NASA SBIR 2022-I Solicitation

PROPOSAL NUMBER: 22-1- **Z2.02-1771**

SUBTOPIC TITLE: High-Performance Space Computing Technology

PROPOSAL TITLE: Pelican: Radiation-tolerant Computational Storage

Small Business Concern

Firm: **Zephyr Computing Systems, Inc.**
Address: **1506 Pullman Way, Oakland, CA 94607**
Phone: **(510) 694-0222**

Principal Investigator:

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Address: **1506 Pullman Way, CA 94607 - 1586**
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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Zephyr proposes to create Pelican, a radiation-tolerant computational storage device. This storage device provides high-capacity solid state storage through the use of 3D-NAND technology and a custom flash-controller implementation. Pelican is designed from the ground up to mitigate the adverse effects of radiation. In addition, Pelican will provide onboard compute resources attached to the flash memory to greatly accelerate IO intensive workloads by co-locating them with the storage. This allows for the generation of data products on the storage device itself, reducing processing time and effectively increasing the bandwidth between Pelican and a host device. The complete storage device will also simplify integration by using a modern specification from the Enterprise & Datacenter SSD Form Factor Working Group (ESDFF); E1.S. This specification uses the computation industry standard Non-volatile Memory Express (NVMe) protocol over a Peripheral Component Interconnect Express (PCIe) Interface. Storage capacity in the first version will be at least 2 TB of usable space. This is not raw capacity, but instead accounts for the redundancy and overprovisioning required to meet reliability requirements. Future versions of the product will increase the capacity to 6 TB and beyond.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- science missions, particularly capturing rare or transient events
- image processing
- rendezvous and proximity operations
- terrain relative navigation
- sophisticated fault detection, isolation, and recovery

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- image processing for Earth observation constellations
- onboard processing for synthetic aperture RADAR and hyper-spectral imaging constellations
- sophisticated routing and edge computing for communication constellations
- rendezvous and proximity operations for satellite servicing missions

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.03-1229**

SUBTOPIC TITLE: Future Aviation Systems Safety

PROPOSAL TITLE: Controller-Pilot Voice Communication and Intent Monitoring for Future Aviation Systems Safety

Small Business Concern

Firm: **The Innovation Laboratory, Inc.**
Address: **2360 Southwest Chelmsford Avenue, Portland, OR 97201**
Phone: **(503) 242-1761**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

With the advent of Natural Language Processing (NLP) and Artificial Intelligence (AI) applications growing in the last decade, many aspects of NLP and AI are ready to be applied to new problems in new domains. This SBIR effort specifically merges NLP and AI technologies in a system that is designed to ensure aviation systems safety. A combination of speech analytics, voice-to-text conversion, intent inference, and anomaly detection are implemented to form a real-time monitoring of system safety.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This effort addresses In-Time System-Wide Safety Assurance (ISSA) objectives of NASA's Airspace Operations and Safety Program (AOSP) System Wide Safety (SWS) Project:

- monitor the ATM system continuously and to extract and fuse information from diverse data sources (voice, ADS-B, weather, map, etc.) to identify emergent anomalous behaviors
- add new intent models as new rules are introduced in the NAS (for instance, with respect to new UAM/AAM concepts and vehicles researched by NASA)

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Airline dispatcher positions will benefit from this technology by providing real-time monitoring of pilot-controller dialog and conformance to the controller directives. Non-conformance can be immediately notified to airline dispatchers as a safety net.

Duration: **6**

PROPOSAL 22-1- **A2.01-1911**

NUMBER:

SUBTOPIC TITLE: Flight Test and Measurement Technologies

PROPOSAL TITLE: On-Board Low-Profile Skin Friction Sensor (OBeLiSk)

Small Business Concern

Firm: **Interdisciplinary Consulting Corporation**
Address: **5745 Southwest 75th Street, #364, Gainesville, FL 32608**
Phone: **(352) 283-8110**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The Interdisciplinary Consulting Corporation (IC2) proposes to develop an ultra-low-profile, ultra-smooth-surface, robust, real-time wall shear stress sensing system using microelectromechanical systems (MEMS) technology that can provide quantitative skin friction measurements during flight tests. The goal of this research is to advance IC2's current capacitive wall shear stress sensor technology that is capable of making quantifiable mean and fluctuating skin friction measurements in controlled wind tunnels, and allow them to be used in harsh, subsonic flight-test environments. Such a transducer would be the first of its kind and will provide information that characterizes complex flow fields, leading to a better understanding of the fluidic phenomena in real-world applications as well as providing a way of validating computational fluid dynamics simulations. The newly designed sensor will feature more robust geometries, sensor bump stops to minimize debris-impact damage, and a protective film coating that prevents moisture, debris collection, and structural damage. Improved electronics will digitize the device signal in the sensor head, replacing the bulky and expensive multi-conductor

analog cabling currently used with inexpensive micro-digital cabling - this eliminates the remote signal-conditioning electronics, which will decrease the effort and cost of sensor installation on a flight-test aircraft. The new electronics will also measure and compensate for changes in temperature and vibrations encountered during flight and will provide its calibration data to the user digitally through a TEDS (Transducer Electronic Data Sheet) interface.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed instrumentation technology has the potential to be usable in multiple NASA flight-test facilities, as well as implemented across government-owned, industry, and academic institution test facilities. The target market is real-time shear stress measurement instrumentation for flight test within test facilities, including the Armstrong Flight Research Center and the Edwards Flight Test Range Complex.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Real-time quantitative measurement of mean and fluctuating wall shear stress is not currently possible with existing technologies. Government agencies (DoD, DARPA) and industry manufacturers (e.g., Boeing, Lockheed, GE) have similar needs to NASA and are limited by the lack of accurate wall shear stress measurement capabilities in flight-test environments.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z14.02-2040**

SUBTOPIC TITLE: Extraterrestrial Surface Construction

PROPOSAL TITLE: Ultra-Electrical-Efficient Process to Perform Regolith Additive Manufacturing of Complex Structures

Small Business Concern

Firm: **Lunar Resources, Inc.**
Address: **6721 Portwest Drive, Houston, TX 77024**
Phone: **(646) 455-8382**

Principal Investigator:

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Phone: **(646) 455-8382**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

Lunar Resources, America's leading space industrial company and the corporate spin-out of NASA's Wake Shield Facility (WSF) program propose to NASA a novel 3D printing system optimized for the lunar environment. The system is an innovative combination of unique mass control in an ultra-energy-efficient pulsed power printing head to perform direct additive manufacturing of lunar regolith without any reagents. Together this new technology enables additive manufacture of lunar structures from lunar regolith and in-situ derivative materials by printing from any direction to make structures with geometries and complexity not before possible on the Moon.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The innovation the team proposes to develop as part of this NASA SBIR Phase I effort includes bulk manufacturing of lunar regolith at low power input levels while expanding lunar manufacturing design options to complex geometries. Specific NASA applications including manufacturing large-scale complex structures from lunar regolith and derived materials bsuch as landing pads, habitats, roads, walls, shields, berms, and beams but

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed innovation can be utilized to produce commercial infrastructure on the Moon such as landing pads, bridges, buildings and other complex lunar surface structures. As well be modified for in-space additive manufacturing applications.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z14.01-2648**

SUBTOPIC TITLE: Lunar Surface Excavation

PROPOSAL TITLE: ADAPTING NOVEL TERRESTRIAL MINING TECHNOLOGIES FOR LUNAR EXCAVATION

Small Business Concern

Firm: **OffWorld, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

For this Phase I SBIR, OffWorld will deliver a conceptual design and tech demo that leverages our proven, rugged terrestrial robotic mining capabilities to develop a viable solution to extract icy regolith from beneath the dry overburden on the lunar surface. Our proposed innovation is distinguished by its heritage as an evolution of our existing, durable modular mining platform and associated machine learning framework.

The proposed Phase I project will:

- Deliver a conceptual design that adapts current OffWorld terrestrial mining digger bot species for excavation operations on the surface of the Moon.
- Propose a development plan for the maturation of the necessary technologies and the development of robot production capacity.
- Calculate the scale of robotic squads necessary to successfully meet NASA lunar excavation production requirements as identified in the SBIR solicitation.
- Consider the unique challenges presented by the lunar environment including temperature extremes, low gravity, radiation, dust, and vacuum.
- Optimize the system to account for the current limited understanding of lunar regolith, considering variations and inconsistencies in the science of lunar geology.
- Maximize reliability and durability of individual components and design a highly robust and resilient system architecture.
- Design autonomous maintenance and servicing strategies to account for component failure and to enable a minimum of 5 years of continuous swarm operation.
- Minimize system mass to the maximum extent possible to reduce lunar mass delivery requirements.

- Incorporate lessons learned and statistical analysis of current OffWorld terrestrial mining programs.
- Define requirements for sensors and feedback mechanisms necessary for system optimization and to achieve fully automated icy regolith excavation.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

OffWorld's lunar surface excavation approach (the proposed innovation) has several NASA applications. All applications are a result of the proposed innovation being a point solution, directly addressing a critical NASA need. These NASA applications include: ISRU, lunar surface overburden penetration, propellant production, propellant depot construction, lunar surface habitat development, landing pad development, and all other lunar surface related activities that require lunar regolith movement and excavation.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The management team of OffWorld has been in discussions with commercial entities that have complementary missions to NASA's. These commercial companies, like Astrobotic and Masten, have funded lunar programs which will require: lunar propellant, landing pads, propellant depots, and other surface infrastructure requiring robust lunar surface excavation capability.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z1.06-2096**

SUBTOPIC TITLE: Radiation-Tolerant High-Voltage, High-Power Electronics

PROPOSAL TITLE: Radiation-Tolerant Vertical GaN Diodes

Small Business Concern

Firm: **Kyma Technologies, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

In this Phase I program, Kyma Technologies will advance the state of the art in kV-class Schottky barrier diode devices utilizing GaN materials and domestically produced, chemically pure halide vapor phase epitaxy (HVPE)-derived epilayers and study radiation effects in these exciting new devices which are poised to offer improvements in size, weight, and efficiency over devices prepared from other wide-bandgap semiconductor materials.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Applications for NASA include kilowatt-class power distribution systems for space vehicles and future lunar or Martian habitats. Additionally, power systems with reduced energy losses for remote sensing instruments or sensors for use in Saturn missions, Jovian moon missions, Venus missions, and deep space exploration are potential applications.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Applications outside of NASA include industrial motor drives, PV inverters, hybrid and electric vehicles, and inverters for wind turbines.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z2.01-1749**

SUBTOPIC TITLE: Spacecraft Thermal Management

PROPOSAL TITLE: Hot End Thermal Management System for Nuclear Electric Propulsion

Small Business Concern

Firm: **Advanced Cooling Technologies, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Nuclear electric propulsion systems provide a variety of benefits including increased science payload, reduced flight times and longer mission lifetimes. These advantages enable a wide range of missions such as manned missions to Mars, unmanned missions to the outer planets and deep-space. The thermal management system linking the reactor to the hot end of the power conversion system must be efficient, lightweight and reliable. These requirements become more challenging as the total power scales to the megawatt level.

