secure Wireless Data Collection for First Responders Using Uncrewed Aircraft Systems

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 4
Technical Abstract (Limit 2000 characters):

This proposal aims to revolutionize wildfire response by developing a secure wireless data collection system using Uncrewed Aircraft Systems (UAS). The innovation addresses NASA's technical need for nontraditional aviation operations in wildfire response by enhancing situational awareness, improving coordination, and enabling efficient data transport in challenging environments. The proposed system leverages mobile-mesh communications networks to enable UAS to share state information, track each other, and route mission-critical data to remote decision-makers. This includes real-time mission and operation data transmission from UAS and ground-based IoT devices. The funding will be used to achieve several technical objectives, including identifying first responder missions and stakeholder needs, determining data requirements, identifying suitable radios, documenting alternative network implementation methods, and developing network performance metrics. Additionally, the project will involve writing software to collect state data, conducting flight tests to determine UAS performance characteristics, developing simulations for network operations, and demonstrating data transport capabilities. The target markets for this innovation include

government agencies and public safety organizations such as fire departments, emergency management agencies, law enforcement agencies, and disaster response teams. By providing a secure and reliable airborne network for low-latency data transport, the system aims to improve strategic planning, resource allocation, and situational awareness, ultimately enhancing the safety and efficiency of wildfire response operations. This proposal directly addresses NASA's need for innovative technologies to improve wildland fire management through enhanced data collection, processing, and communication networks.

Duration: 6

Proposal Details

Proposal Number: A3.02-1038
Subtopic Title: Advanced Air Traffic Management for Nontraditional Airspace Missions
Proposal Title: On-demand Regional Intelligent Operations Network (ORION)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 5
Technical Abstract (Limit 2000 characters):

The On-Demand Regional Intelligent Operations Network (ORION) is an advanced UAS networking architecture designed to enhance aerial wildfire response and emergency operations. By integrating autonomous tasking, intelligent automation, and secure data exchange, ORION enables a scalable, resilient UAS response network, overcoming the limitations of manual coordination and pre-planned missions. Through multi-UAS orchestration, adaptive networking, and real-time mission execution, ORION supports persistent, on-demand aerial data collection in environments lacking traditional airspace infrastructure. Built on ResilienX's OptiX digital operations center, ORION extends real-time safety assurance, task automation, and system monitoring to enable fully autonomous multi-UAS coordination. Integrated with VOTIX's command and control (C2) solution, ORION dynamically assigns and re-tasks UAS assets, equipping first responders with real-time fire perimeter mapping, infrastructure assessment, and search-and-rescue capabilities. ORION also features a third-party application layer, enabling seamless integration of NASA-developed and commercial wildfire modeling and predictive analytics tools. In Phase I, ORION will advance from TRL 1 to TRL 5 through MBSE-derived system architecture development, interoperability validation (OptiX, VOTIX, and third-party UAS), a DIAB trade study, and operational performance modeling in a simulated wildfire response scenario. This research will evaluate network resilience, multi-UAS tasking efficiency, airspace deconfliction, and real-time mission adaptability. Demonstrating ORION's technical feasibility will establish a validated framework for full-scale prototyping and field deployment in Phase II, supporting NASA's objectives in autonomous UAS operations for disaster response and airspace management.

Duration: 6

Proposal Details

Proposal Number: A3.02-1042
Subtopic Title: Advanced Air Traffic Management for Nontraditional Airspace Missions
Proposal Title: A software-based positioning, navigation, and timing solution for

reliable operation in GPS-degraded environments

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 6
Technical Abstract (Limit 2000 characters):

PrecisionTerra proposes an end-to-end software-based GPS signal processor that can acquire, track, and process signals even in GPS-degraded environments. The software's foundational IP is a patented signal tracking algorithm developed at the University of Colorado-Boulder and designed specifically to enhance the tracking of GPS signals in any GPS-degraded conditions. This proposal will explore the use of this technology for NASA ARMD's autonomous aerial wildfire mitigation efforts, as these operations often take place in GPS-degraded locations like mountains, canyons, and forests. The first objective is to characterize the performance of PrecisionTerra's tracking technology in relevant GPS-degraded environments. Data collected will be benchmarked against both simulation results and the current state-of-the-art for GPS units typically aboard small unmanned aircraft systems (sUAS). The second objective is to make PrecisionTerra's software real-time operable, as UASs will need rapid positioning feedback for wildfire operations where speed is

essential. Funding from this proposal will be used to hire one full-time signal processing engineer that will optimize PrecisionTerra's signal processor for real-time, low-latency operation and make changes to the software as more information is learned from in-environment tests. Since the PI works full-time on PrecisionTerra, funding will also be used for the PI's salary, as the PI will be leading data collection and statistical analysis for this project. Finally, funding will be used to purchase the requisite testing equipment, including GPS receiver front-end boards and an inertial measurement unit (IMU) (both manufactured in the U.S.). The three target markets for PrecisionTerra's technology are GPS chipmakers for IoT devices (e.g., smartphones, passenger vehicles, UASs), high-precision GPS receiver manufacturers for commercial applications like construction and agriculture, and navigation device suppliers for the DoD.

Duration: 6

Proposal Details

Proposal Number: A3.03-1010
Subtopic Title: Future Aviation Systems Safety
Proposal Title: Loss Of Control Observer for Safety Assurance

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Recent FAA-sponsored work on certification considerations for advanced aerial mobility (AAM) aircraft has developed an algorithmic approach for detecting the onset of loss-of-control (LOC) events through monitoring of the aircraft remaining control power (RCP). This model-based, recursive filter approach, while powerful, presumes knowledge of the vehicle control effectiveness as a function of flight condition and configuration in the determination of both RCP and disturbance wind conditions. The proposed work plans to significantly expand this capability to address possible LOC events when the control effectiveness itself deteriorates due to unusual flight conditions (such a vortex ring state) or environmental effects (icing, shear flows). The expanded detection capability would provide assurance of autonomy of the associated flight control system to indicate the potential onset of conditions that would degrade vehicle control capability.

Duration: 6

Proposal Details

Proposal Number: A3.03-1012
Subtopic Title: Future Aviation Systems Safety
Proposal Title: Safe Temporal Assignment, Requirements, Deconfliction, and Optimization Model (STARDOM)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

Safe Temporal Assignment, Requirements, Deconfliction, and Optimization Model (STARDOM) is a novel approach to managing Urban Air Mobility (UAM) airspace through time-based reservations rather than traditional first-come, first-served or distance-based separation. By assigning precise arrival times at waypoints/fixes, STARDOM dynamically mitigates collision risk, eases congestion, and improves efficiency for high-density UAM operations. This approach incorporates real-time flight data, probabilistic risk modeling, and adaptive speed adjustments to ensure each aircraft meets its designated time of arrival at each fix, significantly reducing the chance of conflict. Under NASA SBIR Phase I funding, Concept Solutions, LLC will develop and validate key components of this technology: 1. A digital framework for time-based allocation of route segments and waypoints, 2. Probabilistic collision-risk assessments using Monte Carlo simulations, and 3. Preliminary metrics for safety, efficiency, and scalability in busy airspace scenarios. The primary market for STARDOM is NASA and FAA research programs, eVTOL and UAM operators, and broader Advanced Air Mobility stakeholders looking to integrate large-scale, on-demand urban flight into the National Airspace System (NAS). By shifting toward precise temporal reservations, STARDOM seeks to enable safer, more efficient, and data-driven UAM operations and pave the way for

sustainable, large-scale urban aviation.

Duration: 6

Proposal Details

Proposal Number: A3.03-1014
Subtopic Title: Future Aviation Systems Safety
Proposal Title: AI-Enhanced Digital Twin Framework for UAS Component Reliability in Support of In-Time Aviation Safety Management Systems (IASMS)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

AlarisPro proposes a novel framework for the integration of AI techniques with UAS component reliability data to create an AI Safety and Reliability (AISR) Digital Twin technology in support of In-Time Aviation Safety Management Systems (IASMS). As UAS operations increase in the National Airspace Systems (NAS), there is a critical need for advanced predictive maintenance capabilities and real-time safety assessment tools. This approach leverages the convergence of high-fidelity sensor data, component degradation models, and advanced AI algorithms to create a robust prognostic framework that can significantly improve operational safety and system reliability. The AISR Digital Twin maintains synchronization with its physical counterpart through continuous data assimilation techniques that optimize the balance between model predictions and sensor observations. The AISR Digital Twin architecture employs transfer learning methodologies to leverage knowledge across different UAS platforms and component types, allowing for rapid adaptation to new systems with limited historical data. This flexibility enables comprehensive safety assessments that account for propagation of component failures through interdependent systems. The integration with IASMS is facilitated through a real-time risk assessment engine that translates AISR Digital Twin outputs into actionable safety metrics. This research demonstrates the significant potential of AI-enhanced AISR Digital Twin technology to transform UAS reliability assessment and advance IASMS capabilities. The framework provides a foundation for transitioning from reactive maintenance paradigms to proactive, condition-based strategies that optimize safety margins while reducing operational costs. This represents a significant advancement in aviation safety management, providing operators, manufacturers, and regulators with unprecedented visibility into current system and component health and future reliability projections.

Duration: 6

Proposal Details

Proposal Number: A3.03-1028
Subtopic Title: Future Aviation Systems Safety
Proposal Title: Integrated Surface and Approach Risk Monitor

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The increase in safety incidents in the terminal airspace and on the airport surface over the past few years highlights the need for in-time, reliable monitoring and alerting technologies that fill in gaps in currently available systems. For fixed-wing aircraft operations, the most critical phase of flight is during take-off and landing and any interactions during this phase can lead to catastrophic consequences. In busy airports with large number of arrivals and departures, the operational margins are tight, and errors can have ripple effects on the traffic at the airport. With the Integrated Surface and Approach Risk Monitor (ISARM) we propose a tool to monitor the interaction among approach, runway, and taxiway operations and avoid incidents before they occur. ISARM translates measured safety metrics into actionable information through an aircraft risk model for the cockpit, and a runway risk status model for tower control. Several incidents between aircraft on the ground and approach in the past few years arose from the lack of a coherent forward-looking logic model for safety. ISARM offers a discrete event sequence safety logical model for approach and take-off operations that model actions of different aircraft in the airspace into a sequence of necessary discrete steps for safe operation. Similar to a flight checklist that verifies operations of each system within an aircraft, the discrete safety sequence model provides an operational checklist for safely operating at a given runway. The specific risks to operations at a runway can either be isolated (e.g., pilot error) or persistent (e.g., complexity of operations, poor surface conditions, etc.). We will leverage our expertise in speech-to-text models,

real-time data processing, and integrated monitoring to build the Phase I POC for ATL and JFK. We will demonstrate and validate the functionality on live data for the two airports by the end of Phase I.

Duration: 6

Proposal Details

Proposal Number: A3.05-1006
Subtopic Title: Advanced Air Mobility (AAM) Integration
Proposal Title: Weather Information Systems at Heliports and Vertiports for Advanced Air Mobility (AAM)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

The need for advance air mobility (AAM) platforms to take off and land at locations distant from traditional weather information systems (WIS) has driven the requirement for a WIS design process to be developed and used to construct new vertiports and upgrade existing heliports that will be utilized for AAM. TruWeather Solutions Inc. (TruWeather) intends to architect a WIS design process that enables a tailored and performance-based approach to WIS capable of meeting the needs of the rapidly changing AAM community and conforming to ASTM F3673-23. TruWeather will engage with stakeholders, conduct literature reviews, develop the aforementioned WIS design process, and guide NASA and stakeholders towards ideal locations for actualization. TruWeather intends to use funding for compensation of manpower and subcontractors engaging in research and deliverables as well as travel necessary to conduct stakeholder engagement. The design plan proposed can be leveraged by government and non-government entities to develop policy, aid in infrastructure development, and guide OEMs towards identifying the proper solution for the vast variability in market uses of AAM.

Duration: 6

Proposal Details

Proposal Number: A3.05-1007
Subtopic Title: Advanced Air Mobility (AAM) Integration
Proposal Title: Rain Rate Quantification Dissemination and Determination

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 6
Technical Abstract (Limit 2000 characters):

In support of the Advanced Air Mobility (AAM) concept for safe, sustainable, affordable aviation, ASTM International (formerly known as the American Society for Testing and Materials) has formed a Subcommittee F38.02 (part of Committee F38 on Unmanned Aircraft Systems) to establish the ASTM F3673-23 Weather Information Provider standard to address the performance and interoperability requirements for weather data reports, analysis, and services for operations including, but not limited to, uncrewed aircraft systems and AAM end users. While the current standard covers most required weather parameters relevant to AAM, the National Aeronautics and Space Administration (NASA) has identified shortcomings in the measurement of rainfall rate that must be addressed. To address these NASA-identified gaps, Intellisense Systems Inc. (Intellisense) proposes the Rain Rate Quantification Dissemination and Determination (RAINMINDER) effort to address all four stated NASA goals. Specifically, Intellisense will develop and enhance its patented microvolumetric rain rate measurement technology, calibrating it for the full range of weather conditions, and will compare its performance to rain rate estimates produced by nonvolumetric systems. It will also make rain rate data available to AAM operators using either public dissemination through the National Weather Service or through a private data network depending on the preference of each AAM operator. As a current member of the F3673-23 development committee, Intellisense will lobby to include new rain rate thresholds in the F3673-23 Tier 2 performance standard to align with Federal Meteorological Handbook No. 1 standards, thereby increasing the usefulness of the standard. This, in turn, will promote wider adoption and deployment and enhance safe and effective operational decision-making, thus broadening the weather data available to nonaviation customers and increasing the market for hyperlocal and microweather data.

Duration: 6

Proposal Details

Proposal Number: A3.05-1008
Subtopic Title: Advanced Air Mobility (AAM) Integration
Proposal Title: Next-Gen Precipitation Intensity System for Advanced Air Mobility (AAM)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

The proposed innovation enhances observations of precipitation intensity information to support safe and scalable advanced air mobility (AAM) operations. Current precipitation monitoring methods lack the spatial and temporal resolution required for AAM decision-making, particularly for rain rate and drop size distribution (DSD) observations at low altitudes. This effort will develop a novel, near real-time approach to precipitation monitoring by leveraging emerging ground-based radar systems, citizen science networks, and advanced data processing techniques to improve the accuracy and precision of rain rate and DSD measurements. Unlike traditional rain gauges that measure accumulated rainfall, this technology will provide instantaneous rain rate observations critical for optimizing battery efficiency, identifying safe flight routes, and ensuring passenger and cargo safety. Phase I will focus on cataloging existing rain rate and DSD observation techniques, identifying key gaps in current methods, and assessing emerging technologies suitable for AAM applications. This work will inform the design of a high-resolution precipitation monitoring system tailored to AAM corridors. The proposed approach aligns with NASA's broader aeronautics and

weather research initiatives by enhancing real-time atmospheric observations and improving aviation weather models. Beyond AAM, this innovation has broader applications in urban weather resilience, hydrology, and flood risk mitigation. Funding from this SBIR will support the technical feasibility assessment, system architecture development, and the identification of commercialization pathways for the proposed precipitation monitoring technology.

Duration: 6

Proposal Details

Proposal Number: A3.05-1014
Subtopic Title: Advanced Air Mobility (AAM) Integration
Proposal Title: Microweather Data Integration, Classification, and Communication Using a Vertiport Automation System (VAS) for Safe and Efficient Advanced Air Mobility (AAM) Operations

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

Advanced Air Mobility (AAM) promises to revolutionize urban and regional transportation, offering fast, clean, and affordable travel by air. Given that AAM is expected to have high operational density and utilize urban origins and destinations, the management systems at these vertiports will need to be much more robust than the bare-bones or otherwise nonexistent systems deployed at today's heliports. Current limitations in capturing, synthesizing, and communicating critical on-vertiport data, such as localized weather information, hinder situational awareness and increase the risk of incidents and inefficient operations. Altaport proposes the development of a robust Vertiport Automation System (VAS) module focused on microweather data integration and annunciation. This module will ingest data from TruWeather's microweather sensors on and around vertiports, fuse it with other weather data sources (ASOS/AWOS), interpret the weather information to evaluate the likely operational impact of the weather, and present it to vertiport and aircraft operators–both human and machine–in an actionable format. The situational awareness that this module will provide is crucial for safe and scalable AAM operations. This module supports NASA's Nontraditional Aviation Operations for Advanced Air Mobility by "develop[ing] requirements for a vertiport/airport AAM weather information system."

Duration: 6

Proposal Details

Proposal Number: H3.13-1004
Subtopic Title: Oxygen Compatible Habitation Solutions for Exploration Environments
Proposal Title: Polybenzoxazine Aerogels for Insulation in 38% Oxygen Environments

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The proposed work will develop aerogels for insulation based on novel polybenzoxazine resins that exhibit ultra-low flammability in high oxygen concentration environments. These aerogels are designed to provide thermal insulation in high oxygen concentration environments up to 38% vol oxygen. Flame resistance will be provided through the molecular design of the polybenzoxazine structure. The molecular structure of the polymer and the microstructure of the material are both specifically designed to achieve three critical performance characteristics: ultra-low flammability, excellent, thermal insulation, and very low density. This directly targets the need for materials suitable for service in exploration environments where the oxygen concentration may be as high as 38% vol due to habitat, cabin, and vehicle environment optimization. This proposal highlights an aerogel microstructure structure most suitable for thermal insulation applications. However, the ultra-low flammability polybenzoxazine is anticipated to have additional applications such as acoustic barriers, packaging, panels, and other slab, sheet, film, and molded applications. This approach provides a path towards addressing the needs for materials that can perform in high oxygen environments. Performance will be evaluated using NASA-STD-6001B Test 1 Upward Flame Propagation at 38% vol oxygen.

Duration: 6

Proposal Details

Proposal Number: H3.13-1006
Subtopic Title: Oxygen Compatible Habitation Solutions for Exploration Environments
Proposal Title: Insulative Acoustic Composite Materials for Oxygen-Rich Environments

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

NASA seeks oxygen compatible materials that pass NASA-STD-6001B Test 1 Upward Flame Propagation 1 at 38% (volume) for use in habitation systems. New insulative and acoustic composite materials will be produced based on novel polysiloxane copolymer - infused textiles for spacecraft applications. The polysiloxane copolymers will include functionalized fillers for chemical integration into the resin matrix to further fortify commercial flame-resistant textiles. The siloxane copolymer - infused textile shall be integrated into composites as an extension to our HybridSil® InSilbondTM panel technology which passed independent testing per MIL-PRF-32161: High Temperature Fire Protection, Thermal & Acoustic. The new HybridShield® composites shall be evaluated towards NASA-STD-6001B specifications in enriched oxygen environments.

Duration: 6

Proposal Details

Proposal Number: H3.13-1011
Subtopic Title: Oxygen Compatible Habitation Solutions for Exploration Environments
Proposal Title: Multi-Purpose Flame Retardant Materials for Habitation Solutions

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Crewed NASA missions with high frequency EVA operate at reduced pressure and increased oxygen (38% O2), which creates increased flammability risk including lower ignition energy requirements, increased combustion rates and reduced heat dissipation. Very few materials are non-flammable at 38% oxygen. NASA has identified the need for new habitation materials, especially foams and insulation, that pass the rigorous NASA-STD-6001B Test 1 Upward Flame Propagation at 38 vol% O2 test. Giner will develop a novel flame-retardant additive formula that will be demonstrated in polyurethane foams at 38% O2 and reduced pressure. Our improved performance under these conditions is enabled by the rapid response of our intumescent additives which is designed to mitigate the accelerated combustion experienced under the target high O2 low pressure conditions. Rapid activation accelerates the production of diluent gases when exposed to heat, driving O2 away from the ignition point, slowing combustion and starving the flame. Our flame-retardant polyurethane foams will be rigorously tested in-house, followed by 3rd party evaluation as the NASA White Sands test facility in 38% O2 and 8.2 psia.

Duration: 6

Proposal Details

Proposal Number: H3.14-1000
Subtopic Title: Nanobubble Facilitated Hydrogen Peroxide Production In Space
Proposal Title: High-efficiency Photocatalytic Hydrogen Peroxide Production Using Polymeric Optical Fibers and Visible Light

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

NASA is seeking solutions to produce hydrogen peroxide (H_2O_2) in a spacecraft environment for the purposes of disinfection, cleaning, and wastewater stabilization. H_2Optic Insights, in collaboration with Arizona State University, previously conducted a NASA Phase I STTR project (Contract No. 80NSSC23PB439) titled In-Situ Resource Production of Hydrogen and Hydrogen Peroxide from Water Using Nano-Enabled Optical Fibers. This project successfully demonstrated proof of concept for photocatalytic (PC) H_2O_2 production, achieving Technology Readiness Level (TRL) 3-4 for key enabling components, using visible-light photocatalysis on polymeric optical fibers (POFs) in water. Across published literature, PC H_2O_2 production has emerged as a viable and exciting alternative to other in-situ production methods. Our approach uses a PC reactor containing a bundle of POFs that side-emit light, continuously irradiating photocatalysts deposited on the POFs' outer surfaces ensuring consistent activation and high efficiency. We irreversibly embed small masses of nanocatalysts onto low-cost POFs, reducing catalyst mass while enhancing light delivery efficiency compared to competing designs such as catalyst slurry or flat-plate reactors. We use a low-power visible-light LED to drive photochemical reactions and supply oxygen (bubble-free) through hollow fiber membranes (HFMs). Specifically, we plan to: • Fabricate n=4

replicate PC reactors with POF bundles to further demonstrate we meet/exceed NASA performance metrics • Assess catalyst chemical stability and long-term performance • Evaluate the impact of chemical stabilizers on H_2O_2 production rates • Investigate using O_2 nanobubbles as an alternative to our current HFM O_2 delivery system • Analyze system size, weight, and power trade-offs for scale-up Our technology shows significant promise. Our previous work has mitigated key risks and validated that H_2O_2 production rates remain stable for over 500 hours while meeting NASA's criteria.

Duration: 6

Proposal Details

Proposal Number: H3.14-1001
Subtopic Title: Nanobubble Facilitated Hydrogen Peroxide Production In Space
Proposal Title: Compact, Long-lasting Hydrogen Peroxide Generator of Enhanced Stability

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

NASA plans to return crews to the lunar surface and other space missions require addressing environmental control and life support system (ECLSS) challenges, including innovative solutions to provide adequate disinfection, cleaning, and wastewater stabilization. Multiple studies have demonstrated the disinfecting capabilities and wastewater stabilization provided by aqueous solutions of hydrogen peroxide (H2O2). However, for crewed space missions, storing the required H2O2 is a space burden and a safety hazard, with high launching cost. The alternative of resupplying H2O2 is not only very expensive but prohibited for long-term crewed space missions. Thus, mission logistics can be significantly simplified by an on-demand H2O2 generation on location from on-board resources. The aim of this Phase I study is to demonstrate a compact, long-lasting single electrochemical cell operating continuously > 500 hours with a degradation of performance of <10%, capable of delivering high concentration of oxygen from air to the cathode compartment. The output H2O2 concentration can be dialed-in to produce >10 L/day of H2O2 aqueous solutions at H2O2 levels >100 mg/L, with an energy consumption of < 5kW-hr/day. It only requires air, water, and electricity for its operation. Since H2O2 decomposes to water and air, electricity is the only consumable.

Duration: 6

Proposal Details

Proposal Number: H3.14-1015
Subtopic Title: Nanobubble Facilitated Hydrogen Peroxide Production In Space
Proposal Title: Highly reliable and energy-efficient electrosynthesis of high-purity hydrogen peroxide from air and water in a nanobubble facilitated porous solid electrolyte reactor

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 5
Technical Abstract (Limit 2000 characters):

Our proposed project aims to develop a nanobubble-facilitated porous solid electrolyte (PSE) reactor for the direct and continuous electrosynthesis of high-purity H2O2 with low energy consumption and high operational stability. This technology directly addresses the challenges of traditional H2O2 production by enabling onsite, electrolyte-free synthesis, eliminating complex separation processes, and significantly enhancing efficiency and reliability. The intended use of funding is to optimize key design components, including a high-performance $2e^-$-ORR electrode, an ultrathin porous PSE wafer, and a 100 cm^2 prototype reactor, ensuring scalability and long-term operational stability for practical deployment. Our competitive advantages lie in the integration of nanobubble aeration, which enhances oxygen mass transport, allowing for six times higher $2e^-$-ORR current density than the required benchmark and reducing energy consumption to <0.05 kWh/day, a 100× improvement over conventional electrochemical H2O2 production. By eliminating anion exchange membranes (AEMs), our design overcomes stability limitations, extending reactor lifespan and enabling high-efficiency, decentralized H2O2 generation. Beyond NASA applications, this technology has strong commercialization potential in municipal water treatment, healthcare disinfection, pharmaceutical manufacturing, and chemical synthesis,

where high-purity H2O2 is critical. Our target markets include NASA, private space companies, defense organizations, and commercial industrial sectors requiring safe, cost-effective, and sustainable H2O2 production solutions including water treatment, disinfection, semiconductor, etc.. The successful development of this innovation will position our technology as a leading solution for both space-based and more broader applications, providing a scalable and energy-efficient alternative to existing methods.

Duration: 6

Proposal Details

Proposal Number: H4.09-1009
Subtopic Title: Long-Duration Exploration Portable Life Support System (PLSS) Capabilities
Proposal Title: Regenerable, Integrated Trace Contaminant Control and Rapid Cycle Amine System for Sustainable Lunar and Martian EVAs

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

In this Phase I SBIR, XploSafe proposes to confirm the technical feasibility of a regenerable integrated Trace Contaminant Control (TCC) and Rapid Cycle Amine (RCA) system for the continuous removal of CO2 and trace contaminants from the ventilation loop of the Exploration Portable Life Support System (xPLSS). XploSafe has developed regenerable TCC and CO2 adsorbents that are capable of maintaining the CO2 and trace contaminant levels below their xEMU exposure thresholds and scaled their production to commercial scale. In addition, XploSafe has also constructed TCC and RCA test rigs for evaluating sorbents in closed-loop recirculating swing beds, which are capable of simulating Exploration Extravehicular Mobility Unit (xEMU) conditions, including sub-atmospheric pressure, flow rate, temperature control, contaminant source rates, and desired dosing metabolic profiles. The target deliverable is combining the TCC and RCA capabilities toward Lunar and Martian extravehicular activities (EVAs) to simplify the current xPLSS and eliminate redundant sorbent beds. The main advancement is integrating the TCC and CO2 sorbents based on nanoporous silica and acrylonitrile-modified tetraethylenepentamine (TEPAN), respectively, inside a single cartridge. TEPAN comprises of primary and secondary amines that offer adequate regeneration and considerable affinity toward carbon dioxide, while nanoporous silica can reversibly adsorb volatile organics from various chemical classes. Different combinations of these sorbents will be screened against a mixture of nine select TCC compounds and CO2, and their optimal configuration will be identified. XploSafe possesses all the required equipment to complete new material characterization, conduct TCC and CO2 breakthrough experiments, and execute large-scale testing with an xEMU simulating sub-atmospheric swing-bed. Ultimately, a prototype design that can be integrated into the next-generation xEMU with a combined RCA/TCC system will be proposed.

Duration: 6

Proposal Details

Proposal Number: H4.09-1015
Subtopic Title: Long-Duration Exploration Portable Life Support System (PLSS)

Capabilities
Proposal Title: Mars Atmospheric Convective Heat expulsIoN Engine (MACHINE)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 2
Technical Abstract (Limit 2000 characters):

NASA has a need for thermal cooling solutions to be integrated into the Portable Life Support System (PLSS) for Martian EVAs. The state-of-the-art components of the PLSS are not suitable for EVA operation on Mars. To fill this gap, MACHINE is intended to replace the current Spacesuit Water Membrane Evaporator thermal control system, with a hybrid forced-air (mainly carbon dioxide from the Martian atmosphere) convection cooling system. An array of Peltier chips and phase change materials are utilized as secondary heat management subsystems. MACHINE represents a significant departure from prior designs by using a 3-stage convection driven thermal management approach that eliminates the need for transporting cooling water from Earth (or risking not finding it on Mars). This will be a closed-loop system with zero consumables use. Feasibility calculations suggest that not

only can MACHINE handle 460 W steady-state heat flow and the stated 700 W peaks, but can do so in most of the Martian day-night cycle with forced convective cooling alone. Only during the highest measured equatorial daytime temperatures are the secondary elements needed. To operate, we estimate 175 W maximum power draw and total battery energy use of 550 WH for an 8 hour mission. Our calculations indicate that a flat-plate, finned forced air radiator can be designed in a rectangular flat plate geometry that occupies only half of the PLSS backpack rear panel surface area with a likely total thickness of 5 cm and a mass well under 5 kg. With Phase I funding we will design the MACHINE and conduct a PDR-level design review. NASA, and the growing private space sector have a need for components that enable long-duration, closed-loop, exploration PLSS systems for future astronauts on long-term lunar and Mars operations. Applications also include improvements in advanced training systems for astronauts on Earth as well as potential non- flammable coolant systems for an environmental or firefighting PLSS.

Duration: 6

Proposal Details

Proposal Number: H4.09-1018
Subtopic Title: Long-Duration Exploration Portable Life Support System (PLSS) Capabilities
Proposal Title: Passive, Durable, Gravity-independent Condensing Heat Exchangers for PLSSs

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

We propose a 3D-printed, light, durable, passive, gravity-independent condensing heat exchanger (CHX) to meet the rigorous requirements of EVAs in long-duration space exploration missions. The proposed 3D-printed CHX relies on an innovative dual-plane gradient wick structure combining in- and out-of-plane capillary action to capture, collect, and recover the humidity exhaled and perspired by astronauts during EVAs. Unlike current condensers that share a common surface for both droplet nucleation/growth and condensate removal, the out-of-plane gradient wick decouples the nucleation/growth surface from the condensate removal for enhanced humidity condensation and delayed flooding. The in-plane gradient wick then directionally and passively transports the condensed humidity to a capillary reservoir for later drainage upon completion of the EVA. This enables full passive condensate management by preventing flooding and ensuring efficient removal to a reservoir. Previously, we successfully demonstrated the concept of the in-plane gradient wick condenser for enhanced flow condensation of pure dielectric/refrigerant vapors (i.e., no air). Building on this experience, the proposed project conceptualizes and demonstrates a novel dual-plane gradient wick topology for varied g-fields. Phase I deliverables will include: 1. Detailed modeling and simulation results demonstrating the optimal pore size distribution of the dual-plane gradient wick structure will be delivered. 2. A functional prototype of the proposed dual-plane gradient wick CHX complemented with detailed design documents will be delivered. 3. Detailed experimental results demonstrating that the proposed dual-plane gradient wick CHX meets the project's performance metrics will be delivered. 4. A detailed design for a full-scale dual-plane gradient wick CHX will be delivered. Also, a detailed assessment of its potential integration into future PLSSs for lunar and Martian missions will be conducted.

Duration: 6

Proposal Details

Proposal Number: H4.09-1020
Subtopic Title: Long-Duration Exploration Portable Life Support System (PLSS) Capabilities
Proposal Title: Lightweight and Regenerable CO_2 and H_2O Sequestration System

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

The research introduces a compact, lightweight, and regenerable non-venting CO_2 and H_2O architecture for use in Portable Life Support Systems (PLSSs). The architecture integrates spray-based absorption and chemical stripping, featuring a novel gravity-independent Capillary Condensing Heat Exchanger (CCHX) to condense and separate water vapor. A fine-droplet spray reactor enhances CO_2 absorption into a low-viscosity ionic liquid (IL), maximizing efficiency while minimizing mass and volume. The CO_2-rich, droplet-laden flow then passes through a Multiplexed Inertial Filter (MIF), which captures and collects the IL for subsequent stripping and recirculation. For regeneration, a low-power chemical stripping process converts the CO_2 into a solid, storing it without venting. This approach eliminates the need for energy-intensive thermal/vacuum desorption or gas compression, maintaining a closed loop with continuous CO2 uptake and storage. The resulting solid can be reprocessed at a habitat, enabling repeated use. The system meets CO_2 and H_2O requirements for an eight-hour extravehicular activity while adhering to strict mass (<12 lbm) and volume (<10″×8″×5″) constraints critical for partial-gravity. By combining advanced transport technologies, lightweight materials, capillary-driven condensation, optimized IL spraying, and efficient chemical stripping, this design delivers superior resource

efficiency, reduced mass, and reliable closed-loop CO_2/H_2O management.

Duration: 4

Proposal Details

Proposal Number: H4.11-1001
Subtopic Title: Advanced Materials for Durable Spacesuits for the Moon and Mars
Proposal Title: Impact-resistant Composite Structures for Spacesuits

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Composites Automation (CA) is partnering with the University of Delaware Center for Composite Materials (UD-CCM) to investigate innovative composite material and structure concepts that meet projected Mars impact energy goals of >600J with leak rates < 0.5LPM. The proposed effort focuses on hard structural components in the spacesuit pressure garment subsystem. Low-Velocity Impact (LVI) testing protocols will be developed for higher energies exceeding 600J, while addressing relevance to Spacesuit structural geometries. Material innovations evaluated in this effort include hybrid laminate constructions with interlayers and fiber metal laminates; as well as potential synergistic combinations. Material solutions will be screened under LVI and leak resistance testing. Results from screening will be used to design optimum composite architectures combining select concept(s) for synergistic improvement in impact performance.

Duration: 6

Proposal Details

Proposal Number: H4.11-1011
Subtopic Title: Advanced Materials for Durable Spacesuits for the Moon and Mars
Proposal Title: 3D Reinforced Composites for Improved Impact Resistance in Spacesuits

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 5
Technical Abstract (Limit 2000 characters):

This proposal seeks to develop an advanced material solution for the hard upper torso (HUT) component with improvements in impact resistance. The current HUT is a 2D laminate which is more susceptible to delamination between plies under impact conditions. Materials Research & Design is proposing an investigation of 3D braided/woven composites for improved impact strength. The overall objective of this Phase I program is to demonstrate the ability to improve interlaminar shear strength of an S-2 / epoxy composite material with across-ply reinforcement to improve impact resistance. Phase I will focus on the fabrication and characterization of at least one material system consisting of 3D woven S-2 fibers with an epoxy matrix. Characterization of this material will consist of flexure testing and asymmetric four-point bend testing to derive in-plane tensile modulus and strength and interlaminar shear strength. These measured material properties will be used to develop a material model to estimate properties for other woven/braided architectures. These additional material systems, along with the fabricated material will be simulated in finite element models, simulating the performance under impact loading. Results from these cases will be compared for all material architectures to determine which has the greatest potential to survive operational impact scenarios. The architectures evaluated will be ranked by their potential for further evaluation in Phase II. The values for comparison include estimated/measured strengths, mass savings compared to the baseline material, and estimated performance based on the impact loading finite element analysis. Phase II of the program will focus on the maturation of the candidate materials down-selected from the Phase I results. It will include additional testing of candidate materials, specifically impact and permeability testing. Phase II will conclude with a full or sub-scale prototype fabricated of the final material.

Duration: 6

Proposal Details

Proposal Number: H4.11-1016
Subtopic Title: Advanced Materials for Durable Spacesuits for the Moon and Mars
Proposal Title: Additively Manufactured Scalmalloy® EMU Spacesuit Bearings

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Quadrus Advanced Manufacturing Division (QAMD) is pleased to present this proposal for the demonstration of the feasibility of an advanced bearing design solution that extends service life while significantly reducing weight. The current challenge with Titanium 6Al-4V (Ti6-4) bearings is galling and excessive wear due to the high loads applied to the bearing race and the stainless-steel balls. Our innovative approach involves replacing the bearing race and housing with nitrided Scalmalloy® which maintains wear performance while offering significant weight savings. QAMD has been certified by APWORKS to process Scalmalloy® since 2019. The nitriding process will ensure comparable surface hardness to the current Ti6-4 bearings which is crucial in limiting wear and galling. The primary technical objective is to demonstrate the feasibility of utilizing nitrided or TiC-reinforced Scalmalloy® for bearing races and housings in planetary spacesuit applications, achieving weight reduction while maintaining wear performance. Additionally, if necessary, an additively manufactured CoCr race insert will be evaluated as a high hardness contact surface while retaining Scalmalloy® for the housing to optimize mass efficiency. Quadrus Advanced Manufacturing Division aims to establish itself as a key supplier of advanced bearing solutions for next-generation spacesuits, particularly for NASA’s EMU and future planetary exploration suits. By demonstrating the feasibility of Scalmalloy®-based bearings with enhanced wear resistance and weight savings, we position ourselves as an integral partner to suit manufacturers such as Axiom Space, Collins Aerospace, and ILC Dover. Beyond

the completion of Phase II, the goal is to transition from research and development to full-scale production, ensuring integration into NASA's lunar and Martian exploration programs, as well as commercial space ventures.

Duration: 6

Proposal Details

Proposal Number: H4.11-1017
Subtopic Title: Advanced Materials for Durable Spacesuits for the Moon and Mars
Proposal Title: MetPreg Fiber Reinforced Aluminum for Hard Upper Torso Spacesuit Components

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

Currently, NASA is seeking new technologies to be incorporated into their Hard Upper Torso (HUT) design for spacesuits that will be used in off-planet applications. This next generation of spacesuits will require technologies that are stronger and more durable than the current state-of-the-art materials that were used for previous space exploration. Touchstone proposes to replace the existing HUT materials with a lightweight high-strength metal matrix composite (MMC), known commercially as MetPreg. MetPreg is a fiber reinforced aluminum (FRA) composite composed of continuous alumina fibers within a pure aluminum matrix. Metal matrix composites such as MetPreg offer unmatched durability, and composite-adjacent strength to weight ratios, both of which are critical in remote and off-planet applications. Additionally, these materials permit repair, recycling, and remanufacturing opportunities that are seldom considered with traditional epoxy (thermoset) aerospace composites. Therefore, a metallic structure will provide many benefits in off-planet situations, especially regarding durability, maintenance, repair and off-gassing. Phase I of this study intends to prove the ability of MetPreg to be thermally formed into shaped coupons and maintain strength properties. As part of this study, Touchstone plans to manufacture 10 tensile samples and 5 hemispherical shaped coupons. 5 of the tensile samples will be tested to the appropriate ASTM standard and the 5 remaining samples are planned to be delivered to NASA for future vendor testing. 5 Hemispherical coupons will be manufactured to prove the ability to form coupons of MetPreg and manufactured for use within NASA HUTs and for use in future testing. All testing and learnings from this study will be supplied to NASA at its completion.

Duration: 6

Proposal Details

Proposal Number: H5.01-1012
Subtopic Title: Modular, Multi-Use 50 kW Lunar Solar Array Structures
Proposal Title: Modular Operations, Resource, & Power Hub (MORPH)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

Opterus proposed the Modular Operations, Resource, & Power Hub (MOPRH), a modular 50 kW vertical solar array designed to address the power generation needs of lunar missions. The innovative system consists of interchangeable solar panels, supported by Opterus' Tubular Truss Additive Manufacturing (TTAM) technology. The system addresses many of the needs outlined in the topic including novel packaging and modularity concepts, novel lightweight components, mechanisms and seals with exceptionally high resistance to lunar dust, optimized use of composite materials, adaptable solar array concepts for multiple lunar surface use cases, and concepts of operation for fully autonomous deployment, retraction, assembly, operation and repair. Although a full system architecture will be conceived, the primary innovation that will be explored in the proposed Phase I effort is the lightweight panel design with embedded electronics and dust tolerant connection method from the panel to the support structure. The intended use of funding will be to support the design, development, and testing of lightweight solar panel prototypes as well as a full system architecture design and concept of operations for assembly, retraction, and repair of the array and support structure. The focus will be on creating a scalable and reconfigurable power generation system for lunar infrastructure with applications extending to Mars missions.

MOPRH targets NASA’s lunar and Mars exploration programs, aligning with the need for robust, high-power solar arrays for long-duration missions. This technology will also serve commercial space missions targeting the lunar and Martian surface where there are significant market growth opportunities for deployable structures and mechanisms.