In this SBIR program, Advanced Cooling Technologies and USNC-Tech will develop a highly reliable, efficient and lightweight thermal management system for the hot end of the power generation system for nuclear electric propulsion. A high-power two-phase heat transfer system will be used to transport thermal energy, at the megawatt scale, to the hot end of the power conversion unit. The proposed system is passive and highly reliable with built-in redundancy.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The thermal management technology proposed here is relevant to several areas of NASA's Technology Roadmap, including "Power for In-Space Propulsion", "Fission Space Power and Energy Storage" and "Heat Transport for Thermal Control Systems". The system will benefit many space-based fission power systems such as nuclear electric propulsion and power generation on the lunar and Martian surface.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed system is capable of transporting a significant amount of thermal energy from a nuclear reactor to a power conversion system. In addition to space-based applications, the thermal management system is relevant to small modular and micro nuclear reactors. Small reactors have several advantages including reduced capital investment, reduced construction time and scalability.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.04-2107**

SUBTOPIC TITLE: Sensor and Detector Technologies for Visible, Infrared (IR), Far-IR, and Submillimeter

PROPOSAL TITLE: Optical Detection of Lightning via Diffractography

Small Business Concern

Firm: **Lumos Imaging Inc**
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Phone: **(713) 965-4495**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Recording spatial and spectral content has been the traditional domain of hyperspectral cameras. They produce very large datasets that require significant storage, transmission and processing capabilities. Despite the great usefulness of this information, they are captured in a very inefficient way; in many important problems, only a tiny subspace of the signal is necessary to produce the corresponding results. That is the case of classification or target detection problems. Using hyperspectral data with state-of-the-art machine learning algorithms (such as deep neural networks) has been a considerable challenge due to the sheer data sizes, immense hardware requirements and long training cycles.

Our company has developed a technology that overcomes these hurdles. Our system captures spatio-spectral content in a compact, information-rich, monochrome image, termed diffractogram. They can be used directly for inferencing, i.e., target detection and classification. This is achieved via optimally designed nanofabricated, diffractive-filter arrays (DFA) integrated into an existing sensors (FPAs).

Compared to traditional approaches, we have identified strengths that can be exploited for a class of applications:

- Applicable for any spectral range (UV, Vis, NIR, SWIR, etc).
- Adaptable to existing sensors (virtually any FPA can be used)
- Small signals with a high density of information (efficient storage and transmission)
- Produced by optical compression (signals be used directly, no need for any decompression)
- Snapshot capture (no line scanning; well suited for moving targets)
- No moving parts (physically robust)
- Efficient at detecting temporal changes
- High transparency (no filters imply more light can be used)
- Spectral continuity (recorded signal is not spectrally discretized)
- Small size and weight (single optical path and no complex scanning components)
- Multi-purpose (single system produces data that can be used in many applications)

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Detecting lighthing optically from space typically focuses on the single spectral signature at 777.3nm. It came to our attention from conversations with NASA experts Dr. Patrick Gatlin and Dr. Mason Quick that our technology had great potential to improve on the current approach since it can observe other spectral bands simultaneously and efficiently, resulting in an improved detection rate. Moreover, the system can be used for other applications that use space hyperspectral data such as vegetation monitoring, detection of algal blooms, etc.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Despite their usefulness and applicability in virtually every sector, hyperspectral sensors have not attained a wider adoption primarily due to two obstacles: 1) a very high price tag and 2) onerous data requirements. We offer significant reductions (at least 10x) in both, besides other advantages. We are developing a product that aims to satisfy the needs of that untapped market.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.01-2070**

SUBTOPIC TITLE: Aeroelasticity and Aeroservoelastic Control

PROPOSAL TITLE: Advanced Aeroservoelstic Control for a Zero Emission Blended Wing Body Transport

Small Business Concern

Firm: **Systems Technology, Inc.**
Address: **13766 Hawthorne Boulevard, Hawthorne, CA 90250**
Phone: **(310) 679-2281**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

Technical Abstract (Limit 2000 characters, approximately 200 words):

It is a strategic thrust of the NASA ARMD to “realize revolutionary improvements in economics and environmental performance for subsonic transports with opportunities to transition to alternative propulsion and energy.” To this end, JetZero Inc. has introduced the Ascent 2600, a novel zero emission blended wing body (BWB) commercial transport concept, to address this need. A key technology for this vehicle is an innovative landing gear concept, the pivot piston, that facilitates takeoff and landings without the need for high lift devices and enables entry into the single aisle transport market. In NASA SBIR Topic A1.01 a critical gap has been identified wherein “the use of lightweight flexible structures, the development of new airframes (truss-braced wings, blended-wing bodies, etc.), and the intentional exploitation of aeroelastic response phenomena require a comprehensive understanding of the aeroelasticity involved if they are to succeed.” This is certainly a recognized truth for the Ascent 2600 BWB, which will require innovative aeroelastic suppression methods to ensure desired ride qualities and safe operations for passengers that are no longer distributed along a relatively narrow tube. To this end a group of JetZero collaborators led by Systems Technology, Inc. (STI) propose the Active Control for Environmental disturbances and Structural interactions (ACES) system that will introduce novel active control techniques and will a feature a unique blend of the available wing, kink, and body control surfaces to mitigate undesirable aeroelastic interactions. Feasibility of ACES in Phase I will be demonstrated for the challenging gust load alleviation problem using the Ascent 2600 configuration, while in Phase II a broader range of aeroelastic problems including flutter suppression will be addressed with the effectiveness of ACES ultimately demonstrated in flight using the 13.5% dynamically scaled Pathfinder vehicle.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This proposal directly addresses NASA ARMD Strategic Thrust 3 – Ultra Efficient Subsonic Transport. The Ascent 2600 zero emission BWB meets the 2025-2035 stated goal that “Aircraft meet economic demands of airlines and the public with revolutionary improvements in community noise and energy efficiency to achieve fleet-level carbon neutral growth relative to 2005.” The ACES system will utilize active control technology to mitigate the aeroelastic challenges associated with the BWB design including gust load alleviation and flutter suppression.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The target commercial market for the ACES system is the single aisle commercial transport market for which JetZero's Ascent 2600 provides a natural market entry point. The single-aisle segment flies about 50% of all passenger-miles and consumes more than 50% of aviation fuel. The introduction of a new, highly efficient transport in this category provides the greatest environmental benefit.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z1.08-1354**

SUBTOPIC TITLE: Space-Rated Fuel Cell Technologies

PROPOSAL TITLE: Hybrid Water Removal and Reclaimation System (HyWaRRS)

Small Business Concern

Firm: **Lynntech, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

In preparation for future Lunar and Martian surface operations, NASA is seeking viable methods of storing energy captured by solar panels for use in times of limited solar energy availability. Currently used Li-ion batteries, while sufficient for short-term energy discharge cycles, are not optimal for the Moon's 29.5 day diurnal period as their energy storage capacity scales linearly with system mass.

Regenerative Fuel Cells (RFCs) offer an alternative method for storing electrical energy with more favorable scaling metrics, combining electrolyzers (split water into H_2 and O_2 gas in times of energy surplus) with fuel cells (generate energy during energy deficits by recombining gases into water). RFCs have a mass advantage over batteries for Lunar operations, with energy densities of 400 to 550 Wh/kg.

PEM electrolyzers produce saturated gases which, if the temperature drops below dew point, may result in condensation that can freeze and damage fluidic connections in the system. Thus, any solution that incorporates RFCs requires a dedicated dehumidification subsystem.

To meet this challenge, Lynntech proposes a two-stage water removal/reclamation system that involves traditional compression and phase separation, as well as cascading Metal Organic Framework (MOF) based desiccant beds with vacuum heated water reclamation/regeneration. Lynntech intends to design a system with 2 independent canisters with multiple in-series MOFs each for simultaneous absorption and regeneration. One MOF canister will dehydrate water while the other regenerates captured water to the H_2O tank. These canisters then switch, resulting in continual gas dehydration and water regeneration throughout the operating cycle.

Lynntech will team up with Framergy, experts in MOF development and optimization, to design this hybrid MOF-based approach to RFC dehumidification that exceeds NASA's desired mass recovery rate to decrease overall system mass.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Lynntech's development effort will enhance and expand the capabilities of RFCs in NASA application by optimizing system energy density while avoiding proportionally increasing system mass. Such advancements greatly increase the viability of long-term missions to asteroids, planets, moons, or any other operation that experiences cyclic exposure to sunlight. Additionally, improved RFCs may be used for life support during In Situ Resource Utilization operations, providing H_2O or O_2 for human consumption.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Long-term solar-powered flight may greatly benefit from lightweight solutions to increase efficiency in RFC systems. The addition of a MOF-based regeneration system increases the mass recovered throughout each cycle, decreasing the initial on-board water mass required and optimizing system energy density.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S15.01-2666**

SUBTOPIC TITLE: Plant Research Capabilities in Space

PROPOSAL TITLE: Focused LIBS for Elements in Water IDentification (FLEW.ID)

Small Business Concern

Firm: **Impossible Sensing, LLC**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

To effectively monitor plant nutrient uptake and cycling, optimize fertilizing and watering routines, and reproducibly grow healthy plants for consumption, researchers on board the space station must know the concentration of key elements, nutrients, and other constituents present in plant growth systems to a high degree of specificity and regularity. High frequency, accurate, in-situ data is currently not available however, as state-of-the-art elemental monitoring involves taking samples from these systems, returning them to Earth, and performing high sensitivity analysis in the laboratory. As these procedures are costly in terms of time and money, new technologies must be developed to enable in-situ, on-demand elemental analysis of liquids to support the rapid development of plant research in space.

Our innovation, Focused LIBS for Elements in Water Identification (FLEW.ID), enables in-situ, near-real-time elemental analysis of liquid samples in plant research systems. FLEW.ID performs qualitative and quantitative elemental analysis without the need for sampling nor any consumables. FLEW.ID utilizes miniaturized optoelectronic architectures, resulting in a drastic SWaP reduction that makes the instrument easily deployable on board the space station or other research or planetary environments. FLEW.ID meets the analytical needs of the plant research

community to accurately monitor plant health, nutrient cycling, and other metrics to accelerate plant research in support of planned and future manned missions.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

FLEW.ID enables on-demand, in-situ, real-time elemental analysis of fluid samples in plant growth systems for qualitative and quantitative analysis of nutrient cycling. When integrated into a plant research system like NASA's PONDS, FLEW.ID can provide online analysis without any sampling nor consumables. FLEW.ID is application agnostic and can be readily adapted to measuring other fluid systems, such as the closed-loop water recycling system on board the ISS, or solid samples, such as geological samples during planetary exploration.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

FLEW.ID can perform in-situ analysis of heavy metals and other contaminants in aquatic ecosystems for pollution detection and monitoring. In industrial settings, FLEW.ID can perform in-line analysis of wastewater streams and process stream recycling. In medicine, FLEW.ID can detect trace elements and nutrients in liquid samples such as urine to assess and monitor patient health.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.03-1719**

SUBTOPIC TITLE: Guidance, Navigation, and Control

PROPOSAL TITLE: Persistent, Robust Navigation & Control in Autonomous Rendezvous, Formation Flight, and Docking

Small Business Concern

Firm: **Scout Inc.**
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Phone: **(832) 405-3885**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

Autonomous rendezvous and docking is a key technology for many important space missions such as space debris management, supply to the International Space Station, on-orbit satellite maintenance, and large-scale structure assembly and satellite networking. This proposal accounts for an active spacecraft, namely deputy, approaching a chief spacecraft in close-range rendezvous and in proximity autonomously, and simultaneously. A key enabling technology in these missions is autonomous rendezvous and capturing that requires precise position and attitude control. Two main innovations relative to the current state of the art are proposed: robust adaptive unscented Kalman filters using multiple sensors, and fault-tolerant finite-time pose control algorithms deployed via on-orbit flight software.