Duration: 6

Proposal Details

Proposal Number: H5.01-1013
Subtopic Title: Modular, Multi-Use 50 kW Lunar Solar Array Structures
Proposal Title: 50kW Pneumatic Modular Solar Array STAC Mast

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

NASA developed a state-of-the-art scalable conceptual design of a high-performance 60kW/m3 deployable solar array with very low mass, compact stowage, and reliable deployment. The Compact Telescoping Array (CTA) consists of a slender telescoping mast that supports a large area flexible photovoltaic array that can be deployed vertically on the lunar surface. Moonprint will augment the CTA concept with new pneumatic telescoping mast technology and quick disconnect nodes between mast elements, to create a modular structures technology that can be configured multiple ways prior to flight, or repurposed on the lunar surface. The modular mast technology to be developed in this program is a new class of structures apart from deployable mast technologies in use and under development. The pneumatic telescoping mast technology, or Sequential Tip-Additive Construction (STAC), is “assembled” from the top of the mast rather than being pushed up from its base. Therefore, structural stiffness is realized during deployment and can be augmented with guys to generate extremely tall, slender towers. The nodes facilitate vertical stacking of structural elements or deployment in other directions such as in the case of outriggers. The pneumatic STAC elements and nodes can be combined to create solar array deployment and support structures, mast additions on top of solar arrays for communications relays, or as extremely tall towers for a range of purposes that require significant line of sight.

Duration: 6

Proposal Details

Proposal Number: H5.01-1018
Subtopic Title: Modular, Multi-Use 50 kW Lunar Solar Array Structures
Proposal Title: Lunar SCRUB: Lunar Surface Cleaning Robotic Unit with electron-Beam

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 5
Technical Abstract (Limit 2000 characters):

Lunar regolith (dust) poses a critical challenge for equipment life due to its high abrasion and stickiness, leading to degradation of optical properties and extremely fast wear on mechanisms. Vertical Solar Array Technology (VSAT), in particular, will likely output significantly less power when inevitably covered in dust by nearby operations or landings. Orbital Mining Corporation (OMC) will develop a robotic arm-mountable non-contact cleaning apparatus, dubbed "Lunar SCRUB," tailored for removing Lunar regolith from solar panels, mechanical joints with complex geometry, radiator assemblies, and other applicable surfaces. Instead of a subject surface-integrated protective system, this solution uses an electron beam device developed by Space Dust Research and Technologies. It requires little electrical power and no consummables, offering a low cost, flexible dust removal solution for VSAT operations. The beam will be directable on a 2-axis rotation mechanism for complex angle cleaning. With phase 1 funding, OMC will test beam cleaning effectiveness on complex geometry, such as a mechanical arm's joint, seals, photovoltaic surface substrates, and radiator substrates in a relevant dusty vacuum environment. Lunar SCRUB will target primarily VSAT lifecycle cost improvements, but all surface operational equipment are included in the target market.

Duration: 6

Proposal Details

Proposal Number: H5.01-1020
Subtopic Title: Modular, Multi-Use 50 kW Lunar Solar Array Structures
Proposal Title: Friction Stir Extrusion (FSE) of Modular Lunar Solar Array Structures and Sub-Components

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 5

Technical Abstract (Limit 2000 characters):

Lunar infrastructure development presents significant logistical challenges due to payload constraints and reliance on Earth-based manufacturing. This proposal introduces Friction Stir Extrusion (FSE) as an innovative solid-state manufacturing method to enable in situ production of modular structural components and electrical wiring for lunar solar tower arrays and other infrastructure. FSE utilizes a compact, low-power, gravity-insensitive extrusion process that transforms feedstock into high-quality, continuous extrusions of complex geometries without melting the material. Unlike traditional extrusion methods, this approach reduces energy consumption, enhances material properties, and is scalable to produce extrusions of virtually unlimited length. The Phase I effort will focus on designing and fabricating a single-pin FSE system with a ram-rod-style feed mechanism to validate key processing parameters. This will include extruding multiple geometries, performing metallographic and mechanical testing, and delivering samples to NASA for evaluation. Additionally, the study will assess surface finish enhancements via low-friction coatings and establish a roadmap for Phase II, which will expand the process to multi-pin extrusions and continuous feed systems for large-scale lunar applications. Beyond lunar construction, this technology has broad applications in terrestrial aerospace, defense, and industrial manufacturing, offering an energy-efficient alternative to traditional extrusion. The requested funding will demonstrate process feasibility, optimize extrusion parameters, and establish the groundwork for scalable lunar manufacturing, aligning with NASA's TX12.2 H5.01 objectives for modular lunar structures.

Duration: 6

Proposal Details

Proposal Number: H6.25-1010
Subtopic Title: Trusted Autonomy in Space Systems
Proposal Title: NeuroCert: Adaptive Certification Framework for AI in Space

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

As autonomous space systems become more complex, ensuring their safety, reliability, and compliance with mission-critical standards remains a major challenge. Traditional software certification methods are slow, labor-intensive, and not well-suited for rapidly evolving AI-driven autonomy. To address this, M&T Consulting proposes NeuroCert: An Adaptive Certification Framework for AI in Space, an AI-assisted certification framework that accelerates the verification and validation (V&V) of autonomous space software. NeuroCert integrates formal verification techniques, machine learning-based anomaly detection, and model-based systems engineering (MBSE) to create an adaptive, scalable certification process. The framework will leverage AI to automate test case generation, identify failure modes, and validate system behaviors against safety and performance benchmarks. By combining explainable AI (XAI) with formal methods, NeuroCert ensures that autonomous decision-making processes remain transparent and auditable—critical for regulatory acceptance. Phase I funding will be used to develop a proof-of-concept prototype, validate key certification components in a simulated environment, and establish performance benchmarks for scalability and accuracy. The project will also explore integration pathways with existing NASA verification frameworks to ensure seamless adoption. Target applications include NASA's autonomous spacecraft, robotic explorers, and crew-assistive AI systems, as well as broader adoption in DoD space assets and commercial satellite operations. By modernizing the certification process, NeuroCert will reduce the time and cost of validating autonomous space systems while enhancing mission safety and reliability.

Duration: 6

Proposal Details

Proposal Number: H6.25-1019
Subtopic Title: Trusted Autonomy in Space Systems
Proposal Title: ASCENT - Autonomous Software Certification & Evaluation for New Technologies

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 5
Technical Abstract (Limit 2000 characters):

To address the NASA need for certification methods for autonomous system software, STEER Tech proposes to develop a new Autonomous Software Certification & Evaluation for New Technologies (ASCENT) system, based on a prototype standard developed from existing standards and guidelines across industries. This approach incorporates concepts around safe development of autonomous system software, enabling us to meet NASA requirements for trusted autonomy in space applications. The system offers a framework to prove that a defined safety process has been followed to guarantee that the autonomous system meets the required criteria for safe operation. During Phase I, STEER Tech will compile and analyze existing industry standards which can be extended to space applications for the creation of a new prototype standard, the basis of ASCENT. Currently at TRL 2, ASCENT will reach TRL 5. The demonstrated results will offer NASA capabilities to certify autonomous system software currently non-certifiable using existing aviation standards.

Duration: 6

Proposal Details

Proposal Number: H6.25-1032
Subtopic Title: Trusted Autonomy in Space Systems
Proposal Title: Model Validation via Precomputed Transformations (MVPT)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Model Validation via Precomputed Transformations (MVPT) is a proprietary approach to ensuring the reliability of Machine Learning (ML) models deployed in Autonomous Systems (AS) operating in extreme or data-limited environments. Traditional ML validation techniques fail to account for unknown or unmodeled scenarios, leading to potential mission failures when AS encounter novel conditions. MVPT addresses this by precomputing model validation across a set of anticipated data transformations before deployment, allowing real-time validation onboard the

AS with minimal computational overhead. This enables autonomous decision-making without requiring human intervention or time-intensive model retraining. Phase I funding will be used to establish the feasibility of MVPT by conducting a comprehensive literature review of ML validation and transformation techniques, developing a working prototype, and defining a Phase II test plan for full-scale simulation in a NASA-relevant scenario. The target markets for MVPT include NASA's space exploration and Earth observation missions, the Department of Defense (DoD) for autonomous Unmanned Aerial Systems (UAS), and private-sector industries such as autonomous vehicles, healthcare AI, and industrial robotics.

Duration: 6

Proposal Details

Proposal Number: H8.01-1003
Subtopic Title: In-Space Production Applications (InSPA) Flight Development and Demonstrations on ISS
Proposal Title: Autonomous hybrid manufacturing system for in-space manufacturing of reconfigurable microelectronics

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

Our technology is an advanced hybrid manufacturing system that merges electrohydrodynamic (EHD) inkjet printing with laser sintering to enable the in-space production of printed electronics, specifically on platforms like the International Space Station (ISS). By leveraging electrical forces to precisely deposit nano- and micro-scale conductive, dielectric, and semiconducting inks, the system has already been validated in microgravity environments. The incorporation of laser sintering will further enhance the manufacturing process by rapidly fusing printed materials into robust electronic structures while preserving their intricate features, even under the challenging conditions of space. The funding will be dedicated to integrating the laser sintering module with our existing microgravity-validated EHD inkjet printer. This integration will automate the entire manufacturing process, ensuring consistent quality and higher throughput. The additional investment will also support the development of advanced process control algorithms and system optimization for the harsh space environment. By improving automation and process reliability, we aim to reduce manual intervention, minimize production errors, and achieve scalable manufacturing capabilities that are essential for long-duration missions. Our target markets include aerospace organizations seeking on-demand, in-space manufacturing solutions for critical electronic components and satellites, as well as industries in the flexible electronics and printed sensors sectors. These sectors are rapidly evolving and demand lightweight, high-performance, and customizable electronic devices. Beyond space applications, our technology is poised to address terrestrial needs where high-precision, flexible electronics are required for applications such as wearable devices, smart packaging, and advanced sensor arrays. This dual-market strategy positions our technology as a transformative solution both in orbit and earth.

Duration: 6

Proposal Details

Proposal Number: H8.01-1006
Subtopic Title: In-Space Production Applications (InSPA) Flight Development and Demonstrations on ISS
Proposal Title: Lithium Niobate Single-Crystal Wafer Fabrication via Edge-Defined Film-Fed Growth for In-Space Station Production Applications

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

This project introduces an innovative approach of fabricating thin-film and single-crystal lithium niobate ($LiNbO_3$) samples using Liquid Phase Epitaxy (LPE) and Edge-Defined Film-Fed Growth (EFG) techniques. This project offers precise control over thickness, element composition, and crystallographic orientation, enabling high-quality and defect-free materials at a lower cost. Thanks to its exceptional optical, acoustic, and piezoelectric properties, $LiNbO_3$ is critical for optics, telecommunications, quantum sensing, and space technologies. We expect to demonstrate our technology aboard the International Space Station, leveraging

microgravity to minimize structural defects, enhance crystal purity, and enable scalable wafer production. This innovation directly addresses the increasing demand for high-performance $LiNbO_3$ materials, ensuring a secure domestic supply chain.

Duration: 6

Proposal Details

Proposal Number: H8.01-1017
Subtopic Title: In-Space Production Applications (InSPA) Flight Development and Demonstrations on ISS
Proposal Title: The Blueprint for Generative AI chips manufactured on the ISS

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 6
Technical Abstract (Limit 2000 characters):

The democratization of Artificial Intelligence (AI) catalyses an industrial revolution for next generation 3D heterogeneous integrated circuits (ICs) to create generative AI chips. Future demand remains boundless driven by innovations in every industrial sector becoming dependent on automation, AI and data science. Generative AI chips will be used in everything from robotics, data centers, connected cars, to medical technology and cryptocurrency. We propose to develop next generation Extreme Ultraviolet Photomasks on the International Space Station. These photomasks form the hardware blueprint of 3D heterogeneous integrated circuits used for generative AI chips. The ultimate goal of this work is to contribute to a semiconductor ecosystem on board the International Space Station, to create EUV photomasks, which due to the superior manufacturing environment will have superior performance on earth at the leading edge of the semiconductor industry.

Duration: 6

Proposal Details

Proposal Number: H8.01-1021
Subtopic Title: In-Space Production Applications (InSPA) Flight Development and Demonstrations on ISS
Proposal Title: Auxilium Microfabrication Platform Cartridge Modification

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 6
Technical Abstract (Limit 2000 characters):

In November 2024, the Auxilium Microfabrication Platform (AMP-1) was installed on the International Space Station (ISS) and successfully printed clinical-grade implantable medical devices for peripheral nerve injuries. The AMP-1 overcomes the limitations of conventional bioprinting technologies. It offers fast print speeds (up to 1 mm/min), high resolution (1–5 micron pixel size), a fully enclosed sterile print chamber, and the ability to print a wide range of materials for various biological applications. Our technical objectives for the proposed project are to modify the AMP-1 bioprinter cartridge to accommodate cell-printing in a microgravity environment (aboard the ISS). The cartridge has demonstrated its ability to print biocompatible materials and we propose design refinements that will enable the inclusion of cells within the cartridge, while still keeping astronaut involvement at minimum. Specifically, we plan to enhance the existing cartridge by adding fluid inlet and outlet ports to the exterior of the cartridge that connect to the interior of the print chamber via standard fluidic connections and tubing. The exterior ports will be Luer lock connections, allowing the astronaut to connect a syringe and inject a cell/biomaterial bioink directly into the cartridge without opening it. The proposed project aims to modify the design of the AMP-1 bioprinter cartridge to allow stem cells cultured in space to be loaded directly for in-space printing, rather than being pre-loaded on Earth and launched as part of the payload. The global organ transplantation market was estimated at approximately $8.9 billion in 2022 and projected to reach $17.2 billion by 2030. The significance of this project lies in the capability to enable precise 3D-printing of cells in specific locations using our established AMP-1 facility aboard the International Space Station. Our approach will optimize the manufacturing process of functional organs, aiming to improve patients' lives.

Duration: 6

Proposal Details

Proposal Number: H9.03-1003
Subtopic Title: Flight Dynamics and Navigation Technologies
Proposal Title: Plume Impingement Module for Autonomous Proximity Operations

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Successfully executing proximity operations in space, such as docking or in-orbit servicing, requires spacecraft that can intelligently plan and react to the environment in real time. One of the most severe risks during proximity operations is the plume from one spacecraft's thrusters impinging on another. These high-speed plumes can break components, melt materials, contaminate sensitive surfaces, and spin the vehicle out of control, which may result in catastrophic consequences, such as loss of mission or even loss of crew. Currently, rounds of time-consuming and expensive ground-based analyses are required to design a controller that meets plume impingement constraints, and no onboard warning systems exist. In this Phase I effort, an innovative plume impingement module is designed for autonomous onboard control. This novel algorithm uses an engineering flowfield model of high-fidelity plume simulations and simplified impingement equations. The proposed approach captures complex plume interactions in an accurate and efficient manner. The module then outputs quantities of interest and tracks constraints so that the connected controller can be optimized, or the onboard system can react to risks in real time. The culmination of this effort will deliver working preliminary software of the plume impingement module, a feasibility study, and documentation. Modular plume impingement software has a wide range of NASA and commercial applications including ground-based controller development, onboard mission design, and real-time control. In particular, the module is immediately useful for orbital debris mitigation, space station proximity operations, Artemis Orion and

Gateway safety improvements, and deep space or Mars missions.

Duration: 6

Proposal Details

Proposal Number: H9.03-1024
Subtopic Title: Flight Dynamics and Navigation Technologies
Proposal Title: Quantifying Uncertainties in Exploration using Stereophotoclinometry with Topography (QUEST)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Image-based surface reconstruction and characterization is crucial for missions to small celestial bodies, as it informs mission planning, navigation, and scientific analysis. However, current state-of-the-practice methods, such as stereophotoclinometry (SPC), rely heavily on human-in-the-loop verification and high-fidelity information. The proposed work, called Quantifying Uncertainties in Exploration using Stereophotoclinometry with Topography (QUEST), extends a novel framework, called Photoclinometry-from-Motion (PhoMo), that incorporates photoclinometry techniques into a keypoint-based structure-from-motion system. PhoMo estimates the surface normal and albedo at detected landmarks to improve surface and shape characterization of small celestial bodies from in-situ imagery. QUEST significantly advances the PhoMo framework by computing the uncertainties associated with the PhoMo-generated map and using these results to compute optimal terrain relative navigation (TRN) estimates. In particular, both analytical- and numerical-based covariance expressions will be derived using an Unscented Kalman Filter (UKF) to quantify the errors in the QUEST-derived TRN estimates. QUEST will compare the use of a UKF with the factor graph-based smoothing approach that already exists within the PhoMo framework. The UKF is expected to provide significant advantages to 1) assess the expected TRN performance, which can be used for typical error-budget assessments, and 2) increase the existing performance. Another aspect that will be studied is the computational effort required to obtain real-time TRN solutions. Results will be computed using data from NASA’s Planetary Data System.

Duration: 6

Proposal Details

Proposal Number: H9.03-1027
Subtopic Title: Flight Dynamics and Navigation Technologies
Proposal Title: Relative Navigation and Mapping using Visual Point Clouds & Neural View Synthesis

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

In response to the 2025 NASA SBIR Phase I solicitation subtopic H9.03, Advanced Space, LLC (Advanced Space) and partner The University of Colorado, Boulder (CU Boulder) propose to develop through trade studies an RPOD-focused, monocular optical navigation and mapping pipeline for unknown, uncooperative space objects that is robust to the harsh lighting conditions of space. The first algorithm in the pipeline is CloudNav, a new relative pose estimation solution that uses visual point cloud triangulation and matching, which was developed for use in asteroid-relative navigation and mapping. The team at CU Boulder invented the CloudNav algorithm with funding from the NASA JPL SURP Program. Our intent is to leverage this preexisting relationship between CU Boulder, JPL, and Advanced Space to collaborate on the maturation of CloudNav. These same techniques will be applied to RPOD datasets to generate relative pose observables that then can be passed to a specialized Extended Kalman Filter (EKF) implementation to process dynamical constraints, additional parameters, and possibly additional measurements to enhance state observability. The combination of CloudNav measurements with the high-heritage, mature EKF represents a combination of algorithms for relative navigation that is likely amenable to real-time, onboard implementation in future phases of this effort. Finally, with a robust relative navigation solution in

combination with the input camera images, the Advanced Space team proposes to postprocess these outputs in a set of identified neural view synthesis (NVS) algorithms to obtain dense, relightable, photorealistic object reconstructions that could aid investigators in interpreting target object characteristics and even material properties. Advanced Space has already invested in an IRAD project to demonstrate that publicly available NVS algorithms can be trained to produce strikingly accurate reconstructions of asteroid shapes given a set of input images and poses.

Duration: 6

Proposal Details

Proposal Number: H9.08-1004
Subtopic Title: Lunar 3GPP Technologies
Proposal Title: Lunar WiFi Access Point (LWiFi AP)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

With increasing interest in lunar exploration, there is an escalating need for robust communication systems, particularly the initiation of NASA's Artemis program and Commercial Lunar Payload Services. NASA has a technology need for the lunar communication architecture including SWaP-efficient 3GPP hardware and WiFi deployable as hosted payloads on habitats, rovers, Commercial Lunar Payload Services (CLPS), landers, and orbital assets. NASA has specified WiFi throughout the Artemis program. Examples of Artemis systems and subsystems where NASA specifies WiFi include: Human Landing System, CLPS, Lunar Terrain Vehicle Services, the Habitation and Logistics Module and airlock on Lunar Gateway. There is demonstrated high demand for a space-rated WiFi Access Points and WiFi network/client cards in the NASA Artemis and CLPS contractor community. The major critical gaps between the state of the art and the technology needed include space qualification of terrestrial hardware and standards for the lunar environment (with low SWaP), especially radiation tolerance. Other environmental concerns include survivability at extreme temperatures. To address these needs, Solstar Space Company proposes to develop a new Lunar WiFi Access Point (LWIFI-AP) for CLPS and the Artemis Program. This device will support multi-mode, multi-protocol and multi-band communications as required for WIFi other communications services. Through this proposal Solstar can support several applications in a lunar communications architecture consisting of surface assets e.g., astronauts, robotic rovers, vehicles, and Gateway.

Duration: 6

Proposal Details

Proposal Number: H9.08-1007
Subtopic Title: Lunar 3GPP Technologies
Proposal Title: Lunar Digital Twin

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

As DeepSpace Technologies, Inc., in partnership with North Carolina State University's NextG Wireless Lab and pi-Radio, we are excited to present a crucial NASA SBIR Phase 1 initiative focused on developing a cutting-edge digital twin for a Lunar 5G communication architecture. Recognizing the urgent need for a robust lunar communications infrastructure, our initiative aims to support surface assets, communication relay satellites, and facilitate seamless connectivity with Earth-based ground stations. With our combined expertise in lunar surface processes, space weather phenomena, and 5G channel modeling, we are ideally equipped to tackle the unique challenges posed by the lunar environment. This digital twin will employ advanced modeling techniques to simulate lunar conditions and space weather impacts on communication performance, enabling critical what-if analyses for effective network planning and optimization. Accessible to both NASA and commercial users through a scalable cloud framework, this tool will facilitate real-time simulations to support strategic decision-making. Our ambitious six-month work plan will focus on creating a digital twin template, data acquisition, and channel modeling, ultimately delivering a functional prototype while addressing the

complexities of lunar communication systems. Together, we aim to accelerate advancements in this vital sector, ensuring operational readiness by establishing a commercial tool that advances the state of the art in Lunar communications infrastructure that is imminently needed.

Duration: 5

Proposal Details

Proposal Number: H9.08-1012
Subtopic Title: Lunar 3GPP Technologies
Proposal Title: Wireless Channel Simulation for Antennas Mounted on Spacesuits and Lunar Vehicles

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

In this SBIR Phase I, Remcom proposes an extension to channel modeling and coverage analysis capabilities for lunar environments, directed toward addressing shortfalls associated with near-field effects around antennas mounted on spacesuits or lunar vehicles. One key area that poses challenges to simulation lies in the modeling of the complex, layered materials used in spacesuits and their impact on antenna radiation and ultimately on communication links. Several key scenarios for the Artemis missions involve communications between astronauts and 3GPP networks, or use of 3GPP sidelink or alternative protocols to allow device-to-device (D2D) communication between astronauts or network relay when one astronaut is out of network range. A robust simulation capability is needed to evaluate how the positions of single or multi-antenna configurations may impact communication performance in realistic lunar scenarios for these cases. Remcom proposes innovative approaches using Huygens surfaces to merge near-field and far-field domains, while addressing shortfalls in critical effects along surfaces along with accelerations to reduce computation times by multiple orders of magnitude. Key objectives include prototyping and analysis tasks to evaluate feasibility and provide a strong foundation for development of the ultimate capabilities in Phase II.

Duration: 6

Proposal Details

Proposal Number: H10.04-1003
Subtopic Title: In-line Commodity Purity Analysis
Proposal Title: Autonomous Real Time, Multi Species Monitoring System for In-line Commodity Purity Analysis

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

In NASA and commercial aerospace processes involving hydrogen, oxygen, methane, air, nitrogen, and helium, real-time in-line analysis of gas purity is critical for ensuring product quality, process efficiency, and compliance with stringent standards for mission success. Current standard methods like GC/MS require significant downtime, labor, and sample distribution to labs for analysis, struggle with real-time monitoring, and do not allow for sampling in the process stream. There is a need for innovative gas/fluid composition monitoring technologies capable of achieving real-time in-line analysis of hydrogen, oxygen, methane, air, nitrogen, and helium process streams, with a focus on detecting and quantifying impurities such as hydrocarbons, moisture, and total impurities per NASA purity standards. The long-term objective of the proposed effort is to leverage Sporian's prior work on machine learning-enabled spectroscopy-based sensing systems to realize an intelligent, real-time, cost-effective process gas stream composition monitoring system focused on detecting and quantifying both composition and impurities per NASA purity standards. This initial effort will focus on methane process streams and their specific needs and technical requirements, as sensing contaminants in high-concentration methane gas traditionally presents many challenges for conventional in-line sensor types. Phase I efforts will include: 1) working with stakeholders to define system requirements; 2) evaluating revised hardware/electronics architectures and designs; and 3) proof of principle testing and demonstration using benchtop-scale prototype hardware. If successful, Sporian will be well-positioned for the Phase II efforts focused on full system prototyping and relevant environmental testing/demonstration. Work will be done through a collaboration between Sporian Microsystems and the University of Central Florida.

Duration: 6

Proposal Details

Proposal Number: H10.04-1004
Subtopic Title: In-line Commodity Purity Analysis
Proposal Title: Multi-Species Inline Analyzer for Monitoring Process Gases in ISRU Systems

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4

Technical Abstract (Limit 2000 characters):

Physical Sciences Inc. (PSI) proposes the development of a multi-species gas analyzer for monitoring the quality of process streams generated by lunar and Mars in situ resource utilization (ISRU) systems. This multi-component in-line gas analyzer (MIGA) integrates technologies successfully demonstrated in several PSI projects with innovations in ruggedizing lightweight optical gas cells, multiplexing laser sources to reduce footprint, covering more than one gas species per laser, and miniaturizing control and detection electronics for high-sensitivity measurements. The proposed project will target the monitoring of produced oxygen, methane, hydrogen, and carbon monoxide and carbon dioxide from lunar regolith. MIG will also monitor impurities in these process streams including ppmv-level (typical) of hydrogen sulfide, hydrogen chloride, hydrogen fluoride, and water vapor. The innovative integration of field-proven technologies and components will accelerate the development of MIGA and its certification for space applications. The integration of field-proven technologies and components will accelerate the development of MIGA and its certification for space applications. The proposed innovation has very high relevance and significance to the NASA topic H10.04 "In-Line Commodity Purity Analysis" of the solicitation. The benefits of the technology may include a cost-effective tool for wide deployment on systems requiring high purity gases to operate such as fuel cells and electrolysis systems, minimizing losses due to damages to production infrastructure from harmful impurities that would cause corrosion, maximizing heating value of the purchased fuels by verifying the composition of gas mixtures, increasing safety of propellants produced on lunar or Mars outposts to prevent catastrophic failures, and most importantly ensuring the quality of produced oxygen and water for safe human consumption.

Duration: 6

Proposal Details

Proposal Number: H10.04-1005
Subtopic Title: In-line Commodity Purity Analysis
Proposal Title: In-line, real-time gas sensor utilizing a novel, multi-modal spectroscopy concept

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

We will develop a novel gas sensor concept utilizing our proprietary hollow fiber gas cell. The approach has the following advantages: real-time, in-line, broad range of species, high dynamic range, calibration-free, and low SWaP. In Phase I, we will leverage synergistic projects to demonstrate the concept, explore trade-offs, and develop optimized prototype designs for both NASA and commercial applications.

Duration: 6

Proposal Details

Proposal Number: H12.09-1000

Subtopic Title: In-Suit Detection of Venous Gas Emboli
Proposal Title: Wearable cardiac ultrasound imager

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 6
Technical Abstract (Limit 2000 characters):

Astronauts performing extravehicular activities (EVAs) face a heightened risk of decompression sickness (DCS) due to the formation of venous gas emboli (VGE) during pressure transitions. Current monitoring methods rely on transthoracic or transesophageal echocardiography, which are impractical in space environments due to their invasiveness, bulkiness, and operator dependence. To address this limitation, we propose the development of a non-invasive, wearable ultrasound patch capable of real-time, continuous cardiac imaging and automated VGE detection within an EVA suit. The proposed skin-conformal ultrasound device integrates a stretchable piezoelectric transducer array with a wireless electronic control circuit, allowing real-time data transmission to a portable device (e.g., a smartphone). The system employs deep learning-based image analysis to detect and quantify VGE, providing an automated Eftedal-Brubakk score to assess DCS risk. The low-profile, flexible

design ensures minimal interference with astronaut mobility while maintaining high-resolution imaging comparable to conventional ultrasound systems. Phase I will focus on: 1. Developing a high-resolution stretchable ultrasound transducer array optimized for cardiac imaging within the constraints of an EVA suit. 2. Implementing beamforming algorithms for enhanced penetration depth and field of view to acquire an apical four-chamber (A4C) view. 3. Designing a deep-learning model for real-time VGE detection, quantification, and automated risk scoring. 4. Validating system safety using standard ultrasound evaluation metrics. This technology has significant implications beyond space applications, including terrestrial aerospace, deep-sea diving, and clinical embolism monitoring. It represents a transformative advancement for diagnostics in extreme environments, ensuring astronaut safety during space exploration.

Duration: 6

Proposal Details

Proposal Number: H12.09-1001
Subtopic Title: In-Suit Detection of Venous Gas Emboli
Proposal Title: Compact Wearable Ultrasonic Monitoring System for In-Suit Venous Gas Emboli Detection

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 6
Technical Abstract (Limit 2000 characters):

Astronauts undertaking extravehicular activities (EVAs) are exposed to major physiological risks due to reduced pressure environment of spacesuits. One of the most critical risks is decompression sickness (DCS), caused by the formation of venous gas emboli (VGE) during transitions from pressurized habitats to low-pressure EVA suits. While existing pre-breathe protocols reduce DCS risk, they are resource-intensive, requiring substantial oxygen reserves and crew time. The increasing workloads associated with partial gravity EVAs further elevate the risk of DCS, prioritizing the need for innovative monitoring solutions. Current decompression bubble management is based on EVA simulations and defining pre-breath protocols prior moving to space. There is no technology to monitor DCS during EVA. Clearsens Inc. is a start-up company that aims to translate capacitive micromachined ultrasonic transducer (CMUT) technology for wearable ultrasound applications. The company simplifies the manufacturing process and enables highly efficient, wide-bandwidth, and small form-factor CMUT arrays. Our goal is to tailor the patented technology to this NASA need for enhancing astronaut safety, optimizing resource usage, and ensuring mission success. Our findings show that the technology is well suited to make a low-power, wearable ultrasound imaging system. The company proposes to adapt this technology for a wearable, non-invasive ultrasonic sensing system to enable real-time, in-suit detection of VGE. We propose to evaluate this novel technology as a wearable for decompression stress quantification (phase I) and, if successful, optimize its imaging scheme by doing human experiments for real-time processing (phase II). This system will provide critical physiological data, enabling astronauts to monitor their decompression status for a safer EVA operation. The system can be used in other DCS risk management required markets like aviation and diving.

Duration: 6

Proposal Details

Proposal Number: H12.09-1006
Subtopic Title: In-Suit Detection of Venous Gas Emboli
Proposal Title: In-Suit Detection of Venous Gas Emboli

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

Future manned missions to the moon and Mars will be resource constrained. Crew time and oxygen are among the most important resources for any manned mission. Unfortunately, current strategies—dentriogenation by long duration oxygen prebreathe protocols—for mitigating the risk of decompression sickness (DCS) during extravehicular activities (EVA) consume significant time and oxygen. NASA needs new and better strategies for monitoring, mitigating, and managing DCS risk. Creare proposes to adapt our diver-worn DCS risk assessment tool for EVA. Our proposed Body-worn Emboli Notification Device (BEND) will non-invasively monitor the astronaut's blood for venous gaseous emboli (VGE) via two different ultrasound techniques: Doppler and dual-frequency ultrasound (DFU). It has long

been established that there is a very strong correlation between VGE and DCS and that monitoring VGE is a promising avenue for assessing DCS risk in real-time. In addition to monitoring for VGE, BEND will use DFU to monitor microbubbles in the tissue and in the blood. DFU does not require precise alignment with the heart or veins to function (reducing the amount of crew time needed to properly don the device) and DFU requires minimal embedded signal processing (reducing the necessary processing power, which reduces the device size while increasing battery life). In Phase I, we will advance the TRL of our device from 3 to 5 by adapting our existing design for the EVA suit environment, fabricating prototypes, validating prototype performance in the laboratory in reduced pressure oxygen and freefall environments, and delivering a prototype to NASA for evaluation. In Phase II, we will increase our TRL to 6 by iterating the system design, fabricating high fidelity prototypes, and demonstrating performance in mission-simulating environments in the laboratory, in human subject flights in hypobaric chambers, and in an animal model of altitude DCS.

Duration: 6

Proposal Details

Proposal Number: H15.01-1001
Subtopic Title: Autonomous Capabilities for Lunar Surface Mobility Systems
Proposal Title: Robust LiDAR-Stereo Fusion for Lunar Autonomy

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The Artemis mission requires sensing technologies and associated algorithms to enable vehicles to operate autonomously with fast cadence and high reliability. In support of fast cadence and high reliability autonomy, Quartus Engineering will develop a LIDAR-Stereo fusion system using state of the art algorithms optimized for lunar worthy computing platforms. Fusion of LiDAR and stereo image data using state of the art algorithms can enable accurate long range obstacle detection and mapping while preserving dense visual and texture information. Quartus will initially prototype and compare three fusion methods: LiDAR-guided stereo matching, depth completion and fusion techniques, and deep learning-based fusion. Quartus will leverage the NASA POLAR Stereo dataset and LunarSim to generate synthetic LiDAR-Stereo data that closely mimics lunar conditions. This simulated data will be used to evaluate different algorithmic approaches and downselect a particular fusion and stereo matching pipeline. The downselected fusion and stereo matching pipeline will be re-implemented as an optimized C++ library, with highly parallelizable portions of the algorithms factored into subroutines with support for RISC-V Vector, GPU, or FPGA accelerators. This support for hardware accelerators will be achieved through a combination of OpenCL and Microchip's SmartHLS compiler software. Finally, Quartus will select an off the shelf RISC-V computer with comparable properties to anticipated lunar worthy RISC-V platforms and evaluate algorithm performance on this test hardware to demonstrate that desired robustness, accuracy, and latency can be achieved on a representative computing device. This work is the first step towards commercializing a LiDAR-Stereo module comprised of a LiDAR system, a stereo system, precise calibrations, and a lunar worthy compute device hosting robust, high accuracy, low latency algorithms for stereo matching and LiDAR-stereo fusion.

Duration: 6

Proposal Details

Proposal Number: H15.01-1005
Subtopic Title: Autonomous Capabilities for Lunar Surface Mobility Systems
Proposal Title: Visual Intelligence for Situation Awareness

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

A key challenge in remote robot operations is the need to maintain situation awareness during operations. Current LEO ISS operations require operators to manually manage multiple 2D cameras on station and EVA suits to obtain views of the operating environment and demands operators perform mental 3D reconstruction using these views. Remote ground operators face these challenges compounded by restrictions on bandwidth and limited downlinks that require prioritizing camera feeds to downlink. Compared to current LEO operations, it is anticipated that lunar LTV and PR operations will have decreased available bandwidth and downlinks, which will exacerbate these issues. To address this, TRACLabs proposes Visual Intelligence for SiTuation Awareness (VISTA). VISTA

will intelligently select RGB cameras in the remote operating area that provide task-relevant context for current operations. Selected camera feeds will be downlinked and processed on the ground with photogrammetry to provide interactive 3D views of the operating area, allowing for effective monitoring or control of remote systems. Phase I funding will allow the development of a proof-of-concept VISTA system. TRACLabs plans to target Commercial Lunar Payload Services (CLPS) providers and government organizations as targeted markets.

Duration: 6

Proposal Details

Proposal Number: H15.01-1008
Subtopic Title: Autonomous Capabilities for Lunar Surface Mobility Systems
Proposal Title: Multi-Frequency AMCW LiDAR Imager for Next-Gen Planetary Exploration

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

As NASA expands lunar exploration under Artemis, autonomous mobility is crucial for crewed and uncrewed missions. However, current sensing technologies, including LiDAR, are designed for terrestrial use and lack adaptations for the Moon's extreme conditions—radiation, dust, temperature fluctuations, and variable lighting—hindering safe rover navigation. To address this, we propose an Amplitude Modulated Continuous Wave (AMCW) high-frame-rate LiDAR system optimized for lunar operations. AMCW LiDAR offers high-speed, high-precision depth sensing in a compact, power-efficient design essential for surface exploration. Utilizing a four-bucket phase measurement technique and dual-frequency modulation, our system extends unambiguous range and maximizes signal-to-noise ratio (SNR), ensuring reliable performance in harsh lunar conditions. This innovation enhances mobility, hazard detection, and rover lifespan, supporting NASA's long-term exploration goals. Beyond rover navigation, AMCW LiDAR supports hazard detection and terrain assessment for lunar landers, enabling real-time, high-resolution 3D mapping for safe landings. It also aids infrastructure development and resource exploration for sustained lunar habitation, facilitating habitat placement, in-situ resource utilization (ISRU), and construction planning. Additionally, NASA's deep-space robotic missions—including Mars rovers and asteroid exploration—would benefit from AMCW LiDAR's low-power, high-SNR capabilities. Its ability to function in GPS-denied, extreme environments with minimal computational demands makes it a key enabler for future planetary exploration. By advancing LiDAR technology to meet these needs, we provide NASA with a next-generation sensing solution that enhances exploration, safety, and operational efficiency across multiple mission profiles.

Duration: 6

Proposal Details

Proposal Number: H15.02-1002
Subtopic Title: Simulation and Modeling of Lunar Mobility System Interaction with Lunar Regolith
Proposal Title: Modeling of Tire and Regolith Interaction for Surface Mobility Applications

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Exploration and eventual habitation of the surface of the Moon and Mars are highly dependent on our ability to safely and efficiently navigate the complex terrain and terramechanical response of the environment on vehicles and machinery. NASA has awarded contracts to develop new Lunar Terrain Vehicles (LTVs) to transport astronauts and essential equipment during future missions with required ranges of up to 5 km. Designing LTVs that sustain operation in this harsh environment is difficult, especially for LTV tires, which must be designed to operate in soil that behaves vastly different than terrestrial soils. Mimicking the Lunar/Martian

environment and capturing the complex terramechanics of the soil and tire in experiments is limited, and designers must turn to computational approaches to study these interactions. Classical terramechanics models are useful to a degree but fail to properly capture behavior of compliant tires commonly used for LTVs. On the other hand, Lagrangian Discrete Element Methods (DEM) can capture per-particle regolith interaction with the tires with high accuracy but at significant computing cost thus limiting use for full-scale problems. CFD Research aims to address this modeling gap using a coupled DEM-informed Eulerian-Eulerian approach to simulate the regolith with DEM-based compliant tire models. Eulerian-Eulerian methods model a 'granular' volumetric fluid with constitutive models, thus significantly reducing the computational burden of having to track billions of particles required for DEM. DEM-tire models will use bond models to simulate compliant tires, which in turn is less expensive than traditional finite element approaches. The developed capability will be validated against experiments and verified against 'Project Chrono ' soil contact model and a DEM soil model. The resulting tools will facilitate performance analysis of a wheel-based (rigid and compliant) surface mobility system traversing a realistic compound slope condition.

Duration: 6

Proposal Details

Proposal Number: H15.02-1007
Subtopic Title: Simulation and Modeling of Lunar Mobility System Interaction with Lunar Regolith
Proposal Title: Terrain Regolith Evaluation And Degradation (TREAD)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

The proposed Terrain Regolith Evaluation and Degradation (TREAD) project tackles the critical issue of rover wheel and drivetrain degradation in abrasive lunar soil by merging empirical data from a controlled terramechanics testbed with multi-scale simulation tools. The requested Phase I funding will be used to refine a discrete element method–based modeling platform, develop a small suite of advanced wheel materials, and conduct validation tests in the University of Central Florida's RIDER test facility. By focusing on wear rates, traction, and dust ingress mechanics, this project ensures that next-generation lunar vehicles are equipped for the harsh operational demands of the Moon's surface. Beyond serving NASA's Artemis initiative, the technology targets markets where high-fidelity wear predictions offer strong commercial potential: mining, construction, agricultural machinery, and off-road or military vehicles that operate in dusty or sandy terrains. Funding will thus underwrite the design and calibration of a robust predictive engine, enabling engineers in both spaceflight and terrestrial industries to drastically reduce maintenance costs, enhance vehicle reliability, and plan preventative maintenance schedules more effectively. The end goal is to produce a validated tool that mission planners and commercial operators can rely on when forecasting long-term performance of wheeled systems in extremely abrasive environments with 20% less uncertainty than current methods.

Duration: 6

Proposal Details

Proposal Number: H15.02-1012
Subtopic Title: Simulation and Modeling of Lunar Mobility System Interaction with Lunar Regolith
Proposal Title: Physics-Based Continuum Numerical Framework for Large-Scale Lunar Terramechanics Applications

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Outward Technologies, in collaboration with Aperi CMC, proposes a multi-scale modeling framework to accurately simulate the complex interactions between lunar mobility systems and regolith. This innovative framework combines the high-fidelity Discrete Element Method (DEM), capturing the complex micro-mechanics of granular materials, with the computationally efficient Reproducing Kernel Particle Method (RKPM), ideal for large-scale soil deformation and vehicle dynamics simulations. Leveraging existing, validated DEM data from high-fidelity lunar regolith simulations, the framework significantly enhances RKPM accuracy

while substantially reducing the prohibitive computational costs associated with traditional DEM analyses. This addresses the challenge of large-scale lunar terramechanics modeling within reasonable computational limits. Support for this project sought through NASA's SBIR program will enable the development of a robust DEM-RKPM interface, the careful selection and detailed refinement of a highly responsive material constitutive model to accurately capture lunar regolith behavior, the execution of carefully planned preliminary simulations designed to validate the core framework capabilities, and a comprehensive and detailed evaluation of its computational efficiency with a focus on optimization for Phase II. Through continued development, this methodology will NASA to optimize vehicle performance, accurately predict regolith behavior in diverse and challenging terrains, and ensure safer lunar operations. Target markets include NASA, seeking enhanced lunar exploration and mission safety, as well as the commercial sector for terrestrial terramechanics, robotics, and off-road vehicle design. Key innovation lies in the fusion of DEM and RKPM for true multi-scale simulation, with these development efforts ultimately being released as free and open-source software to foster widespread adoption.

Duration: 6

Proposal Details

Proposal Number: S11.01-1001
Subtopic Title: Lidar Remote-Sensing Technologies
Proposal Title: Scalable Optical Phased Arrays, SOPA

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Exciting Technology is the world leader in scalable Optical Phased Arrays, OPAs, that can be made operational size in the relatively near term. Space fed optical phased arrays allow us to steer one dimension at a time. This requires many orders of magnitude less connections than chip scale, or transmit/receive module, based OPAs that others are developing, for example >300,000 times fewer connects for a 50 cm aperture, thousands of connections instead of hundreds of billions. Furthermore, we can make the required number of elements even lower by combining our space fed OPA technology with our patent pending decentered lens technology, and by using what we call an EZOPA approach. Our OPAs can provide rapid, precision beam steering for a variety of space applications, AND can also allow dynamic, non-mechanical, lens fabrication. If we have the ability to add a low-resolution adaptive optics element, there is no loss in generality by steering one dimension at a time, but steering one dimension at a time makes our OPAs much easier to scale to operational sizes. This phase 1 SBIR will allow NASA to design OPAs that replace slow, bulky, mechanical steering with compact OPAs that can be quickly scaled to operational size, from landing lidars to orbital remote sensing lidar. In phase 1 we will fabricate a 1 cm EZOPA with ±15 deg steering. We will demonstrate beam steering with the EZOPA and we will design an OPA based aperture to replace the 3 apertures on the Navigation Doppler Lidar, NDL. We will also design approaches to scale to 50 cm OPA based apertures, using only a 5 cm diameter OPA. Overall, non-mechanical steering is essential for increased lidar performance, a significant reduction in C-SWaP, and for reducing risk of mechanical component failure in a space environment. In phase 2 we will build a space application prototype with a path to space ruggedization and further scalability.

Duration: 6

Proposal Details

Proposal Number: S11.01-1006
Subtopic Title: Lidar Remote-Sensing Technologies
Proposal Title: On-orbit Reconfigurable LiDAR for Mapping and Hazard Detection

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

In order to track and rendezvous with objects on orbit, a sensor is needed that can accurately measure the object in 3D space. The current state of the art is to use scanning lidar or flash lidar systems to measure the location and pose of the target.

When the target is tumbling at high speed, scanning lidars encounter blurring distortions. Flash lidar systems are the only technology that can reliably produce 3D organized point cloud data without motion blurring effects. Enhancing this technology with liquid crystal polarization gratings gives flash lidar the flexibility to change the field of view and staring angle on a per frame basis. Implementing this new step-and-stare lidar design leads to improvements to field of view, angular resolution, and frame rate, while maintaining low SWaP. The goal of this program is to establish the architecture for the Reconfigurable Lidar System. Anon-mechanical variable focus receiver lens and laser beam expander will be designed. The specifications for the liquid crystal optical subcomponents and the controlling electronics will be developed. An on-board processor for built in AI and control software are going to be selected and integrated into the lidar schematics. ASC will work with NASA to tailor the system specifications and performance level to anticipated requirements for future programs. The requirements will be integrated into ASC's lidar simulator so that performance with the reconfigurability enhancements can be quantitatively assessed. ASC will demonstrate a representative mission in this simulated environment. The phase 1 deliverables are a technical report detailing the design of the re-configurable lidar system and demonstrating the feasibility in a simulated demonstration. The reconfigurable lidar is a step forward for the state of the art in on-orbit 3D measurement hardware. This will position ASC to provide a robust, flexible, and low SWaP solution to the satellite servicing and space domain awareness markets.

Duration: 6

Proposal Details

Proposal Number: S11.01-1021
Subtopic Title: Lidar Remote-Sensing Technologies
Proposal Title: Space/Aircraft Blue Laser for Underwater Ocean Science, Sensing, and Communications

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Fibertek proposes a versatile blue laser technology with applications in NASA atmospheric and ocean science, as well as Navy/DoD bathymetry, submarine communications, and underwater threat sensing. The focus of Phase 1 is to establish the feasibility of this technology for Phase 2 development of a space TRL 4/5 laser optical module. Key points: • Support for NASA Science and DoD aircraft/ spacecraft applications. • Space-capable laser: Utilizes Fibertek's core space laser design methods, with potential for high reliability. • Efficiency and size: The proposed laser is potentially 5x more efficient, 2-3x smaller in SWaP (Size, Weight, and Power), and significantly less complex than current state-of-the-art blue laser lidar/comms. • Program goals: Rapidly mature a minimal viable blue laser optical module to TRL 5 by 2028, establishing feasibility for space missions. • Phase II deliverable: A 473 nm blue laser that can be integrated into existing NASA aircraft lidar systems to enable ocean lidar missions. • Data utilization: Aircraft data can be used to model high-altitude and space-based ocean lidar systems using quantified ocean lidar data.

Duration: 6

Proposal Details

Proposal Number: S11.02-1003
Subtopic Title: Technologies for Active Microwave Remote Sensing
Proposal Title: Advanced Narrow-linewidth Tunable Laser for Rydberg Sensors (ANTLRS)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

AOSense proposes to develop a narrow-linewidth, widely tunable, high-power near-infrared laser in a robust, compact, semi-monolithic package compatible with the vibration conditions in suborbital flight. The laser will enable Rydberg excitation in rubidium from the 5D_5/2_ state to target states spanning n=35-100, accessing resonant microwave Rydberg transitions spanning the S band to the W band. The Phase I effort will include designing the laser package, building the laser, testing the laser performance (e.g., wavelength, coarse tuning range, mode-hop-free tuning range, linewidth, and power), and planning further studies of vibration testing and Rydberg microwave-sensing sensitivity response to laser linewidth.

Duration: 6

Proposal Details

Proposal Number: S11.02-1012
Subtopic Title: Technologies for Active Microwave Remote Sensing
Proposal Title: Radiation-Hardened Compact W-band Transceiver

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

QuinStar proposes a radiation-hardened, integrated-chip W-band Gallium Nitride MMIC transceiver front-end designed for high-resolution space descent and landing radars. The design is fully compatible with FMCW phase altimeter and FMCW Doppler techniques for simultaneous altitude and velocity measurement, as outlined in NASA's Report on Planetary Terminal Descent and Landing Radar (PTDLR). When paired with a circulator, it enables a single antenna configuration for both transmit (Tx) and receive (Rx) functions. Operating in the 92-94 GHz range, the MMIC will utilize an advanced GaN-on-SiC process, ensuring high tolerance for Total Ionizing Dose (TID) and high Linear Energy Transfer (LET) conditions.

Duration: 6

Proposal Details

Proposal Number: S11.02-1021
Subtopic Title: Technologies for Active Microwave Remote Sensing
Proposal Title: High PAE 100W W-Band GaN SSPA for Planetary Sensing

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

QuinStar Technology proposes to develop a compact, high-efficiency, lightweight, high-power (>100W) GaN Solid State Power Amplifier (SSPA) with High-PAE 4W PA MMICs operating at 92.5~95.5GHz for space and airborne applications such as remote sensing radar and planetary science missions. QuinStar plans to meet the goals of this program by employing an optimal combination of advanced solid-state Microwave Monolithic Integrated Circuits (MMIC) GaN-on-SiC device technology, unique power-combining techniques, and innovative packaging technologies with a special emphasis on SWaP-C, rad-hard, thermal, and mechanical robustness. We propose to use/design 4 W GaN MMICs to build up the power-combining scheme. Based on this assumption, we will use a two-tier power combing design, 1x16 MMIC drives 2x or 4x 16-way radial combined MMICs to reach 100W and 200W, respectively. We proposed to use class-EF 2nd and 3rd harmonic control through quarter wave microstrip series and shunt stub for high efficiency. The MMIC uses 12V drain voltage to alleviate the junction temperature with a modular distributed PA puck. Each puck seats directly on a heat sink to keep its temperature cool, resulting in a high-efficiency, scalable, and compact SSPA flight unit.

Duration: 6

Proposal Details

Proposal Number: S11.02-1029
Subtopic Title: Technologies for Active Microwave Remote Sensing
Proposal Title: Atomically-Referenced Optical Wavelength Standard

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Radio frequency (RF) measurement techniques are extensively utilized across fundamental research, telecommunications, military and defense, and various industrial sectors. Recently, Rydberg sensors have emerged as a promising advancement, offering significant improvements over existing RF measurement systems. These sensors leverage the exceptional sensitivity of atoms prepared in specialized excited states—known as Rydberg states—to measure RF fields with remarkable accuracy and precision. Furthermore, Rydberg-based measurements provide inherent SI traceability by directly referencing fundamental atomic constants. However, a significant hurdle in deploying Rydberg sensors under practical field conditions, including suborbital and space-based applications, is the absence of a ruggedized frequency stabilization subsystem for the lasers driving the essential atomic transitions required to generate Rydberg atoms. Currently, no suitable field-deployable frequency standards exist for stabilizing these lasers. Traditional stabilization methods, such as referencing the Rydberg transition itself or utilizing frequency combs, are impractical for field deployment due to their complexity and fragility. To address this critical gap, Opto-Atomics Corp. (OAC) proposes the development of an Atomically-Referenced Optical Wavelength Standard (AROWS), specifically targeting NASA's active microwave remote

sensing applications. OAC aims to produce a compact and robust laser stabilization subsystem suitable for field-deployed Rydberg sensors. AROWS will enable SI-traceable sensing in operational field environments, delivering exceptional sensitivity and precision across the S- through W-bands, and optimized for minimal size, weight, and power (SWaP). During Phase I, OAC will develop a breadboard prototype and experimentally validate the feasibility of AROWS.

Duration: 6

Proposal Details

Proposal Number: S11.03-1006
Subtopic Title: Technologies for Passive Microwave Remote Sensing
Proposal Title: A Low-Power 14GHz Spectrometer ASIC

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

NASA uses spectrometer instruments for a wide range of applications, including remote exploration of climate and environmental changes, planetary and astrophysics missions, and searching for habitable exoplanets. Future NASA spectrometers require high-speed operation while maintaining low size, weight, and power (SWaP). However, conventional solutions – using off-the-shelf analog-to-digital converters (ADCs) coupled with field-programmable gate arrays (FPGAs) – often fail to meet these stringent SWaP requirements. Integrating ADC and digital signal processing (DSP) units on a single die offers a promising approach to overcoming these limitations. Pacific Microchip Corp. (PMCC) proposes developing a spectrometer ASIC capable of digitizing up to 14 GHz of instantaneous bandwidth and splitting the signal into 8,192 frequency bins, all while consuming less than 0.5 W/GHz. Drawing on the PMCC's extensive experience in commercializing spectrometer ASICs, this solution will use an overlapped polyphase filter bank to reduce common DSP artifacts such as scalloping loss. The ASIC will be built to endure 3Mrad of total ionizing dose (TID) and to tolerate single event effects (SEEs). To ensure the assembly reliability, the chip will be packaged on a BGA chip carrier previously used for another space-proven ASIC. The Phase I project will focus on establishing feasibility through simulation-based proof of concept. Phase II will involve the ASIC fabrication and comprehensive performance testing.

Duration: 6

Proposal Details

Proposal Number: S11.03-1014
Subtopic Title: Technologies for Passive Microwave Remote Sensing
Proposal Title: Multi-Beam Passive Microwave Radiometer Design using Multi-Path Cross Correlation Radiometry

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Orbital Micro Systems, Inc. (OMS) proposes “Multipath Cross-Correlation Radiometry” (MXCR) as a new means of continuous multi-beam radiometer “self-calibration” that will obviate the need for conventional switched calibration looks, whether from internal noise sources or external blackbody targets. It will simultaneously implement multiple independently radiometric antenna beams that provide a simultaneously sampled push broom imaging capability, thus reducing or eliminating mechanical scan requirements. Importantly, MXCR will facilitate high spectral resolution (0.1-1 MHz bandwidth channel) radiometry over wide (multi-GHz) bands with rejection of out-of-band radio frequency interference due to it’s a unique path gain cancelling inversion algorithm that is unavailable using conventional single-path or two-path correlation radiometry. As a result of this algorithm, 1/f gain fluctuations are entirely cancelled out of the inversion process. This specific study address the implementation of several simultaneous radiometer antenna beams using FPGA-based MXCR detection architecture.

Duration: 6

Proposal Details

Proposal Number: S11.03-1015
Subtopic Title: Technologies for Passive Microwave Remote Sensing
Proposal Title: FFT-based Beamformer ASIC

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

NASA's next-generation spectrometers and radiometers will utilize phased-array receivers, replacing traditional scanned-antenna RF frontends. This transition will significantly reduce size, weight, power, and cost (SWaP-C) for these instruments. Pacific Microchip Corp. (PMCC) proposes developing an 8-channel FFT-based beamformer ASIC with 32 frequency channels across a 1 GHz bandwidth, supporting 128 angular directions. The ASIC will accommodate a phased array of up to 8 antenna receivers, digitizing down-converted signals with 8-bit precision at

2GS/s. These digitized signals will be converted to the frequency domain utilizing polyphase filter banks (PFBs), followed by a second-stage FFT blocks to perform beamforming. Compared to the time-domain, the frequency-domain beamforming offers significantly greater efficiency, and the ability to observe all frequencies from all directions instantaneously. The project's Phase I will define the project in detail and demonstrate its feasibility through extensive simulations of the proposed beamformer features and transistor-level solutions. The project's Phase II will produce an ASIC prototype, and an evaluation PCB which can be used for developing phased-array radiometer and spectrometer instruments.

Duration: 6

Proposal Details

Proposal Number: S11.04-1003
Subtopic Title: Sensor and Detector Technologies for Visible, Infrared (IR), Far-IR, and Submillimeter
Proposal Title: Terahertz Orthomode Transducers

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

The proposed research effort seeks to develop terahertz orthomode transducers (OMTs) suitable for use in sensitive NASA instruments. Prototypes will be developed in the WR-2.8 band 260-400 GHz. Phase I funding will be used primarily for salaries and to cover some of the prototype fabrication costs. OMTs combine/separate two orthogonally polarized signals. They find use in microwave and millimeter-wave (MMW) telecommunications systems. One example is Very Small Aperture Terminal (VSAT) systems where the transmission and reception paths are at 90° with respect to each other. This orthogonal orientation provides very high isolation between the two signals. The OMT protects the receiver or low noise block downconverter from the high output power of the block upconverter. OMTs are also found in terrestrial microwave radio links. A pair of parabolic reflectors operate in a point-to-point microwave radio path using four radios (two at each end). OMTs are mounted at the parabolic feed, separating the signal from the feed into two separate radios, one operating in the horizontal polarity, and the other in the vertical polarity. This arrangement increases the aggregate data throughput. OMTs are widely used by NASA and radio astronomers for the detection and analysis of polarized radio waves from celestial sources. By separating the orthogonal polarization components, OMTs allow astronomers to measure the Stokes parameters, which describe the polarization state of the electromagnetic waves. This information is vital for understanding the magnetic fields in various astronomical objects and the interstellar medium. OMTs are used in experiments studying the Cosmic Microwave Background radiation. CMB polarization can provide insights into the early universe, including information about inflation and the large-scale structure of the cosmos. Another example is the Galactic Emission Mapping (GEM) project where OMTs are used to map the polarized emission from our galaxy.

Duration: 6

Proposal Details

Proposal Number: S11.04-1019
Subtopic Title: Sensor and Detector Technologies for Visible, Infrared (IR), Far-IR,

and Submillimeter
Proposal Title: INFRARED SLS FPAS ON DIGITAL-PIXEL ROICS FOR GREATLY IMPROVED SIGNAL-TO-NOISE PERFORMANCE

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

A measure of the signal-to-noise ratio of a focal plane array (FPA) is the temporal noise equivalent difference in temperature (NEDT) which is a function of FPA operating temperature, spectral band, photon flux, pixel size, and the charge-well-depth of the readout integrated circuit (ROIC). For ANALOG ROICs with typical 10-20 million electron (me-) well-depths, NEDT values of 20-30 mK are observed for longwave infrared type-II strained layer superlattice (LWIR SLS) FPAs. A recent development in the industry is the DIGITAL-PIXEL ROIC (DROIC) which uses a digital counter in each unit cell to greatly increase well-depth to 100 me- and higher. Since background-limited NEDT varies inversely as the square root of the well-depth, DROICs promise much lower NEDT of ~ 3 mK, which translates to detection of fainter objects, longer detection range, etc. In Phase I, we will fabricate

and test both analog and digital FPAs (on analog and digital ROICs, respectively) from the same detector lot and compare performance. Sample FPAs will be delivered. In Phase II, we will develop and deliver a camera using the new DROIC. At a minimum, these new DFPAs will allow NASA to detect fainter infrared targets on the ground and in the sky.

Duration: 6

Proposal Details

Proposal Number: S11.04-1021
Subtopic Title: Sensor and Detector Technologies for Visible, Infrared (IR), Far-IR, and Submillimeter
Proposal Title: Quantum Waveguide Infrared Photodetector for Heterodyne Spectroscopy

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

EMode Photonix proposes to develop a novel, room-temperature Quantum Waveguide Infrared Photodetector (waveguide-QWIP), based on NIST Patent No. US 11,271,023, to advance heterodyne spectroscopy for precise gas detection and distinction. Current mid-infrared detectors often require cryogenic cooling, limiting their practicality for portable and space-based applications. Our waveguide-QWIP technology will enable high-speed, low-noise detection at room temperature, facilitating the development of compact, integrated systems. This Phase I program will focus on the design, fabrication, and experimental validation of prototype detectors, specifically targeting the detection and distinction between methane and ethane using heterodyne spectroscopy. By eliminating the need for cryogenic cooling and demonstrating high performance in targeted gas detection, our innovation will unlock new possibilities for environmental monitoring, industrial process control, and remote sensing. This advancement directly supports NASA's mission for advanced sensing technologies and will drive significant economic benefits through commercialization.

Duration: 6

Proposal Details

Proposal Number: S11.05-1004
Subtopic Title: Suborbital Instruments and Sensor Systems for Earth Science Measurements
Proposal Title: Miniature Nitrogen Dioxide Trace Gas Sensor for In Situ Atmospheric Measurements

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

Nitrogen dioxide (NO2) poses a health risk, particularly for children and individuals with respiratory issues like asthma. It is produced by a variety of sources, including vehicles, industrial plants, and appliances in homes. To better regulate this toxic pollutant, it is important to know where the sources are and how it is dispersed in the atmosphere. Current accounting for NO2 sources and dispersal is done by a combination of measurements and modeling, in which remote sensing from satellites provides data that is used to validate models of chemical transport. However, these models are far from certain and a limiting factor is the interpretation of the satellite data, which requires knowledge of the vertical distribution of NO2 in the troposphere since the satellite measurements do not, by themselves, provide this. Thus, there is a need for in situ measurements of NO2 from airborne platforms on a wide scale. Current sensors are costly and often not suitable for use onboard small aircraft, such as unmanned aerial vehicles, which would help enable widespread measurements. A miniaturized low-cost instrument is proposed for sensitive measurements of NO2 based on laser absorption that will help enable extended in situ measurements that will provide accurate high-fidelity data that is needed to properly interpret satellite measurements and validate chemical transport models. Data obtained with this sensor is expected to lead to an improved accounting of

NO2 sources and distribution in the atmosphere. In the proposed effort, we will develop the sensor and confirm its accuracy, which is projected to be significantly better than existing sensors at a lower per unit cost, thus enabling widespread deployment. A compact, affordable high precision sensor for NO2 would find immediate customers in the air pollution research community, and future versions of the technology should be within the reach of general consumers, opening up a new market for home NO2 monitoring.

Duration: 6

Proposal Details

Proposal Number: S11.05-1008
Subtopic Title: Suborbital Instruments and Sensor Systems for Earth Science Measurements
Proposal Title: Compact Low Power Sensor for Measurement of Multiple Trace Gases

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Development of a highly versatile turn-key sensor for measurement of atmospheric trace gases at high accuracy is proposed. The laser-based sensor targets simultaneous measurement of carbon monoxide, nitrous oxide, and methane with 0.1 second time resolution. The sensor will be designed for use on airborne platforms, including manned and unmanned aircraft, UAVs and drones, and balloons. It will be designed for meaurements throughout the troposphere and lower stratosphere. Key specifications include compact size (volume of 72 cubic inches or less) and weight (1 kg or less), with a power requirement of less than 3 watts. The Phase I research will emphasize establishing feasibility of the approach through laboratory testing, followed by production and testing of prototype sensors in Phase II. Target markets for the sensor include NASA and other federal and international government agencies that are engaged in atmospheric research. Potential markets include wildfire monitoring as well as industrial and agricultural process applications.

Duration: 6

Proposal Details

Proposal Number: S11.05-1010
Subtopic Title: Suborbital Instruments and Sensor Systems for Earth Science Measurements
Proposal Title: The Pandora-Inspired Advanced Hyperspectral Camera for Atmospheric Monitoring (PANCAM)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 4
Technical Abstract (Limit 2000 characters):

This proposal outlines the idea of a ground-based horizontally scanning spectral imaging camera(PANCAM) conceptualized to fill the gaps in monitoring atmospheric pollution and enhance complex atmospheric chemistry models. The system leverages advanced spectral imaging techniques and technologies to capture spatially resolved data of trace gas distributions in near real-time. By integrating a horizontal 2D scanning capability, this innovative instrument enables precise, real time monitoring of Nitrogen Dioxide (NO2) plumes and their evolution, offering critical insights into localized and regional atmospheric processes. Sciglob instruments has seen an increased demand for high-precision atmospheric monitoring instruments due to growing global concerns over air quality, climate change, and regulatory compliance. Governments, research institutions, and industries seek advanced measurement solutions to improve environmental monitoring, support policymakers, and enhance climate models. Additionally, the integration PANCAM into ground-based sensor networks with satellite observations is becoming a priority for improving global air quality assessments. The primary objective of this effort is to develop a feasibility study that establishes the foundation for a next-generation portable and affordable autonomous air quality monitoring system. Funding from this Phase I effort will support the technical

evaluation of off-the-shelf and custom optical solutions, calibration methodologies, and real-time data processing capabilities using GPU acceleration. Additionally, the project will deliver an opto-mechanical blueprint for future system development. The target markets for this technology include government agencies (NASA, EPA,..) and national and international scientific research institutions and universities.

Duration: 6

Proposal Details

Proposal Number: S11.05-1016
Subtopic Title: Suborbital Instruments and Sensor Systems for Earth Science Measurements
Proposal Title: Multiplexed Integrated Cavity Output Spectrometer Driven by Quantum Cascade Laser Arrays

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

We propose to develop a compact, broadband trace-gas measurement instrument that leverages quantum cascade laser (QCL) array technology with cavity-enhanced absorption techniques. Our goal is to achieve high-sensitivity, multiplexed detection of multiple trace gases—including NO, NO_2, O_3, CH_2O, CO, CH_4, and others—within a single, small-footprint system. By exploiting the broad spectral coverage offered by QCL arrays, we will optimize real-time measurements at parts-per-billion (ppb) or even parts-per-trillion (ppt) levels. The proposed design will be tailored for use on small aircraft, uncrewed aerial vehicles (UAVs), and high-altitude balloon platforms. In Phase 1, we will demonstrate the feasibility and benefits of integrating our DFB QCL array sources with cavity-enhanced absorption spectroscopy in a low-SWAP system for highly sensitive and selective multi-species detection. This includes demonstrating broadband operation and multiplexing methods. We expect to reach TRL 4 at the end of Phase I. Successful prototype demonstration and design work will position the technology for further optimization and maturation in Phase II. At the end of Phase II, we will deliver a TRL 6 flight-ready sensor system that addresses the specific airborne and ground-based trace-gas measurement needs outlined by NASA's Earth Science Division.

Duration: 6

Proposal Details

Proposal Number: S12.01-1003
Subtopic Title: Exoplanet Detection and Characterization Technologies
Proposal Title: Ultra Low Reflectance Black Silicon for Visible to IR Light Absorption

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 5
Technical Abstract (Limit 2000 characters):

Matter Intelligence proposes the development of ultra-low reflectance black silicon for visible to infrared light absorption, addressing the NASA SBIR 2025 solicitation (S12.01) on Exoplanet Detection and Characterization Technologies. This innovation aims to improve diffraction control in coronagraphs, critical for achieving the <1e-10 contrast required for direct imaging and spectral characterization of Earth-like exoplanets by NASA's Habitable Worlds Observatory (HWO). The proposed effort will optimize cryogenic etching techniques to achieve broadband reflectance below 0.1% from 0.4µm to 20µm, leveraging prior advancements from the Roman Space Telescope's Coronagraph Instrument (CGI). Phase I funding will support process optimization, sample fabrication, and independent reflectance validation, ensuring compatibility with future flight instruments. The target markets include NASA, astrophysics research institutions, and commercial optical applications requiring advanced light absorption technologies.

Duration: 6

Proposal Details

Proposal Number: S12.02-1000
Subtopic Title: Precision Deployable Optical Structures and Metrology
Proposal Title: Micrometeorite Shield with Tailorable, High-Performance, Thermal/Optical Properties for Spacecraft Telescope Baffle

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

ZeCoat Corporation is developing advanced vacuum-coated thermal, optical, and meteor-shielding materials tailored for space-based optical systems for the Habitable Worlds Observatory (HWO). Leveraging ZeCoat's roll-to-roll vacuum coating system, we will manufacture multilayer coatings on ballistic-reinforced polymer membranes up to 100 feet in length. These membranes will provide thermal control, straylight suppression, and micrometeoroid protection to extend

mission life and improve imaging performance. In Phase I, we will fabricate and demonstrate two thermal/optical coatings on 3-meter-long polyimide membranes provided by NeXolve Inc.: (1) low-emissivity (MLI) coatings for thermal insulation and (2) low-absorption, high-emissivity (OSR) coatings to maintain stable temperatures. Additionally, we will conduct a feasibility study on enhancing the ballistic performance of these membranes. Phase II will scale production to 30-meter membranes, conduct environmental testing, and expand coating capabilities to include high-absorption, low-emissivity straylight suppression coatings. This innovation builds upon NASA SBIR-funded advancements in roll-to-roll coating and offers a significant improvement over current state-of-the-art materials. By integrating advanced coatings with reinforced membrane substrates, we aim to provide commercially available, high-performance shielding solutions for future space telescopes and other optical systems requiring micrometeoroid protection and thermal stability.

Duration: 6

Proposal Details

Proposal Number: S12.02-1002
Subtopic Title: Precision Deployable Optical Structures and Metrology
Proposal Title: Deployable Baffle by SABER System (DeBSS)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Optical payloads are becoming increasingly complex as innovative designs maximize every cubic centimeter available for launch within the expanding range of candidate launch vehicle fairings. Baffles have emerged as critical components on space-based telescopes for enhancing performance by significantly reducing stray light and providing Micro Meteorite and Orbital Debris (MMOD) shielding to protect the sensitive primary mirrors. Heliospace recognizes the growing need for deployable baffle technologies and has begun development on a 1m class tensegrity Deployable Baffle by SABER™ System (DeBSS). The TRL 3 DeBSS design employs a pseudo tensegrity structure aiming to compactly stow for launch and deploy on orbit nominally using Heliospace's TRL 9 Spiral Actuator and Boom, Extended then Rigidized, or SABER™. The phase 1 proposal seeks to assess the feasibility of a class of deployable space telescope baffles ranging in size from 1 to 7+ meters. Using the described DeBSS as an early development model, technical objectives will aim to identify the risks and solutions involved with managing required cables and membranes that must not present snag risks during deployment. The resulting baffle concept may be highly desirable to spacecraft or optical payload operators around the globe for use in minimizing stray light and added MMOD protection to their payload. Heliospace believes that between the civil, commercial, and defense aerospace arenas, the technology and architecture proposed will have use cases that transverse all sizes of optical payloads. Vetting the inherent configuration and deployment complexities of a DeBSS for a nominal 1m class baffle will enable the development of a minimum viable product that could be marketed today to government and commercial customers. Furthermore, a technical assessment at this scale is precursory to better understand the scalability constraints of similar baffle and structure architectures an order of magnitude larger.

Duration: 6

Proposal Details

Proposal Number: S12.03-1001
Subtopic Title: Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical to Mid-/Far-Infrared Telescopes
Proposal Title: Enabling Precise Multi-Layer Optical Coatings on Highly Curved Lenses with Atomic Layer Deposition

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

To improve satellite-based lightning detection for small, short duration flashes that could be key for monitoring severe weather, NASA’s Marshall Space Flight Center (MSFC) has begun development of a new lightning imager named CubeSat Lightning Imaging & Detection Experiment (CLIDE), however it requires small form factor lenses with a wide field of view (FOV). It has been proposed that an affordable lens solution could be a single concentric sphere if a very narrow spectral bandpass filter can be applied conformally onto the lens. Traditionally, such narrow bandpass filters are applied as multilayer coatings deposited by physical vapor

deposition (PVD) and are thus limited to flat or only slightly curved surfaces. RMD proposes to address this challenge by demonstrating both the technical and manufacturing feasibility for producing such bandpass filters using a special technique atomic layer deposition (ALD). ALD is a conformal coating technique ensuring that the bandpass filter will be identical across highly curved lenses enabling a wide FOV for detection across large areas for accurate lightning mapping. In Phase I, RMD will demonstrate the ability of ALD to deliver a uniform multilayer coating on a curved surface. Based on initial simulations, RMD plans to develop and demonstrate scalable ALD processes for low refractive index magnesium fluoride (MgF_2), and high refractive index zirconium dioxide (ZrO_2) as well as utilized an already established process for titanium dioxide (TiO_2). Concurrently RMD will also begin detailed modelling to design MgF_2 and TiO_2 bandpass filters for 777.4 nm and MgF_2 and ZrO_2 bandpass filters for 337 nm with narrow (< 3 nm) bandwidths. Such bandpass filters will be deposited onto flat and curved substrates and evaluated by reflectometry to verify uniform bandpass characteristics across the curved substrate. The end result of this program will be bandpass filters that can be integrated into CLIDE and other imaging systems.

Duration: 6

Proposal Details

Proposal Number: S12.03-1006
Subtopic Title: Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical to Mid-/Far-Infrared Telescopes
Proposal Title: Super Polished Coronagraph Mirrors

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Coronagraph optics require a level of super polishing not yet achieved by any optical manufacturing approach for mirrors optimized for space use, with significant and varying curvature, and large enough for the Habitable Worlds Observatory. Optimax intends to extend years of robotic smoothing and polishing development to manufacture these super polished optics to the extremely stringent specifications required by the next generation of space instrumentation. By merging manufacturing know-how with an investigation of novel force- and active component combinations for robotic smoothing, Optimax will strive to reach a 3 Å RMS surface roughness criteria with correlation lengths in the range of 10-50 µm as specified in the solicitation. In the first Phase, Optimax will investigate smoothing techniques in light of material properties, geometry (including compensation for light weighted optics and differential deflection during polishing), and tool/ slurry modification to demonstrate the desired optical surface outcome. Additionally, fabrication and metrology techniques will be assessed in light of the correlation length requirement, which is relatively new to the optics manufacturing environment. These outcomes will be assessed for scalability to optics of larger geometry during Phase II and beyond, moving toward the 1-3.5 m segments expected for the Habitable Worlds Observatory.

Duration: 6

Proposal Details

Proposal Number: S12.03-1014

Subtopic Title: Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical to Mid-/Far-Infrared Telescopes
Proposal Title: Ultra-stable Affordable Mirrors: USAM

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

NASA will require ultra-stable mirrors that are both lightweight and affordable to support HWO, as well as other near-term and long-term NASA missions with visible imaging systems requiring ultra-stable mirrors. Additional applications for such mirrors include the growing commercial space market, defense and intelligence community imaging systems, well as directed energy applications. EvolvOptic proposes to leverage the combination of three key initiatives to meet the needs of future NASA space-based imaging systems. These initiatives are: • Mass efficient closed back mirror designs • Low CTE, affordable material • Supply Chain Optimization EvolvOptic will demonstrate the feasibility of ultra-stable affordable closed-back mirrors produced with CLEARCERAM®-Z and advanced bonding. Over the course of 6 months, EvolvOptic will • Identify 2-3 bonds and bonding

processes to investigate. • Design, and produce bonded glass-ceramic samples. • Test strength, thermal sensitivity, moisture sensitivity. • Design and build a 0.4 meter, flat, closed-back demonstration mirror from Ohara CLEARCERAM®-Z. As deliverables for this Phase 1 SBIR EvolvOptic will deliver: • A report that describes the results of the design concepts evaluation, the bonding approach evaluation, the production and supply chain evaluation, the findings from the construction of the 0.4-meter mirror, and a definition of the initial scope for Phase 2. • The manufactured 0.4-meter, flat mirror produced with the process identified in this project.

Duration: 6

Proposal Details

Proposal Number: S12.04-1000
Subtopic Title: X-Ray Mirror Systems Technology, Coating Technology for X-Ray-UVOIR (Ultraviolet-Optical-Infrared), and Free-Form Optics
Proposal Title: Diamond Turning High Aspect Ratio Mandrels for X-ray Mirror Manufacturing

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 6
Technical Abstract (Limit 2000 characters):

Diamond turning of high aspect ratio mandrels is a critical capability required to advance high-energy astrophysics missions, such as those conducted by NASA. A highly experienced team comprising WaveFront Technology Inc. (WFT), Moore Nanotechnology LLC (MNL), and Precision Optics Prototyping (POP) proposes to enhance the equipment, processes, and metrology developed during the 2018 manufacturing of the Imaging X-ray Polarimetry Explorer (IXPE) mirror mandrels. This enhancement aims to meet the advanced resolution and collecting area requirements for future X-ray optics. WFT operates a Horizontal Drum Lathe (HDL), which successfully produced the IXPE mirror mandrels. However, this platform needs further modifications to meet the requirements for next-generation full-shell Wolter-I X-ray optic mirror module assemblies. MNL has developed design concepts for components that can be integrated into WFT's HDL, while POP brings the necessary expertise in programming and operational integration to ensure the successful implementation of these changes, ultimately meeting NASA's stringent X-ray optics specifications. A significant gap exists between the current capabilities of the HDL platform and the specific requirements for X-ray optics manufacturing, particularly in terms of hardware modifications and tolerance specifications for mandrel machining. This Phase 1 project will generate the necessary modeling, analysis, software, and hardware schematics to demonstrate that the proposed modifications can fulfill these critical hardware requirements. Phase 1 Objectives: 1. Specify the high aspect ratio mandrel requirements. 2. Define process requirements for the desired mandrel finish. 3. Determine diamond turning platform requirements. 4. Establish metrology requirements. 5. Prepare for system integration and feasibility assessment in Phase 2. The outcomes of Phase 1 will provide detailed specifications for the equipment required in Phase 2.

Duration: 6

Proposal Details

Proposal Number: S12.04-1003
Subtopic Title: X-Ray Mirror Systems Technology, Coating Technology for X-Ray-UVOIR (Ultraviolet-Optical-Infrared), and Free-Form Optics
Proposal Title: Extended Range Optical Metrology

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 4
Technical Abstract (Limit 2000 characters):

To address the National Aeronautics and Space Administration (NASA) need for future optical systems with wider fields of view (FOVs) in a smaller package, Intellisense Systems, Inc. (Intellisense) proposes to develop a new Extended Range Optical Metrology (EROM) system based on the innovative combination of adaptive (prescription-free) null lensing and a phase-shifting interferometer. The innovations in the proposed integrated interferometric optical metrology design enable surface figure measurements to resolutions of <10 nm and roughness of <1 Å. By using an adaptive null lens, high-accuracy measurements can be performed over a large range (>1 mm spherical departure) by effectively changing the optical

path difference to compensate for large surface displacements or varying surface curvatures. In Phase I, Intellisense will conduct research and analysis of component technologies, architectures, and algorithms through simulations, modeling, and demonstrations to support and predict the suitability of the proposed design and development of a viable conceptual system, satisfying NASA free-form optics (FFO) metrology needs for accurate metrology of FFO components with large spherical departures (>1 mm). An initial system design will be developed, and prototypes of key technological components will be demonstrated via laboratory experiments and analysis to demonstrate achieved specified requirements. Based on this Phase I effort, we will outline the Phase II transition plan for prototype development with risk mitigation strategies. In Phase II, Intellisense will develop a breadboard prototype and test the results to show sufficient data verifying the performance of the proposed EROM design. Intellisense will work closely with NASA's scientists and end users to bring the technologies to full operational and/or commercial use.

Duration: 6

Proposal Details

Proposal Number: S12.04-1008
Subtopic Title: X-Ray Mirror Systems Technology, Coating Technology for X-Ray-UVOIR (Ultraviolet-Optical-Infrared), and Free-Form Optics
Proposal Title: Polishing Iridium Coatings for Zero-Net-Stress

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Research on the topic of coating silicon mirrors with iridium has shown that the task of reducing coating stress to minimize mirror distortion remains a subject of continuous study and an area of ongoing improvement. Many efforts have been pursued on the deposition of iridium in a manner that aims to reduce and/or balances coating stress, including bi-layer deposition with chromium and iridium, front and back coating, heat treating, annealing, ion beam figure correcting and atomic layer deposition. It has been determined through our investigation of this topic that one of the simplest and most effective ways to coat these optics in a distortion-free manner is by using the atomic layer deposition ALD coating method. ALD offers 3 main advantages including lower operating temperatures, simultaneous front and back coating and accurate thickness. These advantages allow the iridium coating to be deposited without distorting the mirrors, but the trade off is an increase in surface roughness that can be twice as high as the desired 0.4-0.5 nm RMS specification required for X-Ray mirrors. OptiPro is proposing that their Elastic Emission Machining (EEM) process be used as a solution for smoothing these ALD iridium coated thin mirrors and consequently solving the issue of thin mirror distortion. EEM is capable of atomic-level machining that does not inject heat into the surface, nor does it damage the atomic lattice structure, which as a result leaves a very smooth surface and prevents sub-surface damage. These attributes of EEM also include a precision polishing tool that greatly reduces the risk of inducing mid-spatial frequencies onto the surface, making it an ideal method for accurately smoothing the rougher iridium surface that results from ALD coating.