SCOUT is building fault-tolerant and robust 6-degree-of-freedom finite-time controllers to conduct proximity operations with faster, more accurate tracking performance and more efficient control energy consumption than the conventional controllers in the presence of actuator faults, parametric uncertainties of the system, and unknown external disturbances. Developing autonomous relative navigation systems for rendezvous, proximity operations, and docking will yield persistent, robust and precise pose (position and attitude) state estimations remotely. For close-range rendezvous, absolute and relative GPS navigations using GPS C/A code measurements will be developed while star-trackers and Inertia-Measurement Units (IMUs) are used for relative attitude estimations between the chief and the deputy spacecraft. SCOUT shall build real-time orbit determination systems for absolute GPS navigation using onboard GPS C/A code measurements, which can be used for supporting autonomous navigation.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This effort will yield advancements in autonomous, resilient space system operations across a wide range of NASA applications necessitating distributed, persistent multi-satellite operations. Navigation does not commonly implement dynamic control for changing conditions, momentum, and maneuvers. RPO and science mission planning is time-consuming and scheduling-intensive with lacking real-time data; proximity operations are highly prone to abort maneuvers due to state measurement deviation or false-positive conjunction data messages.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Persistent, proactive tracking and state estimation, including during maneuvers, will facilitate rendezvous and proximity maneuvers. Orbital servicing and logistics end-users lack closed-loop, persistent, robust control for rendezvous and proximity operations: this has led to SCOUT's on-board navigation capabilities being adopted by Orbit Fab, Momentus, and potential commercial and Defense users.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H4.06-1580**

SUBTOPIC TITLE: Low-Power Multi-Gas Sensor for Spacesuits

PROPOSAL TITLE: Power efficient, miniature mid-infrared sensor

Small Business Concern

Firm: **Pendar Technologies LLC**
Address: **30 Spinelli Place, Cambridge, MA 02138**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

The substopic described the need for a multi-gas sensor that is power efficient, consistent with a wearable form factor, and can reliably operate under a wide range of temperature, humidity, and pressure conditions. We propose a CO_2 gas sensor that maintains the required dynamic range, accuracy, and sensitivity even under significant environmental variations. We employ distributed feedback quantum cascade lasers (QCLs) to perform intrapulse spectroscopy in the mid-infrared, which allows us to reach targeted sensitivities with ultra-low duty cycle measurements to dramatically reduces power consumption and system complexity. Pendar's expertise in monolithic quantum cascade laser integration will enable integration of multiple quantum cascade lasers to incorporate detection of up to 5 gases, including H_2O and O_2, all within an anticipated system footprint of 5 cm x 5 cm x 3 cm. Phase I will focus on building a breadboard prototype to experimentally verify that 1) the system draws <100 mW, and 2) CO_2 detection

accuracy is unaffected by varying pressure and temperature. A conceptual design of the Phase II miniaturized and integrated prototype will also be proposed at the end of Phase I.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed system is directly relevant to the design of the new Exploration Extravehicular Mobility Unit (xEMU). The intended goal of the proposed gas measurements is to ensure that the spacesuit maintains a safe environment without drawing significant power.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed CO_2 sensor can be adopted for capnography (CO_2 detection in breath, and for indoor/outdoor air quality control by measuring CO_2 in ambient air. The miniaturized sensing platform can also be easily adapted to target chemical threats for Department of Homeland Security, and natural gas leaks for Department of Energy and the oil and gas industry.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.06-1952**

SUBTOPIC TITLE: Command, Data Handling, and Electronics

PROPOSAL TITLE: Sigma-Netics Sensor Support Electronics (SN:SSE)

Small Business Concern

Firm: **Sigma-Netics inc**
Address: **2 North Corporate Drive, Riverdale, NJ 07457**
Phone: **(716) 418-4194**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Sigma-Netics intends on developing a hybrid microchip version of the MEDLI SSE that will meet the requirement of MIL-PRF-38534.

NASA wishes to equip all future planetary missions with a MEDLI like EDL system. Many planetary missions do not have the funding or project timeline to fly an EDL sensor suite similar to the MEDLI and MEDLI2. Sigma-Netics will develop a low cost Data Acquisition System that can survive the rigors of space flight and be cost effective to fly on all planetary missions. A fully qualified target cost of less than 1 million dollars is achievable by the innovative approach we are outlining. By using hybrid technology to make a custom EDL “system on a chip” massive size and weight saving will be had. In addition by utilizing MIL-PRF-38534 will maintain the ruggedness and reliability of the MEDLI & MEDLI2 SSE.

Cabling makes up considerable mass in all data acquisition spacecraft systems. By going wireless the entire system size and mass is greatly reduced. This will allow for the agency’s desire to deliver larger payloads to planets.

The SBIR has requested a module size of less than 10 cm^3 with a max number of four modules. Sigma-Netics believes this achievable by integrating all of the signal conditioning and multiplexing into hybrid microcircuits specifically designed for EDL type applications. With our experience with MEDLI & MEDLI2 SSE the fundamental circuity would remain similar.

The electrical system design and brass board prototypes will demonstrate that this new design meets and performs similar to MEDLI2 SSE with its measurement uncertainty. This will be fully demonstrated during phase one. Then we will begin the integration of that base design into hybrid microcircuit design. This way we keep the performance, but create our system on chip structure and the smallest EDL sensor support electronics ever built.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This technology would be especially relevant to upcoming Science Mission Directorate (SMD) planetary missions,
such as DAVINCI and VERITAS, but low-cost data acquisition systems with these capabilities would also be
relevant to the other science lines of business, especially for future cost and volume-constrained and distributed systems
missions.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Aerojet Rocketdyne, Astrobotic, Astranis, Masten Space Systems, Collins Space Systems, AVS-UK, Busek, Curtis Wright Nuclear, and CERN provide Sigma-Netics real time market intel to availability and opportunity for a product solution like the one proposed here. Success here will translate to higher volume opportunities with private and public companies, not just relevant space agencies.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H6.22-2264**

SUBTOPIC TITLE: Deep Neural Net and Neuromorphic Processors for In-Space Autonomy and Cognition

PROPOSAL TITLE: Scalable Neuromorphic Energy-Efficient Accelerator for Heterogeneous Processor Architectures

Small Business Concern

Firm: **Niobium Microsystems**
Address: **444 East 2nd Street, Suite 250, Dayton, OH 45402**
Phone: **(937) 207-2473**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

Under this effort, Niobium Microsystems, Inc. is proposing a low power computing architecture accelerator for neuromorphic processing which can enable real-time sensor data processing and autonomous decision making that is cost-effective and scalable to the growing data ingestion and processing needs of future autonomous systems. The proposed architecture will be highly scalable and compatible with modern processor systems (such as RISC-V or ARM), so that it can be easily adopted in a variety of new systems, and also easily integrated into existing systems. Additionally, Niobium proposes to integrate the proposed accelerator into a larger SoC that will serve as a proving ground and reference design for the accelerator concept. The SoC will be capable of acting as a primary processor in systems or as a co-processor to existing

systems. Ultimately Niobium intended to utilize this accelerator as a standard block in its family of heterogeneous processor architectures.

Niobium proposes the following four technical objectives for Phase I:

(1) Study prior efforts and capture the performance and efficiency metrics as well as the limitations of existing platforms;

(2) Propose a novel architecture for a neuromorphic accelerator compatible with heterogeneous processor platforms (RISC-V- or ARM-based);

(3) Explore available MRAM technology (GlobalFoundries 22FDX), characterize its PPA and propose ways for incorporating into the architecture; and

(4) Estimate performance, power and efficiency metrics for comparison to existing solutions.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Space platform which require on-board energy efficient inference capabilities and possibly decision making and action will benefit from the low-power energy efficient inference capability of Neuromorphic processors. Long range missions that will require long-term unsupervised learning and adaptation based on constantly evolving unpredictable conditions can also benefit by the learning modalities that Neuromorphic architectures uniquely support.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Niobium is pursuing a fabless semiconductor model & planning to incorporate this accelerator into future energy-efficient SoCs along with existing accelerators for DNNs, cryptography & other computationally intensive functions. These energy-efficient processor SoCs will target energy-constrained application markets (unsupervised sensors & sensor networks, lightweight robotics, drones, wearables).

Duration: **6**

PROPOSAL NUMBER: 22-1- **H9.07-1529**

SUBTOPIC TITLE: Cognitive Communication

PROPOSAL TITLE: Reactive Routing: Harnessing Advanced Software Modems

Small Business Concern

Firm: **Adirondack IT Solutions, LLC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Reactive Routing is an innovation in space networking by which unplanned changes in link performance
are detected and analyzed, enabling automatic and immediate adjustments to the “contact plans” on which
route computation in delay-tolerant networking (DTN) is based. These changes in contact planning will
result in route revisions that will accurately reallocate traffic load to the revised transmission opportunities,
improving network performance while reducing operations costs. Reactive Routing is only the first step
toward the deployment of instrumented networks that monitor and examine their own operational experience
and use the resulting insights to configure themselves for optimality. A key element of that future architecture
will be software-defined radios that will support multiple wave form options, error correcting code options,
and security features, and will interact with their networks to optimize spectrum use; antenna evolution will
add beam steering, nulling, and frequency reconfiguration capabilities. These advanced software modems
(ASMs) will incorporate control systems that manage the range of their capabilities to support network
communication and science. Reactive Routing is the beginning of our initiative to bring the power of ASMs
to networks built on the DTN Bundle Protocol (RFC 9171), culminating in autonomous cognitive networks
that require little or no routine human management.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Reactive Routing will enable a DTN BPv7 node to recompute routes and revise its bundle forwarding decisions automatically in responses to changes in the properties of communication links. It will improve link utilization, minimize throughput loss and management workload in all DTN-based networks

supporting NASA missions. The immediate beneficiary will be LunaNet, but the benefit will be even greater for interplanetary missions where route revision in response to a link change would be delayed by at least one round-trip communication to Earth.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The same performance improvements that will accrue to NASA space flight missions from adopting Reactive Routing will likewise benefit space flight operations mounted by all commercial space businesses and other national space agencies that use DTN for mission communications.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.02-1357**

SUBTOPIC TITLE: Quiet Performance - Aircraft Propulsion Noise

PROPOSAL TITLE: Testing System to Enable Development of Active Noise Cancelation on Open Rotor Propulsion