Duration: 6

Proposal Details

Proposal Number: S12.04-1013
Subtopic Title: X-Ray Mirror Systems Technology, Coating Technology for X-Ray-UVOIR (Ultraviolet-Optical-Infrared), and Free-Form Optics
Proposal Title: Scalable Nanofabrication Technology for Free-form Reflective Diffraction Gratings

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

This research addresses the need for compact, high-performance optics in future NASA science missions, particularly for spaceborne instruments like CubeSats, SmallSats, and NanoSats. Freeform optics, offering non-rotationally symmetric surfaces, enable efficient packaging while maintaining high image quality, making them ideal for missions requiring wider fields of view and low f-numbers. However, freeform optics are still in early development stages, with existing design and fabrication methods being costly and challenging. This project develops a scalable nanofabrication solution for high-performance freeform reflective diffraction

gratings using advanced semiconductor manufacturing techniques. The proposed solution integrates e-beam lithography, Confovis nanoscale surface mapping for precise alignment and position, conformal coatings, and scalable nanoimprint replication. These innovations provide viable high-performance free-form grating manufacturing, meeting NASA's stringent optical requirements. The approach also ensures durability under space conditions, including thermal cycling, contamination, and atomic oxygen erosion. By advancing grating design, simulation, fabrication, and scalable production, this research aims to deliver cost-effective, robust optical components for space missions, supporting NASA's needs in spectroscopy, imaging, and other high-precision applications. The outcome will enhance the performance, manufacturability, and reliability of next-generation space optics.

Duration: 6

Proposal Details

Proposal Number: S12.06-1003
Subtopic Title: Detector Technologies for Ultraviolet (UV), X-Ray, and Gamma-Ray Instruments
Proposal Title: High-efficiency and high-resolution x-ray and gamma-ray imaging detectors for space science

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

In the past few decades, there have been significant advances in photodetectors and imaging arrays for ultraviolet (UV) and longer wavelength light. However, for revealing some of the mysteries of the cosmos, x-ray observations are indispensable because much of the baryonic matter, and the sites for the most active energy releases in the Universe, are primarily observable in x-rays. Closer to home, NASA's future exploration of our solar system will require significant advances in hard x-ray detectors and imaging arrays, particularly in quantum efficiency, spatial resolution, and pixel count. For the 2030s and beyond, an x-ray observatory with power matching the capabilities in other wavebands, such as NASA's planned LYNX x-ray observatory, is a necessary discovery engine for a better exploration of the Universe.

Duration: 6

Proposal Details

Proposal Number: S12.06-1004
Subtopic Title: Detector Technologies for Ultraviolet (UV), X-Ray, and Gamma-Ray Instruments
Proposal Title: Additive Manufacturing Process for Magnetic Shielding

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

Additive manufacturing of superconducting magnetic shields offers the ability to improve instrumentation sensitivity, reduce weight, and lower cost for space exploration. SkyVision Sciences proposes a method for 3D printing of superconducting metals/alloys. In the Phase I effort niobium and niobium-tin superconductors will be fabricated using the proposed method. These materials will be characterized using x-ray diffraction, scanning electron microscopy, and energy dispersive spectroscopy. Fabricated parts will be tested for dimensional accuracy, defects, and their critical temperature. A manufacturing cost assessment will be made. A potential Phase II effort will look to further optimize the method, demonstrate the production of superconducting magnetic shield with complex designs, and produce shields for evaluation by NASA.

Duration: 6

Proposal Details

Proposal Number: S12.06-1010
Subtopic Title: Detector Technologies for Ultraviolet (UV), X-Ray, and Gamma-

Ray Instruments
Proposal Title: Vertically Integrated Silicon Carbide/Silicon Detectors for UV/Vis Multicolor Sensing

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

We propose to design and fabricate vertically-integrated Silicon Carbide/Silicon (SiC/Si) detectors for high-responsivity and performance Ultraviolet/Visible (UV/Vis) sensing in the ~200 to 1100 nm range. We will initially stack single sensors and integrate them with readout circuitry into a single package. The development effort will include identifying the design requirements for individual sensors, fabricating a custom SiC UV sensor for the purpose, developing and demonstrating the integration scheme (including stacked chip assembly techniques and packaging and lid selection), and readout circuit development and integration. The effort will also include a feasibility study and roadmap creation for our plans to scale this design to stacking sensor arrays into a detector system for e.g. spectroscopic applications, with significant enhancements to NASA’s capabilities in planetary science, Earth

science, astrophysics, and heliophysics. Two-color detectors are typically used for measurement applications requiring increased spectral range and comprise one photodiode (for shorter-wavelegnth light) mounted over a second photodiode (for longer wavelengths). In the SiC/Si system, this requires the SiC sensor to be above the Si sensor, since SiC is transparent to visible light. The two-color sensor and detector concept allows measurements and detection in broader wavelength ranges with a more compact device. Target commercial markets include defense applications (such as rocket plume detection), biological and health applications (such as sterilization, water purification, laser surgery monitoring and feedback), industrial applications (flame detection, combustion control), semiconductor fabrication equipment applications, and metrology.

Duration: 6

Proposal Details

Proposal Number: S13.01-1001
Subtopic Title: Robotic Mobility, Manipulation, and Sampling
Proposal Title: HERA: A Cost-Effective and High-Performance Robotic Arm Architecture for Versatile Space Applications

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The Hyper Extension-Retraction Actuator (HERA) robotic arm architecture, developed by Sol Robotics, is a high-performance, versatile, and cost-effective manipulator technology designed for both terrestrial and non-terrestrial applications. HERA robots feature a novel parallel-actuated extension system, providing exceptional reach, stowability, payload capacity, and precision. Sol Robotics proposes a space-qualified HERA robot to help NASA transition away from bespoke robotic arm designs, ultimately reducing costs across various mission types. The funding requested for this Phase I SBIR will be used to assess the feasibility of adapting an existing terrestrial HERA prototype—already with 400+ pre-orders—for space applications through simulation. These findings will also inform the development of a conceptual design package for a space-qualified HERA, along with a parametric cost assessment to help NASA evaluate the technology’s value proposition. With a commercially viable terrestrial model sharing many components, Sol Robotics aims to position a space-adapted HERA as a highly cost-effective solution for a target market that includes NASA, the U.S. Space Force, and allied commercial space companies.

Duration: 6

Proposal Details

Proposal Number: S13.01-1009
Subtopic Title: Robotic Mobility, Manipulation, and Sampling
Proposal Title: Photonically Sensorized Robotic Subsurface Sampling System

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

IFOS will work with Stanford University's Center for Design Research to advance a robotic system with optical fiber-based physical sensing capabilities (particularly force, vibration, texture and temperature). The robotic system will be designed for probing and in situ analysis of solar system ices below the outer subsurface appropriate to Enceladus, Europa, Titan and Triton. In Phase 1, a feasibility prototype with the capability to operate on laboratory samples will be demonstrated.

Duration: 6

Proposal Details

Proposal Number: S13.01-1015
Subtopic Title: Robotic Mobility, Manipulation, and Sampling
Proposal Title: Lightweight Instrument Manipulator Boom (LIMB)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

The Lightweight Instrument Manipulator Boom (LIMB) is a low-power, highly SWaP-optimized robotic arm designed for small cube rovers and aerial platforms supporting NASA’s lunar, Martian, and deep-space missions. Unlike traditional robotic manipulators, LIMB features a bistable boom structure that deploys and retracts using small brushless motors while maintaining position with a self-locking mechanism, eliminating the need for continuous power draw. LIMB provides multi-orientation deployment, allowing it to support scientific instrumentation, sample collection, and communication relay tasks in extreme environments such as lunar regolith, Martian dust storms, and Venusian high-pressure atmospheres. The Phase I effort will focus on designing, modeling, and prototyping the LIMB system to

validate its structural feasibility, power efficiency, and operational adaptability across multiple planetary environments. Key objectives include Finite Element Analysis (FEA) for structural validation, development of a functional prototype, and performance testing for dust resistance, thermal tolerance (-180°C to 500°C), and deployment reliability. Deliverables include system architecture, simulation results, a working prototype, and a commercialization roadmap for Phase II development. LIMB directly supports NASA's Artemis program, CADRE, and Commercial Lunar Payload Services (CLPS) by enabling autonomous, energy-efficient robotic operations. Beyond NASA, LIMB has commercial applications in DoD reconnaissance systems, autonomous industrial robotics, and hazardous environment operations. The SBIR funding will advance LIMB toward mission-ready deployment, providing a scalable, lightweight, and multi-mission-capable robotic solution for planetary exploration and beyond.

Duration: 6

Proposal Details

Proposal Number: S13.01-1017
Subtopic Title: Robotic Mobility, Manipulation, and Sampling
Proposal Title: Highly Insulating Structures for Thermal Preservation of Sample Return Mission Samples

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

To maximize reliability, Earth entry vehicles (EEV) for robotic sample return missions will comprise an aeroshell, a crushable layer that will absorb the energy of the ballistic impact landing, and a sample container inside the crushable layer; parachutes will not be used. In current work for NASA, Ultramet is designing, fabricating, and testing a lightweight engineered open-cell foam for use as the crushable layer to absorb the impact energy and minimize the gravitational loading on the sample container. Modeling results based on high strain rate crush testing indicate that engineered foams can reduce the mass of a 44-kg EEV by 10 kg. The downselected foam is based on Ultramet's off-the-shelf glassy carbon foam, which has a very low thermal conductivity (0.08 W/m·K at room temperature), but even lower conductivity will be needed for cryogenic preservation of samples. In previous work, Ultramet pioneered the use of aerogel-filled foam (AFF) insulation for both cryogenic and high temperature applications. At 300°C, Ultramet's glassy carbon foam has a thermal conductivity of 0.163 W/m·K, but by filling the pores with certain aerogels, the conductivity drops to 0.11 W/m·K. As the temperature is reduced to –88°C, the conductivity of the AFF drops by nearly an order of magnitude to 0.02 W/m·K at ambient pressure, and at a pressure of 0.01 mtorr it drops by almost another order of magnitude to 0.003 W/m·K. In this project, Ultramet will bring together the two technologies to develop an AFF that can simultaneously provide thermal protection for cryogenic samples and absorb the landing impact energy. Specifically, Ultramet will fabricate carbon foams with optically dense aerogels filling the pores to block ligament-to-ligament radiative heat transfer. The crush strength of the AFFs will be measured at strain rates relevant to EEV design (~300 sec-1). The resulting data will be incorporated into Ultramet's existing model for predicting the mass of the EEV.

Duration: 6

Proposal Details

Proposal Number: S13.01-1020
Subtopic Title: Robotic Mobility, Manipulation, and Sampling
Proposal Title: Long Range LiDAR (LR-LiDAR)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 5
Technical Abstract (Limit 2000 characters):

To address this technology gap and NASA's non-mechanical LiDAR beam steering need, Torrey Pines Logic, Inc (TPL) proposes developing a novel High-power Magneto-Optical beam Deflector HMOD. The principle of operation is to modulate the polarization rotation using a magneto-optic faraday polarization rotator with a wound electro-magnetic coil to modulate the magnetic field. The modulated linear polarization direction will be deflected in a binary fashion as the beam enters a birefringent prism depending on whether the Faraday Rotator is switched into the extraordinary or ordinary polarization state of the prism (Figure 1). TPL proposes to demonstrate the HMOD system in a multi spot scanning configuration collimated by a 5 cm diameter telescope as part of the Phase I effort.

Duration: 6

Proposal Details

Proposal Number: S13.03-1010
Subtopic Title: Extreme-Environments Technology
Proposal Title: Wide-temperature-range and low-temperature-capable dry film lubricated BMG planetary gears

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4

Technical Abstract (Limit 2000 characters):

This is a proposal to systematically study the influence of dry film lubrication (DFL) on the performance and durability of BMG planetary gearboxes in cryogenic environments. Planetary gearboxes are vital for NASA missions, providing precise motion control, high torque transmission, and compact, lightweight designs. These drives enable rover mobility across rocky, sandy, and icy surfaces and power robotic arms, drill systems, and deployment mechanisms for antennas, solar arrays, and scientific instruments. Next-generation planetary gearboxes capable of surviving the extreme cold of space, including the lunar night and permanently shadowed regions of icy moons and asteroids are critical. In such environments, traditional oil- and grease-based lubricants fail, necessitating thermal management systems. However, thermal management systems add mass, complexity, and power consumption, restricting mission capabilities. This underscores the urgent need for cryo-capable gears and actuators that can operate in extreme environments without thermal management. In previous work we showed that BMGs outperform steel and resulted in a more than 20X improvement in lifespan compared to steel gearboxes in unlubricated conditions. DFLs have the potential of increasing the lifespan of BMG gearboxes while still avoiding the use of thermal management systems. Fully assessing the potential of BMGs as a replacement for existing materials requires a deeper understanding of their performance when coated with DFL and relative to DFL-steel solutions. To achieve this, we will (I) fabricate BMG planetary gearboxes (II) apply dry film lubrication, (III) test their performance and lifespan at cryogenic temperatures (-100°C) against dry film-lubricated steel gears, and (IV) investigate their failure mechanisms. Phase I will establish the foundation for Phase II, which will expand the performance analysis to additional mission-relevant conditions such as vacuum and dust.

Duration: 6

Proposal Details

Proposal Number: S13.03-1012
Subtopic Title: Extreme-Environments Technology
Proposal Title: Venus Energy Converter

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

The primary goal is to demonstrate practical, functional power generation sources based on thermionic energy conversion (TEC) capable of operation at extreme temperature environments such as those found on the surface of Venus, propulsion systems and in Long-Lived In-Situ Solar System Explorer (LLISSE) missions. TEC provides an effective way of capturing the abundant source of heat energy found in environments such as Venus and LLISSE. TEC is analogous to solar/photovoltaic (PV) cells with temperature/heat being the energy source for TEC compared to light/optical being the energy source for PV. Unlike thermoelectrics which require and rely on a large temperature difference for operation, TEC can operate with a small or no temperature (isothermal) difference by judiciously using differences in thermionic work functions to convert temperature/heat to electrical energy. Recent advances in material science and nanotechnology as well as the understanding of the underlying physical processes form the basis for this proposed effort to develop Isothermal TECs. This Phase I effort focuses on identifying suitable materials for the creation of the extreme environment TECs and applying the use of integrated circuit, additive manufacturing, and Micro-Electro-Mechanical System (MEMS) technology InnoSys has developed and is developing for, for example, extreme temperature transmitters for Venus to fabricate extreme temperature TECs. Small

emitter to collector spacing and properly chosen emissive low work function cathodes and low emission collectors allow conversion of temperature/heat to relatively large electrical current densities at relatively high TEC conversion efficiencies with simple system integration of TECs. Extreme/harsh environment protective packaging will be used. Also, when coupled with sources of heat energy such as radioisotopes and integrated into General Purpose Heat Sources (GPHSs), TEC can be used for planetary and others missions including moon missions.

Duration: 6

Proposal Details

Proposal Number: S13.03-1014
Subtopic Title: Extreme-Environments Technology
Proposal Title: -200°C Rad hard Cold Capable Thermally multiplexed controller

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Frequency Management International (FMI) proposes to deliver a conceptually validated feasibility study (in Phase 1) for a novel, Rad-hard Cold Capable Thermally multiplexed integrated controller (aka TMC) to discipline electronic components and sensors. The concept is adaptable to various components and it is a thermal stabilization engine. In Phase 1 we will investigation to apply TMC to the design of a highly accurate cold capable and compact clock source with frequency stability in parts per billion (ppb) range when operating at temperatures as low as -200°C. TMC electronics (in the form of ASIC) includes coarse and fine temperature range detection as well as integrated PWM to steer the temperature to delivery the desired temperature stability. The two level thermal multiplexing is expected to provide 4 orders of magnitude accuracy improvement compared to a standalone and uncompensated clock. The miniaturized enclosure will be a breakthrough compared to any alternative that does not even offer cold capable and rad hard operation. Upon sufficient investigation in phase 1, we will in phase 2 implement and fabricate the TCM and also a part-per-billion clock (PPBC). TMC design will be fabricated on semiconductor process with proven history and availability. Our design partner is University of Tennessee with a team working with Dr. Blalock. The resonator in the stable clock will be designed based on our investigation of the very small form-factor packaged crystals that minimize power requirements for stabilization. The stable clock will be an efficient, low mass, low power, and agile. The design range PPBC offers scalable output frequency in the 20 to 120MHz range, superior output spectral purity (low jitter-low phase noise) and deliver ultra stable clock accuracy operating to -200°C for which there is no present component based alternative.

Duration: 6

Proposal Details

Proposal Number: S13.04-1008
Subtopic Title: Contamination Control and Planetary Protection
Proposal Title: On-orbit Reducer of Contamination Apparatus (ORCA)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

NewBridge Partners proposed innovative solution, on-orbit reducer of contamination apparatus (ORCA), provides a straightforward, highly reliable mechanism for precision cleaning of spacecraft surfaces once in orbit. Controlling molecular contaminants minimizes performance degradation caused by the deposition of molecular contaminants on mirrors, optical sensors and critical surfaces. For space optical sensors, contamination effects include transmission reduction, off-axis radiation scattering due to particle clouds, and an increase in mirror scattering. Minimizing contamination plays a critical role in maintaining performance and reliability as well as improving the cost-effectiveness of mission results. Data has shown that there is significant contamination post thermal-vacuum

testing through launch and on-orbit operations, which necessitates the importance of doing this in orbit. The innovation possesses all the attributes necessary for ready adoption in space, once validated. It is inherently space-qualified with ultra-high reliability. ORCA combines proven high-performance contamination control methods with a high reliability space mechanism in a new and innovative manner. Although it presents an obvious single point of failure in space, its design is no different from other deployment mechanisms that also inherently feature single point failures. We believe a straightforward qualification effort could be undertaken to ensure successful use in space for the most demanding missions. The flexible design and low cost of this approach make it suitable for a wide range of applications.

Duration: 6

Proposal Details

Proposal Number: S13.04-1009
Subtopic Title: Contamination Control and Planetary Protection
Proposal Title: A Microgravity-Compatible Liquid-Free Surface Sampling Pen (SSP)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 6
Technical Abstract (Limit 2000 characters):

AI Biosciences, Inc. (AIBI) proposes to develop and demonstrate the performance of a handheld, versatile surface sampling pen (SSP). Our device will assist with Contamination Control (CC) and Planetary Protection (PP) implementation and verification. The SSP can be used in various NASA cleanrooms to monitor microbial contamination. This SSP is capable of performing diverse sampling tasks and will aid NASA in tracking microbial presence on the ISS and among the crew. Utilizing super absorbent polymer (SAP) hydrogel, the SSP functions on flat or curved surfaces for microbial and chemical analysis without leaving residues behind. The SSP is naturally premoistened and does not require water or buffer to wet the surface beforehand. After sampling, the spent SAP gel can be sliced off, exposing a fresh sampling surface. The gel can be stored or immediately tested without a high elution step, as the microbes are trapped only in the outer layer (unlike a swab or sponge). Closed environments, such as the ISS and spacecraft for planned interplanetary destinations, necessitate monitoring for microbial contaminants and potential pathogens. Current sampling and post-collection processing are intensive in crew time. Thus, our proposal is highly relevant to NASA's mission. Phase I will allow us to design and 3D print the hydrogel pen holder, as well as develop a simple processing tube to elute the collected material from the surface and its storage tubes. We anticipate being ready to test the sampling operation in zero-g flights to demonstrate a TRL level of 6 following Phase I. We will collaborate with Professor Chris Mason, a microbiome and sequencing expert at Weill Cornell Medicine, to showcase its effectiveness. We aim to contact the U.S. Pharmacopeia (USP) for future collaboration. USP provides microbiological solutions that assist in controlling microbial contamination, with wide-ranging applications, including biologics and compounded medications.

Duration: 6

Proposal Details

Proposal Number: S13.04-1013
Subtopic Title: Contamination Control and Planetary Protection
Proposal Title: In-Situ Radioisotope Sterilization for Backward and Forward Contamination - Enabling low-mass, Low-Complexity Solutions for Planetary Protection

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The quest to protect planetary bodies from contamination by Earth life and to shield Earth from potential extraterrestrial life forms is a critical concern for NASA's planetary science missions. The Mars Sample Return and other decadal missions targeting the icy moons of the outer solar system are flagship missions prioritized by NASA. However, they face significant cost and complexity issues from stringent planetary protection needs. Current planetary protection measures involve complex sterilization processes, redundant seal containments, lengthy quarantines, power, and special handling procedures, all adding significant mass and cost to the

missions. Our proposal introduces a paradigm-shifting radioisotope-based sterilization system. Unlike traditional methods that use heat or chemicals, which can damage samples and leave residues, this innovative technology utilizes primary ionizing radiation to sterilize nucleic acids (DNA and RNA) and prions without affecting the bulk material. This method is particularly advantageous for long-duration missions, as it allows for sterilization over the extended return trip from Earth (forward contamination) and returning from Earth (backward contamination). The long duration allows for a low-activity, low hazard radiation source. This approach provides a low-mass, low-complexity, low-cost solution for robust planetary protection. In addition, our sterilization techniques can target multiple types of radioisotopes, which can be used either to sterilize a surface or a volume based on the type and energy of radiation. This technology would add a new tool to the planetary protection toolbox and help NASA and emerging commercial companies comply with planetary protection rules at a low cost and minimal impact on conops.

Duration: 6

Proposal Details

Proposal Number: S13.05-1003
Subtopic Title: In Situ Instruments and Instrument Components for Lunar and Planetary Science
Proposal Title: High Temperature Seismometer for Planetary Science Applications

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

In-situ instrumentation is needed that can withstand the harsh environments imposed by planetary atmospheres in order to make advancements in solar system exploration. Technologies that can withstand the corrosive/caustic gases, radiation levels, stresses, and high temperatures and pressures, while still producing reliable, real-time data are a major facilitator for planetary missions, and extreme environment tolerant in situ technologies are being sought to enable instruments with reduced mass, power, and volume without loss of scientific capability. Specifically, seismometry is key to satisfying a number of priority science questions and strategic research objectives outlined by NASA and the National Research Council Planetary Decadal Survey, notably related to understanding planetary interior composition, volcanic activity, and tectonic processes of Venus and other extreme planetary environments (mercury, etc.). Sporian Microsystems has significant prior experience in the development of ultra-high-temperature sensors for aerospace propulsion and ground power energy generation applications. The long-term objective of the proposed effort is to heavily leverage this prior knowledge and translate it to realize an ultra-high temperature (>1000C/1830F) inertial vibration sensor that can be used in support of seismometry for planetary sciences, specifically Venus applications. Phase I effort will include: 1) working with NASA and industry stakeholders to define system requirements am foster transition; 2) evaluating revised hardware/electronics architectures and designs; and 3) proof of principle testing and demonstration using benchtop-scale prototype hardware. If successful, Sporian will be well positioned for the Phase II efforts focused on full system prototyping and relevant environment testing/demonstration to satisfy NASA's technical readiness level expectations.

Duration: 6

Proposal Details

Proposal Number: S13.05-1006
Subtopic Title: In Situ Instruments and Instrument Components for Lunar and Planetary Science
Proposal Title: In-situ, Robust, Low Size, Weight, and Power Trace-gas Detector

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

In response to the NASA Science Mission Directorate's need for advanced in-situ technologies to detect organic molecules and trace gases on planetary surfaces, Intelligent Optical Systems, Inc. (IOS) proposes to develop a multi-wavelength infrared cavity ring-down spectrometer (IR-CRDS) designed to enhance the detection and identification of targets of interest. This technology addresses critical needs outlined in the Planetary Decadal Survey and the Artemis III Science Definition Team Report, specifically for detecting organic compounds and trace gases in extreme environments such as on Europa, Enceladus, and Titan. Phase I of the project will focus on verifying the feasibility of the proposed IR-CRDS system

by demonstrating its ability to detect targets of interests with high sensitivity, resolution, and specificity. The system will leverage a multi-wavelength light source combined with a cavity ring-down technique, enabling highly accurate and rapid analysis with minimal mass, power, and volume requirements, crucial for small spacecraft and missions to distant planetary bodies. In Phase II, we will enhance the system's robustness and improve its survivability under high-G forces, making it suitable for deployment on impactors to planetary surfaces. Efforts will focus on ensuring the system can withstand the harsh conditions of space, including radiation, temperature extremes, and launch stresses. By improving the design and integrating advanced materials and technologies, we aim to deliver a highly resilient, low-cost, and compact instrument capable of conducting in-situ scientific measurements for planetary exploration. This novel IR-CRDS technology has the potential to enable a new class of scientific discovery and numerous commercial applications in environmental monitoring and chemical analysis. Its versatility and robustness make it valuable for both space exploration and terrestrial applications, including industrial and research sectors.

Duration: 6

Proposal Details

Proposal Number: S13.05-1011
Subtopic Title: In Situ Instruments and Instrument Components for Lunar and Planetary Science
Proposal Title: Lunar Materials Analyzer (LuMA)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Optimizing lunar regolith ISRU and construction processes requires the knowledge of the raw materials composition. We propose to develop a Lunar Materials Analyzer (LuMA) which primary functions are to monitor the mineral phase composition and the elemental composition of a lunar regolith feedstock of ISRU or construction processes. LuMA uses X-ray diffraction (XRD) and X-ray fluorescence (XRF), two analytical techniques that are well proven and have already been developed for in-situ planetary science. This SBIR will 1) adapt proven planetary science instrument technologies to the constraints and requirements of in-line analysis, 2) develop a robust robotic sample handling system for maintenance-free operation on the surface of the moon over periods exceeding one year, 3) automate XRD and XRF data interpretation, 4) investigate additional analytical capabilities for measurements such as regolith softening and melting points, and/or the viscosity of a melt. The Phase I research will focus on concept refinement and demonstration of feasibility, with a particular focus on the XRD instrument geometry and XRD sample configuration, and XRF optimization. The work will be approached via simulations and experimentation with existing prototypes modified to test new layouts. Foreseen NASA markets are future ISRU applications, missions intended to identify/quantify resources, and robotic or astronaut-operated instruments for in-situ science. Commercial markets are automated applications of XRD and/or XRF for in-line monitoring of raw materials or products, in industries such as cement, mining, petroleum, pharma, food, etc.

Duration: 6

Proposal Details

Proposal Number: S13.05-1017
Subtopic Title: In Situ Instruments and Instrument Components for Lunar and Planetary Science
Proposal Title: Miniaturized Ion Trap Mass Spectrometer for In Situ Lunar and Planetary Analysis

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

The proposed project focuses on developing a miniature Linear Ion Trap Mass Spectrometer (LIT-MS) optimized for space exploration, particularly for planetary science missions. This compact, low-SWaP (Size, Weight, and Power) instrument

will feature ruggedized ion optics, including an ion funnel and quadrupole ion guide, designed to withstand the harsh conditions of extraterrestrial environments. To accommodate varying atmospheric conditions, flow control will be achieved using fixed apertures tailored for Mars' low-pressure atmosphere and the near-vacuum conditions of Enceladus. The requested funding will support the design, simulation (via SIMION), and feasibility assessment of the ion optics, with a focus on improving alignment stability and reducing power consumption. Target markets include space agencies such as NASA, ESA, and commercial space companies engaged in planetary exploration and resource prospecting. The LIT-MS system aims to become a critical tool for future missions investigating geochronology, exospheric studies, and the search for biosignatures, contributing to a deeper understanding of planetary environments and the potential for extraterrestrial life.

Duration: 6

Proposal Details

Proposal Number: S13.05-1020
Subtopic Title: In Situ Instruments and Instrument Components for Lunar and Planetary Science
Proposal Title: Cold Electron Sources for Low Size Weight and Power Mass Spectrometers

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Electron emitters are key components of many instruments with scientific, industrial, or medical applications. The first stage of mass spectrometers involve ionizing the sample by electron impact at high energy. Presently, the default source of electrons in most cases are hot filament cathodes. Hot filaments have a number of drawbacks, including high power draw, heating, high vacuum requirements, gradual burn-out, and a wide range of emitted electron energies. For space-based applications, they are not replaceable. Long lifetime cold cathodes have been a goal for decades. Field emitters such as Spindt and CNT emitters are the most prominent. They rely on a sharp tip to enhance electric fields to eject electrons. However they also eject their tip material and have short lifetimes. Metal-Insulator-Metal tunneling cathodes impart the energy to escape into vacuum by accelerating electrons as they tunnel across an insulator towards a thin top metal exposed to vacuum. We are designing and fabricating a similar structure involving a semiconductor, insulator, and a 2D material top electrode. The insulator is designed for stability, low defect density, and high tunneling current. The top electrode creates a tunneling potential across the insulator without the need for scattering metal films that can damage the insulator. The top of the insulator will be in contact with the 2D material, which is very stable and will not diffuse into the insulator, which is the biggest contributor to this type of device degradation and failure. In addition to these desirable properties, our device is fabricated on-chip using semiconductor processing methods. Importantly, they will take less than 15 volts to operate. This is extremely low power, as the tunneling current is 10 mA/cm2, so operating the device takes 150 of milliwatts/cm2 in contrast to a hot filament, which uses 5 or more watts/cm2, and the field emitters, which require extremely high voltages.

Duration: 6

Proposal Details

Proposal Number: S13.06-1000
Subtopic Title: Dynamic Power Conversion
Proposal Title: Sensorless Position Estimator for Reciprocating Linear Actuator Hardware

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

This Phase I project aims to demonstrate the effectiveness of a new sensorless piston position estimation technique for reciprocating linear actuators. During this six-month SBIR Phase I project, we propose constructing a model-based dynamic piston position observer in software and validating its performance using moving-coil linear actuator hardware. Our sensorless position estimator approach holds the potential to enhance the reliability and performance of NASA Radioisotope Power Systems (RPS) missions by supporting controllers that: 1) adjust the piston amplitude in response to radioisotope fuel decay or when individual redundant multi-converter units are activated or deactivated 2) identify and correct for piston

mean position offset (“drift”) 3) coordinate the piston phase and amplitude of dual-opposed converters to minimize net vibration 4) manage single converter piston motion for optimal use of active/ passive vibration absorbers We understand that many of the convertor controllers developed by NASA already monitor coil current and terminal voltage. Therefore, controllers that contain microprocessors could, in principle, be upgraded to host our position estimation algorithms without requiring additional sensors or current injection hardware, thus enhancing overall system reliability. Furthermore, utilizing information about piston position (including amplitude, offset, and phase) could improve specific power density by allowing the controller to operate safely closer to the physical limits of piston travel while synchronizing with other converters and vibration absorbers. It may be feasible to implement our sensorless position observer for the linear actuator of an active (driven) vibration absorber, potentially eliminating the need for a separate accelerometer. Our piston position observer is suitable for moving-magnet-based converters and the low-power, low-inductance moving coil alternator-based converter developed by NASA-GRC.

Duration: 6

Proposal Details

Proposal Number: S13.06-1002
Subtopic Title: Dynamic Power Conversion
Proposal Title: Rad-hard Electronic Control and Power Integrated Circuit for Stirling-based Radioisotope Power System

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

In response to the NASA SBIR topic S13.06 “Dynamic Power Conversion”, subtopic “Radiation-hardened electronic controllers and power processing” from 1 to 100 watts, Alphacore Inc. will develop a full Radiation-Hardened (Rad Hard) Controller and Power Management Integrated Circuit (PMIC) for Radioisotope Power System (RPS) free-piston Stirling cycle converter inclusive of Stirling engine, engine controller, and DC/DC converter, yielding a 28V regulated output with total high system efficiency (>30%). We refer to it as the PMIC or simply the Controller. Alphacore controller will work with hardware from our partner Sunpower, both the 65W Sunpower Robust Stirling Convertor (SRSC) and the 35W EE-35 Stirling converter. Professor Seth Sander from University of California at Berkeley will consult with Alphacore on the controller design. Prof. Sanders spent about 15 years on the Stirling engine front, mostly developing free-piston type machines. The controller will be simulated in Phase I and a complete RPS prototype will be delivered in Phase II. The controller will have a credible path to flight and able to control a dynamic convertor without relying on feedback from vulnerable short-lived sensors. The controller radiation tolerance will be greater than 5x1011 n/cm2 + 3x102 krad + 40 MeV-cm2/mg (linear energy transfer) to achieve higher tolerance to radiation, thereby enabling a reduction in shielding mass. The controller will operate over a wide temperature range(-150 ºC to 150 ºC). The developed PMIC will have a reduced component count, enabling reduced failure modes, and smaller area of PCB (printed circuit board). It will include over-voltage protection, fault tolerance, load monitoring, as well as allow control and status monitoring by a remote power system controller. This PMIC includes all controller circuitry and drivers integrated in a single die and drives an external wide-bandgap (WBG)-based power stage for electric power delivery.

Duration: 6

Proposal Details

Proposal Number: S13.06-1007
Subtopic Title: Dynamic Power Conversion
Proposal Title: Regulatory-Compliant Tritium Mini-RHU: A Scalable Alternative for Next Gen. Space Power

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

City Labs proposes a Tritium Mini-Radioisotope Heater Unit (Mini-RHU) utilizing advanced tritium metal hydride technology to provide scalable, long-duration thermal energy for dynamic power conversion systems. The Tritium Mini-RHU is a compact, cost-effective alternative to traditional Pu-238-based Radioisotope Power Systems (RPS), offering thermal power ranging from milliwatts to hundreds of watts and beyond. Leveraging City Labs' expertise in tritium betavoltaics and metal hydride storage, the Mini-RHU uses titanium tritide as a heat source. Tritium's advantages include minimal shielding requirements, long half-life, commercial availability, and low regulatory overhead. Following NSPM-20 guidelines, tritium RHUs will provide a streamlined regulatory framework for space launches. City Labs' state-of-the-art facility, capable of safely handling and loading tritium, positions the company to support future missions. The Mini-RHU's modular design enables scalable power generation and meets NASA's needs for high-efficiency, autonomous power systems in harsh space environments. Unlike Pu-238, tritium is readily available, significantly reducing both costs and regulatory complexities. City Labs' facility is capable of managing tritium under high pressures and temperatures. Furthermore, City Labs is actively pursuing FAA payload approval for a 2026 launch of betavoltaic devices containing up to 20 kCi of tritium, reinforcing its

commitment to safely integrating tritium-based technologies in space missions. This project's intended deliverable, the 1,000 Ci Mini-RHU can be bundled to provide scalable power while reducing regulatory barriers, streamline mission planning, and provide a cost-effective, reliable power solution for lunar and deep-space exploration. It directly supports NASA's goals for long-duration lunar operations and high-power energy generation, advancing the integration of tritium-based RHUs into NASA's RPS program.

Duration: 6

Proposal Details

Proposal Number: S14.01-1001
Subtopic Title: Space Weather Research-to-Operations and Operations-to-Research (R2O2R)
Proposal Title: Improved Probabilistic Forecasts of Solar Energetic Particles with MagPy

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 7
Technical Abstract (Limit 2000 characters):

NASA's strategy for returning to the Moon is part of its broader Moon-to-Mars exploration, of which the Artemis program is a critical component. A crucial aspect of this concerns the safety of the crew and their hardware, of which solar energetic particles (SEPs) play a major role. MagPy (based on MAG4) is a probabilistic forecasting tool designed to predict solar events such as flares, (fast) CMEs, and SEPs using SDO/HMI SHARP magnetogram data. It forecasts event probabilities within 24 hours by analysing magnetic parameters like strong-field neutral line length, magnetic flux areas over 100 Gauss, and magnetic field shear and gradient. MagPy is the Python-based evolution of MAG4 and is now maintained and developed by NASA's Space Radiation Analysis Group (SRAG). It offers operational outputs, including graphical active region representations and a "Threat Gauge" for event probabilities, making it a core tool for predicting solar activity. We propose to refine and substantially improve MagPy's capabilities. During Phase I, we will focus on developing a robust implementation of the MagPy tool, incorporating field line connectivity, investigating other refinements, and demonstrating a successful prototype tool in preparation for Phase II. During Phase II, we will add a number of other refinements, including, but not limited to (1) improved datasets incorporating Solar Orbiter's PHI images off the Sun-Earth line; (2) a flux transport model to capture the evolution of ARs better as they propagate across the solar disk; (3) a complementary approach for calculating the likelihood of a flare/CME; (4) an alternate PIL detection routine; and (4) robust statistical and machine learning (ML) methodologies for both input data selection and model validation and verification. Additionally, we will work with NASA personnel to develop and refine robust metrics and skill scores for forecast verification and validation.

Duration: 6

Proposal Details

Proposal Number: S14.01-1011
Subtopic Title: Space Weather Research-to-Operations and Operations-to-Research (R2O2R)

Proposal Title: GLOBAL FORECASTING OF EARTH'S ELECTRON RADIATION BELTS WITH DATA ASSIMILATION

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 6
Technical Abstract (Limit 2000 characters):

Accurately nowcasting and forecasting the near-Earth space radiation environment is critical to mitigate risk to our space-based assets and NASA's near-Earth space missions. Precise forecasting requires detailed knowledge of the current state of the radiation belts, a robust physics-based forward propagation model, accurate forecasting of model input parameters and model driving parameters, as well as exhaustive confidence tracking to evaluate the uncertainties. There are no US-based capabilities that currently provide global nowcasts and forecasts of energetic particle conditions encountered by spacecraft within Earth's magnetosphere. Space Science Innovations (SSI) has an existing data assimilative physics-based model, and is capable of transitioning to real-time nowcasting and forecasting that meet all of the above requirements. Specifically, this work will improve upon an existing electron radiation belt model to provide accurate predictions and nowcasts of the

global outer radiation belt electron space environment, aid in spacecraft anomaly resolution, and assist spacecraft operators. The proposed work leverages a well-validated physics-based data assimilative code, the Versatile Electron Radiation Belt 3D code (VERB-3D). After more than 15 years developing the code, the group at SSI has developed a framework for historical reconstruction that has high-performance metrics. The proposed work will develop a proof-of-concept nowcast and forecast product that will provide actionable predictions for space weather situation awareness of the global electron environment in near-Earth space. These capabilities will allow for real-time prediction of spacecraft environmental risks that can be offered to stakeholders as actionable data products. Target markets include NASA/CCMC for R2O2R advancement and as well as the private sector for mission operations.

Duration: 6

Proposal Details

Proposal Number: S14.01-1022
Subtopic Title: Space Weather Research-to-Operations and Operations-to-Research (R2O2R)
Proposal Title: Producing a Benchmark HASDM Forecast Density Database

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

In this proposal, we address the looming international challenge of harmonizing the use of accurate, validated, and agreed upon thermospheric density models for improved current and predicted satellite drag estimates. Specifically, to facilitate improvements in forecasting methods, we propose to firstly build, and make publicly available, a High Accuracy Satellite Drag Model (HASDM) forecast density database spanning a solar cycle from 2013 to 2027. This database can become a forecasting benchmark of current U.S. operational capabilities and, from the experience of the nowcast density database we have already released, it can facilitate community-wide density forecasting research and development. This database is the first step of the proposed work toward improved density forecasting methods for the benefit of LEO operations. In addition to generating the HASDM forecast density database, we will also extend the existing Space Environment Technologies (SET) HASDM nowcast density database [Tobiska et al., 2021], currently covering 2000 to 2019, into the year 2025. The existing database is publicly available at https://spacewx.com/hasdm/ and has become widely used in the international thermospheric density modeling community as the de facto global density baseline. This work is a direct R2O2R application; we will transition current operational space weather forecasting capabilities to a research setting for evaluation of performance and data sharing. The expanded knowledge will then be transitioned back to operations to improve future capabilities via development of a Machine-Learned (ML) HASDM model.

Duration: 6

Proposal Details

Proposal Number: S14.01-1038
Subtopic Title: Space Weather Research-to-Operations and Operations-to-Research (R2O2R)
Proposal Title: Space Weather Alerting Platform (SWAP)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

MyRadar's Space Weather Alerting Platform (SWAP) is an AI-enhanced space weather observation system designed to improve near-real-time hazard detection and predictive capabilities. Space weather events—such as solar flares, coronal mass ejections, and solar energetic particles—pose significant risks to space-based and terrestrial infrastructure, yet existing monitoring systems lack the spatial and temporal resolution needed for improving nowcasting and forecasting. SWAP will address these gaps by leveraging miniaturized, proliferated spacecraft with onboard AI processing to autonomously detect and analyze space weather phenomena. SWAP's multi-sensor payload includes a boom-mounted magnetometer, an EUV

imaging camera, and a scintillation detector for X-ray and gamma-ray spectroscopy. AI-driven onboard processing will enable autonomous anomaly detection, reducing reliance on ground-based processing and enabling low-latency alerting. Phase I will focus on designing the SWAP spacecraft architecture, conducting a trade study for key components, and developing a Phase II low Earth orbit demonstration plan to validate spacecraft performance. SWAP's innovation will enhance operational space weather forecasting, benefiting commercial, government, and scientific users.

Duration: 6

Proposal Details

Proposal Number: S14.01-1041
Subtopic Title: Space Weather Research-to-Operations and Operations-to-Research (R2O2R)
Proposal Title: High Performance Modeling of Space Weather Effects for Lunar Missions Operations Support

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Understanding the radiation environment variability is crucial to NASA to provide accurate estimates of the exposure for any robotic or crewed mission from low earth orbit to the moon. For NASA and the commercial sector, new cosmic ray and solar wind monitoring technology is needed to deliver the impactful improvements in monitoring and advanced radiation shielding technologies needed to protect humans and electronics from the hazards of space. During design, space engineers need to simulate the effects of space radiation on humans and electronic in all possible radiation environments and through very complex vehicle geometries. Our existing RSim application uses Geant4, a radiation transport modeling tool widely adopted for NASA space missions where it is applied to studies such as apparatus simulation for pre-launch design and post-launch analysis, planetary scale simulation of radiation spectra, and micro-dosimetry simulation for single-event failure effects on electronics components. Innovations to RSim are proposed that include interfaces from the desktop and scalable speed enhancements to Geant4 enabling engineers to run radiation transport simulations with complex geometries on fast time scales. The new interfaces will allow users to add space weather particle sources and perform speed-enhanced Geant4 radiation modeling simulations on remote supercomputers and in the cloud at unlimited scales. Phase I will concentrate on demonstrating a space-weather enhanced and fast mode of operation on high-performance clusters in the cloud. In Phase II, we will implement more performance enhancements, improve user features, and integrate more user feedback.

Duration: 6

Proposal Details

Proposal Number: S14.02-1008
Subtopic Title: In Situ Particles and Fields and Remote-Sensing-Enabling Technologies for Heliophysics Instruments
Proposal Title: Sodium Excitation Laser for Mesospheric Analysis

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

The sodium layer in the upper atmosphere provides a unique opportunity to study mesospheric and ionospheric dynamics, as its density, temperature, and altitude fluctuate due to various atmospheric and geophysical factors. These variations can be probed through remote sensing, with sodium serving as a natural tracer. Despite its significance, the mesosphere and lower thermosphere (MLT) region remain poorly characterized, even though they are critical for understanding atmospheric dynamics. Pulsed lasers with high peak power have traditionally been the primary light source for probing the sodium layer via LIDAR detection. However, achieving remote detection at a 90 km range typically requires bulky, power-intensive laser systems, limiting their use to ground-based applications. To enable space-borne and/or balloon-borne LIDAR operations, Opto-Atomics Corp. (OAC) proposes the development of the Sodium Excitation Laser for Mesospheric Analysis (SELMA)—a compact, continuous-wave (CW) 589.16 nm laser transmitter designed for remote sodium detection in the upper atmosphere. SELMA's primary objective is to facilitate field deployment of sodium LIDAR for characterizing the mesospheric sodium layer, enabling remote sensing of temperature, winds, density, and other key

atmospheric parameters in this critical region. SELMA will provide a high-power, frequency-agile, nearly diffraction-limited laser output at the sodium D2 line in a field-deployable, ruggedized package. In Phase I, OAC will develop a high-power sodium laser prototype and experimentally demonstrate SELMA feasibility.

Duration: 6

Proposal Details

Proposal Number: S14.02-1009
Subtopic Title: In Situ Particles and Fields and Remote-Sensing-Enabling Technologies for Heliophysics Instruments
Proposal Title: Meta-optic Spectropolarimeter For Heliophysics Imaging

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Spectropolarimetric measurements show great promise for heliophysics in many wavelength regimes, including for observing hydrogen-alpha (H-alpha) emissions in solar flares, or UV features of the K-corona. Recently, under NASA contract 80NSSC22CA172, Nanohmics and Professor Andrea Alù's research group at the City University of New York (CUNY) demonstrated the potential of multifunction meta-optics that can focus light and can also analyze both spectrum and polarization state for light in the deep red, NIR, and SWIR. To adapt this metamaterial technology to H-alpha and other visible (VIS) spectral bands used for heliophysics missions, Nanohmics proposes to develop a VIS band, low-SWaP imaging spectropolarimeter using an ultrathin, light-weight, microfabricated multifunction meta-optic. The proposed imaging spectropolarimeter combines a single multifunction meta-optic with a commercial off-the-shelf (COTS) focal plane array (FPA). It will collect polarization, spectral, and one-dimensional (1D) imaging data simultaneously at video rates and hyperspectral resolution. Its mass and volume will be approximately 1/10 of that of existing spectropolarimeters. The core metamaterial-based optic performs polarization, wavelength, and spatial discrimination with no moving parts. In Phase I, the team will demonstrate the feasibility of low-SWaP, high-performance heliophysics-suited sensors by fabricating a brassboard imaging spectropolarimeter using a single multifunction meta-optic. Laboratory testing will advance the brassboard to TRL 4. In Phase II, the team will advance the brassboard to the prototype stage (TRL 5) through ruggedization and testing. Longer term, the proposed technology can be integrated into NASA heliophysics missions, e.g., CubeSats and other SWaP-constrained vehicles. Meta-optic fabrication using standard CMOS microfabrication techniques will reduce costs and provide a rapid route to commercialization.

Duration: 6

Proposal Details

Proposal Number: S14.02-1015
Subtopic Title: In Situ Particles and Fields and Remote-Sensing-Enabling Technologies for Heliophysics Instruments
Proposal Title: Low-Energy Charged-Particle Detection via an Avalanche Silicon Detector coupled to an Amorphous Silicon Active Layer

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

This SBIR Phase I project will develop a solid-state sensor with on-chip amplification to deliver low-energy (< 10 keV/e-) particle-detection with similar sensitivity and timing performance as existing vacuum-tube multiplication instruments, but do so at low-bias, low-cost, and in a compact, ruggedized package. The work will complete the prototype development of a silicon-based detector scheme for electrons, protons, and heavy ions with a thin-film (4 – 1000 nm) amorphous silicon front active layer and an integrated silicon avalanche layer for on-chip amplification. The amorphous silicon creates charge-pairs for even the lowest of energies, and the p+/n silicon detector produces multiplication gain at low voltage (< 100 V). Compared with channel electron multipliers or microchannel plates that operate at ~1 kV, this not only reduces the power requirements, but it eliminates the arcing risks that can accompany compact instrument and spacecraft designs. The detector: (a) eliminates the need for the ultra-high vacuum required for the vacuum tube technologies, (b) tolerates dust via its solid-state design, and (c) can deliver charged-particle flux measurements with CMOS integration. The Phase I work will establish the simplest design that allows low-energy particle detection

by evaluating: (a) thinned silicon avalanche diodes operating at ~50 V, (b) amorphous silicon thin-film diodes operating at 0 V, and (c) a combined device that marries the amorphous silicon sensing layer with the multiplying silicon back layer.

Duration: 5

Proposal Details

Proposal Number: S15.02-1000
Subtopic Title: In Situ Sample Preparation and Analysis for Biological and Physical Sciences in a Microgravity Environment
Proposal Title: Automated DNA Extraction in Space

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 5
Technical Abstract (Limit 2000 characters):

The proposed technology addresses NASA’s need for in situ sample prep and analysis in a microgravity environment and offers a new approach for processing biosamples in space. The WRKR-B is an automated nucleic acid extraction device based on proprietary engineering and biochemistry innovations that combines library prep for next-generation sequencing of microbes and animal cells into a seamless protocol. Automated DNA extraction and library prep technology in orbit will enable efficient, higher throughput biosample processing and address NASA’s needs for rapid, iterative science in space while also providing fundamental research tools needed to stimulate the LEO bio-economy. As such, this proposal aims to adapt the automated system for space-based applications aboard the ISS and commercial space stations. WRKR-B will enable routine analysis of the spacecraft environment via on-demand DNA extraction and sequencing of samples collected from the spacecraft and plant surfaces, water systems, as well as astronauts. This technology will streamline workflows, reduce crew effort, and support real-time on-demand analyses critical for microgravity research in LEO and missions to the Moon and Mars. Phase I funds will be used to elevate the TRL, design iteration, testing, and integration guided by NASA SME to ensure compatibility with the unique space environment. The global terrestrial market for automated DNA extraction systems is growing rapidly and includes many applications: (1) increasing demand for molecular diagnostics, particularly for infectious diseases and cancer; (2) expansion of personalized medicine and precision therapies; (3) increasing adoption of decentralized testing solutions; (4) growth in genomics research fueled by declining sequencing costs; and (5) strong market interest in agricultural biotechnology, food safety, and environmental monitoring. Routine end-point omics analysis in space is poised to not only stimulate but disrupt the space economy.

Duration: 6

Proposal Details

Proposal Number: S15.02-1011
Subtopic Title: In Situ Sample Preparation and Analysis for Biological and Physical Sciences in a Microgravity Environment
Proposal Title: Recycling Enabled Autonomous Cell Culture System

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

Characterization of the effects of radiation on biological specimens Beyond Low Earth Orbit (BLEO), while dealing with the difficulties of isolation and distance from earth presents a challenging problem for multiple reasons. Organisms require that physiologically relevant environmental conditions to be maintained for optimal performance, including temperature, pressure, pH, and dissolved gases. Additionally, nutrients need to be added to the culture to facilitate sustained cell growth, and these nutrients must be balanced against the cells' secretion of waste products into their microenvironment. Due to the minimal power available and a limited supply of compressed gas, feed, and fresh media, there is a finite time that experiments can theoretically run. Sciperio will apply their innovations in biomanufacturing to biologic experiments on the International Space Stations (ISS) or commercial space stations as a proving ground before extended BLEO missions. Many of the challenges presented such as automation, resource management, in-situ measurements, and autonomous decision making have been addressed by Sciperio. A key technology that will be adapted is the media recycling capability which presents a clearly unique solution to the metabolic waste generated by cells and has a minimum 20 to 1 weight and volume reduction in the media needs for a biologic experiments. Sciperio's modular and highly sensorized bioreactor will be adapted to

the space domain and will allow for in line analysis and environmental control as well as parallel or expandable cultures. A database and supporting software developed will allow for logging and remote monitoring of bioreactor operations and Machine Learning algorithms that are currently under development give a clear path to augmented or fully autonomous experimental decisions to be made.

Duration: 6

Proposal Details

Proposal Number: S15.02-1013
Subtopic Title: In Situ Sample Preparation and Analysis for Biological and Physical Sciences in a Microgravity Environment
Proposal Title: High-sensitivity Quantum Spectrometer for Autonomous Biological Analysis

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

Our proposal aims to develop a cutting-edge quantum spectrometer based on Nitrogen-Vacancy (NV) centers in diamond, capable of detecting NMR signals from biological liquid samples with unprecedented sensitivity and resolution. By utilizing advanced sensing techniques and signal processing, our technology will significantly enhance the detection of weak NMR signals, which are critical for applications in molecular biology, medical diagnostics, and environmental monitoring. The funding will be used primarily for the fabrication and testing of the initial prototype, including the development of a 3D printed sensing probe, integration of NV centers in diamond, and the implementation of sensing techniques. This will involve procuring necessary materials and equipment, assembling the system, and conducting calibration and testing on initial samples to demonstrate its performance and capabilities. Our target markets include the biomedical sector, particularly for non-invasive diagnostic tools, as well as environmental testing and research laboratories that require high-sensitivity NMR spectroscopy. The technology could also have applications in the pharmaceutical industry for drug development and molecular analysis. By offering a portable, high-performance spectrometer, we aim to provide a transformative solution for these industries, enabling faster, more precise analysis of complex biological and environmental samples.

Duration: 6

Proposal Details

Proposal Number: S15.03-1001
Subtopic Title: Environmental Monitoring for Micro-G and Partial-G Experiments
Proposal Title: Plant Health Monitoring with Multimode Imaging and Artificial Intelligence

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

SafetySpect Inc. proposes integrating its innovative MoonLight multimode imaging system with environmental sensors and advanced artificial intelligence (AI) to monitor plant health in extraterrestrial environments autonomously. This technology aims to provide real-time, non-invasive detection of plant stress, nutrient deficiencies, and diseases, significantly enhancing the efficiency of food production systems aboard NASA missions, such as the ISS, Lunar Gateway, and Mars habitats. The MoonLight system combines hyperspectral reflectance imaging (HRI), hyperspectral fluorescence imaging (HFI), and LiDAR to identify early-stage stress, nutrient deficiencies, and diseases not visible to standard photographic techniques currently used in space-based plant monitoring systems. By integrating additional environmental sensors for CO_2, humidity, temperature, and light intensity, this project will enrich data collection, allowing AI-driven models to effectively correlate plant health indicators with environmental conditions. Funding from NASA will support the adaptation and integration of these sensors into MoonLight, system validation under simulated space conditions, extensive data collection from selected crops, and the development of AI algorithms capable of autonomously

detecting and classifying plant stress. Additionally, funds will support the design adaptations necessary for stable operation in low-gravity environments. The primary market is NASA and international space agencies, which require autonomous plant health monitoring technologies for sustainable food production in extraterrestrial habitats. Secondary markets include private space exploration companies like SpaceX and Blue Origin and terrestrial commercial sectors such as vertical farming, greenhouse operations, and agricultural research institutes that demand efficient, resource-optimized plant monitoring solutions for sustainable food production.

Duration: 6

Proposal Details

Proposal Number: S15.03-1002
Subtopic Title: Environmental Monitoring for Micro-G and Partial-G Experiments
Proposal Title: OPERA-S: AI-driven selective smoke sensor

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

The potential for fire on spacecraft is one of the major threats for long-term crewed space missions. The impact of low-gravity significantly alters the properties of fire and related smoke particles in spacecraft relative to Earth. Additionally, the materials likely to drive participate in fire is very different in spacecraft compared to structures on Earth. Recognizing the importance of early fire detection, early detection of smoke particles from materials close to likely source of fires is critical. Current sensing technologies are neither smoke-specific nor sensitive enough for early detection. There is a need for new sensing technologies that are selective and sensitive to smoke, and compact and low-cost in size for large-scale deployment throughout a spacecraft. In this Phase 1 project, we will demonstrate that a small compact sensor based on optical-sensing and electrical-mobility measurements can provide a means to identify and classify smoke in real-time. This Phase 1 project will build on our development of an advanced aerosol classification sensor called OPERA (opto-electrical real-time aerosol sensor) for NASA. While the OPERA is being built to provide PM2.5 measurements and broadly classify particles by type, its design forms a starting point to expand for smoke specific sensing. In Phase I, we will modify the OPERA to develop OPERA-S (OPERA- Smoke-specific) and demonstrate in lab studies that the OPERA-S can successfully identify smoke particles generated from combustion of space relevant material.

Duration: 6

Proposal Details

Proposal Number: S15.03-1007
Subtopic Title: Environmental Monitoring for Micro-G and Partial-G Experiments
Proposal Title: Autonomous Platform for Phyllosphere Monitoring in Space Habitats

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 5
Technical Abstract (Limit 2000 characters):

Advanced Growing Resources (AGR) proposes an autonomous platform for monitoring plant health in space habitats that addresses NASA's need for continuous environmental sensing with minimal crew intervention. The system integrates four key technologies: an embedded hyperspectral imaging system, canopy monitoring module, tunable broadband luminaire, and unified AI transformer model for early detection of crop afflictions. The core innovation is a "smart light" that represents a paradigm shift from "sample and wait" with wet chemistry testing to "scan and act" by creating an early detection system that detects pathogens, nutritional deficiencies, and water stress days before visual symptoms appear. In field trials, the technology demonstrated 97% accuracy in diagnosing powdery mildew 8 days before visual symptoms were apparent in addition to water and nutrient stresses. The Phase I funding will be used to develop and validate the four key components of the system, culminating in a TRL 5 greenhouse demonstration. Specific objectives include adapting hyperspectral imaging technology for early detection of crop afflictions in space, developing unified AI models for comprehensive crop health monitoring, enhancing our Spectre spectroscopy technology for space applications, and developing a tunable broadband luminaire. The technology aligns with NASA's top Civil Space Shortfalls while supporting Key Science Questions

from the 2023 BPS Decadal Survey. Beyond NASA applications, the technology has significant commercial potential in the $4.2 billion global crop monitoring market, which is expected to reach $17.2 billion by 2034. Initial target markets include grape producers, with plans to expand into row crops and citrus production. This technology will improve food security both in space and on Earth by enabling reliable crop production through early disease detection, minimizing crop loss, and maximizing resource utilization in environments where resources are limited.

Duration: 6

Proposal Details

Proposal Number: S15.03-1010
Subtopic Title: Environmental Monitoring for Micro-G and Partial-G Experiments
Proposal Title: Portable Major and Trace Constituent Gas Analyzer for Habitable Environments

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

This proposal will use high sensitivity charge detectors developed for NASA mass spec in planetary science missions to develop miniaturized mass spec systems for environmental monitoring. NASA uses a mass spectrometer onboard the ISS to monitor the major constituents and trace gasses in the atmosphere, but it is a large system. At the same time NASA uses handheld chemical sensors to monitor specific gasses like oxygen and carbon dioxide. The portable system under development in this proposal will allow the analytical power and sensitivity of a mass spec system while being portable. These will be designed for use in habitable and built environments in space and on lunar missions. Major constituents of the atmosphere are important to measure for health and safety. Trace gas components can also indicate dangerous conditions. The aim is to provide astronauts and NASA with better monitoring systems for gas composition in their environment. Right now the mass spec system takes significant time to service and operate, and an astronaut's time is scarce and incredibly valuable. The instruments will serve a dual purpose as monitoring equipment for biological and other science experiments where trace gas composition is a variable of interest. Monitoring the atmosphere is an important component of biological experiments as well. Plant or other living organisms modify the atmosphere around them as they grow, and this is often important experimental information. These instruments would be ideal for moving to an experiment as needed to monitor the atmosphere over time. Portable mass spec instruments have a strong dual use case. Air quality monitoring outside and inside of industrial facilities such as chemical plants and refineries is mandated by EPA regulations. Less sensitive portable mass spec instruments are already in use for detection of hazardous substances like drugs and explosives.

Duration: 6

Proposal Details

Proposal Number: S16.03-1004
Subtopic Title: Guidance, Navigation, and Control
Proposal Title: Active Spacecraft Jitter Cancellation Using Deployable Panels

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Samara Aerospace proposes to advance spacecraft attitude control and jitter mitigation through its Multifunctional Structures for Attitude Control (MSAC) technology. MSAC integrates distributed strain actuators into deployable spacecraft structures, such as solar panels, to enable active jitter cancellation and large-angle slewing. This approach eliminates bulky, failure-prone flywheel-based control systems and passive vibration isolation methods, reducing spacecraft mass, volume, and complexity while improving precision pointing performance. MSAC achieves active noise cancellation by dynamically actuating deployable structures in response to disturbance forces, significantly improving settling time and stability for high-sensitivity payloads. This capability is particularly beneficial for missions requiring ultra-stable imaging, laser communications, and fine-pointing instruments. Unlike traditional reaction wheels and control moment gyroscopes, MSAC scales with spacecraft size—larger deployable panels provide greater attitude control authority, enabling both enhanced power generation and improved agility in a single system. In this Phase I SBIR, Samara Aerospace will demonstrate and quantify MSAC's active noise-canceling capabilities using an existing two-panel test platform. The

project will also validate controller scalability through simulation, ensuring MSAC can support spacecraft ranging from 50 to 500 kg. Key deliverables include a comprehensive performance report detailing jitter reduction and settling time improvements achieved with MSAC. MSAC has the potential to enhance stability for NASA deep-space observatories, large deployable structures, and high-precision science missions. Beyond NASA, the technology is well-suited for commercial satellite constellations, optical communication networks, and next-generation small satellite platforms that demand low-jitter, high-agility performance.

Duration: 6

Proposal Details

Proposal Number: S16.03-1008
Subtopic Title: Guidance, Navigation, and Control
Proposal Title: Event-Driven High Angular Rate Star Tracker

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

CubeSats have emerged as vital tools for remote sensing, particularly for Earth's atmosphere and surface, yet their compact size poses a challenge for sensors which incorporate rapidly spinning antennas. We propose the development of a CubeSat-ready star tracker capable of providing accurate attitude information to rapidly spinning CubeSats hosting Earth-observing instruments. Current star trackers offer high pointing accuracy under stable conditions but struggle with rapidly spinning platforms. Our solution addresses this critical gap by developing a compact, low-power star tracker that maintains precision even at high spin rates, enabling CubeSats to acquire accurate Earth observation data. The proposed star tracker aims to achieve a pointing accuracy of 0.05° or better across roll, pitch, and yaw axes while the CubeSat spins at up to 20 revolutions per minute (rpm) in low Earth orbit. This capability is essential for off-nadir observations necessary for retrieving ocean surface winds and other atmospheric parameters. We will ensure the SmallSat readiness of the tracker, targeting SWaP (Size, Weight, and Power) characteristics comparable to existing CubeSat payloads. Phase I focuses on demonstrating technical feasibility, outlining a clear path for Phase II integration and testing. Phase II will involve developing a laboratory-tested to space-qualified hardware prototype of the star tracker, reaching TRL 5 to 6. This project aligns with NASA's goals of advancing CubeSat technology for Earth observation, with potential applications in oceanography, meteorology, and environmental monitoring. By enhancing CubeSat attitude control capabilities, this project contributes to the broader objective of improving space-based remote sensing and scientific research.

Duration: 6

Proposal Details

Proposal Number: S16.03-1023
Subtopic Title: Guidance, Navigation, and Control
Proposal Title: Asynchronous Star-Tracker for Real-Time, High-Spin Attitude Control

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

As a response to this solicitation, Alphacore Inc. is proposing a novel star-tracker architecture that leverages Alphacore's patent-pending in-house developed radiation hardened event-based sensor (EBS), offering significant advantages in handling high angular rates crucial for applications encountering high-spin scenarios.It incorporates Alphacore's high-speed image sensor and a powerful processor, enabling attitude computation through advanced algorithms that efficiently process streams of data. EBS introduces a groundbreaking imaging approach for space, potentially solving numerous issues faced by traditional star tracker systems.EBS only record changes in the scene, in a µs temporal resolution and asynchronously; with pixels operating independently. Alphacore's EBS offer several unique advantages that make it particularly well-suited for space applications addressing Space operations' need for speed,Asynchronous Updates providing over 10,000 fps (equivalent),High Dynamic Range for Varied Space Lighting Conditions in space (over 120 db), Lower Latency (order of µs),Reduced Data Volume (shown to be 100x compared to conventional),Robustness to Motion Blur, Payload Limited Power Consumption (<100mW is typical) and Simplified Spacecraft System

Design.In Phase I, Alphacore plans to create a “digital twin” of the system which will be a virtual representation of the physical system (by detailed modeling of each module), that is designed to simulate performance and behavior. and help aid in design of development of the system. The modules will consist of (1) Input Star Pattern Generation (2) Baffle/Stray light suppression (3) Optics (4) Image Sensor; EBS and other image sensors(5) Algorithm (6) On-board real-time computation (FPGA/ GPU/CPU) and (7) Mechanical. We will conduct a comprehensive trade-space study and prototype optimization. As a final step, lab-based proof-of-concept tests using COTS components will be conducted – which will also be used to test the model.

Duration: 6

Proposal Details

Proposal Number: S16.04-1006
Subtopic Title: Suborbital Platform Technologies
Proposal Title: Lattice-based Thermal Mitigation Skin Material for High-Altitude Sounding Rockets

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

This proposal introduces a lattice-based thermal mitigation skin designed to enhance thermal protection while reducing mass for high-altitude sounding rockets and reentry vehicles. The innovation consists of a pure alumina (Al_2O_3) lattice covered with a fused silica-phenolic composite ablative coating, combining high-temperature resistance, mechanical strength, and superior heat dissipation. The alumina lattice provides structural support and thermal stability, while the ablative silica-phenolic layer minimizes heat penetration through controlled charring and insulation. The resin film infusion (RFI) method ensures efficient, scalable manufacturing without autoclave curing, reducing production costs. To validate thermal and mechanical performance, Density Functional Theory (DFT) simulations will optimize lattice porosity, composite formulation, and infusion techniques. Aerothermal simulations (leveraging SpaceWorks' QuickShot™) will model the material's behavior under reentry conditions, while a desktop-scale prototype will undergo thermal and mechanical testing to compare experimental data with computational predictions. This innovation directly supports NASA's Sounding Rocket Program (NSRP) by offering a lightweight, high-performance alternative to traditional TPS materials like PICA and Avcoat. Key advantages include lower areal density, enhanced insulation (thermal conductivity ~0.05 W/m·K), and streamlined manufacturing, positioning it for suborbital reentry and hypersonic applications. Phase I will establish feasibility, paving the way for Phase II suborbital flight tests and collaborations with NASA and commercial aerospace partners.

Duration: 5

Proposal Details

Proposal Number: S16.04-1007
Subtopic Title: Suborbital Platform Technologies
Proposal Title: Stratospheric Balloon Free-Space-Optical Communication (SB-FSO)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 5
Technical Abstract (Limit 2000 characters):

Torrey Pines Logic, Inc. (TPL) proposes developing a complete Free Space Optical communication system design, initial BoM and Phase II development roadmap for a lightweight FSO communication link designed to accommodate the sub-orbital to ground communication requirements. The Phase I effort will conclude with a TRL 3-5 demonstration. Target markets include NASA, DoD, and international needs for low-power high-speed 99.9%+ reliability remote data connection nodes.

Duration: 6

Proposal Details

Proposal Number: S16.05-1002
Subtopic Title: Thermal Control Systems
Proposal Title: Freeze Tolerant Water Heat Pipe and Thermal Switch

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 6
Technical Abstract (Limit 2000 characters):

unar night poses a significant thermal challenge to small, low power payloads, rovers and landers. Due to the slow rotation of the lunar surface, the environmental temperature drops to below 100K for approximately 14 earth days. In order to enable long duration science missions on the lunar surface it is necessary to

maintain the electronics above survival temperature during the lunar night. This requires thermal management technology with high turndown ratios, capable of rejecting waste heat during the hot lunar day and minimizing heat leaks during the lunar night. Other key features include passive operation, high reliability, and lightweight. Variable conductance heat pies (VCHP) and thermal switches can achieve many of these goals but come with drawbacks. For example, ammonia VCHPs require bulky reservoirs of gas and stainless-steel envelopes to achieve the high turndown ratio, and many thermal switches are limited in how much power they can transport. In this SBIR program, Advanced Cooling Technologies will develop a freeze-tolerant water-based heat pipe that uses freezing of the working fluid as a thermal switching mechanism to provide a high turndown ratio (>1000:1). ACT's innovative approach to freeze tolerance will enable the heat pipe to survive an indefinite number of freeze/thaw cycles without experiencing damage due to the expansion of freezing water. The thermal switching feature enabled by freezing the working fluid results in a highly versatile thermal management device with many advantages for lunar applications as well as other space missions and terrestrial uses.

Duration: 6

Proposal Details

Proposal Number: S16.05-1003
Subtopic Title: Thermal Control Systems
Proposal Title: Innovative Advances in Coatings for Extreme Environmental Thermal Radiators and Complex Surfaces

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

This proposal fulfills the technology needs and provides the durable, stable thermal control material systems (TCMS) coatings that is Operator-sprayed with needed structural/adhesive tolerance to coating thickness variation and is dust shedding in charging environments and can furthermore survive and operate in the extreme environments. The recent efforts at AMSENG for the Lunar Applications indicated that the Charge Dissipating TCMS based on the secondary emission engineering are the promising concepts and have very low dust sticking ability to the lunar simulant dust. We propose extending this work towards coatings with newly designed required shelf life Binder concepts for the Cementatious Sols for the extreme environments with the requirements of the Operator-sprayed coatings with needed tolerance to coating thickness variation while meeting the thermal cycling vacuum environments and have the stable space optical, dissipative performance with accelerated, elevated cure schedules with innovative New Engineered Binder systems. Thus, the proposed efforts can address the feasibility evaluation of the advanced dust shedding TCMS coatings for the Lunar and Mars Extreme Environments through: • Process Newly Designed Cementatious Sols for the Shelf life with PZT™, BNNM™, Doped Zn/Mg:βAGO™ and Synthetic Low EOL Pigment Concepts for the passivated Y_2O_3 and $Y_2Ga_5O_{12}$ • Process Selected Pigments with New Rad Hard Cementatious Sol concepts with Elevated Temperature Cure iterations. • Provide the Dust Shedding TCMS coatings concepts for Thermal Control for durable long life and harsh extreme environments • Evaluation and selection of low cost coating processing options, with feasibility proof through GEO simulation, and Dust Simulation • Qualify and recommend Validation efforts for the Reliable Material Systems and processing options for Lunar / Mars Mission hardware

Duration: 6

Proposal Details

Proposal Number: S16.05-1017
Subtopic Title: Thermal Control Systems
Proposal Title: Artificial Intelligence for Spacecraft Thermal Control Systems

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The proposed innovation involves the creation of a user-friendly software tool for the generation of surrogate models for thermal modeling using Physics-Informed Neural Networks (PINNs) and Physics-Informed Deep Operator Networks (PI-DeepONets). When users provide basic system parameters (e.g., geometry, material properties, nominal boundary conditions), the software will generate the relevant

physics-based loss functions and boundary/initial conditions for PINN or DeepONet models. Under the hood, adaptive training schedules adjust the relative weighting of physics losses and data-driven losses, ensuring consistent convergence across a wide parameter space. Users will be provided feedback on training progress, residual errors, and parameter coverage, helping engineers quickly diagnose convergence issues or refine the problem setup. We will also investigate the reliability of generating thermal results directly from CAD geometry, which would significantly reduce the human labor involved with thermal modeling by avoiding the need to mesh geometry. With this automated pipeline, spacecraft thermal engineers can rapidly explore numerous configurations of spacecraft designs without the overhead of manually re-deriving equations or building new surrogate models from scratch. We will use our validated heat transfer software TAITherm/MuSES to generate training and validation data for the physics-informed surrogate models. Once trained, the surrogate models generate reliable temperature predictions in near- real-time, enabling accelerated design iterations and on-demand thermal analysis for operational missions. The tool will target NASA and aerospace industry markets, including commercial and government spacecraft engineers seeking streamlined, cost-effective, and reliable thermal modeling solutions.

Duration: 6

Proposal Details

Proposal Number: S16.05-1019
Subtopic Title: Thermal Control Systems
Proposal Title: Active Thermal Switching OHP Radiator for Lunar Science

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 5
Technical Abstract (Limit 2000 characters):

The number one shortfall identified by NASA technology is the ability to survive and operate through the lunar night. ThermAvant Technologies (TAT) proposes a freeze-tolerant thermal switching Oscillating Heat Pipe (OHP) assembly using a low toxicity working fluid and freeze tolerant azeotrope working fluid to address the challenge posed by S16.05. NASA SBIR S16.05 calls for new capabilities in thermal management for long-duration lunar science, especially focused on surviving the lunar night with temperature excursions as low as -213°C for as long as 14 days, with low toxicity radiator working fluids, and gravity independent performance. TAT proposes to demonstrate the following capabilities not found in State of the Art (SOTA) radiator systems: Thermal conductance ratio of ON to OFF (or turn down ratio) in excess of 600:1. 240:1 has been demonstrated by TAT under a privately funded effort. TAT radiator panels will have a reservoir into which working fluid may be condensed (emptying the OHP and lower conductance) when an OFF condition is desired. This fluid reservoir will be managed with low power heaters to ensure reservoir stays warmer than the OHP when an ON condition is required and by turning the heaters off to allow reservoir to cool below radiator temperature and begin condensing fluid into the reservoir when OFF condition is desired. Calculated conductance in case study (ref Fig 1), is 2.27 W/K when the OHP is ON and 0.0033 W/K when OFF resulting in 688:1 predicted turn down ratio. This will be achieved with a 58% reduction in specific mass and 62% reduction in areal density compared with SOA radiator systems increasing lunar science SWaP-C as reduced mass reduces launch costs.

Duration: 6

Proposal Details

Proposal Number: S16.07-1012
Subtopic Title: Cryogenic Systems for Sensors and Detectors
Proposal Title: Low Vibration Cooling Technology for IR Detectors

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 4
Technical Abstract (Limit 2000 characters):

Cutting-edge space detector technologies rely on low noise sensors that require operation at extremely low temperatures and with virtually no vibration. Examples of these technologies include infrared detectors and low noise amplifiers. Future deep space missions, including the Habitable Worlds Observatory, will benefit from enhanced cryocooler technology that delivers efficient low temperature cooling with

virtually no vibration. On this program, we will develop an ultra low vibration cryocooler configured for the thermal and jitter requirements needed for deep space telescopes similar to the Habitable Worlds Observatory. Our cryocooler is a hybrid cryocooler that simultaneously delivers 100 mW at 4.5 K for cooling a lower temperature cryocooler and several watts of cooling at higher temperatures for intercepting heat. The focus of the effort will be cycle optimization, design and demonstrations for low emitted vibrations. Successful completion of the effort will allow advanced detector technologies to be utilized on future space science missions.

Duration: 6

Proposal Details

Proposal Number: S16.07-1018
Subtopic Title: Cryogenic Systems for Sensors and Detectors
Proposal Title: Advanced Cryogenic Insulation with reduced thermal conduction and high performance at low temperatures

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

Quest Thermal will study engineering options to reduce low temperature conductivity in a novel discrete spacer insulation system. Heat flux at low temperatures, such as found in new integrated cryocooler designs for cryogenic instruments and cryopropellent tanks, is significantly higher than expected. Quest will study discrete spacer design, interlayer height, spacer density and radiant barrier materials to design a novel insulation system. This new system, Low-Temperature-Optimized IMLI, could reduce solid heat conduction through the insulation 2.5-fold, significantly reducing total heat flux. This advanced insulation will reduce cryocooler loads on instruments, and help achieve near Zero Boil Off of propellants. In this Phase I, Quest will design, model, analyze, build and test two prototypes. A new concept, variable spacer density, will be studied and developed, in which the density of discrete spacers is varied, directly reducing heat conduction and increasing thermal performance. A new discrete spacer will be designed. Thermal and structural analysis will be performed. Low emissivity and increased stiffness radiant barrier materials will be studied. Benchtop testing on test samples will be done. A complete small-scale tank insulation system will be designed, built, installed on a test tank, and thermal performance measured using LN2 boiloff calorimetry. Low-Temperature-Optimized IMLI could offer immediate benefits to Artemis landers and vehicles. This new advanced thermal insulation system could be used by numerous lunar landers, rovers and transport vehicles currently in design. NASA, aerospace Primes, commercial lunar payload service hardware providers and commercial satellite providers will all benefit from this new technology and product.

Duration: 6

Proposal Details

Proposal Number: S16.07-1019
Subtopic Title: Cryogenic Systems for Sensors and Detectors
Proposal Title: Miniature 30K Cryocooler

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

West Coast Solutions (WCS) and the Georgia Institute of Technology (GT) propose the development of a Miniature Stirling / Pulse Tube 30K Cryocooler in response to Topic S16.07, Cryogenic Systems for Sensors and Detectors. The proposed effort is essentially the miniaturization of the cryocooler demonstrated on the 2024 NASA Phase I SBIR Sub-10K Cryocooler program, on which 4.88K was achieved with a similar but larger hybrid Stirling / pulse tube 2-stage cryocooler. WCS proposes to leverage miniaturization techniques from our ongoing Missile Defense Agency (MDA) Sequential Phase II SBIR SmallSat Stirling Cryocooler (SSC-X) program to achieve this end. While the target operating point for the proposal is single-stage cryocooling at 30K per the Topic objectives, the use of a two-stage hybrid Stirling/ pulse tube cold head provides operational flexibility to meet a wide range of mission needs, including those benefiting from two stages of cooling and/or utilizing an upper stage to intercept parasitic loads on the lower stage. The use of a Stirling first stage enables high thermodynamic efficiency while the addition of a pulse tube provides a distinct second stage with no additional moving parts, no additional failure mechanisms, no fundamental changes to the upper stage and

essentially the same drive electronics, i.e., the 30K target is met with essentially the same mechanical complexity as a single-stage cooler. During the proposed Phase I, WCS and GT will complete the detailed thermodynamic/fluidic design of a miniature, high-efficiency 30K cryocooler based on the Stirling / pulse tube hybrid architecture, an inherently flexible architecture that broadens the applicability well beyond 30K. The analytical models will be supported by and shown consistent with preliminary solid models to help reduce implementation risk. WCS also proposes under Phase I to perform preliminary performance testing of the pulse tube (2nd) stage.

Duration: 6

Proposal Details

Proposal Number: S16.08-1005
Subtopic Title: Quantum Sensing: Atomic sensors, optical atomic clocks, and solid-state systems
Proposal Title: Atomic beam quantum sensor on a chip

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The miniaturization of high flux, cold alkali atom sources is key to bringing quantum sensors into space applications, as outlined in Science Mission Directorate topic S16.08. This is particularly true for novel areas such as atom-interferometry based precision gravimetry and inertial sensing that are in many ways two sides of the same coin. Achieving these goals requires fundamental innovations that can reduce sensor SWaP (Size, Weight and Power). Currently atom source size is a severe bottleneck due to a fundamental size/flux tradeoff. Existing, mature technologies available for cold atom production still rely on bulky 2D MOTs for which centimeter scale dimensions are usually required. This funding will be used to design and simulate the performance of a chip-scale gyroscope relevant to these applications that uses miniature slow atomic beams. This will disrupt the current paradigm of hand-assembled sensors by deploying semiconductor batch fabrication in all areas of the cold atom sensor architecture that can lower the sensor cost and bring these innovations to everyday use in the growing space markets for government and private customers.

Duration: 6

Proposal Details

Proposal Number: S16.08-1008
Subtopic Title: Quantum Sensing: Atomic sensors, optical atomic clocks, and solid-state systems
Proposal Title: Cooling Lasers for Optical Clocks in Space (CLOCS)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Vescent Technologies, Inc. (Vescent) proposes to develop an ultra-compact, high-power laser system suitable for laser cooling and trapping in space-borne optical atomic clocks. In response to NASA SBIR Topic S16.08 that prioritizes the development of space-qualifiable clock component technologies, the laser system will meet a critical and as yet unmet need for high-power cooling/trapping lasers required to realize field-deployable optical clocks. Current solutions for these laser sources are large (>10 L), power hungry (> 50 W), and sensitive to temperature and vibration, making them unable to leave the laboratory. The proposed MEmbrane eXternal cavity Laser (MEXL) system will output optical powers >500 mW at fixed wavelengths that cover many relevant cooling/trapping transitions for optical lattice and trapped ion clocks. Importantly, the proposed MEXL module has a size, weight, and power (SWaP) that is commensurate with being deployed outside the laboratory, occupying an estimated volume < 500 cm3 and having an electrical-to-optical power conversion efficiency of 10% or better (offering operation with only 12 W of wall plug power). However, these MEXLs have been developed for less stringent performance in biomedical applications and have not been demonstrated in laser cooling/trapping applications that require exquisite control of the laser frequency. Leveraging its expertise in laser frequency stabilization techniques, Vescent will evaluate the frequency and intensity noise properties of commercially available miniature MEXL modules to determine their effectiveness for laser cooling and trapping in optical clocks. The results of these studies will be applied in the follow-on Phase II effort to design, build, and test ruggedized low-SWaP

prototype MEXL systems that have the requisite frequency stability for laser cooling and trapping and a realistic pathway to flight.