Small Business Concern

Firm: **Great Lakes Sound & Vibration, Inc**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The proposed innovation is an adaptable aircraft propulsion platform broadband acoustic emulator for rapidly testing and characterizing revolutionary aircraft noise reduction treatments. The proposed platform is capable of emulating the acoustic environment within an aircraft propulsion platform by generating a target noise signature using acoustic actuators. Revolutionary noise control treatments can then be introduced into the generated acoustic environment to rapidly characterize and tune their behavior. The platform is capable of emulating many aircraft propulsion platforms at different engine operating conditions as well as generating diagnostic noise signatures which can aid in the characterization and calibration of aircraft noise treatments. The proposed emulator is flexible in that it allows characterization of a treatment over a wide variety of propulsion platforms and operating conditions. It is also inexpensive to build and maintain as compared to the infrastructure required to utilize a full propulsion platform test bench.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This emulator is relevant to the Advanced Air Transport Technology (AATT) project by allowing the characterization and testing of propulsion noise reduction technologies. The Transformational Tools and Technologies (TTT) Project would also benefit by providing a testing platform on which advanced material systems such as acoustic liner concepts and adaptive materials that reduce propulsion noise can be tested.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The commercial aviation industry has a strong interest in reducing aircraft noise as it is a primary limiter in the growth of the nation's aviation transportation fleet. The aviation industry would benefit from a flexible and low cost acoustic test bench which has the potential to significantly increase acoustic testing throughput compared to traditional testing methods.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z7.04-1530**

SUBTOPIC TITLE: Landing Systems Technologies

PROPOSAL TITLE: Rapid Parametric Sensitivity Analysis for Plume-Surface Interaction Simulations

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

Technical Abstract (Limit 2000 characters, approximately 200 words):

All NASA modeling and simulation activities are mandated to provide uncertainty characterization and quantification of the underlying physics submodels and their propagation towards the simulation output metrics. Recently developed simulation tools to predict Plume-Surface Interaction (PSI) effects such as dust lofting, obscuration, debris transport, and surface cratering lack practical uncertainty assessment capability. The multi-physics, multi-phase, gas-granular media interaction modeling relies on complex algorithms and numerous physics submodels derived from experimental datasets with limited fidelity and considerable uncertainties. Model and algorithmic complexity and the frequent immaturity and sparsity of the fundamental physics submodels elevates the urgency of sensitivity analysis capability for PSI simulations. This project proposes development of an efficient Forward Automatic Differentiation (FAD) based sensitivity derivatives in conjunction with non-intrusive UQ methodologies for gas-granular flow solver Loci/GGFS. The FAD will enable run-time sensitivity analysis and propagation of underlying sub-model uncertainties through the overall PSI simulation model towards uncertainty quantification of simulation output metrics. The approach is efficient, especially for large parameter spaces and requires a limited number of simulations compared to sampling methods. Sensitivities analysis allows identification of dominant sub-model contributors of uncertainty, guide improvements, and provide a rapid propagation of critical uncertainties to the simulation output metrics. The resulting tools will be delivered to NASA for ready application for Lunar and Martian landers, including the Human Lander System, to aid in quantifying and identifying uncertainties and deficiencies in current simulations.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Immediate NASA applications include the support of a broad range of numerical simulations, especially in determining uncertainties present in models used therein. Identification and understanding of model uncertainties will have a direct impact on missions requiring propulsive landing and take-off, such as the Commercial Lunar Payload Services (CLPS) landers, for the Human Lander System (HLS), and future Martian robotic and human landers.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Potential non-NASA applications include a wide range of sand and dust related military and civilian applications such as rotorcraft sand/dust brownout and engine dust ingestion. In addition, multiphase flows occur in many applications in chemical, and fossil-energy conversion industries where accurate physics modeling plays a huge role in the flow behavior of real particulate systems.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z8.02-1733**

SUBTOPIC TITLE: Communications and Navigation for Distributed Small Spacecraft Beyond Low Earth Orbit (LEO)

PROPOSAL TITLE: Multi-Beam Autonomous Multi-Aperture Transceiver for Optical Navigation

Small Business Concern

Firm: **Intellisense Systems, Inc.**
Address: **21041 South Western Avenue, Torrance, CA 90501**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

To address the NASA need for enabling communication and navigation technologies for distributed small spacecraft beyond low Earth orbit, Intellisense Systems Inc. (Intellisense) proposes to develop a new Multi-Beam Autonomous Multi-Aperture Transceiver (M-BEAMAR) for optical navigation of distributed CubeSats. The proposed free-space-optical (FSO) navigation transceiver for inter-CubeSat and/or lunar surface communication is based on multi-aperture tiling of wide field-of-view (FOV) multi-beam transceiver modules with no moving parts. The innovations in the use of wide FOV optics and digital micro-electromechanical system (MEMS) switching with IR focal plane array (FPA) tracking and avalanche photodiode array detection will

enable a modular compact integration of the proposed system capable of scanning multiple, simultaneous laser beams for providing robust connectivity between CubeSats and/or from CubeSats to the lunar surface. In Phase I, Intellisense will develop a viable conceptual design of M-BEAMAR that satisfies NASA's communication and navigation requirements, including SWaP-C, relative and absolute position, timing, FOV, pointing and tracking, and link power budget, demonstrate the design's feasibility by prototyping and testing key enabling technologies, and develop a Phase II plan. In Phase II, Intellisense will develop a prototype of the M-BEAMAR system that will be integrated with a commercial off-the-shelf or government off-the-shelf FSO modem to support laboratory testing and field demonstration towards development into space-qualifiable and commercially available CubeSat communication payloads.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

With its low SWaP-C design, M-BEAMAR will be applicable to many NASA applications including lunar and deep space distributed science missions, distributed aperture virtual telescope, small spacecraft swarm for gravimetry and transient phenomena observation, and proximity operations for inspection of space assets. Additional applications include high-altitude, balloon-to-balloon relay, UAV-to-UAV, UAV-to-manned platform, and satellite-to-satellite and ground-to-satellite optical communications.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Government and commercial (dual-use) applications of M-BEAMAR include high data rate FSO communication in near-all-weather operation, FSO nodes on UAV platforms, deconfliction of RF spectrum allocations, and low-cost, on-demand communication. The multi-beam spatial diversity of M-BEAMAR could also enable the scientific community to exchange large amounts of data without having to run fiber.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z13.01-2056**

SUBTOPIC TITLE: Active and Passive Dust Mitigation Surfaces

PROPOSAL TITLE: Low Temperature Durable Siloxane/epoxy Nanocomposite Coating for Drastic Reduction in Lunar Particulate Adhesion

Small Business Concern

Firm: **TDA Research, Inc.**
Address: **12345 West 52nd Avenue, Wheat Ridge, CO 80033**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Lunar dust is the fine powder of the moon's surface regolith. The dust particles can be highly charged due to solar irradiation, and the dry lunar environment helps these particles hold their static charge and adhere to surfaces. Lunar dust degrades both spacesuits and equipment. TDA proposes to develop a nanocomposite coating offering excellent passive dust mitigation (more than 90% efficacy). The nanocomposite coating will perform at cryogenic temperatures; be abrasion resistant; adhere to the underlying metal, plastic, and fabric surfaces; has low surface energy; and match the lunar dust's work function. The combination of these properties will minimize dust adhesion in a challenging cryogenic lunar environment. Also, the coating properties are compatible with existing active dust mitigation technologies. In the Phase I project we will demonstrate the lunar dust mitigation of the coating in experimental testing under ambient and vacuum conditions. In Phase II we will optimize the properties of the coat to reject dust adhesion, and perform the qualification steps for the flight infusion demonstration. There are no similar cryogenic coating technologies that are commercial or have been reported in the open sources.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed technology will be applicable to all lunar and planetary applications (*e.g.,* Mars) where there is a surface that attracts the dust. This includes structural elements such as buildings, doors, vehicles (especially the heat exchangers), and generally any equipment where a coating of dust degrades the performance.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Our technology can be used for coating heat exchanger fins and honeycombs. It is easy to apply in a thin layer, without degrading the heat exchanger properties. Since it is thin and we have a continuous pathway of high thermal conductivity metals (versus the polymer) it will not degrade heat transfer. It will reject dust adhesion on the fins or honeycombs, preserving heat exchanger efficiency.
Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.01-2430**

SUBTOPIC TITLE: Lidar Remote-Sensing Technologies

PROPOSAL TITLE: Monolithic Q-switched waveguide laser fabricated by ultrafast laser inscription for pulsed lidar source

Small Business Concern

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

We plan to develop a monolithic Q-switched Waveguide Laser, using ultrafast laser inscription (ULI) technology. The proposed prototype is enabled by a Q-switched operation of waveguide realized by ULI inside diffusion-bonded laser media. Owing to its flexibility, ease for integration, and three-dimension nature, ULI of waveguides in laser materials and dielectric media enables transformative lidar system architectures.

The proposed device integrates three components through direct ULI of waveguide inside two diffusion-bonded crystals as active laser media and as saturable absorber for Q-switching. The laser cavity is ended by a dichroic dielectric coating at the input and the output sides. This architecture will result in a monolithic nanosecond pulsed laser at 1064 nm leading to a low-cost, compact, and durable solution.

The waveguide structure leads to better confinement and excellent overlap between pump and laser modes over the entire length of the media. This will lead to small lasing thresholds, high slope efficiency, and high output power.

The proposed device addresses NASA's wavelength of interest for aerosol detection. The prototype and its technological translation and implementation are interesting for alignment-free, low-cost, weight, and power requirement of small platforms and applications, overcoming the drawbacks of current microchip laser systems for lidars. In the future, this will lead to more robust integrated ULI-based lidar systems at other wavelengths from near-surface, airborne, and spaceborne platforms.

The offeror, Aktiwave LLC, is exceptionally well aligned for the technological development and commercialization of ultrafast-laser-based fabrications. Recently, the offeror demonstrated the lowest threshold and high slope efficiency ULI waveguide-based Nd:YAG continuous-wave laser at 1064 nm.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- Monitoring aerosols: climate modeling, air quality measurements, and understanding the health impacts of atmospheric pollution.
- Trace Gas Sensing: global and regional quantification of methane fluxes by potential integration with IPDA lidar.
- Spectroscopy: laser mass spectrometry to identify and characterize trace amounts of astrobiological content.
- Advanced data processing: high-performance computing based on high-speed waveguide circuitry for galactic evolution study.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed device offers the solution for lidar altimetry in urban photogrammetry, ecological measurements. Other applications include bathymetric lidar, sensors for self-driving cars, optical communications, signal processing, Raman spectroscopy, Lab-On-Chip, and imaging.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z4.07-2655**