Duration: 6

Proposal Details

Proposal Number: S16.08-1020
Subtopic Title: Quantum Sensing: Atomic sensors, optical atomic clocks, and solid-state systems
Proposal Title: Nonlinear Optical Converters for Next-Generation Optical Clocks (NOCNOC)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

We propose to develop Nonlinear Optical Converters for Next-Generation Optical Clocks (NOCNOC). The NOCNOC project will address a critical NASA need for ultra-stable timekeeping in space-based environments by significantly reducing the size, weight, power-consumption, and cost (SWaP-C) of the laser subsystems that currently restrict optical-based clock technologies to the laboratory environment. Our key innovation is the development of a photonic-integrated circuit platform for harmonic frequency conversion to visible and near-ultraviolet wavelengths with record efficiency. While a major strength of the proposed platform is its general applicability to many key quantum systems, NOCNOC will specifically target integration with a Sr+ ion clock targeted for spacecraft use. Phase 1 funding will support subsystem design and modeling, while also de-risking experimental challenges related to thin-film preparation. Beyond NASA, commercial markets for this technology include quantum information processing, secure communications, remote sensing, and spectroscopy.

Duration: 6

Proposal Details

Proposal Number: S16.08-1028
Subtopic Title: Quantum Sensing: Atomic sensors, optical atomic clocks, and solid-state systems
Proposal Title: Robust All-Optical Solid-State Magnetometer for Space

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

Magnetometers are key components of space missions, used for navigation and orientation, sensing planetary magnetic fields and other functions. State-of-art (SOA) magnetometers like fluxgates and helium vector magnetometers have been essential for space exploration and scientific missions, providing valuable data about magnetic fields in space and on planets. They have significantly enhanced our understanding of the solar system's evolution. Magnetometers also play a crucial role in attitude sensing and magnetic geological mapping. Quantum sensors, particularly for magnetometry, have been ranked by NASA (i.e., NASA Civil Space Shortfalls Item #1599) as a promising technology for future space and aviation missions. Systems are highly desired that are simple, ultracompact, highly sensitive, resistant to drift, and stable and robust under swings of temperature (-50 to 250C), radiation and platform noise and vibration. We identify optimal conditions for low-field all-optical diamond nitrogen vacancy (DNV) sensing compared to conventional optically detected magnetic resonance (ODMR) techniques, enabling new applications using all-optical (AO) measurements with less system complexity, size, weight, and power (SWaP). This approach is attractive due to broad sample compatibility, reduced experimental complexity, and inherent robustness to high temperature and radiation. Our AO diode-based vector magnetometer uses no lasers, no microwaves and no signal generators. Its sensitivity (<20 pT/rtHz), accuracy (<1 nT) bandwidth (>500 Hz) and dynamic range (+/- 100 uT) competes with current fluxgates, but with simpler design in smaller footprint (volume < 1 liter, mass < 1 kg and power < 0.5W) that self-calibrates a tri-axial vector measurement based on DNV hyperfine splitting, providing long-term stability. This approach simplifies the system, mitigates need for multiple independent sensors and booms, and resets the engineering trade between magnetometer performance and SWaP.

Duration: 6

Proposal Details

Proposal Number: S16.08-1029
Subtopic Title: Quantum Sensing: Atomic sensors, optical atomic clocks, and solid-state systems
Proposal Title: A Space-Qualified Optical Frequency Comb with Integrated Nanophotonic Heterodyne Module

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 5
Technical Abstract (Limit 2000 characters):

This Phase I NASA SBIR funding will be used to accelerate the development of a compact, space-qualified, octave-spanning optical frequency comb (OFC), an essential component of next-generation optical atomic clocks. The deployment of

optical clocks to space carries far-reaching implications for deep-space travel, global navigation, and precision timing. However, current state of the art OFC designs are not space-qualified due to limitations in size, weight, and power (SWaP) and environmental (vibration and radiation). We will develop a low SWaP, space-qualified OFC system with multi-octave spectral coverage, enabling self-referencing and coverage of relevant atomic transitions for Yb and Sr optical atomic clocks. Our design, based on robust packaging and the replacement of bulky, radiation sensitive components with integrated nanophotonics, will lead to dramatic reduction in SWaP, and to the level of robustness necessary for long-term space travel. Our compact, low-SWaP frequency comb will have a broad impact in both space and non-space based applications. In particular, atomic clocks and (ion/atom-based) quantum computing both require the simultaneous referencing and stabilization of different wavelength lasers, and thus stand to benefit enormously from a low-SWaP, multi-octave-spanning OFC design. We are well-positioned both professionally and geographically to capitalize on this opportunity - the Chi3 Optics team has decades of experience in OFC/nonlinear optics, and is located in Boulder, CO, in close proximity to industry and academic leaders in atomic clocks and quantum computing. We thus expect that this project will naturally drive advancement in the development of these essential technologies.

Duration: 6

Proposal Details

Proposal Number: S17.01-1002
Subtopic Title: Technologies for Large-Scale Numerical Simulation
Proposal Title: TAU Performance Engineering of HPC and AI Applications Programmed in Julia

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 6
Technical Abstract (Limit 2000 characters):

The increased complexity of exascale high-performance computing systems compared to previous generations creates difficulties in productively creating performant and portable scientific codes. At the same time, there is growing demand for techniques for memory-safe programming to increase confidence in correctness. One approach to solving these problems is the use of high-level programming languages designed specifically to target scientific computing. One such language is Julia, which has recently been gaining popularity in high-performance computing for government, academic and industrial uses. High-level Julia code is lowered to an LLVM intermediate language and then to native code, and may also incorporate native library code and be part of multi-language workflows. To get the best performance from Julia code requires performance tools capable of spanning these levels of abstraction. To address this problem, this project proposes to extend the TAU Performance System, a widely-adopted suite of HPC performance tools which currently targets primarily C, C++, Fortran and Python to additionally target Julia. Phase I activities will include evaluating and developing proof-of-concept implementations of Julia profiling support for CPU codes and GPU codes using an NVIDIA CUDA backend. Phase II will extend this to multiple GPU platforms and distributed computing models. The target market includes all organizations which develop scientific codes in Julia.

Duration: 6

Proposal Details

Proposal Number: S17.01-1008
Subtopic Title: Technologies for Large-Scale Numerical Simulation
Proposal Title: QubitCast: A Quantum-Inspired Environmental Forecasting System

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 5
Technical Abstract (Limit 2000 characters):

Our proposal introduces a quantum-inspired multivariate representation learning system to enhance Subseasonal-to-Seasonal (S2S) forecasting and extreme weather event prediction. This innovation addresses key challenges in Earth system modeling by improving the efficiency, accuracy, and interpretability of latent space representations used in forecasting models. Technology Purpose & Innovation: By integrating wavelet transformations, Hierarchical-Tucker (H-T) decomposition, and quantum-inspired optimization, our approach aims to better capture the interactions of Earth system components and thus: - Improves forecast lead times and accuracy for S2S predictions. - Enhances extreme weather event detection, such as heatwaves, cold snaps, squall lines, and high wind events. - Reduces computational

costs associated with model training and inference, making forecasting more efficient. NASA's funding will support the development, validation, and demonstration of QubitCast system. Target Markets & Applications: QubitCast is designed to support NASA's Science Mission Directorate (SMD), as well as broader applications in: - Disaster Preparedness & Emergency Response - Energy, Agriculture, and Insurance Industries, which depend on accurate weather predictions - Trading & Financial Markets, where weather-driven risks impact commodities, and energy markets - Logistics & Supply Chain Management, where better forecasting optimizes shipping routes and operations By delivering a more interpretable, computationally efficient, and accurate forecasting approach, our technology will help improve global resilience to extreme weather events and climate variability.

Duration: 6

Proposal Details

Proposal Number: S17.01-1025
Subtopic Title: Technologies for Large-Scale Numerical Simulation
Proposal Title: NetCDF4 / HDF5 Format Extension Pack (NFEP): Transparently Adding More Formats to NetCDF4 and HDF5

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 6
Technical Abstract (Limit 2000 characters):

This project aims to develop specialized plugins for the HDF5 and netCDF4 libraries, enabling seamless access to NASA's Earth science data formats, including CDF, BUFR, GeoTIFF, and GRIB2. These plugins will allow existing netCDF4 and HDF5 applications to read data in these formats without requiring any code modifications. Our innovative approach will significantly enhance NASA's ability to efficiently manage and analyze diverse Earth science datasets while reducing storage requirements and computational overhead. Additionally, this innovation establishes a unified framework that preserves the advantages of specialized data formats while improving interoperability within the broader scientific data ecosystem through netCDF4 and HDF5. It directly addresses NASA's need for "technologies that can enhance data processing and interoperability across heterogeneous computing resources." Beyond NASA and academia, the targeted markets include industries that rely on NASA's remote sensing data, such as agriculture, disaster management, climate research, and geospatial finance.

Duration: 6

Proposal Details

Proposal Number: S17.02-1002
Subtopic Title: Integrated Campaign and System Modeling
Proposal Title: Campaign Modeling with Data-Oriented Modeling Architectures

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

The space industry faces a critical bottleneck: while launch costs have plummeted, spacecraft development remains expensive due to slow and inefficient design processes. Complex designs exacerbate this issue by increasing the likelihood of costly failures when attempting to cut costs. Vis Viva Space applies data-oriented programming architectures from the video game industry to develop a new data-oriented approach to Model Based Systems Engineering (MBSE) and digital engineering tools for aerospace design applications. This proposal would develop an open source MBSE tool with a design data repository to integrate and automate analysis models as part of a continuous integration pipeline. This approach allows distributed science and engineering teams to interchange data with open, industry-standard interfaces which can be readily adapted to existing analysis tools and does not require developing new digital engineering models. This technology is initially targeted at the aerospace engineering software market, but it also has potential applications in the broader engineering software market.

Duration: 6

Proposal Details

Proposal Number: S17.02-1020
Subtopic Title: Integrated Campaign and System Modeling
Proposal Title: Set-Based Modeling, Visualization, & Trade-Space Exploration for Superior Conceptual System Design

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 5 - 6
Technical Abstract (Limit 2000 characters):

This proposal first explains how TCC's set-based analysis addresses the "cross-cutting challenges" that Topic 17.02 lists that must be addressed to successfully perform conceptual design of the complex system / mission design projects that NASA faces. It then explains how it enables the necessary cross-tool integration. And further, it explains how the set-based design is delivered as an active solver that defines the set of possibilities in a way that you can input narrower decisions and

measurements and see the impact on the conceptual design space, thereby bridging the “phase transition boundaries”. In those explanations, it is fully covering all that is asked for by Topic 17.02. The proposal then sets out Technical Objectives supporting NASA's request of delivering "a working prototype suitable for demonstrations with a compelling case for NASA. Use and development of the model—including any and all work performed to verify and validate it—shall be documented.” It follows with a Work Plan for Phase I that constructs a prototype of such a "compelling case" that can be reviewed by NASA engineers providing feedback on what more will be needed in Phase II for that case to be truly compelling. The proposal then outlines the related R&D in the areas of set-based modeling and analysis, conceptual modeling and analysis, model-based systems engineering, and the handling of uncertainty in modeling and analysis. Finally, the proposal lays out the significant market opportunity that exists, the substantial positive impact that the technology could have on the world, and the role that organizations like NASA could play in exposing that potential.

Duration: 6

Proposal Details

Proposal Number: S17.03-1000
Subtopic Title: Fault Management Technologies
Proposal Title: System Health Monitoring for Deep Space Electrical Power Systems

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

NASA is interested in advanced techniques to provide fault diagnosis for increasingly complex space electrical power systems requiring higher levels of autonomy. Okean Solutions proposes to provide system health monitoring including fault detection and isolation/identification (FDI) to enable reliable and resilient space power. The software solution will support autonomous recovery and reconfiguration of space power systems. Our model-based FDI system called MONSID® determines the health state of power system components so appropriate action can be taken whether the system is healthy or not. It can be applied to monitor any electrical power system, including but not limited to Gateway, Deep Space Transit Vehicle, and Lunar power microgrids. The system can be implemented standalone or integrated with an onboard executive/controller. The primary use case will be in support of load shedding and reconfiguration but health state knowledge and history can also be used for power forecasting. Knowledge of failures can be used autonomously or by human operators to minimize downtime by swapping to alternate components or replacement. MONSID utilizes physics models of hardware functionality similar to digital twins. The modeling technique captures nominal behavior so it can uncover unanticipated off-nominal behavior in addition to known faults. Explicit fault models are not required to isolate the source of faults, which reduces model complexity and simplifies validation. The fault diagnosis engine is compact, deterministic, and application-agnostic making it completely re-usable. During the program, through Phase II, Okean Solutions will demonstrate the effectiveness of the modeling approach and FDI technique for NASA Glenn's autonomous modular power architecture. We will develop MONSID models of power system components and functions, run test cases for nominal and fault scenarios, integrate MONSID with the autonomous power control (APC) architecture, and provide training.

Duration: 6

Proposal Details

Proposal Number: S17.03-1001
Subtopic Title: Fault Management Technologies
Proposal Title: Mission Assurance and Risk Mitigation in the Design of Autonomous Systems using Fault Management

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Fault Management (FM) is a crucial component for ensuring success in science and human spaceflight programs that have systems designed with built-in autonomy for performing complex goals while lowering operations costs. NASA uses a variety of tools to conduct its FM activities. However, these tools are varied and "silo'ed", and

require manual intervention to transfer data from output of one tool to input of another. This process is tedious, error-prone and scales poorly for large, complex systems. This prevents FM engineers from gaining insight into overall system-level design and characteristics that are the key to transparency, verifiability and efficiency of implementing and testing FM. QSI's TEAMS® toolset facilitates the creation, evaluation and integration of FM concepts early in the design process so that adequate detection and diagnosis is built into the system design, thereby lowering the total cost of development; enhanced communication and coordination among stakeholders; reduced development risks through improved quality and traceability; and model reusability to reduce operational costs. QSI plans to develop techniques and concomitant software tools to (1) capture diverse data and multi-source FMEA information into TEAMS® for standardizing FM techniques and processes, (2) develop an FMEA exchange tool that can interchange information in various source formats, and import into TEAMS®, (3) output the TEAMS® FMECA reports and Fault Tree Analysis reports in industry standards-compliant format, and (4) support risk engineering studies, link the design trade metrics to overall system autonomy. The solution will be of interest to NASA and industry including aerospace, efficient buildings, offshore oil-and-gas, industrial automation, offshore drilling, remote research stations, shipboard systems, aviation, and space system developers. The target of the technology is also of commercial value to commercial space sectors and contractors/suppliers of NASA systems.

Duration: 6

Proposal Details

Proposal Number: S17.03-1005
Subtopic Title: Fault Management Technologies
Proposal Title: Robust System Fault Classification & Detection System (RobustDetect)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

NASA Glenn Research Center (GRC) is actively seeking improvements to fault detection and diagnosis, prognosis, fault recovery, and mitigation strategies to achieve greater system autonomy and resilience. For this, American GNC Corporation (AGNC) is proposing the Robust System Fault Classification & Detection System (RobustDetect) based on the observation that a classifier can only be as good as the quality of input data provided to it. The traditional neural network classification approach for fault diagnostics entails training the model on a variety of healthy and faulty operational states of a system to be monitored and deploying the model for real-time inference of system states given input sensor data streams. This assumes that the sensor data itself is an accurate measurement (of similar quality to the sensor data in the training set). However, transducers themselves can experience a myriad of faults (noise, drift, bias, etc.) that can be either intermittent or sustained. Using inherently incorrect data to make a conclusion about the state of a system being monitored is flawed as it will yield false positives/negatives regardless of classifier quality. The RobustDetect system addresses this problem by providing a sensor data validation algorithm that can be applied on sensor data to assign greater weight to sensors that are more likely to be healthy before being fed to a downstream classifier. The scheme involves a learning stage where a set of neural networks are trained to learn different relationships and correlations among the available sensors. Changes to these learned correlations can then be leveraged to determine if a given sensor is experiencing a fault itself and to either generate a virtual reading for that sensor (as a temporary self-healing strategy) or to assign less weight to that sensor within the classification pipeline. The result is a new approach to fault classification that is robust to sensors with degraded or faulty measurements.

Duration: 6

Proposal Details

Proposal Number: S17.03-1021
Subtopic Title: Fault Management Technologies
Proposal Title: Robust Fault Management Tool Suite to Investigate, Develop, and Support FM Approaches and Solutions

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 6
Technical Abstract (Limit 2000 characters):

In Phase, Ridgetop Group, Inc., Tucson, Arizona, shall complete the design and development of a rapid prototype implementation of a Robust Fault Management (FM) tool suite comprising a system of frameworks that enable NASA to investigate, develop, and support the Verification and Validation (V&V) of FM approaches and solutions. The tool suite fills a critical gap in fault classification and management and addresses the following NASA FM needs: 1. Fault management operations and approaches to realize greater system autonomy; FM "in-the-loop," including algorithms, computing, and state estimation and/or classification; and fault detection and diagnosis, prognosis, fault recovery, and mitigation of faults; 2. Fault management design and implementation tools: formalize and optimize onboard FM using model-based system engineering (MBSE) using improved modeling and approaches; and model and define complex systems of systems of data nodes exhibiting faults, failures, FM-related events, and changes in status of complex systems. Significant Phase I activities include completing the rapid prototyping of the following frameworks: (1) System Definition; (2) Input Definition; (3) Output Data, (4) Build System, (5) Load System, (6) Run System. Phase I shall also include the following: (1) prototype demonstration, (2) interim & final proposal for Phase II and III, (3) interim and final Phase I report(s), and (3)

any other deliverables per the contract. Significant functionality includes the following: (1) support distributed data; (2) FM-related events and activities such online/offline; active/standby; maintenance schedule, begin, complete; (3) multiple types of data (existing/historical, simulated, near-real time)from existing files, simulated data, and simulated data: and (4) FM alerts and actions.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.01-1002
Subtopic Title: Enabling Power and Thermal Technologies
Proposal Title: Innovative 20-kW Delta Stirling Generator for Fission Surface Power

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Stirling Innovations, LLC (SI) has introduced innovative delta Stirling machines. Delta engines and coolers are a subset of double-acting alpha free-piston Stirling machines. They are characterized by having a piston on each end of a linear alternator/motor and by optimal heat exchanger interfaces and manifolds. This leads to the potential for the highest efficiency, lightest weight and lowest cost possible for Stirling machines. Development of a 20-kW delta Stirling engine is proposed to directly address NASA needs for high efficiency and high reliability fission surface power convertors. SI uses the flexure bearings with clearance seals technology developed by Infinia and Qnergy to enable unparalleled life and reliability for Stirling machines. These are exemplified by three Infinia engines that have operated at NASA GRC for over 17 years with no maintenance or degradation and thousands of Qnergy remote power generators in the field with no issues for up to 60,000 hours. The proposed Phase I project will expand the existing 20-kW delta engine conceptual design to a fully resolved preliminary design that will be ready for final design at the beginning of Phase II. The anticipated Phase II prototype will be much closer to a pre-production engine than a typical lab prototype because it uses critical components directly from the Qnergy production line.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.01-1010
Subtopic Title: Enabling Power and Thermal Technologies
Proposal Title: Extremely power-dense solar for the extremes of space

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Arinna, Inc. proposes the development of extremely power-dense transition metal dichalcogenide (TMD) solar cells to meet NASA's increasing demand for advanced photovoltaic technologies capable of withstanding extreme space environments. These next-generation solar cells offer exceptional power-per-mass, high radiation resistance, flexibility, and self-healing properties, ensuring sustained performance for deep-space missions, small satellites, and lunar exploration. This Phase I effort aims to rigorously evaluate TMD solar cells under critical space-related stressors, including ultraviolet radiation, atomic oxygen exposure, and thermal cycling. In collaboration with D2Solar, we will conduct environmental testing to validate performance and durability. SpaceWorks Enterprises will assist in optimizing the thermal design, structural integration, and power management of TMD solar arrays for a range of spacecraft configurations. Key deliverables include proof-of-concept validation, performance benchmarks, and recommendations for large-scale system integration, paving the way for further technology maturation in Phase II. Beyond NASA applications, TMD solar cells have significant commercialization potential in commercial satellite operations, defense applications, and terrestrial markets, including IoT, automotive, and building-integrated photovoltaics. Their lightweight, flexible, and durable design enables extended mission lifetimes, reduced launch costs, and enhanced spacecraft efficiency, while their scalability positions them as a disruptive solution in the broader solar energy sector. By overcoming the limitations of traditional photovoltaic materials, Arinna's TMD solar technology represents a transformative advancement in next-generation power solutions, ensuring more resilient, efficient, and adaptable solar energy systems for both space and terrestrial applications.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.01-1012
Subtopic Title: Enabling Power and Thermal Technologies
Proposal Title: Large Format Ceramic Oscillating Heat Pipes

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

In response to NASA FY 2025 SBIR solicitation topic Z-ENABLE.01 “Enabling Power and Thermal Technologies”, scope “Advance Thermal Transport Technologies for Space Missions”, sub-system “Power Conversion System (PCS) Heat Transport” -- ThermAvant Technologies (TAT) proposes a ceramic oscillating

heat pipe (OHP) solution to address two subcomponents: “Reactor to the power conversion system” and “Advanced Heat Exchangers at power conversion system interface”. High temperature heat acquisition and transport is a critical technology gap inhibiting implementation of nuclear energy propulsion (NEP). The development priority is reflected in the STMD 2024 Civil Space Shortfall report, with ID 709: Nuclear Electric Propulsion for Human Exploration at rank 8 of 187 technology areas. NEP requires the acquisition of MW-levels of heat at 1000-1400K from the reactor core, and transport to the power conversion system with temperature drop <150K. Alkali metal heat pipes 3-5 meters long are required. TAT has active NASA funding for development of metallic OHPs for this application and recently demonstrated the first known 3-meter heat pipe operating > 1000K (with SS316 envelope). There is potential to significantly improve reactor designs if large format neutron transparent envelopes (e.g. alumina) are manufacturable and reliable. Target markets: space and terrestrial nuclear heat pipe reactors

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.02-1007
Subtopic Title: High-Performance Space Computing Technology
Proposal Title: Assured Isolation of AI (AI^2) for HPSC Platforms

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Our reliance on space systems continues to increase yet there has been little focus on securing these systems. The same cybersecurity methods that have been adopted on Earth based systems have not yet made their way into space. This may in part be due to the lack of performance and capabilities of Space hardware. Seeing this need to increase the performance and capabilities of space systems, Microchip developed a new High-Performance Spaceflight Computing (HPSC) series of processors that are designed to significantly improve computational capacity for future space missions. With this increased capability, space systems can take advantage of more modern and emerging technologies such as AI. Despite this increase in capability, adoption of emerging technologies within space systems can still be difficult due to the high safety requirements of such systems. For example, adoption of non-deterministic AI algorithms can be difficult because of the unpredictable effects on the safety critical aspects of the system. Also, as space systems become more capable and more complex, they become larger and more impactful targets for malicious actors who may want to compromise these systems through cyber-attack. This proposal presents a solution to mitigate these issues by providing a high assurance base platform using the seL4 Hypervisor on the Microchip HPSC processor. The seL4-based hypervisor on Microchip HPSC solution addresses these challenges by providing a robust and formally verified platform capable of running emerging technologies such as AI algorithms in a secure, isolated, and resilient environment. This solution will provide space system developers with a method to isolate non-deterministic or untrusted applications from the safety-critical subsystems while also providing robust security in their next generation space systems.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.02-1017
Subtopic Title: High-Performance Space Computing Technology
Proposal Title: Multi-Spacecraft On-orbit Space Computing Testbed

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 4
Technical Abstract (Limit 2000 characters):

The future of High-Performance Space Computing (HPSC) promises collaborative decision making and dynamic load sharing across distributed spacecraft, but NASA and the HPSC industry lack an off-world platform needed to rapidly develop and test these capabilities at scale. EarthTraq proposes developing a standalone HPSC testbed into our low-cost small satellite clusters, leveraging our fully funded 4-satellite mission launching in early 2026 as an over-the-air development sandbox needed by the industry. Each low-Earth orbit (LEO) spacecraft, flying in tight formation (<100 km apart), will host a dedicated hardware/firmware/software HPSC testbed for digital signal processing (DSP) and artificial intelligence (AI) coprocessors. This will enable first-of-its-kind advancements in performance,

energy efficiency, scalability, versatility, and resilience of emerging HPSC technologies in a cooperative multi-spacecraft environment. In this Phase I proposal, EarthTraq will develop & prototype the hardware/firmware/software necessary to provide a "sandboxed" testbed using open interface standards for a flexible platform to meet evolving needs. The testbed will be evaluated and integrated into our flight avionics, likely with a Mentium coprocessor or Microchip PIC64-HPSC MPU, onboard each of the four spacecraft. Planned Phase II activities: proton, vibe, and TVAC testing, providing NASA with over-the-air access to the orbital testbed for rapid software iteration, demo coprocessor-based DSP offloading for primary mission tasks, cluster-wide collaborative AI/DSP processing to optimize thermal & power constraints, cluster-wide “tip and cue” activities. Target markets include NASA Exploration, Science, and Space groups looking to eval AI models & distributed autonomy software, HPSC manufacturers seeking flight heritage, commercial & government teams looking for real-world benchmark opportunities or to demonstrate HPSC superiority.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.02-1024
Subtopic Title: High-Performance Space Computing Technology
Proposal Title: PiM-enabled Inference Co-Processor for Long-Range Missions (PICO-LRM)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 4
Technical Abstract (Limit 2000 characters):

Onboard AI/ML processing is becoming increasingly prevalent when finding solutions to latency, bandwidth, and power constraints. PICO-LRM is a co-processor for AI/ML workloads designed specifically for deep space and long-term missions. Processing-in-Memory (PiM) computing eliminates the need to move data between separate memory and processing units, which constitutes the majority of power consumption in traditional computing architectures. Utilizing non-volatile memory (NVM) arrays and radiation-hardened FPGA, PICO-LRM is radiation resistant at the hardware level. PICO-LRM adapts NVIDIA's Deep Learning Accelerator (NVDLA) to offer an end-to-end software/firmware/hardware framework that will allow scientists to develop models using familiar tools, such as PyTorch/TensorFlow + CUDA, for optimized deployment on spacecraft. PICO-LRM is designed for seamless integration into NASA's High-Performance Spaceflight Computing (HPSC) ecosystem as an AI/ML coprocessor and can enable NASA's target of 100x improvement in computational capacity within the same power budget.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.03-1007
Subtopic Title: Advanced In-Space Laser Welding and Nondestructive Evaluation
Proposal Title: Space-Capable Laser for Mars/Lunar ISAM Robotic Vacuum Welding

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Fibertek proposes developing a space-capable laser for Laser Beam Welding (LBW) on Mars, the Moon, and other planetary surfaces, as well as for on-orbit satellite-based NASA and commercial applications. This high-powered laser is crucial for automated robotic LBW manufacturing, which will be used to build communications towers, infrastructure, and habitats on Mars and the Moon initiatives and commercial space stations. Laser Welding might provide a significant cost saving and program accelerant for the US new Golden Dome initiative. The program aims to rapidly mature a minimal viable space welding laser product to TRL 6 by 2029-2030 for a potential space tech demo mission. The laser will be designed to meet space launch and lunar surface environmental requirements. The Phase II deliverable can be tested by NASA in a laboratory or during a parabolic aircraft flight testing program. This SBIR will initiate development towards a near-term tech demo and a roadmap for a high-reliability, 5–10-year space laser welding capability. Laser beam welding is essential for creating larger structures, repairing assets, and repurposing materials. It enables automated robotic manufacturing, which can build tall communications towers, infrastructure, and habitats. Laser welding in space reduces costs and produces stronger, more reliable joints than other methods. It also offers flexibility for real-time repairs, recycling, and re-

purposing of materials.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.03-1017
Subtopic Title: Advanced In-Space Laser Welding and Nondestructive Evaluation
Proposal Title: Laser Ultrasonic Testing for In-Space Welding Environments

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

NASA has expressed a key need for the development and hardening of in-situ instrumentation to support ground-based thermal vacuum chamber testing in which the effectiveness of welds may be studied in a space analog environment, in preparation for inspection during space-capable laser beam welding. In-situ laser ultrasonic inspection has not previously been used to meet this need. This alternative technology has a long history of successes in demonstrating its capability to identify and characterize welding flaws and defects with submillimeter dimensions in-situ, but only in terrestrial environments. Current imaging technologies are limited to flaws and defects apparent at the surface, while current ultrasonic and X-ray technologies are generally not practical in space environments. We propose to adapt a terrestrial laser ultrasonic inspection system for in-situ use in space analog environments. In Phase I we will perform laser ultrasonic inspections of relevant weld samples in our laboratory, and study space analog environments, to arrive at inspection system adaptations that will meet this need. We anticipate demonstrating flaw detection in our laboratory, developing initial designs and test plans for a suitable prototype system to test in space analog environments in Phase II, and developing an initial design for an in-space laser ultrasonic system for detection of critical flaws in welds.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.03-1018
Subtopic Title: Advanced In-Space Laser Welding and Nondestructive Evaluation
Proposal Title: Lightweight High-Energy X-ray Source for In-Space Nondestructive Evaluation

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Long-duration space operation require novel convenient methods of in-space manufacturing. Additive manufacturing (AM) is ideal for the space industry, where part production is low volume and highly customized. However, in order to be fully implemented, the AM components must be inspected for seeing hidden flaws via non-destructive evaluation (NDE). In order to enable accurate NDE of in-space fabricated objects by radiography or computed tomography methods, the MeV-grade X-ray source is required. Although electron linacs represent a mature technology, with an established industrial base, at the present there is no state-of-the-art device suitable for in-space applications. In this project, we will develop a hand-portable X-ray source based on a 2.0 MeV electron linac. The mass and size reduction will be achieved thanks to the operation in Ku-band regime enabled by the revolutionary split linac fabrication technology and novel Marx modulators. In Phase I, we will design the modulator, the X-ray conversion system, and optimize the layout of peripheral components to keep the total weight within 50 lbs. In Phase II, we will build and test the full linac system and fully demonstrate the designed beam and X-ray parameters.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.03-1022
Subtopic Title: Advanced In-Space Laser Welding and Nondestructive Evaluation
Proposal Title: Phase Reflectors as an In-Situ Passive, Unpowered, Wireless Structural Health Monitor for Lunar Excavation Vehicles

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Frequency Selective Surfaces (FSSs) have been used for Structural Health Monitoring (SHM) for detection of normal/shear strain and temperature but must be applied as an external patch to the surface being inspected to monitor changes in the amplitude vs. frequency response of the FSS. This leads to several disadvantages. The first is needing an adhesive to affix the FSS to the surface, which degrades during large temperature excursions (common for in-space use). The second is moduli differences of the adhesive/FSS and the substrate being inspected. This leads to large strain mismatches under load, resulting in a correction factor to properly describe the strain state of the material being monitored. The same applies for

monitoring temperature due to thermal expansion differences. The way that the FSS is installed can affect its performance. Ideally, the FSS could be completely integrated into the base material being monitored. Integration into the parent material itself is now possible by monitoring changes in the phase vs. frequency of the FSS. In this work, Texas Research Institute Austin and the Missouri University of Science and Technology will demonstrate using surface features of the parent material as an in situ FSS (phase reflectors) as a passive, unpowered, and wireless means to remotely monitor the state of the parent material. In Phase I, this will be examined for metallic materials, but the technology will be developed for a wide range of materials such as: metallic, composite, and dielectric (in this case lunar regolith) structures, so a final version of this sensing mechanism would allow: SHM that could provide varying levels of feedback on the health of the parent structure and direct remote inspection of lunar vehicles for engineering properties, such as, but not necessarily limited to: strain, stress, load verification, cracking, corrosion, erosion, disbonds/delaminations, pressure, impact damage, and damage from thermal cycling or impact damage.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.04-1002
Subtopic Title: Robotic Hardware for In-Space Manipulation
Proposal Title: Multi-modal Tactile Sensor for Extreme Environments

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Human beings are exceptionally good at handling and assessing objects in unstructured environments without damaging them. This differs from many robotic applications which require a priori dimensional knowledge of the part. This strategy fails when grasping something like fruit where the irregular size and shape would result in poor grasping and/or damage. Vision-based quality control and assembly tasks also have their limitations. For example, suppose single- or double-digit micron tolerance is required to fabricate a part. This exceeds the tolerance of typical industrial robots and vision systems. Sensate Robotics proposes the Sensate Fingertip, a multi-modal tactile sensor designed for extreme environments, with applications in NASA's robotic manipulation and automation efforts. This innovative sensor integrates force, thermal, and conductivity sensing within a compliant elastomeric structure, enabling robotic systems to achieve human-like dexterity in unstructured environments. Phase I funding will be used to develop and evaluate a functional prototype, focusing on sensor construction, performance validation, and feasibility studies for Diffuse Optical Tomography (DOT) and thermal effusivity sensing. The sensor uses LED-phototransistor arrays for force detection, thermistors and a Peltier device for thermal regulation, and a conductive elastomer layer for material classification. These capabilities enable tasks such as precision assembly, tool operation, and autonomous infrastructure construction. Beyond NASA applications, the Sensate Fingertip has significant commercial potential in advanced manufacturing, quality control, and agricultural automation. It can be integrated into robotic inspection systems for gauge checking in precision machining or automated fruit sorting based on ripeness and firmness.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.04-1005
Subtopic Title: Robotic Hardware for In-Space Manipulation
Proposal Title: Rad-tolerant Avionics & Mechanisms for the Modern Space Economy- RAMMSE

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

Motiv Space Systems (Motiv) proposes RAMMSE—a cost-effective, radiation-tolerant advancement of power-dense actuation, motor drive, and control electronics for in-space robotic manipulation. By leveraging Motiv's existing xLink Gen2 motion control and actuator hardware, RAMMSE bridges the gap between high-cost, long-lead spaceflight hardware and rapidly deployable, lower-cost alternatives. This effort will evaluate, modify, and qualify Motiv's EDU-grade Motor Controller (DELTA Stack) and next-generation actuators to advance toward spaceflight readiness. The active components and sensors within the EDU DELTA Stack motor controller and actuators, derived from Motiv's flight-proven xLink Gen1, will

undergo Total Ionizing Dose (TID) testing and Single Event Effects (SEE) evaluation to validate radiation tolerance. Hardware modifications, including component substitutions, shielding techniques, and firmware mitigations, will be implemented as necessary to enhance survivability in extreme environments. By utilizing pre-existing hardware, this program maximizes development efficiency while reducing cost and schedule risks. The Path to Flight Plan will outline a streamlined approach for transitioning the modified EDU hardware to a space-qualified system in Phase II, enabling broader adoption across NASA and commercial space applications. RAMMSE directly addresses NASA's need for efficient, space-qualified robotic actuation and motor control systems, supporting applications in lunar surface operations, in-space servicing, and ISAM. This technology aligns with NASA civil space shortfalls #1545, #1546, and #1538, establishing a scalable, cost-effective solution for future robotic missions.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.04-1008
Subtopic Title: Robotic Hardware for In-Space Manipulation
Proposal Title: Standardized and Radiation-Tolerant Motor Controllers for Space Robotics

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

The Zeta motor controller is a modular, radiation-tolerant motor control solution designed to meet the demanding requirements of space robotics, satellite actuation, and deep-space mechanisms. The objective of this project is to develop firmware that ensures full compliance with the DS402 standard, enabling seamless integration with existing robotic platforms and expanding support for multiple motor types, including brushed DC, brushless DC, and stepper motors. The firmware development will focus on implementing position, velocity, and torque control modes while ensuring high-precision feedback and robust fault tolerance. The CAN-based communication protocol will be optimized for reliable, low-latency data exchange in space environments. Additionally, adaptive auto-tuning algorithms will be incorporated to streamline motor parameter configuration, reducing the need for manual adjustments and improving performance across various operational conditions. To validate the firmware, software-in-the-loop (SIL) and hardware-in-the-loop (HIL) testing will be conducted, ensuring compliance with DS402 and compatibility with multiple motor configurations. A graphical user interface (GUI) will be developed to provide intuitive control and real-time monitoring of motor parameters, enhancing usability for space and terrestrial applications. By leveraging Novium's dual-path development strategy, the firmware will be tested on terrestrial controllers before transitioning to a radiation-hardened version for spaceflight qualification. The resulting firmware will provide a cost-effective, adaptable, and high-reliability motor control solution for NASA missions and commercial space applications.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.04-1026
Subtopic Title: Robotic Hardware for In-Space Manipulation
Proposal Title: High Dynamic Range Force Torque Sensor

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

A force-torque sensor concept with a high-dynamic range achieved by implementing a multiple flexure design. In this approach, the first smaller set of flexures is attached between the two sensor bodies while another larger flexure set is attached at one body and encapsulated/contained in the other. A gap in the encapsulation/containment allows for the first flexure to deflect freely under specific loads measuring six-axis force and torque before the other set is engaged. Once engaged, the second deflects providing support to the first flexure set and measures six-axis force and torque. This unique multiple flexure design allows for accurate measurement at low loads via the smaller flexure and at high loads via the combined stiffness and deflection measurements of both flexures. Loads are

measured utilized stain gauges and method standard to current force-torque sensors adapted to this unique multiple flexure design. Funding shall be utilized to validate the multiple flexure force-torque concept and compare its dynamic range against standard single flexure designs. Prototypes shall be developed and tested to aid in validation and comparison. Target markets include mechanisms and robotics for lunar, cislunar, and earth orbit. Additional markets include terrestrial robotics and mechanisms.

Duration: 5

Proposal Details

Proposal Number: Z-ENABLE.05-1022
Subtopic Title: Extensible Perception, Manipulation, and Interoperability for Autonomous Robotic Systems
Proposal Title: ATHENA (Autonomous Technology for Habitat Environmental Navigation and Assistance)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

The Autonomous Technology for Habitat Environmental Navigation and Assistance (ATHENA) is an AI-driven robotic system designed for autonomous spacecraft maintenance, anomaly detection, and logistics management. As NASA extends human spaceflight beyond low Earth orbit, ATHENA will enhance operational efficiency by autonomously performing critical tasks, reducing astronaut workload, and ensuring long-term habitat functionality. ATHENA's core capabilities include: AI-powered perception and manipulation, using deep-learning models for object recognition, pose estimation, and adaptive grasp planning. Autonomous anomaly detection, identifying structural issues, leaks, and environmental hazards in real time. Simultaneous Localization and Mapping (SLAM) based navigation, enabling precise movement and interaction within spacecraft interiors. In Phase I, ATHENA will be validated within the Astrobee Gazebo Simulator to ensure seamless integration with existing NASA robotic systems. Funding will support the development of AI-based perception, grasp planning, and navigation capabilities, laying the foundation for hardware-in-the-loop testing in Phase II. Beyond NASA, ATHENA's autonomous capabilities have commercial applications in space station operations, deep-space logistics, and terrestrial industries requiring intelligent robotic automation in complex environments.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.05-1023
Subtopic Title: Extensible Perception, Manipulation, and Interoperability for Autonomous Robotic Systems
Proposal Title: DRAGOMAN: Tools to exchange information between ROS 2 and space mission data formats

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Upcoming missions to the Moon and deep space will require sophisticated software architectures that can support the growing autonomy needs on remote surfaces; such needs are expected to be handled by robotic assets in the absence of permanent human presence. As missions grow in complexity and scope, we can foresee that, rather than depending on a single robot, missions will rely on a variety of robot platforms that will work side by side, collaborating and complementing their technological capabilities to complete complex tasks that a single robot would be unable to realize. To achieve this, robots in space missions will need to leverage the latest technical advances on terrestrial operations. We posit that in order to facilitate the use of state-of-the-art robotic developments for space missions, robot researchers should have available a framework that allows them to develop new technology using their default backend (ROS), while providing them with tools that allow the integration of such ROS-based code with ground & flight mission software, which uses their own particular data exchange formats, such as XTCE - used by the popular YAMCS ground mission control framework - and FPP, the modeling language used by F', and supported by JPL. In this project, named DRAGOMAN (Tools to exchange information between ROS 2 and space mission data formats), TRACLabs proposes to implement a set of software tools that

enables the exchange of data between the ROS software framework and two modeling languages that are fairly used in the space community, XTCE and F Prime (FPP) . Besides their extended use within the space community, we are proposing to create data exchanging tools for these 2 languages and ROS because both of the former are based on XML (FPP files can be converted to XML), so we expect that some of the conversion software tools will be common to both languages.