SUBTOPIC TITLE: Advanced Materials and Manufacturing for In-Space Operations

PROPOSAL TITLE: Solar On-orbit Welder for Assembly, Repair, and Manufacturing

Small Business Concern

Firm: **Blueshift, LLC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA is requesting technologies for Advanced Materials and Manufacturing for In-Space Operations. Blueshift, LLC doing business as Outward Technologies proposes to develop an in-space welding process and robotic system for on-orbit service, assembly, and manufacturing (OSAM) of habitats, space telescopes, antennas, solar array reflectors, and a wide range of potential in-space structures. The proposed process and method utilizes concentrated solar energy (CSE) as the primary power source for the welding and joining of metallic and thermoplastic components in space. Benefits of the proposed innovation include a reduction in electrical power requirements compared to current electron beam and arc welding systems designed for OSAM and further power reduction compared to laser welding systems; a lightweight deployable design that minimizes launch costs; precision spot size and energy flux control enabling precision welds on a wide range of materials, material thicknesses, and joint configurations; and a radiation based welding process that enables welding non-conductive materials including thermoplastics and ceramics while reducing the risk of damaging sensitive electronics that may be close to the weld. The Phase I effort will focus on defining a full-scale SO-WARM system, concept of operations for the full-scale system, and associated subsystem requirements including a well-characterized welding testbed; evaluating different solar concentrator configurations based on mass, launch volume, lifetime/durability, and complexity; quantifying full-scale production rate and functional specifications; and demonstration of the solar welding process in an inert atmosphere through a closed-feedback-loop testbed with three aerospace materials including metals and non-metals.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary application within NASA's technology roadmap for SO-WARM is TX12.4: Manufacturing for which the SO-WARM accommodates the desired capabilities outlined in technology candidates TX12.4.1 for in-space fabrication, assembly, and repair. Secondarily, SO-WARM fits into TX13.2: Test and Qualification. SO-WARM can be incorporated into several NASA in-space construction efforts such as OSAM-1, OSAM-2, the lunar Gateway, and the ISS. It can also be used as a free-flying module, servicing satellites and structures as needed on-orbit.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

There are several applications of the proposed solar welding technology that will benefit the DoD, NSF, and other federal agencies interested in advanced manufacturing techniques. These include a solar welder for use in remote locations on Earth and by underserved communities who may not have access to established infrastructure.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.06-1953**

SUBTOPIC TITLE: Vertical Lift Technology for Urban Air Mobility -Electric Motor Fault Mitigation Technology

PROPOSAL TITLE: Electric Motor Fault Resilience

Small Business Concern

Firm: **PC Krause and Associates, Inc.**
Address: **3000 Kent Avenue, Suite 1701, West Lafayette, IN 47906**
Phone: **(765) 464-8997**

Principal Investigator:

Name: **Ning Wu**
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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 2
Technical Abstract (Limit 2000 characters, approximately 200 words):

The detection and mitigation of electric motor faults is vital to the safety and reliability of Urban Air Mobility (UAM) vehicles using electric propulsion. The proposed research aims to advance the state of the art of motor fault resilience research relevant to the NASA Revolutionary Vertical Lift Technology (RVLT) Project in two aspects: (1) develop fault resilience measures appropriate to the motor drive systems used in RVLT, and (2) study the tradeoffs between fault resilience and other motor drive system performance metrics such as weight and efficiency. Phase I research will explore fault resilience measures using analytical methods such as modeling and simulation.

The Phase II research will expand the scope of fault resilience measures considered and will validate the research findings with hardware experiments.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The direct NASA application for the proposed research is the Revolutionary Vertical Lift Technology (RVLT) Project. The research will also contribute to other programs in the NASA Aeronautics Research Mission Directorate (ARMD) where electric propulsion is used. Other potential NASA applications include spacecraft and lunar bases, where fault resilience will increase system reliability due to the time and cost involved in motor replacements in these settings.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The findings of the proposed research can potentially be applied to any system where motor fault resilience provides safety, reliability, or other benefit. Some examples of such applications include hybrid and electrical vehicles, and industrial electrical drive systems.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H12.07-2147**

SUBTOPIC TITLE: Protective Pharmaceutical Packaging

PROPOSAL TITLE: DoseShield Packaging for Improved Pharmaceutical Protection in Space

Small Business Concern

Firm: **Luna Labs USA, LLC**
Address: **706 Forest Street, Suite A, Charlottesville, VA 22903**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

While medications can be replaced or provided with relative ease to those on low Earth orbit missions, long-duration lunar or planetary exploration missions will require an expanded pharmacy. In addition to the need to supply a larger collection of medications, the pharmaceuticals within the medical kits will need to maintain appropriate stability. Current practices involve repackaging medications outside of manufacturer's packaging to conserve mass and volume on the spacecraft. Although operationally necessary, it is not known how the repackaging affects the shelf-life of the drugs. Improved packaging systems are needed, as it has been shown that medications are susceptible to the unique conditions experienced during spaceflight, including radiation, microgravity, and vibration.

To address this critical need, Luna Labs proposes the development of DoseShield™. This protective packaging system will include both primary and secondary packaging components in a comprehensive solution to maintain pharmaceutical stability while reducing stowage. For primary packaging, high-efficiency blister packages will provide protection to susceptible solid pharmaceutical doses against environmental exposures (e.g. moisture, oxygen) *without the typical costs to mass and volume*. This solution will maintain additional advantages of blister cards, including protection from vibration, and the packs will be developed to be compatible with a range of medications through broad protection against failure mechanisms. Secondary packaging will be explored to address the concerns of radiation exposure during spaceflight. The secondary packaging will be reinforced with radiation resistant additives to reduce penetration of galactic cosmic rays.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed packaging solution will be designed for easy integration into current NASA processes for medical kit packaging for spaceflight. Specifically, it will be engineered to provide stability to pharmaceuticals by protecting them from environmental conditions such as temperature, humidity, and radiation.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Additional non-NASA applications may include military and civilian operations that require a smaller pharmaceutical footprint than what is provided by original manufacturer packaging. This packaging solution has the potential to decrease the burden of large and bulky medical kits during long-term deployment or travel.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H9.03-2217**

SUBTOPIC TITLE: Flight Dynamics and Navigation Technologies

PROPOSAL TITLE: CETACEAN: Autonomous and Modular Onboard Relative Navigation Software for On-Orbit Proximity Operations & Docking

Small Business Concern

Firm: **Starfish Space, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

CETACEAN is Starfish Space's onboard relative navigation software for satellite proximity operations and docking that will reliably determine the relative state between two spacecraft. There are two areas of development needed to advance relative navigation towards onboard autonomous viability: 1) Improvement in machine vision image processing and 2) Development of navigation filter structure to blend machine vision measurements with a combination of sensor types to enable flight software and hardware modularity. CETACEAN embodies these development areas, and will offer accurate relative position, velocity, attitude, and pose. CETACEAN generates relative estimates using rapid image processing and several, new, and Commercial-Off-The-Shelf onboard sensors—including various cameras, LiDAR, RADAR, GPS, star trackers, and Inertial Measurement Units. CETACEAN is designed as a plug-and-play solution that can run on multiple software stacks and has been successfully integrated with existing software platforms, including NASA's core flight system (cFS). CETACEAN further advances rapid image processing capabilities and machine vision to autonomously conduct optical relative navigation and Rendezvous, Proximity Operations, and Docking (RPOD) in low and variable lighting conditions and without the need for target spacecraft fiducials or human decision-making. CETACEAN's autonomy and modularity will help realize a low Size, Weight, Power, and Cost (SWaP-C) spacecraft. The ability to easily swap out different sensors and update sensor processing filters, will allow organizations to more rapidly design spacecraft to meet mission needs. For spacecraft RPOD to be done in a safe and reliable manner, a robust relative navigation software like CETACEAN is required, for without it, autonomous on-orbit approach and docking would not be possible.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

CETACEAN enables a variety of NASA missions: 1) Proximity operations and docking in Earth orbit, cislunar space, lunar orbit, and Mars orbit (including Mars Sample Return), which require increased autonomy and reduced human involvement, 2) Servicing, upgrading, and extending the life of multibillion-dollar NASA science satellites, and 3) Removal of defunct satellites and orbital debris that endanger NASA spacecraft and critical space infrastructure such as the International Space Station.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Starfish recently raised $7.25M from top VC's, won a $1.7M Space Force contract, and is building relationships with major satellite operators, who are interested in CETACEAN to enable commercial missions such as satellite life extension and defunct satellite removal. Customers have also indicated interest in on-orbit: satellite relocation, assembly, materials transport, and inspection.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.06-2820**

SUBTOPIC TITLE: Earth Science Decision Support Tools Focused on the Mitigation of Climate Change Impacts

PROPOSAL TITLE: Spatiotemporally Aligned POSIX-Compliant Data Store for Event-based Analysis

Small Business Concern

Firm: **Bayesics, LLC**
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Phone: **(202) 492-3408**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Our proposed innovation harmonizes diverse data through **spatiotemporal co-alignment** in a **POSIX-compliant data store** to enable scalable, performant parallel processing required by in-depth **event-based analysis** for supporting risk-informed decision making in wildfire and water management.

Both the spatiotemporal co-alignment and event-based analysis innovations build upon the same technological foundation, i.e., the *SpatioTemporal Adaptive-Resolution Encoding*, STARE, a geo-spatiotemporal encoding methodology developed to support combining diverse datasets in their native states for integrative analysis. STARE encodes spatiotemporal coordinate locations, along with neighborhoods (or intervals, or resolutions), of the data elements using two (2) 64-bit integers in a hierarchical manner.

The spatial scheme of STARE encodes geolocation and spatial neighborhood hierarchically in 8 branches of quadtrees, whereas its temporal scheme encodes International Atomic Time and temporal intervals hierarchically also in a tree but with branching following calendrical units, such as day, week, month, etc. Mapping space-time intervals onto tree hierarchies then encoded into integers not only 1) provides an outstanding way to uniformly index and thus organize geo-data of different, irregular layouts with spatiotemporal co-alignment for scalable processing but also 2) establishes a solid foundation to facilitate efficient event-based analysis.

We plan to use the POSIX-compliant flexFS of Paradigm4 to implement a directory (folder) hierarchy mirroring that of STARE for Cloud web objects. Such a POSIX-compliant data store not only realizes the spatiotemporal co-alignment of diverse, unaltered data for easy, performant retrieval and utilization but also present the Cloud web object store in a “view” compatible with the all-familiar filesystem, to which most users are accustomed, e.g., in on-premises high-performance computing (HPC) environments and on individuals’ desktops or laptops.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Our technology possesses the unique capability of harmonizing geo-spatiotemporal data varieties for fusional analysis in their native resolutions and layout, including the vast barely-tapped resource of NASA Level 1 and 2 data currently in HDF files in Distributed Active Archive Centers. This data-variety harmonization facilitates spatiotemporal data placement alignment first in storage for effortless search-and-filter and second in memory for performant and scalable distributed parallel processing, including Cloud and minimizing duplication.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Our technology will enhance analysis productivity while reducing resource demand and cost for all geospatial analytics practitioners in academics, government agencies, and industrial-commercial organizations. The industries relying on geospatial analytics include, but are not limited to, transportation (air, sea, and land), logistics, tourism and travel, risk management, insurance, etc.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.04-2726**

SUBTOPIC TITLE: Unpiloted Aerial Platforms and Technologies for NASA Science Missions

PROPOSAL TITLE: Swift Modular Payload HALE UAS for Various Scientific Mission Sets

Small Business Concern

Firm: **Swift Engineering, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

There is a lot of expected return on investment for Commercializing Stratospheric Operations for military, scientific, and private industry markets. The development of aircraft, payloads, subsystems and propulsion for this type of effort has been in work for a while. These technologies are finally being integrated so that commercializing the stratosphere is real and will be done within the next 3-5 years.

Swift believes both are required, and even with collaboration from balloons and satellites, but as a steppingstone, the focus should be on the cheaper, efficient, smaller, but still capable solar craft. This should meet a SWaP target of the payload being ~22 lbs, about a shoebox or two in size, and have an operational requirement of <250watt continuous. Multiple aircraft carrying that

size SWaP target 1) allows for technologies now and in development to be commercialized and tested while 2) keeping the overall development of the aircraft/payloads, mission operations, and MRO costs down.

This trade study should result in a HALE UAS capable of achieving a payload SWaP during operations (both day and night) of at least 22 lbs, 250 watts operational (based on market research), and fit within 1 or 2 shoebox size configuration. This vehicle will be designed to have modular payload capabilities, some of which are photogrammetry, gas-particle collection, ISR, maritime, observation overtime periods, disaster relief, communication relay, and other scientific research requirements. Swift developed 50+ mission sets with NASA representatives in the design of the current configuration UAS that will be expanded under this SOW. This paper describes Swift's HALE UAS technology as it currently stands and what is to be achieved to meet the mission outlined in this NASA topic.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

ROSES, scientific research, Urban Air Mobility (UAM), air traffic management, disaster relief, communication relay, internet services, stratospheric gaseous observation, understanding the atmosphere, extreme hazardous storm and weather condition observation, long-term persistent area observation and analysis (erosion), satellite payload testing, operational services, air quality monitoring, agricultural monitoring, polar observation, coastal zone monitoring, vegetation incubation, surface topography, and many more.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

US DOD HAPS, port security, search and rescue, fire-fighting observation, persistent ISR, maritime observation, telecommunications, 5G-internet, disaster relief, payload testing, hypersonic observation, air traffic management, dropping sensors, and more. We have spoken to private customers, USAF, SOCOM, Army, Navy, and other Gov agencies interested in this technology.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z13.02-1222**

SUBTOPIC TITLE: Mechanisms for Extreme Environments

PROPOSAL TITLE: Novel Durable Silica-based Transparent Coatings

Small Business Concern

Firm: **Pioneer Astronautics**
Address: **11111 West 8th Avenue, Unit A, Lakewood, CO 80215**
Phone: **(303) 984-9346**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

Dust mitigation is a critical issue in space missions, especially lunar exploration missions. UV light present on the bright side of the moon causes the dust particles to have a net positive charge, increasing their likelihood of adhering to surfaces. To make the matters worse, moon dust particles are irregularly shaped with sharp edges due to its formation over millions of years of meteorite impacts that melted silicates, creating shards of glass and fragmented minerals. This aspect of lunar dust makes many terrestrial anti-dust and self-cleaning coatings unacceptable for space applications because soft materials are easily damaged.

The proposed Novel Durable Silica-based Transparent (NoDuST) coating minimizes (potentially eliminates) lunar dust adherence to hatches and covers used for protection of delicate components from harmful effects of lunar dust. NoDuST is a silica-titania based coating that can be used to prevent regolith from adhering to these as well as other mechanical components such as actuators, wheels, hinges that need to operate in dusty lunar conditions. The NoDuST coating passively minimizes dust adhesion based on reducing adhesion forces between the coating and lunar regolith particles. This coating has increased hardness to be able to withstand operation in lunar conditions with sharp particles constituting lunar regolith, it is clear to visible light and suitable for applications requiring visibility of the surface under the coating (camera lenses and filters, visors, etc.), absorbs UV and will protect surfaces covered with these from fading and degradation, can potentially have increased resistance to space radiation and will not degrade due to space radiation. For NoDuST coatings, Pioneer Astronautics proposes to combine silica and titania nanoparticles with a wide particle size distribution to minimize dust adhesion while maintaining a high film hardness to withstand abrasion in harsh lunar conditions.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Dust is the biggest challenge for human operation on the lunar surface, NoDuST coating has direct application for NASA Artemis program: this coating will minimize lunar dust adherence to mechanisms and moving parts (actuators, pistons, wheels, hinges etc.) as well as to enclosures and hatches protecting delicate components from harmful effects of lunar dust.

This technology will also be useful for future space exploration and other dusty planetary destinations.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial space exploration is quickly developing and this technology will be useful for all commercial lunar investigation efforts.

This technology has terrestrial applications and can be beneficial for all industries where mineral dust is common: construction business, mining and even agriculture.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S12.06-1903**

SUBTOPIC TITLE: Detector Technologies for Ultraviolet (UV), X-Ray, and Gamma-Ray Instruments

PROPOSAL TITLE: Integrated SiC Photodiode Arrays for UV-Spectroscopic Applications

Small Business Concern

Firm: **CoolCAD Electronics, LLC**
Address: **7101 Poplar Avenue, Takoma Park, MD 20912**
Phone: **(301) 405-3363**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

We propose to design and fabricate passive and active SiC UV linear sensor arrays, to build upon and scale up our technology for the eventual fabrication of 128x2 SiC active UV sensor arrays with <40 um pitch, with the first stage of the readout circuit integrated on the same chip, next to the sensors themselves, to minimize parasitic effects. The circuit design will use external signals to reset the photodiodes, buffer the output signal, and let diode selection for read-out by multiplexing. Building upon our background, we will demonstrate 128x2 arrays in an aspect ratio suitable for future spectroscopic use, and incorporate deep trenches for electrical isolation between neighboring pixels. We will also demonstrate 8x2 active arrays in a similar aspect ratio, integrating the first readout circuit stage (a 3T pixel circuit) next to the sensors themselves. We will layout and fabricate pn-junction and Schottky diodes with a range of designs for sensitivity in the target spectral range. We will also optimize each 3T circuit transistor at the semiconductor device level, tailoring their electrical characteristics to their role in the circuit, with the trade-offs between size, threshold voltage, current drive and leakage. The diodes, transistors, and the circuit architecture all will be co-optimized self-consistently. Looking forward, we will design for a 40-µm pitch pixel with the 3T readout circuit integrated within the pixel itself. This work enjoins the unique advantages of SiC, such as its low dark current at high temperatures, its inherent visible-blindness, and its capability to grow a native oxide, to the advantages of active pixel sensor technology such as higher sensitivity and low power consumption, to revolutionize UV sensing in the 120 to 350 nm range. This opens up a way to the development of advanced, flexible instrumentation with lower design complexity for applications in spectroscopy, remote sensing and characterization, and imaging.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

SIC UV sensors for spectroscopy and imaging: Planetary Science missions for water signature detection, surface/atmosphere/plume characterization, mineralogy; future versions of the Lunar Trailblazer and other SIMPLEx program missions, or of LUVOIR Concept Study, Cosmic Origins, Living with a Star, CubeSat/SmallSat missions; solar/terrestrial probes (DYNAMIC, MEDICI); future instruments like CUVIS (the DAVINCI+ probe); instrumentation development (PICASSO, MATISSE, DALI). SiC sensors can be in handheld units (no cooling/visible filter needed).

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Applications for UV sensing, spectroscopy and imaging include: sanitation (e.g. water/air filtration monitoring), fire and rocket plume detection, bio-detection, instrumentation, industrial monitoring, high-resolution fault inspection, and oil/gas logging systems. The high-temperature capability and inherent visible blindness of SiC allow applications in extreme conditions and simpler designs.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.01-1451**

SUBTOPIC TITLE: Advanced Air Traffic Management System Concepts

PROPOSAL TITLE: Alternate Route Availability Tool

Small Business Concern

Firm: **Mosaic ATM, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

This proposal is highly relevant to NASA's SBIR Topic A3.01, "Advanced Air Traffic Management System Concepts," within Focus Area 20, "Airspace Operations and Safety."

In the NAS, approximately 70 percent of flight delays are caused by weather, according to FAA statistics. By providing a planning tool to explore alternate routes in a timely manner using the most up-to-date Traffic Management Initiative (TMI) and weather information, flight delays can be mitigated or reduced. The Alternate Route Availability Tool (ARAT) will apply TMI information consumed from NASA's Digital Information Platform (DIP) with current and forecasted weather to assess alternate routes between city pairs. Flight routes impacted by these conditions will be recommended to be avoided based on the severity of the restriction or weather phenomena.

ARAT applies to this specific topic because it allows flight operators to better understand weather implications on proposed alternate routes and efficiently choose the best route amendment to file.

ARAT will accelerate the implementation of NASA technologies in the current and future National Airspace System (NAS) by leveraging the DIP platform and providing a means to demonstrate the benefits of DIP.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Under the Digital Information Platform (DIP) project, NASA is demonstrating collaborative rerouting capabilities from the Airspace Technology Demonstration 2 project using the Collaborative Digital Departure Re-routing tool, with a focus in the D10 TRACON area. By

developing the Alternate Route Availability Tool (ARAT), we extend this concept of optimal alternate routes between city pairs within a lightweight capability that will apply NAS-wide. ARAT will connect to DIP and demonstrate its potential to improve air traffic decision making.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The Alternate Route Availability Tool (ARAT) has a market in the aviation community, specifically for airlines as well as Air Traffic Control. Prospective customers in the airline industry include all major commercial (Part 121) airline and air taxi services (Part 135). Other potential customers include companies that market route generation tools.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.04-1028**

SUBTOPIC TITLE: Unpiloted Aerial Platforms and Technologies for NASA Science Missions

PROPOSAL TITLE: Helium Transfer Scroll Pump System (HTSPS)

Small Business Concern

Firm: **Air Squared, Inc.**
Address: **510 Burbank Street, Broomfield, CO 80020**
Phone: **(513) 238-9778**

Principal Investigator:

Name: **John Wilson**
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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

In order to revisit Venus and explore its climate, atmosphere, and surface for the first time since the 1985 VeGa mission, NASA is interested in developing aerial vehicles capable of in situ investigation. Four potential aerial platforms: fixed altitude super-pressure balloons, variable altitude balloons, solar airplanes, and hybrid airships were evaluated by JPL for their mission suitability according to scientific merit, size and complexity, and technological maturity. This downselection is critical as the aerial platform must float and fly between 52 and 62 km in the atmosphere while experiencing temperatures ranging from -30°C to 62°C, pressures from 80 kPA to 18 kPA, solar fluxes as high as 2,300 W/m2, and IR heat flux up to 830 W/m2. Balancing these three selection criteria, JPL identified variable altitude controlled robotic balloons, or aerobots, as an optimized and achievable solution for near-term Venusian in situ atmospheric exploration.