Duration: 6

Proposal Details

Proposal Number: Z-ENABLE.05-1024
Subtopic Title: Extensible Perception, Manipulation, and Interoperability for Autonomous Robotic Systems
Proposal Title: Space ROS Improvements for Space Flight

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 5
Technical Abstract (Limit 2000 characters):

NASA's Moon-to-Mars objectives necessitate robust autonomous robotic systems capable of performing critical tasks in extreme space environments. However, the lack of a fully mature, spaceflight-verified robotics software framework has hindered the adoption of terrestrial autonomy technologies in space missions. This proposal addresses this gap by enhancing Space ROS, a flight-ready version of the widely used Robot Operating System (ROS), to meet the stringent requirements of spaceflight verification, validation, and performance optimization. PickNik Robotics proposes targeted improvements to Space ROS, focusing on three key areas: (1) reducing static analysis warnings by 50-60% to improve software trustworthiness, (2) optimizing binary sizes by 50% to enable deployment on space-rated hardware, and (3) integrating the IKOS formal verification tool to detect critical runtime errors pre-deployment. These enhancements will streamline Space ROS for real-time operation in resource-constrained environments, facilitating its adoption in NASA's lunar surface infrastructure, In-Situ Resource Utilization (ISRU) systems, and autonomous robotic missions. The Phase I will support the development of systematic code quality improvements, automated dependency management tools, and continuous integration enhancements, ensuring that Space ROS becomes viable for future spaceflight applications. By contributing these advancements to the open-source community, this effort will not only accelerate NASA’s robotics initiatives but also drive broader commercial adoption of Space ROS for safety-critical applications in space, defense, and industrial automation markets.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.01-1002
Subtopic Title: Servicing and Assembly Applications
Proposal Title: Compressor for In-Space Gas Transfer and Pressurization

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Future space exploration missions will entail extended, complex operations in space or on lunar and planetary surfaces, including many that require the efficient transfer and compression of gaseous propellant, pressurant, expendables, or products. Storage pressures may be extremely high, and gases of interest range from helium to xenon. Creare proposes to develop an innovative, compact compressor that will enable collection of essentially all the gas from the supply vessel while pressurizing to extremely high pressures (up to 6,000 psia) in the receiver. Our innovative compression and drive technology enables isothermal compression of any gas using high-reliability components that provide high rates of transfer, maintain ultrahigh gas purity, provide accurate measurement of the transfer rate, and simplify

integration with spacecraft systems. In Phase I, we will prove the feasibility of our compressor through performance analysis, proof-of-concept testing, fabrication demonstrations, and mechanical design.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.01-1006
Subtopic Title: Servicing and Assembly Applications
Proposal Title: Clean Orbital Robotic Arm - COBRA

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The next generation of space-based observatories will benefit from robotic servicing however their performance requires cleanliness not available in state-of-the-art robotics. In addition to telescopes, other applications for ISAM requiring high levels of cleanliness include Silicon-germanium (SiGe) crystal manufacturing and space-based biotechnology. COBRA is a unique architecture which provides a completely sterilizable robot arm which, by design, creates no debris. The hyper redundant kinematic nature of COBRA is modular in two degree of freedom (2-DOF) segments resulting in an “n-DOF” arm as it can be configured to any length desired. Motiv’s 6-DOF customizable force torque sensors can be placed at both the distal and proximal ends of the arm in addition to torque sensing at each joint. That level of sensing can result in high fidelity compliance control. Typically, hyper redundant manipulators are disadvantageous in an Earth gravity environment due to their increased mass relative to conventional configurations and a resulting inability to support their own mass. However, this is not a concern in a micro gravity environment. COBRA is a hyper redundant arm completely sealed in an impermeable barrier. Various methods exist to determine levels of cleanliness of a robotic arm and ensure that an arm is sufficiently clean for ultra-clean environments involves a combination of particle detection, surface analysis, and chemical residue testing. The proposed configuration of COBRA presents a straightforward approach to the inspection methods described above as it is a hermetically sealed device with all exterior surfaces exposed for inspection and aggressive cleaning methods. The scalable and modular COBRA system will deliver the clean robotics NASA requires in a short time while also seeding a commercial market for future ISAM activities.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.01-1007
Subtopic Title: Servicing and Assembly Applications
Proposal Title: Clean Robotics Containment Covers

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

In-space servicing, assembly, and manufacturing (ISAM) is an emerging national initiative to transform the way spacecraft are designed, built, and operated in space. The goal of the initiative is to develop a strategic framework to enable robotic servicing, repair, assembly, manufacturing, and inspection of space assets. Significant improvements in cleanliness of robotic systems that will enable in-space servicing and assembly of highly sensitive spacecraft and platforms, such as the Habitable Worlds Observatory and other future telescopes (Figure 1). With increasing inclusion of in-space servicing, assembly, and manufacturing in future architectures, there is a need to reduce contamination for operations around highly sensitive platforms. The current state of the art for robot systems poses risks for servicing of platforms with ultraviolet systems that may be susceptible to contamination which could dramatically reduce instrument performance. Moving parts, lubrication, thermal management systems, harnesses, and sensors are likely to result in outgassing, particulate ejection, and other forms of contamination. Moonprint will develop containment solutions that can be applied to a range of robotic systems to capture and sequester any contaminants from robotic systems. Containment solutions offer a predictable accounting of contamination sources that can be factored into future standards for quantifying contamination ranges to be

expected. This will aid with verification and validation approaches for mission assurance and account for changes in ISAM robotic equipment over time such as component wear or unpredictable circumstances. Containment solutions will support a layered strategy of contamination mitigation to meet mission specific contamination budgets, including ISAM robotic systems and terrestrial cleanroom equipment such as lifts during manufacture. ISAM cover solutions provide design freedom for robotic system developers and reduce mission costs.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.01-1008
Subtopic Title: Servicing and Assembly Applications
Proposal Title: Helium Refueling Demonstration for On-Orbit Servicing Applications using Efficient High-Pressure-Ratio Compressor

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Flight Works Inc. proposes to develop an efficient helium compressor for on-orbit servicing applications and to demonstrate key elements of the concept under Phase I with hardware tests. As noted in the topic description, the current state of the art for efficient and timely on-orbit transfer of gaseous fluids, specifically helium, in large quantities is nonexistent. Flight Works has been developing such capability for Xenon up to 3000 psi and will adapt that concept to the higher pressures needed for efficient helium transfer. The approach uses a multi-stage compression scheme with inter-stage cooling to optimize the work done on the fluid and reduce waste heat. This scheme allows for a large pressure-ratio of both high outlet pressures (6000 psia) and low inlet pressure (500 psia) to maximize the applicability of this servicing technology. The Phase I R&D technical objectives focus on obtaining high pressure test data with helium to guide the design of the high-pressure helium compressor. This is done by leveraging the Xenon compressor design and using that compressor as a point of departure for helium. This leads to a preliminary design of the flight unit capable of compressing helium from 500 psia to 6,000 psia with less than 600 W. It also includes the development of a (near) detailed design of a flight engineering development unit to be finalized, built and tested under Phase II.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.02-1007
Subtopic Title: Orbital Infrastructure Assembly
Proposal Title: Project Theseus: Orbital Infrastructure Outfitting enabled by a Universal OSAM Connector for Cost-Effective In-Space Assembly

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Starfish Space is building a future where autonomous robotic interaction in space is ubiquitous, enabling a thriving in-space community. An underlying capability critical to these missions is the ability to perform robotic assembly and construction by installing modular components that seamlessly interface to transfer and route power, data, fluids, and more. Starfish Space proposes a Phase I effort to identify an orbital assembly and outfitting mission of interest to NASA, characterize the mission's corresponding Concept of Operations, perform a cost analysis of such a mission with and without OSAM services, and develop and test a functional prototype of a universal OSAM connector to enable the mission with a focus on assured connection, repeatability, and reliability. The innovations proposed here will dramatically boost NASA and industry's ability to upgrade and outfit in-space infrastructure as needed – a key element in meeting NASA's exploration objectives. Imagine a world in which autonomous robotic agents assemble and outfit ambitious structures in space by installing functional modules thanks to universal OSAM connectors prototyped in this work plan. Specifically, multiple commercial satellite operators have experienced hardware anomalies in recent years that could be solved by the type of modular hardware architectures and capabilities for in-orbit interaction that Starfish proposes to develop the groundwork for in this effort. In each case, the OSAM connector proposed for development in this Phase 1 would be a critical element of the mission. For commercial operators, Otter offers a cost-effective way to earn years of additional revenue at a fraction of the cost of building and launching a replacement satellite. Operators find this flexibility very valuable –

and in the future, they could drive that cost down even further by upgrading individual subsystems from propulsion to the revenue payload.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.02-1012
Subtopic Title: Orbital Infrastructure Assembly
Proposal Title: ThinkPlatform: Modular In-Space Construction Powered by ThinkToolkit

Small Business Concern

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Business Official

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

ThinkOrbital's ThinkPlatform is a modular, self-assembling orbital infrastructure powered by ThinkToolkit, a suite of robotic assembly and outfitting technologies designed for large-scale autonomous space construction. This innovation enables the assembly of persistent space stations, fuel depots, large observatories, and multi-mission assets in Low Earth Orbit (LEO) and cislunar space. Current orbital infrastructure is highly customized, constrained by launch vehicle size, and requires extensive pre-assembly on Earth. ThinkPlatform eliminates these limitations by providing a scalable, robotic-assembled framework that can be expanded and reconfigured in orbit, reducing reliance on bespoke, single-use space missions. ThinkToolkit integrates robotic actuators for manipulation, welding, alignment, and latching mechanisms, autonomous inspection tools, and standardized interfaces for power, mechanical mounting, data, and fluid routing. Phase I will establish feasibility through structural framework definition, robotic actuation testing, and core outfitting system development. ThinkOrbital will evaluate key joining methods, interface standardization, and assembly workflows, ensuring that ThinkPlatform can support long-duration, multi-mission infrastructure in space. The effort will conclude with a validated system design, risk assessment, and Phase II implementation roadmap, positioning ThinkPlatform as a cornerstone technology for sustainable, autonomous space construction.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.02-1025
Subtopic Title: Orbital Infrastructure Assembly
Proposal Title: Adaptive Robotic Systems for Orbital Infrastructure

Small Business Concern

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Principal Investigator

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

The construction and maintenance of sustainable orbital and lunar infrastructure including persistent platforms, space stations, space based solar power, space stations, large aperture observatories, and large fuel depots requires flexible, autonomous robotic assembly systems. PickNik Robotics proposes to develop an AI-driven robotic assembly system to revolutionize construction in space. Our solution addresses key limitations in current space-based robotic assembly by leveraging Large Language Models (LLMs) to autonomously generate behavior tree-based task plans from high-level procedural descriptions, removing the need for manual programming. Our system integrates real-time task success verification, allowing robots to self-assess and recover from errors autonomously, reducing reliance on human intervention. With funding from this SBIR Phase I, we will develop and validate our technology using MoveIt Pro, our advanced robotics development platform. We will use our simulation platform to generate training data and simulate orbital assembly conditions. We will train and test LLM-based task planning and verification models, equipping them with anomaly detection and autonomous correction capabilities. By demonstrating feasibility in high-fidelity simulations, we will lay the groundwork for future hardware integration in Phase II. Our target markets include NASA's In-Space Servicing, Assembly, and Manufacturing (ISAM) and Moon to Mars initiatives, commercial satellite servicing, and future deep-space infrastructure projects. Beyond space, our technology extends to terrestrial automation in advanced construction, manufacturing, and logistics. By enabling intelligent, adaptable, and scalable robotic assembly, we are positioning this innovation to drive down costs, increase efficiency, and make long-term space infrastructure viable.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.03-1032
Subtopic Title: Space Debris Prevention for Small Spacecraft
Proposal Title: Deorbit Object with Navigation (DOWN)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

NASA seeks a low-cost and effective method to ensure that all future satellites have postmission disposal. NASA-STD-8719.14C states “NASA space programs and projects are to plan for the disposal of a space structure,,,at the end of their respective missions.” More than 8 million kgs of debris has accumulated in the

near-Earth space environment and if the growth of debris continues, then collisions between satellites and debris will increase in frequency resulting in even more debris. The best way to prevent these future collisions is to remove satellites at the end of their mission. There currently is not a bolt-on non-toxic propulsion system that can provide both a means to deorbit the satellite and do so in a controlled way. What is needed is a smart bolt-on and productized propulsion system that uses autonomous navigation software to coordinate and manage a controlled deorbit. This new system would enable an entire constellation of satellites to be disposed of with minimal human effort. Benchmark Space Systems (BSS) is a leader in space mobility and has multiple commercial product propulsion solutions. BSS proposes to adapt our current bolt-on kits into a Deorbit Object with Navigation (DOWN) bolt-on kit utilizing our in-development ASCENT thrusters and our SmartAIM™ GNC control software for rapid, safe, and controlled disposal of satellites either with direct reentry or Earth escape. The utilization of existing BSS bolt-on kits to base DOWN on greatly accelerates this project. BSS will develop a conceptual design (TRL 4) of the DOWN kit family and perform a system-level analysis as a proof-of-concept to validate the design. Intended markets for this include any companies or agencies manufacturing satellites or developing missions that require controlled disposal at the end of the mission. Additional customers of interest include companies engaged in the building of a constellation of satellites such as Starlink or Project Kuiper.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.03-1036
Subtopic Title: Space Debris Prevention for Small Spacecraft
Proposal Title: Fast Turn-On Thrusters for Space Debris Removal

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 5
Technical Abstract (Limit 2000 characters):

A promising approach to space debris removal is the use of SmallSats to detect, intercept, capture and slow objects in orbit. These satellites must be highly maneuverable and responsive. They must have propulsion systems that have long life and high power and yet are not encumbered by excessive weight or size. They must have great dynamic range to allow them to rapidly respond when debris is detected. Ion propulsion is the most economical and practical approach to this end. Both Hall and Ion Thrusters will be considered. The most critical performance limiting element in these thrusters are the discharge cathodes that provide the electrons for ionization of the inert gas that is fed into the ionization chamber. This proposal offers three state-of-the-art cathodes which will provide the quick response times, fast turn-on and long life (15 years) that are needed for this purpose. The cathodes are planar scandate, ternary alloy, and planar reservoir. Further, it offers a new cathode geometry that supersedes present hollow cathode art. The new geometry allows thrusters to have turn-on times as little as 8 seconds.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.03-1042

Subtopic Title: Space Debris Prevention for Small Spacecraft
Proposal Title: Enhanced On-Orbit Safety through Autonomous Operations Across Domains

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Scout Space proposes a groundbreaking autonomous Space Traffic Management (STM) system to mitigate the increasing collision risks posed by the rapid proliferation of spacecraft and orbital debris. Traditional ground-based tracking systems suffer from latency and coverage limitations, creating operational blind spots that threaten spacecraft safety. Scout's innovative approach integrates low Size, Weight, Power, and Cost (SWAP-C) optical SDA payloads with proprietary real-time collision analysis algorithms, enabling onboard autonomous decision-making for self-protect maneuvers. Unlike conventional STM methods that rely heavily on ground-based intervention, Scout's AI-driven system enables real-time autonomous collision risk assessment, reducing operator workload and enhancing orbital safety. By leveraging multi-source tracking—including Slingshot

Aerospace's Global Sensor Network (GSN)—Scout's solution ensures more precise conjunction analysis and dynamic risk mitigation. This next-generation STM architecture reduces reliance on human-in-the-loop operations and significantly improves spacecraft survivability in increasingly congested orbits.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.03-1048
Subtopic Title: Space Debris Prevention for Small Spacecraft
Proposal Title: Green Propellant Rapid Orbital Mobility Bus

Small Business Concern

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Principal Investigator

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Parabilis Space Technologies is pleased to propose the development of a low cost, high thrust, hybrid propulsion module using indefinitely storable, non-toxic, green technology propellants to provide rapid mobility for collision and threat avoidance as well as enhanced orbit insertion, deorbit, and disposal. The solution is designed to operate in LEO to Cislunar orbit regimes and scalable to support payloads or spacecraft ranging from Cubesats to ESPA Grande class smallsats. ROMBUS-Evolved (ROMBUS-E) is steered via gimbaling the entire hybrid motor, which is enabled by a novel case design and the short form factor of the motor. Nitrous oxide is stored in four tanks in the corners of the vehicle, which also provide the primary load path between the launch vehicle MLB and the payload. The entire stage fits within a 24-inch by 28-inch by 22-inch height volume. Benefits include significantly lower cost than traditional mono-prop or bi-prop chemical systems, indefinitely storable on-orbit or on the ground, high thrust for rapid mobility, throttleable and restartable, and low freezing non-toxic propellants. The baseline concept will provide over 1000 m/s delta-v to small payloads and 635 m/s to a 105kg payload. The design is scalable to larger payloads. During Phase I, Parabilis will manufacture, and test a nitrous-oxide reaction control system, burning down both technical risk and the effort required for a successful hot fire test in a subsequent Phase II effort. This effort leverages previous successful NASA-funded R&D at Parabilis for a “NanoLaunch” hybrid upper stage in addition to over 3 years of Smallsat hybrid propulsion R&D efforts for a Proprietary major aerospace company. This approach will rapidly and substantively reduce risk for further Phase II development.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.04-1007
Subtopic Title: Low Earth Orbit (LEO) Sustainability
Proposal Title: LEO Debris Tracking and Remediation Using Advanced Beam Control

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

A high level system design for detecting, tracking and delivering a pre-compensated pulsed laser beam to LEO debris will be developed. The system will employ Rayleigh and sodium guidestars and multiple adaptive optics loops with high resolution deformable mirrors. Analysis will be performed to establish technical requirements and assess expected performance and efficacy. Funding will support the necessary research, design, and analysis work. Target market are NASA LEO debris mitigation in particular, but may also include free-space optical communication with ground and satellite terminals, astronomy, and long-range imaging.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.04-1017
Subtopic Title: Low Earth Orbit (LEO) Sustainability
Proposal Title: Adaptive 4D Radar for Debris Tracking

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Maintaining SSA dominance requires a pivot to include a more agile, predictive, and intelligence-driven solution that can fill in geographical and time-based gaps in coverage into the space enterprise SSA effort. A novel system is proposed that combines 4D radar, AI algorithms, and onboard computing in a small SWaPC component implementation on a commercially available small satellite to demonstrate the feasibility. The proposed platform technology will address subtopic Z-EXPAND.04 (LEO Sustainability), by providing agile solutions where: 1) more small debris is detected, tracked, and custodied on orbit, 2) potential detect/track gaps from a ground system are covered to increase safety of manned space flight, and 3) onboard software can be updated as needed to enable future high-

performance. Initial Operational Capability would follow a SBIR Phase III effort and commercialization plan to deploy a constellation to provide continuous initial coverage of regimes of interest out to 1500km as an additional SSA layer to planned solutions. Numerous scientific studies relating to space-based millimeter wavelength sensing and communication technologies exist, although none focused on specific detection of 1-10 cm-sized debris object detection in Low Earth Orbit (LEO). This proposal offers the opportunity to combine several technologies into a low cost solution for a challenging technical problem of small orbital debris detection and tracking at agile timeframes: COTS microelectronics capable of high speed, high bandwidth multi-channel signal processing; advanced radar techniques that take advantage of small footprint/GHz compute speeds; This FPGA approach is combined with powerful computing at the edge to maintain custody of debris for further tracking (via a small constellation) or handoff to remediation assets on the ground for elimination. A small constellation that provides this service serves to maintain continuous custody, subject to sensor refresh windows.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.04-1019
Subtopic Title: Low Earth Orbit (LEO) Sustainability
Proposal Title: Bolt-On Capture Detumble Deorbit Device

Small Business Concern

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Principal Investigator

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The development of technology to enable the capture, detumbling, and, if necessary, de-orbiting of errant orbiting space objects is crucial for the long-term sustainability and safety of space operations. As the number of satellites and spacecraft in Earth's orbit increases each year, so does the amount of space debris which pose a serious danger to both current and future space missions. Without the ability to manage the growth of these errant objects, the likelihood of collisions will increase dramatically, triggering a cascade of events often referred to as the Kessler Syndrome, where each collision generates more debris, further escalating the risk of additional collisions. In the proposed effort, we will carry out a design for a Bolt-on Capture, Detumbling, De-orbit Device for Space Objects, the BoCaD. The design will build on the work we did in the past, where we used inflatable booms constructed from laminates of structural fabric. The booms start as straight, and upon contact with the object, can be commanded to grapple around it. The tumbling rate is reduced with the use of small thrusters in combination with a pair of cable-attached yo-yo masses. If de-orbiting is desired, a BoDe (Bolt-on Deorbiter for Satellites) device deploys, increasing the system's surface area against the atmosphere. For higher altitudes, where there is very little to no atmospheric drag, a passively self-articulating vane skirt powered by shape memory alloy material is used. The vanes passively follow and unfollow the sun to capture and avoid solar radiation pressure, depending on what side of the orbit the device is on. The object loses orbital energy on the ram side of the orbit and avoids absorbing solar pressure on the other side. The end result is a gradual decrease in orbital altitude, eventually leading to orbit decay. The vanes can be reversed if it is desired to place the object in a higher altitude parking orbit.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.04-1025
Subtopic Title: Low Earth Orbit (LEO) Sustainability
Proposal Title: Extending Space Debris Tracking to Sub-10 cm Objects with Next-Generation Radar

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 6
Technical Abstract (Limit 2000 characters):

LeoLabs Federal, Inc. (LeoLabs) proposes to develop a next-generation ground-based radar system to protect satellites and astronauts from small debris in low Earth orbit (LEO). This technology will address the critical gap between shielding, which is effective for debris I centimeter and smaller, and active collision avoidance, which currently tracks debris IO centimeters and larger. LeoLabs proposes to pursue two activities to deliver on this objective. One, to verify its Ranger™ ground-based radar technology will track debris as small as I centimeter-wide. Designed with modular architecture, this technology supports a range of radar types, from small, mobile radars for monitoring highly maneuverable satellites to

powerful fixed-site radars capable of tracking smaller debris. We will also investigate enhancements to enable tracking of the smallest objects, including possible enhancements to develop a higher frequency version of the radar. Two to design the software algorithms to detect and catalog hundreds of thousands of previously untracked small debris. This will be done in a scalable manner, that optimizes the use of radar time and cloud resources. LeoLabs currently maintains an operational catalog with 23,000 objects. LeoLabs will execute Phase I within 180 days, delivering a final report that lays the groundwork for the next phase of development. By the end of Phase II, the company will have a prototype tested on the benchtop, demonstrating its feasibility. Ultimately, this technology will be deployed into LeoLabs' operational, world-wide LEO safety system that today serves 75% of all the satellites in LEO, US government agencies, and allied government agencies. The current network consists of seven ground-based radar sites housing a total of 11 phased-array radars. LeoLabs designs and operates its own radar technology and maintains the world's largest commercial satellite catalog, along with the cloud-based software system that manages it.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.05-1007
Subtopic Title: Beyond LEO Sustainability
Proposal Title: Lunar Sentinel

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

Advanced Space and partner AstronetX envision a future constellation of spacecraft at the Moon in low lunar orbits (LLO) and/or an array of telescopes at Commercial Lunar Payload Services (CLPS) landing sites that provide close-approach risk assessment of spacecraft at the Moon. This vision is called Lunar Sentinel. In our strategic mission concept, our team aims to optimize the use of space-based sensors to provide metric observations of non-transmitting spacecraft and cooperative assets orbiting the Moon. The primary goal of this proposed effort is to provide space situational awareness (SSA) for the growing cislunar market and to prevent collision events at the Moon. The collaboration proposed here is our plan to de-risk vital technical elements of the Lunar Sentinel mission concept for NASA. Advanced Space is the prime contractor for the Oracle-P mission for AFRL/RV, which is the first step toward SSA stationed at the Earth-Moon Lagrange Point 1 (EML1). Additionally, Advanced Space owns and operates the Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE™) mission with NASA STMD funding, which has provided strategic lessons learned in cislunar operations, navigation, and communications. AstronetX currently has a Phase III contract with AFRL/RV to mature their Lunar-Cam (L-CAM) space-based sensor to be hosted on commercial orbiters and lunar landers to provide unique size, weight, power, and cost (SWaP-C) efficient optical tracking data services. This team and the collective vision for the proposed effort are designed to prove out key capabilities necessary to make the Lunar Sentinel mission architecture an effective reality: specifically, the framework for an accurate SSA system capable of detecting, tracking, and maintaining custody of multiple non-transmitting spacecraft through high-resolution, rapid imagery enabled by precision position, navigation, and timing (PNT) capabilities.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.05-1011
Subtopic Title: Beyond LEO Sustainability
Proposal Title: Clavius-S: Lunar Surface Sensor Payload for Orbital Object Detection

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Astrobotic proposes the development of a lunar lander-based imaging payload to detect and track spacecraft in lunar orbit. Operating from the surface of the Moon brings the sensor closer to targets and below the glare of the lunar surface. We propose Clavius-S, a lunar surface derivate of Astrobotic's existing low size, weight, and power space situational awareness (SSA) sensor to enable practical detection and tracking of non-transmitting spacecraft and debris in low lunar orbit (LLO). Astrobotic's high performance space compute combined with heritage SSA software enables real-time detection. Integrated aboard lunar landers under NASA's CLPS initiative, this instrument would provide affordable access to data required to

perform reliable conjunction assessments and safeguard lunar missions. The proposed effort adapts an SSA sensor system developed under AFRL contracts to operate from a lunar lander and survive the extremes of the lunar night. This system already incorporates a low SWaP design, a validated optics and imaging train that exceeds LLO detection requirements, and significant onboard processing to handle inherent downlink limitations. In Phase I, the Astrobotic-led team will: 1. Develop a detailed ConOps capturing system architecture, mission environments, and a reference mission, 2. Assess requirements for obtaining metric observations of LLO spacecraft from the lunar surface, 3. Perform a trade study of lunar night survival approaches and develop a thermal model of the sensor, 4. Generate and deliver a synthetic image dataset and assess algorithmic tuning for the existing SSA pipeline, and 5. Identify technology maturation goals and Phase II plan to develop a lander hosted payload. Following Phase I, the system will be well-positioned to rapidly develop and test a prototype and flight hardware design. Our path-to-flight approach emphasizes our intention to field Clavius-S for operation on the Moon, e.g., on one of Astrobotic's future lander missions.

Duration: 6

Proposal Details

Proposal Number: Z-EXPAND.05-1016
Subtopic Title: Beyond LEO Sustainability
Proposal Title: Monolithic Highly Porous Aluminum Deployable Micrometeoroid Impact Shields

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

McMurchie Engineering, LLC proposes to investigate the performance of additively manufactured very high porosity aluminum as a monolithic shielding material, to be printed as panels and deployed around the Habitable Worlds Observatory (HWO) in a quasi-cylindrical form. These panels will be structurally sound to the point of being able to support not only their own mass, but also other key systems like thermal insulation. The panel design is itself an excellent insulator and is easily adaptable to match the range of micrometeoroid sizes and fluxes expected at Earth-Sun L2. Over the course of this Phase I SBIR we will print several varieties of this highly porous aluminum shielding material and directly compare its impact shielding performance to conventional Whipple shields using a light gas gun shooting 2mm diameter projectiles at velocities up to 6km/s.

Duration: 6

Proposal Details

Proposal Number: Z-GO.01-1003
Subtopic Title: Cryogenic Fluid Management
Proposal Title: Magnetic Bearings for Cryogenic Fluid Management

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Cryogenic Fluid Management (CFM) systems aboard spacecraft employ reverse turbo-Brayton cryocooler compressors and turboalternators that require maintenance-free operation up to 400,000 RPM for an operational lifetime of 50,000 hours. At these speeds, traditional rolling element bearings fail due to the friction between the rotating and stationary components and require frequent maintenance due to lubrication requirements. Mainstream proposes a hybrid magnetic bearing system that offers non-contact operation over the full range of rotational rates. The hybrid system employs passive magnetic components to reduce the size, weight, and power required while the remaining active components provide the controllability that is necessary to maintain stable operation in the presence of dynamic loads. In the Phase I, Mainstream will leverage our experience in magnetic bearing and turbomachinery design to optimize, fabricate, and test a bench-scale prototype bearing system. At the end of Phase I, Mainstream will validate the design by measuring the performance of the bearings in terms of load capacity and stiffness under static conditions. In the Phase II, Mainstream will design a full-scale system and integrate the hybrid bearings. At the end of Phase II, Mainstream will

demonstrate the system and bring the technology to TRL 6.

Duration: 6

Proposal Details

Proposal Number: Z-GO.01-1004
Subtopic Title: Cryogenic Fluid Management
Proposal Title: Robust Highly-Multiplexed Fiber Optic Sensor Array for Cryogenic Fluid Management

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 6
Technical Abstract (Limit 2000 characters):

In response to NASA’s requirements for a distributed temperature measurement system for cryogenic fluid management (CFM), Opterro proposes to demonstrate the feasibility of a scalable high-resolution temperature measurement system that can accurately measure temperature at multiple locations on a single optical fiber at least 1 meter long at cryogenic temperatures. Innovation is in the combination of features including interrogation and sensor array having ruggedness, reliability, sufficient number of sensors, high spatial resolution, high sensitivity, and excellent measurement repeatability in the cryogenic temperature range to meet the CFM needs. In Phase I, Opterro will demonstrate an end-to-end fiber-optic cryogenic temperature measurement system comprising a photonic-integrated-circuit (PIC) based interrogator and a meter-long temperature measurement fiber with better than centimeter-scale spatial resolution and 0.5 K temperature measurement resolution down to liquid hydrogen temperature (20 K). Opterro will leverage its previous spectrally-multiplexed multipoint temperature sensing work, performed in cryomodules for the particle accelerator community, and translate the learnings and results to high-TRL application for NASA and commercial CFM applications.

Duration: 6

Proposal Details

Proposal Number: Z-GO.01-1007
Subtopic Title: Cryogenic Fluid Management
Proposal Title: Fiber Optic Sensing for Temperature (FROST) for CFM

Small Business Concern

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Principal Investigator

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

The Fiber Optic Sensing for Temperature (FROST) system is an advanced, high-resolution cryogenic temperature sensing solution designed to enhance propellant storage, fuel transfer, and structural health monitoring (SHM) for space applications. Unlike traditional point-based sensors (e.g., RTDs, thermocouples, and discrete FBGs), FROST leverages high-definition distributed fiber optic sensing (HD-FOS) to provide continuous temperature measurements along a single fiber strand with sub-millimeter resolution from 350K down to 20K. FROST integrates seamlessly into Type I–V Composite Overwrapped Pressure Vessels (COPVs), cryogenic pipelines, fuel transfer lines, and insulation layers, offering real-time temperature mapping, gas/liquid interface detection, and structural monitoring without the need for electrical components inside the cryogenic environment. This innovation is critical for NASA's long-duration space missions, lunar/Mars ISRU propellant storage, and in-space refueling architectures, reducing boil-off losses, enhancing safety, and improving system efficiency. Funding from the Phase I will be utilized to advance the FROST system through initial prototype demonstration of distributed direct-internal and indirect-external temperature sensing and identify key materials, designs, and manufacturing considerations for Phase II development supporting scalable temperature sensing of CFM systems. Phase I funding ($150,000) will focus on design, prototype development, and validation down to 77K, with Phase II advancing the technology for full-scale integration to 20K. The commercialization strategy will target NASA's Artemis, Lunar Gateway, and deep-space fuel depot programs, as well as commercial spaceflight and terrestrial applications in hydrogen energy storage, superconducting power systems, and industrial cryogenics. FROST's scalable, lightweight, and electrically passive design positions it as a breakthrough sensing solution for next-gen. CFM systems

Duration: 6

Proposal Details

Proposal Number: Z-GO.02-1002
Subtopic Title: Space Nuclear Propulsion
Proposal Title: Radiation and H2 Durable Nuclear Thermal Propulsion Fuel Element Insulator

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

NASA’s Marshall Space Flight Center (MSFC) has identified a need for new higher-temperature fuel element insulators for fission-based, liquid hydrogen (H2) fueled, Nuclear Thermal Propulsion (NTP) engines. NanoSonic is a small, advanced materials company currently supporting two NASA CubeSat flights in 2025 with

our radiation shields as well as the LGM-30G Minuteman III Intercontinental Ballistic Missile (ICBM) with parts that must survive extremely harsh environments. While NTP reactors offer a specific impulse of ~ 900 seconds, more than twice that for state-of-the-art chemical rocket engines such as the Saturn V, weight reductions are still needed. Space nuclear propulsion (SNP) and doubled fuel efficiency may cut current transit time to Mars of 6-months by half, as well as astronauts' exposure to galactic cosmic radiation (GCR) and supplies needed. Current insulators are based on combinations of SiC, ZrC, and graphite materials. For this SBIR, a new low thermal conductivity nanoporous ceramic insulator is offered based on SiC and ZrC MXenes layered with HfC and TaC to increase thermal stability up to ~4,000 ºC. This design shall minimize heat transfer between the high temperature fuel elements of 2727 ºC and lower temperature moderator material of 527 ºC to enable further mass reductions and higher-temperature gas-reactor performance for future small NTP reactors.

Duration: 6

Proposal Details

Proposal Number: Z-GO.02-1006
Subtopic Title: Space Nuclear Propulsion
Proposal Title: Lightweight Zirconium Carbide Insulation for High Temperature Space Nuclear Propulsion Systems

Small Business Concern

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Principal Investigator

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The thermal insulator for fuel assembly structures of nuclear-thermal propulsion (NTP) reactors must withstand the high temperature (>2500°C) hydrogen operating environment and provide sufficient thermal resistance to ensure adequate heat retention within the fuel assemblies for propellant heating and to achieve the target specific impulse. The insulation package must possess low thermal conductivity within a hydrogen environment at the upper range of reactor operating temperatures. Zirconium carbide (ZrC) is a favored insulator material for the extreme temperature ranges of NTP reactors given its stability in hot hydrogen and acceptable neutronics characteristics. In previous work for BWX Technologies (BWXT), Ultramet established the initial feasibility of producing a low-density ZrC insulator by converting porous carbon structures (felt and open-cell foam) to ZrC through reaction of the carbon structures with a vapor containing zirconium at high temperature in a chemical vapor deposition reactor. However, significant materials optimization and properties testing remains to be performed to optimize the thermal conductivity and structural integrity of porous ZrC insulation. In this project, Ultramet will team with BWXT (the end user of the technology) to further develop the insulation through materials fabrication, thermal and mechanical properties testing of small development specimens, and thermal modeling. Mapping of thermal conductivity across various porous ZrC insulator architectures will be performed to identify insulators capable of achieving the target range of thermal conductivity while also exhibiting satisfactory mechanical properties and resiliency to be incorporated into the overall insulation package envisioned for high specific impulse NTP reactors.

Duration: 6

Proposal Details

Proposal Number: Z-GO.02-1008
Subtopic Title: Space Nuclear Propulsion
Proposal Title: High Temperature Radiator Coating

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

The proposed innovation centers on a high-temperature radiator coating designed for use in nuclear-electric spacecraft, where long-term stability, high emissivity, and low solar absorptivity significantly reduce the radiator area for a heat rejection system. The technology's purpose is to provide a robust, thermal control coating operating at temperatures up to 750 K, withstand harsh space conditions, and reliably bond to lightweight carbon-carbon substrates. Phase I funding will be used to demonstrate the feasibility of a zirconium silicate-based thermal control paint by compounding the new coating, applying it to carbon-carbon test panels, cycling it between low and high temperatures, and characterizing its optical properties and adhesion performance. The broader aim is to lower spacecraft mass and volume by

enabling more efficient heat rejection in nuclear-powered missions. Target markets include NASA programs and commercial entities requiring high-temperature radiators, such as spacecraft utilizing nuclear-electric energy, lunar or Mars exploration platforms, and industries needing vacuum-compatible coatings (e.g., semiconductor equipment and high0-temperature industrial processes).

Duration: 3

Proposal Details

Proposal Number: Z-GO.03-1000
Subtopic Title: Solar Photon Sails Research and Technology Development
Proposal Title: Scalable Optically-tuned Lamellar cerAmic Reflective Intra-heliospheric Sail (SOLARIS)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

We propose Scalable Optically-tuned Lamellar cerAmic Reflective Intra-heliospheric Sail (SOLARIS), an innovative solar sail designed to explore the inner heliosphere extremely close to the Sun (perihelion of 0.03 AU, or ~6.45 solar radii). SOLARIS employs a scalable, three-layer ceramic structure with honeycomb-corrugated geometry, optimized for thermal stability (up to 2000 K, 3-4 times higher than polymer solar sails), structural integrity, and constructive optical interference. At this distance (0.03 AU) and temperatures (~2000 K, assuming absorptivity of 0.007 and emissivity of 0.08), SOLARIS significantly improves thermal resilience compared to traditional polymer-based sails (e.g., aluminized polyimide), while maintaining low areal density, high broadband reflectivity, and ease of scaling beyond 1600 m^2. Importantly, our scalable fabrication process does not require photo or e-beam lithography. SOLARIS provides critical capabilities for heliophysics and interplanetary science, especially for NASA missions requiring a large Delta-v (through Oberth maneuver), such as (1) high-inclination solar imaging, (2) out-of-the-ecliptic maneuvering, (3) accessing hard-to-reach asteroids, and (4) fast transit to the solar gravity lens. In comparison, traditional aluminized polyimide sails (IKAROS) operate under 600 K and cannot safely approach within even 0.2 AU of the Sun. The anticipated outcome of this Phase I project is to provide NASA scientists with Goeppert's proof-of-concept development of the three-layer, honeycomb-corrugated, broadband-reflective ceramic sail. The funding sought in this proposal is intended for the modeling, fabrication, and characterization of SOLARIS. This work sets the stage for further collaboration with NASA MSFC team to align our work to their needs. Target markets include next-generation heliophysics and interplanetary science missions led by NASA and private space companies, as well as the industry of high-temperature reflective materials.

Duration: 6

Proposal Details

Proposal Number: Z-GO.03-1006
Subtopic Title: Solar Photon Sails Research and Technology Development
Proposal Title: High Thermal Performance Booms and Integrated ACS

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

Opterus proposes the development of High Thermal Performance Booms enabling low complexity, mass efficient solar sail attitude control systems for missions 0.40 AU and nearer to the Sun. Solar sails harness radiation pressure from the Sun for propulsion, negating the need for exhaustible propellants. As solar sails travel closer to the Sun their operational efficiency increases. This can be leveraged for dynamic orbital sling shot maneuvers around the Sun to achieve high velocities for interstellar exploration. Additionally, the increased solar radiation pressure allows solar sails to combat the Sun's gravitational pull to achieve rapid decelerations for observational missions near the sun. To take advantage of the strong radiation pressure near the Sun, solar sail components must be able to survive and operate in the inherently more extreme thermal environment. With the funding allocated for this program high performance boom architectures will be adapted for manufacturability with high thermal performance materials that will enable the structure integrated attitude control approach previously developed by Opterus. This technology will address current gaps in thermal survivability for sail controls and structures enabling near term and future science missions for NASA and NOAA.