To fill this critical gap and enable aerobot exploration on Venus, Air Squared proposes the Helium Transfer Scroll Pump System (HTSPS); a semi-hermetic, orbiting scroll, oil-free helium transfer pump proof-of-concept experiment coupled to a venting method for altitude control to be pursued in Phase I.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- ISRU atmospheric investigation on Venus and other extra-terrestrial atmospheres
- Terrestrial weather observations

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- Commercial terrestrial weather observation
- Defense intelligence, surveillances, and reconnaissance (ISR)
- Commercial low earth orbit space tourism

Duration: **6**

PROPOSAL NUMBER: 22-1- **A2.02-2214**

SUBTOPIC TITLE: Enabling Aircraft Autonomy

PROPOSAL TITLE: Enhanced Detect and Avoid Optical Sensing for Urban Air Mobility

Small Business Concern

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Circle Optics has developed and patented novel parallax-free, wide field of view (WFOV) multi-camera capture system technology that provides real time, stitch free, panoramic imaging. For this NASA Phase I SBIR project, Circle Optics proposes to develop new optical and mechanical designs for the purpose of satisfying NASA interests in improving air traffic safety. Under Focus Area 19, Integrated Flight Systems, Topic A2.02, Enabling Aircraft Autonomy, NASA and the FAA are seeking technologies to enable intelligent vehicle systems, including new software and hardware sensing and perception technologies. With the goal of enabling piloted vehicles augmented with autonomous capabilities to increase air safety, as well as autonomous unmanned air vehicles, NASA needs a next generation optical imaging and sensing system to address the gaps in situational awareness. In response, Circle Optics proposes to develop an EO/IR visor type sensing system that provides improved detect and avoid sensing in accord with the FAA DO-365B Detect and Avoid MOPS and thus help support NASA's goals for intelligent vehicle systems. Towards meeting these goals, Circle Optics would engage with both eVTOL and UAV companies, and companies developing detect and avoid hardware and software, to better understand the operational environment and the SWaP-C limitations that may impact such systems. Circle Optics mechanical design efforts will then include lens and system mounting, mechanical and thermal stability, electronic support, and the anticipated assembly fixtures and tools. Circle Optics would also advance the optical design, while focusing on SWaP-C requirements, manufacturability, and mechanical compatibility, to develop a nearly fabrication ready design. As a result, Circle Optics imaging devices can move NASA closer to having the optical sensing capabilities to enable situational awareness and safety for future air vehicles, their drivers or passengers, and their airspace environments.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA is collaborating with the FAA to anticipate the future world of urban air mobility by developing standards, and encouraging technical innovation, so eVTOLs and UAVs will be able to travel safely within the national airspace. Once developed, Circle Optics EO/IR sensors may be useful to NASA on vehicles that are used for space, lunar, or extra-planetary navigation and collision avoidance. Similar Circle Optics camera systems may also be useful to NASA in capturing panoramic scenes or photogrammetry during space exploration missions.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The Circle Optics visor system for detect and avoidance EO/IR sensing can be optimized for use on DOD / USAF aircraft to image the airspace to provide situational awareness and search and

track functions of potential hostile aircraft. Small commercial drones or UAVs will likely need similar optical detection, avoidance, and navigation imaging, but with a smaller SWaP-C than needed for eVTOLs.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.01-1648**

SUBTOPIC TITLE: Lidar Remote-Sensing Technologies

PROPOSAL TITLE: ErYAG Energy Scaling for Water Vapor DIAL

Small Business Concern

Firm: **Fibertek, Inc.**
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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

Fibertek proposes to develop technology for power scaling a frequency doubled Er:YAG single frequency laser source to meet the needs for a planned water vapor DIAL space-based instrument. Our approach will focus on quantifying the system level benefits of reduced-

temperature operation of a power-scaled Er:YAG oscillator and power amplifier. A primary challenge to the Er:YAG laser system is inherently low gain and quasi-three-level lasing transitions of the erbium activator ions. It is well-established that reducing the laser gain medium to sub-ambient temperatures improves achievable laser efficiency. *However, models based on cross-section data from the current literature that simply use Boltzman statistics for scaling cannot account for the observed improvements, inhibiting system trades of performance versus temperature.* Fibertek proposes to address the lack of data in the current literature by collecting spectroscopic data over the temperature range 77K-300K to determine the optimum gain medium temperature for Er:YAG. This data will be integrated into an advanced energetics model to accurately predict improvements in laser efficiency. The model predictions will be validated through laser demonstrations as well as to guide a study to assess the improvements relative to potential SWaP penalties associated with operating at a reduced temperature. Energy scaling of Er:YAG could potentially provide NASA with a compact laser transmitter that could revolutionize weather and climate research by providing three dimensional distributions of water vapor profiles, estimates of perceptible water vapor, high resolution methane column measurements, distributions of planetary boundary layer heights, and attenuated profiles of aerosols and clouds.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The key NASA application include the following all of which have been identified as mission and technology development area in the 2018 Earth Science Decadal Survey. An Er:YAG MOPA could provide a higher energy, more efficient, more robust and lighter weight approach for

1. Water Vapor and Methane Differential Absorption Lidar systems
2. Coherent detection 3-D wind measurement systems

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

1. DoD: Lidar systems and illuminators require high pulse energy for greater range and wider field of view, with a requirement for operation in the eyesafe window (1400-1700nm). Er:YAG at 1645nm is well suited for these applications.
2. Commercial: An Er:YAG laser with higher pulse energy can extend range for current wind lidar systems for wind farm and other types of commercial wind measurements.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S14.02-2896**

SUBTOPIC TITLE: Particle and Field Sensors and Instrument-Enabling Technologies

PROPOSAL TITLE: Solar-blind solid-state energetic particle detection for next-generation instruments

Small Business Concern

Firm: **Advent Diamond Inc**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

In this project, Advent Diamond is developing diamond-based particle detectors, utilizing doped and undoped diamond structures to enable new space-based particle detection instrumentation. This line of detectors will be enabled by chemical vapor deposition growth of diamond with controlled incorporation of dopants into the diamond lattice. Diamond brings a number of advantages for space-based particle detectors, and is anticipated to enable a new generation of instrumentation. Specifically, the bandgap of diamond is 5.5eV, an energy greater than the photon energy of the majority of the solar spectrum. This is in contrast to silicon, which is the most commonly used semiconductor for solid state detectors, and has a bandgap of 1.1eV. By using diamond, our proposed detectors are naturally solar-blind without the use of metalized foils needed by silicon or other solid-state detectors. In turn, this means the detectors can be used to detect lower energy particles. The detectors will target sensitivity to 50keV-10sMeV particles, with solar blind response for direct solar viewing.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Suppressing response from solar UV/visible light emission has long been a challenge for solid-state particle detectors on NASA instrumentation. This project will benefit the NASA Living With a Star Program missions, including HERMES and the Geospace Dynamics Constellation. Understanding energetic particle composition, sources, and properties can aid in understanding the complex processes in the solar system environment and solar sysem evolution.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Diamond-based detectors can be used in a range of industry, scientific and medical applications. Our market research study revealed that the short-term market for niche and custom diamond detectors will be 3-5M/year for niche applications, and is expected to grow to 15-20M/year in 10 years by achieving commercialization and cost targets to expand into mass market applications.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.08-1413**

SUBTOPIC TITLE: Atomic Quantum Sensor and Clocks

PROPOSAL TITLE: Kerr-soliton On-chip Microcomb with Optimized Dispersion for Octave-spanning Output (KOMODO)

Small Business Concern

Firm: **Octave Photonics, LLC**
Address: **325 West South Boulder Road Suite B1, Louisville, CO 80027**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

We are proposing Kerr-soliton On-chip Microcombs with Optimized Dispersion for Octave-spanning Output (KOMODO). The KOMODO platform will be a chip-scale optical frequency comb compatible with compact, deployable, next-generation optical atomic clocks and quantum sensors. Our proposed solution brings together engineered nano-scale waveguides, precision laser stabilization techniques, and advanced photonic packaging to realize true chip-integrated comb sources for demanding terrestrial and space-based applications in timing, spectroscopy, and quantum sensing. The project will translate directly into a commercial device that will provide a stabilized broadband frequency-comb output with low size, weight, and power (SWaP) requirements.

Frequency combs are extremely stable multi-wavelength laser systems that provide a coherent link between the optical and microwave domains. Octave-spanning combs are essential for modern atomic timekeeping, where the comb is required to read out an optical atomic clock laser. The current state-of-the-art in compact frequency combs are fiber-based mode-locked lasers. While such systems have been instrumental in starting the transition of frequency combs

outside of the laboratory, the SWaP requirements are still incompatible with many uses, especially space-based applications.

In contrast, microcombs offer a path towards reducing the SWaP of these systems by an order of magnitude, opening possibilities for the integration of combs into hand-held devices and low-power spacecraft. The proposed KOMODO platform represents a new paradigm for fully stabilized microresonator frequency combs with low SWaP. We will achieve this by improving the TRL of four key technologies in this program: 1) turn-key comb generation with hybrid-integrated pump lasers, 2) advanced dispersion control through engineered photonic-crystal ring resonators, 3) self-referenced microcomb stabilization, and 4) environmentally robust photonic packaging.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The development of octave-spanning microcombs addresses needs for stable and broadband frequency references with low size, weight, and power in NASA focus areas including precision timing, navigation, geodesy, LiDAR, atmospheric spectroscopy, and precision-radial-velocity measurements. Our Phase 2 demonstration of a fully stabilized packaged microcomb in an optical clock system will directly address the critical technology gap with low-SWaP components for atomic sensors and clocks suitable for space-based operation.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Compact chip-scale frequency combs have broad applications outside NASA interests including low-noise microwave generation, optical frequency synthesis, optical coherence tomography, single photon and entangled state generation, and optical communications. KOMODO will provide a general-purpose solution for these uses by offering broadband and stabilized combs in a robust turn-key package.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z7.03-1718**

SUBTOPIC TITLE: Entry and Descent System Technologies

PROPOSAL TITLE: Domestic Blended Yarn Solution for 3D Woven Ablative TPS

Small Business Concern

Firm: **T.E.A.M., Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA has previously developed its 3D-TPS concept which offers superior mass efficiency relative to legacy carbon-phenolic TPS. Multiple 3D-TPS recipes developed to date include a spun carbon:phenolic yarn constituent. Future recipes may require alternate yarn constructions (denier, blend ratios, fiber chemistries, etc.) in order to tailor TPS properties to specific mission requirements. Stretch-breaking and subsequent processing of carbon based yarn blends is technically challenging and domestic based sources for such expertise are extremely limited. T.E.A.M., Inc. proposes to address these issues by using our newly minted yarn fabrication facility to develop and characterize a carbon-phenolic yarn solution. Baseline machine settings for current carbon yarn blend recipes being developed for the Army will be used as a starting point. A significant portion of Phase I focus will be on quantitative characterization of yarn properties at each step of the process (tensile strength, blend quality, denier, twist level.) This will establish baseline properties and characterization techniques to be used for further iterations anticipated in Phase II. In addition to quantitative characterization, TEAM's knowledge of 3D-TPS weaving with the legacy carbon:Kynol solution will be leveraged to evaluate overall "quality" and "weaveability" of the yarn that is developed.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed carbon-phenolic spun yarn solution will provide NASA a domestic source for the yarn solution used in multiple NASA 3D-TPS recipes. Examples include dual layer 3D-TPS (i.e. NASA HEEET) and the single piece heat shield solution for Earth Entry Vehicle (EEV) on the Mars Sample Return (MSR) mission. The yarn development process and related characterization methods proposed by TEAM will also establish a model to be followed for development of new carbon-polymer yarn recipes of potential value in future TPS designs.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The DoD and their sub-contractors have a vital need for spun carbon yarn variants to support carbon-carbon (C-C) materials on various hypersonic vehicle programs. Additionally, spun carbon-polymer yarn solutions such as carbon-PEEK and carbon-PA6 are of interest for use in thermoplastic composites for defense, aerospace and commercial applications.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H9.03-2251**

SUBTOPIC TITLE: Flight Dynamics and Navigation Technologies

PROPOSAL TITLE: A novel subset simulation-based technique for calculating the probability of collision