Duration: 6

Proposal Details

Proposal Number: Z-GO.03-1007
Subtopic Title: Solar Photon Sails Research and Technology Development
Proposal Title: Ultra-Thin, Flexible InGaP Solar Arrays Embedded In Solar Sails for Power Generation

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 6
Technical Abstract (Limit 2000 characters):

Solar sail missions can only use embedded photovoltaic (PV) arrays that are low-mass, high-performance, radiation-hard, and stable in near sun environments. Amorphous Si (<10% AM0 eff.) and CIGSe (< 11%) have been tested for these reasons, but their already low efficiency drops at high temperature. MicroLink Devices proposes a single junction (SJ) epitaxial lift-off (ELO) InGaP PV device that can be embedded in solar sails. ELO removes the PV device structure from the growth substrate, providing ~50x mass reduction, ~30% cost reduction, and results in very flexible PV. It allows for a back surface that reflects ~80% of solar photons (> 650nm), provides thrust, enables low temperature operation in near Sun environments (~50oC cooler vs. conventional space PV), and simplifies power management and distribution. High efficiency is expected under operating conditions (>15% AM0 eff., >900 W/kg) with excellent radiation tolerance (<4% drop at 1 x1015 e/cm2, 1 MeV electrons). These features make the proposed cell an ideal candidate for powering distributed solar sails.

Duration: 6

Proposal Details

Proposal Number: Z-LAND.01-1002

Subtopic Title: Parachute Systems for Maneuverability and Wireless Data Acquisition
Proposal Title: Wireless Instrumentation for Sensing of Parachute Systems (WISPS)

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

The Interdisciplinary Consulting Corporation (IC2) proposes to develop a battery-operated, low-power, compact wireless data-acquisition (DAQ) system specifically designed for instrumenting parachute systems during entry, descent, and landing (EDL). This system will enable model validation and identification of potential failure modes, while ensuring minimal impact on the parachute system being instrumented. The proposed system leverages a distributed wireless sensor network to address challenges associated with sensor installation, including technological, logistical, weight, and cost barriers. By utilizing wireless communication, the system simplifies installation and eliminates the risk of wires tangling with parachute suspension lines. Additionally, it allows for the deployment of more

sensors by easing cable routing and weight constraints. Reducing cable routing requirements not only minimizes installation effort compared to current systems but also offers greater flexibility in sensor placement. While the primary target application is parachute system instrumentation, the system's capabilities also support other applications requiring environmentally hardened, low-power, battery-operated, time-synchronized wireless instrumentation. Funding will be used to establish target specifications and requirements based on NASA input and design constraints, develop the concept and proposal for a system level deployment, develop the conceptual design for a prototype system, build a functional prototype, and characterize the results.

Duration: 6

Proposal Details

Proposal Number: Z-LAND.01-1003
Subtopic Title: Parachute Systems for Maneuverability and Wireless Data Acquisition
Proposal Title: A Synchronized Wireless Transmitter System for Parachute Strain Data Acquisition

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The project aims to develop a compact wireless data acquisition system (DAS) for gathering parachute strain data, featuring synchronized measurement channels and centralized data storage. This system will address the limitations of current wireless DAS platforms, which are not suitable for flight parachute instrumentation. Funding will be used to adapt Bloomy's existing soldier-borne wireless power monitoring sensor platform to meet the requirements for parachute applications, including the implementation of Wi-Fi for long-range data transfer, improved packing pressure withstand, and increased channel density. Additional focus areas for the funding include environmental testing, technical studies, and component selection. These innovations will bridge the TRL gaps of current wireless DAS platforms, which are not appropriate for flight parachute instrumentation. Innovations include pressure packing withstand of up to 45 lb/ft^3, rapid data transmission and storage across distances of at least 30 meters, synchronized wake-up to 20 outer nodes, and channel density per node of up to 10 sensors. Target markets for this technology are diverse. The primary markets include parachute systems, soldier systems, UAVs/UGVs, energy storage systems, and microgrids. The parachute systems market encompasses space agencies, the military, and parachute manufacturers. The soldier systems market consists of the US Department of Defense and NATO forces. The UAV and UGV markets feature both military and commercial applications, along with research organizations. Additionally, this technology can be applied to energy storage systems, microgrids, and other industrial applications. This project strategically leverages Bloomy's existing eSoldier platform, enhancing its capabilities and creating opportunities in markets beyond soldier and space equipment.

Duration: 6

Proposal Details

Proposal Number: Z-LAND.01-1006

Subtopic Title: Parachute Systems for Maneuverability and Wireless Data Acquisition
Proposal Title: In-Canopy Bleed Air Control to Enable a Steerable Subsonic Parachute System

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 6
Technical Abstract (Limit 2000 characters):

This proposal focuses on the development of an innovative in-canopy bleed air control system for round parachutes, specifically targeting spacecraft entry, descent, and landing (EDL) applications. Currently, parachute systems used in EDL rely on unguided round parachutes, which are subject to significant landing location uncertainty due to the influence of atmospheric winds. This lack of active control limits the precision required for successful planetary landings, especially in future missions to Mars and other celestial bodies. The proposed technology aims to address this issue by integrating a bleed air control system within the parachute canopy. This system will utilize small, lightweight actuators and sensors to manipulate vents in the canopy, enabling active steering during descent. By

reducing the impact of unpredictable atmospheric conditions, this system will enhance the accuracy and reliability of parachute-based landings, contributing to the success of planetary exploration missions. Funding will be used to design, build, and test the in-canopy bleed air control system, starting with the MC-6 parachute as a baseline. The Phase 1 effort will focus on creating and testing multiple in-canopy control configurations, with the goal of optimizing control authority and minimizing actuator force. Prototype systems will be fabricated and tested through flight experiments to validate performance, including control authority, power consumption, and reliability. The target markets for this technology include NASA, the U.S. military, and international allies, with potential applications in both personnel and cargo airdrop systems. The first product developed will be an in-canopy control system for the T-10 parachute, marketed as an autopilot kit for personnel use. Further development will include similar systems for cargo parachutes such as the G-11 and G-12. This technology has broad potential for improving landing precision in a variety of applications.

Duration: 6

Proposal Details

Proposal Number: Z-LAND.01-1012
Subtopic Title: Parachute Systems for Maneuverability and Wireless Data Acquisition
Proposal Title: Autonomous Paragliders for Martian Landings

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 5 - 6
Technical Abstract (Limit 2000 characters):

Outpost is proposing Phase I research and development including design and manufacturing of a scaled paraglider system to be used in future flight test activities for verification and validation of system performance and scalability. This development effort would focus on the design of a passively stable paraglider system capable of deployment in a low density and pressure environment similar to that of the Martian atmosphere. Successful inflation and stable flight are prerequisites for precision guidance of the paraglider system. The largest risks of deploying a paraglider system at higher altitudes, and therefore lower pressures and densities, are the potential for aggressive surge leading to stall or failure to inflate and insufficient ram pressure for tip inflation.

Duration: 6

Proposal Details

Proposal Number: Z-LAND.02-1004
Subtopic Title: Entry and Descent System Technologies
Proposal Title: An integrated multi-physics and multiscale modeling framework for simulating infusion and curing of Thermal Protection System (TPS) materials

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

This proposal introduces an integrated simulation framework designed to optimize the manufacturing of advanced thermal protection systems used in aerospace applications. The framework employs a multi-physics, multi-scale modeling approach that captures both the macro-level resin infusion and the micro-scale curing processes. It integrates commercial CFD (STAR-CCM+) and FEA (Abaqus) third party tools with AnalySwift's proprietary micromechanics code, SwiftComp, to simulate complex phenomena such as variable porosity within 3D woven preforms, resin off-gassing, curing-induced shrinkage, and chemical kinetics. Funding will support the development of physics-based models, the creation of user-friendly software plugins, and experimental validation to ensure the accuracy of predicted infusion quality and structural performance. By reducing reliance on trial-and-error methods and streamlining process optimization, the resulting toolkit will lower production costs and accelerate design cycles for high-performance heat shield components. Target markets include both aerospace sectors and high-performance composite manufacturing industries, where precise process control is critical to ensuring reliability under extreme conditions.

Duration: 6

Proposal Details

Proposal Number: Z-LAND.02-1009
Subtopic Title: Entry and Descent System Technologies
Proposal Title: Durable and Flexible Oxidation Resistant Coatings Deposited Via Aerosol Impact Driven Assembly

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 5
Technical Abstract (Limit 2000 characters):

Swift Coat is actively developing coatings for space-based applications including anti-reflective coatings for space-photovoltaic modules and anti-fog coatings for use in spacesuits and vehicles. As these coatings are often on exterior surfaces, Swift Coat has engineered them to be resistant to exposure to atomic oxygen. The work proposed in this project focuses on modifying elements of these existing coatings to not only be resistant to atomic oxygen themselves, but to also protect underlying sensitive substrates, specifically the woven carbon fabric canopy used as part of the Adaptive Deployable Entry Placement Technology platform. Over the course of this project, the investigators will produce a coating with the following properties: 1) Coated woven carbon fabric has 75% less rate of mass loss upon exposure to atomic oxygen when compared to uncoated fabric. 2) Coated woven carbon fabric maintains performance after abrasion, folding, thermocycling, exposure to high temperatures and general handling. 3) Coating can be applied to substates at least 0.5 m x 2 m with a path to expanding to much larger substrates in Phase II.

Duration: 6

Proposal Details

Proposal Number: Z-LAND.02-1012

Subtopic Title: Entry and Descent System Technologies
Proposal Title: Thin, Flexible Oxidation-Resistant Coatings for 3D-Woven Carbon Fabric TPS Materials

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The flexibility of deployable decelerators enables more efficient use of the launch vehicle payload shroud volume through smaller packed volume, reducing design constraints on entry vehicle structures and thermal protection systems (TPS). Mission applications for this technology cover a variety of classes and scales, ranging from sample return from planets and moons to payload recovery from low Earth orbit. Some mission applications use ADEPT (Adaptable Deployable Entry and Placement Technology), a state-of-the-art mechanically deployed hypersonic decelerator, to enable sample return and Earth aerocapture missions for a range of payload sizes and masses. ADEPT utilizes a three-dimensionally (3D) woven flexible carbon aeroshell combined with a rigid nose made of a phenolic ablative TPS material such as PICA. Currently, 3D-woven carbon fabric materials have been

tested and integrated into small-scale hypersonic heat shields in ADEPT configurations. While demonstrating excellent survivability under heat fluxes as high as 250 W/cm2, 3D-woven carbon fabric materials lack sufficient oxidation resistance that would enable missions to Mars, Venus, and other solar system destinations. In this project, Ultramet will investigate the use of titanium carbide (TiC) as an oxidation-resistant coating material for ADEPT applications. The high temperature oxidation resistance of TiC combined with the flexibility of thin TiC films makes it an ideal material for use on carbon fiber TPS. Ultramet will leverage its expertise in chemical vapor deposition (CVD) to develop a process to infiltrate and deposit uniform TiC coatings on carbon fibers.

Duration: 6

Proposal Details

Proposal Number: Z-LAND.02-1014
Subtopic Title: Entry and Descent System Technologies
Proposal Title: Mixed Gas Generator for Inflatable Decelerators

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Deployable aerodynamic decelerators are an enabling technology for missions to planets and moons with atmospheres as well as for returning payloads to Earth. These decelerators require a gas source for inflation, and the objective is to develop a noncombustible gas generator which will enable a wider range of applications, including near-term commercial applications, in the Earth environment. Anasphere has experience developing pyrotechnic gas generators for hydrogen and other gases, but to date all have used a similar design. Here, Anasphere will apply its experience to an all-new generator design and chemistry. This new family will feature more mass-efficient cooling, single-grain construction for reliable zero-g performance, and initially will focus on producing noncombustible gas mixtures. An exceptionally high flow rate capability is a distinguishing feature of these generators. Phase I will begin with refining and testing the pyrotechnic grain composition. Sample grains will then be fabricated with that composition and tested. Phase I will conclude with firing a small complete gas generator to demonstrate the production and cooling of a noncombustible gas mixture. Phase II work would include scaling up the new design and subjecting it to extensive environmental tests. Target markets include HIADs used for launch vehicle asset return and payload return from Earth orbit.

Duration: 6

Proposal Details

Proposal Number: Z-LAND.03-1001
Subtopic Title: Plume-Surface Interaction (PSI) Technologies
Proposal Title: Soil Cohesion Effects on Cratering and Transport of Regolith due to Plume-Surface Interaction

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

The plume-induced environment from propulsive landing of robotic and human-rated vehicles is one of the top unresolved critical risks for extraterrestrial missions. Primary risks of plume-surface interaction (PSI) are the creation of large craters and high-speed ejecta that can impact and damage the vehicle or surrounding infrastructure. NASA analysts use advanced modeling and simulation capabilities to predict the PSI-induced environment, but a critical gap in these tools is soil cohesion. Cohesion, or the ability of soil grains to adhere to one another, dominates in low-pressure, reduced-gravity environments and is a primary driver in the initiation and resistance to motion and suspension and resettlement of soil. Without accounting for cohesion, predictions of soil behavior in a PSI-induced environment fail to accurately capture erosion onset, the evolution of crater formation, and soil berming as seen from Apollo and other missions. Experiments targeting cohesion processes in the low-pressure, reduced-gravity environment are minimal, so validation of models is difficult. In this effort, CFD Research and University of Central Florida's (UCF) Center for Microgravity Research (CMR) Lab will implement, validate, and improve existing cohesion models for the PSI-induced environment. Cohesion and bulk cohesion models will be implemented into CFD Research's Gas-Granular Flow Solver, Loci/GGFS, and validated against existing

terrestrial cohesion data sets from UCF. UCF will perform additional cohesion-focused experiments in the low-pressure, reduced gravity regime, which will also enable the identification of critical gaps in current models in the PSI-induced regime for further improvement. The resulting experimental data and predictive simulation tool will be delivered to NASA, dramatically improving the PSI simulations and enabling further pathways for model development and validation for any existing simulation tool.

Duration: 6

Proposal Details

Proposal Number: Z-LAND.03-1005
Subtopic Title: Plume-Surface Interaction (PSI) Technologies
Proposal Title: Crater Profile Roughness Tool That Predicts PSI Physics

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 3
Technical Abstract (Limit 2000 characters):

Gaseous or solid impactors can disrupt the regolith-covered surfaces of small bodies or the moon, causing extensive surface modification and posing a severe risk to on-surface structures. Gas-granular plume surface interactions (PSI) cross multiple physics regimes, featuring a mixture of viscous (Navier-Stokes assumptions are valid) and rarefied flow (particle-particle collisions dominate; the plume behaves as a granular gas), high turbulence, and fluidization of the soil. Understanding the behaviors of these granular materials in vacuum and microgravity environments is vital for mitigation of unwanted plume surface interaction effects. This proposal focuses on developing the innovative use of crater profile roughness as an indicator of the PSI physics behaviors and regimes at play during any given landing scenario. Development of this model in 2D (Phase I), expansion into 3D space (Phase II), and development of a software product ("Lunar CPR") to allow access to this data for commercial applications and NASA missions (Phase III) will result in a robust model (Phase I-II) and tool (Phase III) which can be used to predict the PSI physics of cratering and surface erosion in low-pressure and rarefied environments. This tool, validated with experimental data, will allow customers to access geotechnical properties of landing zone regolith, only requiring (a) information about the lander such as thrust, descent rate and height over time, and total mass, and (b) a camera capable of imaging the surface, both of which are available for historical landings of record and will be available for any future commercial or private landers. Much like the maps referenced when building on Earth, this data would allow for creation of geotechnical maps vital for making informed geoengineering decisions on the Moon or remote locations on Earth.

Duration: 6

Proposal Details

Proposal Number: Z-LAND.03-1011
Subtopic Title: Plume-Surface Interaction (PSI) Technologies

Proposal Title: Multi-View X-Ray Diagnostics for Ejecta and Core Behavior in Plume-Surface Interactions

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

NASA's propulsion and landing research facilities require high-speed, multi-view diagnostics to accurately characterize plume-surface interactions (PSI) in planetary landing environments. Current PSI measurement techniques struggle to resolve core ejecta and surface dynamics in optically dense flow regions, particularly during late-stage interactions where data is currently unavailable. The goal of the proposed work is to develop a flexible multi-view X-ray imaging system capable of high-speed, quantitative, spatio-temporally resolved measurements of the particle mass distribution and dynamics in relevant PSI flowfields.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.01-1007
Subtopic Title: Surface Power Technologies
Proposal Title: Rechargeable Lunar Battery

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

Survivability in low-temperature lunar conditions and sustained lunar surface operations require a new generation battery modules capable of operating in ambient conditions as low as -200 °C, combined with >200 Wh/kg specific energy at room temperature. Lunar surface temperatures range from -230 °C at night to -90

÷ +120 °C during day, depending on latitude. It is critical for cell chemistry to support both charge and discharge at low temperature to enable continuous lunar surface operations. Conventional Li-ion cells degrade fast when repeatedly charged at low temperature due to lithium plating. A novel cell design expanding the temperature range of operation combined with novel battery thermal management is needed to address the extreme temperature challenges presented by upcoming NASA lunar and other missions.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.01-1031
Subtopic Title: Surface Power Technologies
Proposal Title: Feasibility Demonstration of Prussian Blue Sodium-Ion Batteries in Lunar Applications.

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 5 - 6
Technical Abstract (Limit 2000 characters):

Prussian blue sodium-ion batteries are an emerging energy storage technology with unique characteristics. This technology boasts the highest available power density in any current battery technology on the market, potentially unlocking new possibilities for power system design and diverse applications previously deemed unattainable. Prussian blue sodium-ion technology is proven on Earth, but it has not yet been rigorously tested through laboratory experimentation to demonstrate feasibility for lunar missions. This project aims to demonstrate the utility of Prussian blue sodium-ion batteries within the Moon to Mars missions with focus on lunar applications. The secondary aim is to characterize the battery materials and identify functional relationships for the battery materials that will enable design of Prussian blue sodium-ion battery packs. It is expected the outcome of this project will culminate with the delivery of a design document and design review of a battery pack suitable for delivery to the moon for lunar testing.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.01-1037
Subtopic Title: Surface Power Technologies
Proposal Title: High Pressure, In-Situ Hydrogen Sensor For Space Based Regenerative Fuel Cell Systems

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 5
Technical Abstract (Limit 2000 characters):

Makel Engineering Inc. (MEI) will develop a miniaturized, in-situ, stable, long-life hydrogen sensor for use in high pressure oxygen process streams within regenerative fuel cell systems. The hydrogen sensor will be able to be used directly in oxygen streams operating up to 3600 psia to monitor trace hydrogen which can pose a safety issue. MEI will adapt a miniaturized hydrogen sensor technology that has been successfully used for safety monitoring of low pressure oxygen generators, fuel cells, and for launch vehicle leak detection applications. This program will innovate on this demonstrated hydrogen microsensor technology with application specific design modifications and packaging required to meet the unique challenges of the space based regenerative fuel cell systems including tolerance to condensed water vapor, high pressure, low power and mass, and long calibration life without servicing or replacement. The sensor will be designed to easily integrated and embedded in systems with interfaces similar to small pressure and temperature transducers. The technology is based on MEMs based Pd/alloy hydrogen detection elements on silicon with operational capability up to 100% hydrogen. The technology has recently been extended to higher temperature and pressure applications. The sensing element design (resistive and diode) elements are formed with thin film fabrication processes and the Pd/alloy composition has been demonstrated to be highly specific to hydrogen. able to operate with or without oxygen in the background, and insensitivity to common process stream contaminates such as carbon monoxide and hydrocarbons. Phase I will demonstrate and test a prototype sensors which can detect hydrogen in the 0 to 4% range with high accuracy at pressures up to 3600 psia with saturated oxygen.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.02-1002
Subtopic Title: Spacecraft Thermal Management
Proposal Title: Multi-VCHP (Variable Condenser Heat Pipe) Radiator

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 4 - 6
Technical Abstract (Limit 2000 characters):

Advanced Cooling Technologies, Inc (ACT) will develop a high turndown ratio, freeze tolerant and passive Variable Heat Rejection Radiator for Planetary Surface and Space Habitats based on multiple Non-Integrated Hot Reservoir Variable Conductance Heat Pipes (HR-VCHPs). Habitat waste heat is acquired by a single-

phase loop (SPL) using a benign fluid and further transferred to a series of these VCHPs charged with ammonia (or propylene depending on freezing and toxicity requirements) and argon (or neon, again, depending on the freezing requirements) that in turn transfer the heat (with self-adjusting resistance) to the radiators for ultimate rejection. In addition, the HR-VCHPs, that mainly consist of aluminum extrusions, will be flexible/deployable because of stainless steel bellows inserted as adiabatic sections that act as thermal barriers during survival. To develop the proposed system ACT will leverage concepts developed during several previous SBIR programs. One of them is the high reliability Non-Integrated HR-VCHP as the key component that was recently developed by ACT and successfully tested (both thermal control and reliability) on Peregrine 1 Lander in microgravity. This success elevated its TRL to 8. The primary Phase I objective is to demonstrate the feasibility of the concept by analysis, modeling, design and experimental validation. ACT will develop a four-HR-VCHP radiator prototype that will cool a single-phase pumped loop. One of the VCHPs will be flexible to demonstrate deployability. In addition, a preliminary design of a single-phase pumped loop to VCHP evaporator heat exchanger will be developed. The main objective in Phase II will be to demonstrate a full-scale Passive Non-integrated HR-VCHP Radiator system by designing, building and testing a full-scale proof of concept system elevating the TRL to 6. ACT will conduct a series of trade studies for different configurations potentially drifting away from the base-line design obtained in Phase I.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.02-1006
Subtopic Title: Spacecraft Thermal Management
Proposal Title: Gravity-Independent Heat Exchangers and Oil-Free Compressors for Modular Refrigeration System

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

A modular refrigeration system using a vapor compression cycle with gravity-independent heat exchangers and oil-free compressors will be developed to meet targeted space refrigeration needs for lunar and planetary missions, capable of near-term technology infusion. The system will be capable of scaling to meet capacities ranging from 200 W to 1000 W and will deliver an efficiency equivalent to 45% of Carnot. Linear compressor technology will be leveraged to provide oil-free operation. Together with optimized, small diameter tube heat exchangers, the system will be capable of providing robust operation in microgravity conditions. Phase I activities will focus on full design development based on analytical modeling as well as experimental validation of the linear compressor technology. These activities will enable development of a comprehensive design for full prototype validation in Phase II.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.02-1008
Subtopic Title: Spacecraft Thermal Management
Proposal Title: Freeze Tolerant Water Azeotrope Radiators

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

The “Freeze Tolerant Water Azeotrope Radiator” is a heat rejection technology that can survive the 14 day lunar night without trace heaters or other energy sources. Its purpose is to reject multi-kilowatt thermal loads (10’s to 100’s of kWt) during hot operations plus be able to survive a lunar night anywhere on the moon whether operating or in standby mode. Combining large deployable radiator panels with embedded water azeotrope heat pipes that allow flexure at the joints provides a system which can be stowed and mobilized or deployed and operational with the ability to survive freeze and thaw cycles as needed depending on the mission and fault tolerance of its parent system. This freeze tolerant and mobile radiator subsystem can integrate with power generation and distribution, mobility assets, and

In-Situ resource processing plants. It can be designed to operate on the moon or Mars with and without gravity assistance. This is achieved by utilizing the unique properties of water azeotropes that turn to a slush consistency when frozen which greatly reduces structural stresses. This allows the heat pipe pressure vessel to be designed with thin walls that increase heat transfer, reduce mass, and allow thin walled bellows or like structures needed for deployable operations. Phase I will focus on down selecting water azeotrope fluids, heat pipe design, and deployable radiator architecture. Subscale testing of a loop heat pipe and thermosyphon are expected to help support decisions leading to a phase II program. If selected, phase II will include a deployable multi-panel radiator in a thermal vacuum chamber that demonstrates freeze thaw operations from 400K (TBD) down to 80K and back for multiple cycles. Phase III will be target a lunar lander demonstration. Markets for this technology will include all moon to Mars systems that require freeze tolerant heat rejection with two phase fluids.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.02-1010
Subtopic Title: Spacecraft Thermal Management
Proposal Title: High Efficiency, Modular T-form Space Refrigeration

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Space refrigeration systems are essential for preserving medicines, biological samples, and research materials during space missions. Future manned space and interplanetary missions will require refrigerators designed for low-volume storage that can keep food nutritious over long durations. Unlike conventional refrigerators, space food refrigeration needs specialized components to function in zero gravity, posing challenges for heat exchange and compressor lubrication. Mechanical Stirling coolers are optimized for colder temperatures but may be difficult to scale for long-term food storage. Solid-state ThermoElectric (TE) coolers are ideal for space applications due to their compact size, low profile, lightweight design, and lack of moving parts, making them unaffected by zero gravity. Although TE coolers have a slightly lower efficiency compared to vapor-compression or Stirling refrigerators, advancements in materials and methods are improving their efficiency. Scalable, modular TE systems promise ultra-compact, efficient solutions for space food refrigeration, critical for astronaut health, mission success, and scientific progress. To address NASA's critical gap of high-efficiency, food storage refrigeration devices, Nanohmics team proposes to design a modular, high cooling power, space vehicle refrigeration system configured as a Volumetric-Interdigitated, T-form, Thermoelectric array for Lightweight, Efficient, food Storage (VITTLES). The Space VITTLES refrigeration system will include provisions for both material and system performance improvements vs. conventional solid-state TE cooling that does not require mechanical moving components for operation and are seamlessly interfaced with the heat rejection cryofluid connected to the space vehicle heat management system or directly to a radiator.

Duration: 5

Proposal Details

Proposal Number: Z-LIVE.02-1018
Subtopic Title: Spacecraft Thermal Management
Proposal Title: Engineered Solar Reflective Coating with High Infrared Transparency

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Thermal management is an enduring need for all space platforms and vehicles. Spacecraft are routinely exposed to extreme temperature fluctuations, and options for regulating temperature in the vacuum of space are limited and challenging. To address spacecraft temperature fluctuations, Plasmonics Inc. has been developing a new class of mission-tailorable, and autoregulating, thermal radiators. The primary limitation with Plasmonics Inc.'s current state of the art variable emissivity materials (VEM) is their high solar absorptivity. An ideal VEM surface should have low solar absorptivity, to help mitigate solar loading. The surface should also be conductive to help mitigate electrical charge build up. To address these needs,

Plasmonics Inc proposes to develop a new-class of radiator overcoats for VEMs and other similar radiator systems with high solar reflectivity, infrared transparency, and high conductivity. The team has identified three candidate coating technologies which we will investigate. After downselect, the team will fabricate a coating prototype on silicon and verify the visible reflectance and infrared transparency. A successful coating will find utility in a wide range of markets with the commercial satellites and smart surfaces as the most promising.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.03-1012
Subtopic Title: Space Resource Processing for Consumables, Manufacturing, Construction, and Energy
Proposal Title: Integrated Regolith Excavation and Water Extraction Using Auger-Dryer Systems

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

AeroFly's integrated excavation and water extraction system is designed to drastically reduce the cost and logistical burden of sustaining human presence on the Moon by enabling efficient in-situ resource utilization (ISRU). By eliminating the need to launch and transport water from Earth, this technology significantly reduces payload mass and mission costs, making long-term lunar operations more feasible. Building on our team's proven excavation technology from the NASA Break the Ice Lunar Challenge, this system combines excavation, volatile extraction, and real-time resource collection into a single continuous operation. The auger-based drying unit, optimized through high-fidelity simulations and advanced thermal management, ensures efficient extraction of water and other volatiles from lunar regolith, meeting NASA's target of 1.5 kg of water per hour under the extreme conditions of permanently shadowed regions (PSRs). By integrating excavation and processing into one system, material handling losses are minimized, energy efficiency is increased, and scalable ISRU capabilities are achieved, making this a mission-critical technology for Artemis, Gateway, and future Mars exploration. Phase I funding will support system validation through subscale prototyping, computational modeling, and regolith simulant testing to refine auger geometry, sublimation dynamics, and filtration efficiency, ensuring the system is optimized for sustained lunar habitation.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.03-1015
Subtopic Title: Space Resource Processing for Consumables, Manufacturing, Construction, and Energy
Proposal Title: Electrochemical Compression of Martian Atmospheric CO2 for In-Situ Resource Utilization

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 1 - 3
Technical Abstract (Limit 2000 characters):

Martian in-situ resource utilization (ISRU), critical for methane fuel production and long-term human presence, necessitates pressurized CO_2. We propose developing an energy-efficient electrochemical CO_2 pump tailored for Mars, enabling direct capture and pressurization. This innovation not only reduces reliance on Earth-launched resources but also addresses terrestrial carbon capture, utilization, and storage (CCUS) challenges. With a projected booming space economy and growing CCUS market, this technology offers significant commercial potential across both planetary and terrestrial applications.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.03-1017
Subtopic Title: Space Resource Processing for Consumables, Manufacturing, Construction, and Energy
Proposal Title: High-Test Peroxide Generation System for Scalable In-Situ Monopropellant Production from Lunar Water and Oxygen

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

The Prometheus system is a compact, end-to-end platform for generating 90-98 wt% high-test hydrogen peroxide (HTP) directly from water and oxygen, leveraging an integrated solid electrolyte reactor and membrane concentrator. In the bench-scale design, an electrochemical cell converts water and oxygen into hydrogen peroxide without consumable additives. A hollow-fiber membrane unit then upgrades this intermediate solution to medium-high concentration levels, proving feasibility for continuous HTP production. At a pilot scale of 1,000 kg/year HTP output, the reactor stack and membrane system would operate continuously at low

power, positioning the approach as both energy-efficient and readily scalable for Lunar or Martian propellant production. Funding from this proposal will be used to demonstrate feasibility through a bench-scale prototype, conduct detailed safety analyses, and refine scaling strategies to reach pilot-plant output. The design emphasizes modularity, minimal moving parts, and low maintenance, making it suitable for austere environments such as the Moon and Mars, where water and oxygen can be extracted from icy regolith or metal oxide reduction. By eliminating the need for terrestrial transport of bulky or hazardous propellants, Prometheus directly supports NASA's in-situ resource utilization (ISRU) objectives. Beyond space applications, the system also targets terrestrial markets (e.g., launch pads seeking on-demand high-test peroxide, or industries such as paper milling needing a flexible, safer supply of HTP). This dual commercial focus underpins a robust business strategy with near-term terrestrial revenue potential and long-term viability in the evolving cislunar economy.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.04-1000
Subtopic Title: Components for Extreme Environments
Proposal Title: Multistage Umbilical Disconnect (MUD) System

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 4
Technical Abstract (Limit 2000 characters):

Paragon proposes a novel universal umbilical quick disconnect assembly designed to protect against intrusion of lunar regolith and extreme temperature changes on the surface of the Moon and beyond for extended periods of time. The MUD system protects the umbilical internal flow or electrical path from regolith intrusion and thermal flux by utilizing four protection systems: softgoods cover, exterior active protection via vibration/resonance, exterior mechanical protection and interior coupling protection. The protection systems are dissimilar mechanisms which allows for additional mitigation of regolith intrusion and will be designed to be operated with space suit gloves. The MUD quick disconnect assembly is a practical solution to one of the biggest challenges in lunar exploration: regolith intrusion. As Lunar and Martian missions become more complex, the MUD assembly will play a key role in maintaining reliable infrastructure, supporting long-duration operations, and enabling sustained human and robotic presence on other planetary surfaces. Additionally, vibrational resonance removal for regolith could prove to be a very compelling way to mitigate intrusion in areas other than disconnecting hardware such as solar panel, radiators, habitats, optics, sensors, landing zones, sample collection tools, suits, and rovers. With Phase I funding, Paragon will design, test, and prepare analyses of this new technology using low cost materials and manufacturing methods to validate the design concepts with the objective of moving to Phase II and, ultimately, developing an innovative product within the quick disconnecting hardware market. The primary go-to-market strategy for MUD system focuses on securing partnerships with space agencies such as NASA to integrate the technology into lunar and Mars missions. Simultaneously, the products simple mechanical nature makes it easily adapted for industrial markets where contamination resistance is critical such as oil, gas and defense.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.04-1007
Subtopic Title: Components for Extreme Environments
Proposal Title: HSC Mast for Extreme Environments

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

Opterus proposes to develop and test a high-performance high-strain composite (HSC) mast for lunar, Martian, and deep-space applications. Building on the existing TCTM boom and deployer developed for orbital applications, this effort will enhance durability, expand the operational temperature range, assess the effects of lunar regolith damage, and increase lifting capacity for extraterrestrial use. Originally designed for zero-gravity deployment, the TCTM boom must be adapted to withstand extreme temperature fluctuations, regolith abrasion, and gravitational loads. Through environmental testing, Opterus will evaluate structural performance, identify design improvements, and conduct an analytical scaling study to refine the system for long-term reliability. These advancements will position the TCTM boom

as a versatile, cost effective, and scalable mast technology for lunar solar arrays, communication towers, and space infrastructure, expanding its utility across planetary and deep-space missions. The intended use of the funding will be to support the testing of the TCTM boom in extreme environments and incorporate the insights into the development of an improved TCTM boom capable of use in these extreme extraterrestrial environments. In addition to enabling critical lunar infrastructure, Opterus has identified an express commercial need for shorter but more mass and volume efficient mast solutions. Opterus is confident this boom technology will enable other applications such as commercial companies pursuing in-situ resource utilization. Improvements to the boom in extreme thermal environments could enable other applications such as deep space exploration.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.04-1008
Subtopic Title: Components for Extreme Environments
Proposal Title: Advanced Polymer Nanocomposites for Lunar Dust Mitigation and Surface Longevity

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 3 - 5
Technical Abstract (Limit 2000 characters):

Lunar dust presents a significant challenge to long-term surface operations due to its high abrasiveness, strong electrostatic adhesion, and extreme environmental conditions. Existing dust mitigation strategies remain inadequate. To address this, RockyTech proposes the development of advanced polymer nanocomposite coatings that leverage a combination of mechanical compliance, optimized surface energy, and controlled surface interactions to actively reduce dust adhesion and improve removal efficiency. This six-month Phase I effort will focus on demonstrating the dust-repellent performance of lead polymer nanocomposite candidates under simulated lunar conditions. The research will investigate the interplay between surface energy and mechanical properties in dust adhesion and removal. Incorporation of hydrophobic/hydrophilic silica nanoparticles will be investigated to further tune surface properties. Experimental validation will be conducted through vacuum-based dust adhesion testing, thermal cycling from -173°C to +127°C, and plasma/UV exposure studies in collaboration with Space Dust Research & Technologies (SDRT). Dust removal efficiency will be studied using centrifugal force testing, where deposited dust particles are subjected to rotational forces to evaluate detachment behavior. The proposed coatings will be lightweight, optically clear, conformal, durable, and repairable, making them suitable for spacesuits, solar panels, optical instruments, and long duration lunar operations. If successful, this work will not only provide critical insights into lunar dust mitigation mechanisms but also position RockyTech's materials for integration into NASA Artemis missions and commercial lunar ventures. Additionally, these coatings could serve dual-use applications in aerospace, renewable energy, and defense, where dust, radiation, and temperature extremes impact performance.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.05-1004

Subtopic Title: Regolith Excavation and Manipulation for Surface Operations and Infrastructure with Assembly and Outfitting of Lunar Surface Structures
Proposal Title: Lunar In-Situ Thermal Wadis

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Lunar Thermal Wadis are structures that store thermal energy in a large thermal mass, and either release it slowly to allow assets like rovers to survive the lunar night, or use it to generate power. No credible hardware architectures have been proposed to quickly create a large enough thermal mass to use in a Wadi. Ethos Space intends to mature an innovation for an implement which is a modular and detachable piece of equipment to directly melt the lunar regolith in-situ and at depth to rapidly produce a large thermal mass that is extremely hot at the beginning, and can also be recharged after it cools. The proposed effort will create computer simulations of the Wadi, design an implement that uses the Ethos Durandal heaters to create a thermal mass, and carry out a small demonstration of creating a thermal mass with lunar regolith simulant in a vacuum chamber. The intended use of

funding includes salary, and equipment for the small demonstration. The target markets are governments and private companies who are sending expensive hardware to the Moon, such as the Lunar Terrain Vehicle, the Pressurized Rover, and other mobility systems and equipment. Ethos intends to offer survive-the-night as a service by building and/or leasing use of Thermal Wadis to diverse customers who will use them to greatly increase the longevity of their missions, getting closer to the goal of sustained lunar exploration.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.05-1018
Subtopic Title: Regolith Excavation and Manipulation for Surface Operations and Infrastructure with Assembly and Outfitting of Lunar Surface Structures
Proposal Title: BUILDER: Leveraging BIM information to automate robot task planning for lunar assembly applications

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

In order to support permanent human presence on the Moon, a number of critical infrastructures must be built on the lunar surface. Robots are expected to play a crucial role in the construction process, performing autonomous assembly and outfitting of a variety of systems, such as tall towers for solar power generation, shelters for crew and asset protection, and lander plume containment shields for launch & landing pads. As it has been noted in state-of-the-art work, the knowledge of building data is critical for the application of robotic solutions in terrestrial construction and operation. Specifically, these works leverage the information contained in Building Information Modeling (BIM) files that describe a target infrastructure, to extract and provide the robotic agent with the geometric, semantic and scheduling data that can then be used to assist in the generation of assembly plans to be carried out by the robot. In this proposal, TRACLabs proposes BUILDER (Leveraging BIM information to automate robot task planning for lunar assembly applications), a set of software tools that facilitate the integration of BIM data - describing an assembly infrastructure - with ROS, the standard software framework to build robot applications. The BUILDER tools are expected to provide 3 types of utilities: (1) Translate geometric data (3D models and poses) from the BIM files into objects natively usable by ROS-based tools, such as motion planning libraries; (2) Translate scheduling and semantic BIM data - describing the assembly and its construction - into a format suitable to be used for generic task planning tools; (3) Build upon our existing task planning tools, we'll integrate the geometric, scheduling and semantic data now accessible to ROS-based tools, into our framework, enabling it to autonomously generate task plans that are specific to a robotic platform, with the robot plans being encoded using a hierarchical approach based on Behavior Trees.

Duration: 6

Proposal Details

Proposal Number: Z-LIVE.05-1020
Subtopic Title: Regolith Excavation and Manipulation for Surface Operations and Infrastructure with Assembly and Outfitting of Lunar Surface Structures

Proposal Title: Cosmic-XT, A Truss-Traversing General-Purpose Outfitting Robot

Small Business Concern

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Summary Details

Estimated Technology Readiness Level(TRL Begin - TRL End): 2 - 4
Technical Abstract (Limit 2000 characters):

Cosmic Robotics, Inc. proposes the development of Cosmic-XT, an autonomous, self-powered robot designed for truss traversal and outfitting in lunar and space environments. The primary function of Cosmic-XT is to climb, navigate, and outfit Tall Lunar Towers (TLTs) with electrical wiring, sensors, lighting, and other secondary systems. Equipped with truss-grippers, an extendable arm, and a harness installer, the robot moves using an inchworm-like motion to attach and secure electrical components to truss structures. Additionally, the Particle AI error detection system enables real-time identification of issues such as tangled wires and foreign object debris. The NASA SBIR Phase I funding will be utilized to advance the technology to TRL 4 maturity, with milestones including a conceptual system design review, a proof-of-concept harness installer mechanism, and a conceptual design review of the AI-based error detection system. This funding supports proof-of-concept development, de-risking technical challenges such as autonomous wire

handling, efficient power usage, and AI-driven error detection. The target market includes NASA and commercial space infrastructure providers, focusing on lunar base construction, on-orbit servicing, and autonomous maintenance. Beyond space, potential applications extend to commercial construction, power line maintenance, oil and gas, and disaster response, where robotic outfitting can enhance safety and efficiency in hazardous or hard-to-reach environments. The lunar market alone is estimated at $170 billion, making Cosmic-XT a viable solution for the long-term sustainable development of space infrastructure.

Duration: 6