Small Business Concern

Firm: **Kayhan Space Corp**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Analytically computed value of Probability of Collision for long term engagements between two space objects using traditional schemes, which only consider some time span around the time of closet approach, can sometimes be incorrect by orders of magnitude. Sampling based methods are presented as a robust alternative to analytical schemes. To decrease the computational burden of simulating a large number of particles, a novel subset simulation based MCMC scheme is introduced to compute in-orbit space-object collision probability. The collision probability is expressed as a product of larger conditional failure probabilities by introducing intermediate failure events. Well-chosen large (relative to collision probability) values of nested conditional failure probabilities can be estimated by means of simulating only a limited number of samples. The resulting efficiency and accuracy of the suggested scheme are demonstrated

against independent benchmarks that use other techniques for calculating the probability of collision.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA CARA has a great interest in improving the conjunction assessment processes that are used to protect the scientific and defense satellites. With the addition of many smaller objects (<10cm) to the catalog of tracked objects that are only visible by Space Fence, NASA satellite operators will face more irregular conjunction events that do not follow 2-D PC assumptions. Our solution will reliability and accurately identify such events and help the operators save hours of analysis time or unnecessary avoidance maneuvers.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

With the dramatic increase in the number of ridesharing activities, more and more spacecraft are released by the launch vehicle into orbit along with tens of other spacecraft, resulting in many long-period encounters that cannot be assessed accurately with conventional methods. Our proposed method can accurately and efficiently quantify the risk associated with long-period conjunctions.
Duration: **6**

PROPOSAL NUMBER: 22-1- **S17.03-1060**

SUBTOPIC TITLE: Fault Management Technologies

PROPOSAL TITLE: Multidisciplinary Analysis of Fault Management Design for System Autonomy and Resilience

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

A major step in fulfilling NASA's technology needs to increase system autonomy and resilience is to connect fault management (FM)/System Health Management (SHM) to systems engineering (SE) and operations. There are recent trends to improve SE through the use of models to create model-based SE (MBSE) and connect FM to SE and operations. One such approach for performing a rigorous SE is the Goal-Function Tree (GFT) representation using Systems Modeling Language (SysML) that was developed at NASA JPL and MSFC.

Despite their inherently close relationship to SE in practice, SHM/FM practices have remained disjoint and not tightly integrated with SE. Historically, SHM has been designed into the system only after the nominal system is designed, which essentially makes it a band-aid of the problems without consideration of how these might have been prevented or mitigated. Between SE and SHM/FM, separate sets of Subject Matter Experts (SMEs), knowledge repositories, modeling methodologies and analyses processes with non-relatable results are typical. This lends itself to a large technology and knowledge gap between the two sets of practices that result in significant inefficiencies throughout the life cycle, from design through verification and validation (V&V) through operations.

Qualtech Systems, Inc. (QSI) plans to integrate TEAMS® analytic capabilities with GFT to provide a multidisciplinary solution that connects an important SE approach with a tool that provides analytic capabilities for FM design and operations. It intends to integrate SHM/FM directly within SE from the beginning of a project, thereby suitable for FM of future spacecraft. This effort: (1) performs FM design analysis of a system design modeled in GFT, (2) enables FM design to be evaluated in an operational context by performing SHM functions, (3) supports Trade Studies to evaluate merits of FM architecture; and (4) enables "System" level assessment and visualization of FM qualities modeled in GFT.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

QSI's technology will enable NASA to better plan and execute future Space Missions. It's applications include verification testing of NASA's next generation launch vehicle such as the SLS, cis-lunar infrastructure including the Gateway and deep space human exploration such as the Habitat. Exploration Upper Stage is also a target. TheGateway spacecraft has vehicle models, which can be integrated in the MBSE environment and evaluated against FM robustness. Europa is a candidate for demonstrating FM capabilities within GFT driven MBSE practices.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The technology can be applied to DoD's Mission planning and Rapid design of space missions / satellites including Geosynchronous earth orbit (GEO), Medium earth orbit (MEO), and Low earth orbit (LEO), commercial space launch vehicles (e.g., SpaceX), NORAD, Space Command ground segments, JSF, Navy shipboard platforms, submarines, BMD systems, UAVs, UGVs and unmanned submersible vehicle markets.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.05-2522**

SUBTOPIC TITLE: Computational Tools and Methods

PROPOSAL TITLE: Robust and Efficient WMLES Unstructured Grid Generation with HeldenMesh

Small Business Concern

Firm: **Helden Aerospace Corporation**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

Successful completion of our Phase I effort results in development and delivery of an enhanced version of HeldenMesh demonstrated for accurate, efficient, and automated CFD mesh generation for WMLES applications. HeldenMesh is an existing commercial CFD mesh generator already in widespread use in industry and NASA for generating meshes for Navier-Stokes CFD flow solvers like FUN3D and USM3D. It was originally developed under Helden internal research and recently enhanced under several NASA and Air Force Research Laboratory (AFRL) funded SBIR efforts. Our proposed effort builds upon these past efforts by incorporating two enhancements to enable more accurate and robust WMLES simulations. First, HeldenMesh is modified to generate a quad-dominated surface mesh and a hex-dominated near-wall layer mesh for a more efficient and accurate cell type which is more suited to WMLES

analysis. Second, HeldenMesh is modified to generate wedge elements in the viscous layers at sharp trailing edges to improve the overall grid quality and grid normal alignment. Any further development required to improve HeldenMesh's WMLES mesh generation capability is identified under Phase I and plans made for completion under a follow-on Phase II. With these enhancements in place, we then demonstrate the accuracy and efficiency of HeldenMesh for WMLES applications using the FUN3D flow solver on two test cases coordinated with NASA. As part of these demonstrations, WMLES meshing best practices are developed in terms of grid quality, impact of anisotropic stretching near and far from the wall vs. isotropic meshing, number of viscous layers, layer growth rate/profiles, as well as spanwise/chordwise spacing requirements in the critical near-wall regions. A grid convergence study is also performed with impact of cell count in critical regions vs. accuracy. Our effort culminates with delivery of an enhanced HeldenMesh executable with a direct FUN3D interface for independent testing.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The successful completion of this Phase I effort supports all NASA programs and projects that use CFD. HeldenMesh is already used extensively by NASA for generation of unstructured meshes and is already a key component of their CFD process. The technology developed under this project will enable design decisions by Aeronautics Research Mission Directorate (ARMD) and Human Exploration Operations Mission Directorate (HEOMD).

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Helden Aerospace has already successfully transitioned its existing HeldenMesh commercial grid generator to industry. Grid quality improvements made under Phase I benefits users running WMLES and also the majority of users performing RANS simulations. This effort results in an improved product ready for widespread use by our growing base of industry users.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H5.01-1626**

SUBTOPIC TITLE: Lunar Surface 50 kW-Class Solar Array Structures

PROPOSAL TITLE: 50 kW-Class Retractable Rollable Mast Lunar Surface Solar Array

Small Business Concern

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

Technical Abstract (Limit 2000 characters, approximately 200 words):

The 50 kW-Class Retractable – Rollable Mast Array (R-ROMA) vertically deployed and retractable solar array in addition to its critical enabling components: the Trussed Collapsible Tubular Mast (TCTM), Recirculating Belt Deployer (RCB), Composite Blanket Elements (CBE), Double Parallelogram Arms (DPA), and the R-ROMA Pedestal directly address and enable NASA's Moon to Mars program objectives.

The Moon to Mars campaign requires numerous 50 kW-class solar arrays for powering the Foundation Surface Habitat, ISRU equipment, lunar bases, rovers, landers, science equipment. These solar power systems ideally are also reusable for solar electric propulsion (SEP) in route to Mars. NASA requires sustainable power on the lunar surface to support a proliferated human presence on the lunar surface. This will be accomplished by working closely with small business and commercial entities who will provide the sustainable power infrastructure required by NASA.

In the proposed effort Opterus will work closely with current NASA Lunar Vertical Solar Array Technology (VSAT) program participants to scale prior art 10 kW-class solar arrays and related critical components to field a second generation 50 kW-class deployable and retractable solar array solution. Opterus has engaged multiple VSAT participants including Lockheed Martin, Astrobotic, Honeybee Robotics, and Space Systems Loral (Maxar). Formal statements of support have been submitted by Lockheed Martin to drive Opterus' design towards a second-generation LM solar array.

Over the course of the Phase I structural requirements will be defined for a 60 kW R-ROMA, existing component designs will be scaled and critically analyzed to evaluate theoretical performance. Key components will be prototyped and experimentally demonstrated to validate a TRL 3, 50 kW-class R-ROMA design.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA's Moon to Mars campaign requires many 50 kW-class solar arrays for powering the Foundation Surface Habitat, ISRU equipment, lunar bases, rovers, landers, science equipment. These solar power systems ideally are also reusable for solar electric propulsion (SEP) in route to Mars. NASA requires sustainable power on the lunar surface to support a proliferated human presence on the lunar surface. This will be accomplished by working closely with commercial entities such as the current Lunar Vertical Solar Array Technology program participants.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Opterus' Trussed Collapsible Tubular Mast and Recirculating Belt Deployer are highly scalable deployable structures technologies ideally suited for extremely large aperture spacecraft structures. Current Non-NASA efforts include space solar power beaming architecture, spacecraft deployed solar arrays for solar electric propulsion, high power radar, deep space power systems.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H6.23-2442**

SUBTOPIC TITLE: Spacecraft Autonomous Agent Cognitive Architectures for Human Exploration

PROPOSAL TITLE: Virtual Explanation Reasoning Agent (VERA)

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Future human deep space missions will place crews at increasing distances from Earth and present several challenges to overcome. Currently, ground teams entirely manage the spacecraft, helping astronauts with scheduling, procedure execution, estimation and interpretation of current state, and other tasks. As the distance from ground support increases, so does time lag in communications, increasingly requiring astronauts to independently work through problems such as diagnosis of critical faults in spacecraft systems and their corresponding cascade effects. This places a much higher cognitive burden on astronauts who must use multiple pieces of information from many different sources to identify and prioritize underlying issues. To meet these deep space support needs, SoarTech proposes the Virtual Explanation Reasoning Agent (VERA), a cognitive agent built on the Soar cognitive architecture and capable of helping humans solve problems in deep space missions through diagnostic reasoning, explanation, and learning. VERA will provide advanced state estimation and explanations for astronauts to help them more quickly, easily, and accurately identify and correct problems with spacecraft system, and will learn from its experience and interactions with astronauts and other information sources to improve its capabilities and resilience to novel, surprising, and evolving circumstances when updates from ground are unavailable.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

AI diagnostic assistants for system operation, maintenance, repair, and troubleshooting in spacecraft and orbital systems.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

AI diagnostic assistants for system operation, maintenance, repair, and troubleshooting in general aviation and any complex systems environment, including manufacturing, power generation, and medical systems.
Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.06-1610**

SUBTOPIC TITLE: Earth Science Decision Support Tools Focused on the Mitigation of Climate Change Impacts

PROPOSAL TITLE: Wildfire Integrated Modeling, Prediction, and Learning Environment (WIMPLE)

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

The risk of wildfires has increased significantly in recent years and touched communities not previously at high risk. Effective mitigation of wildfire risk is essential to reduce the potential for catastrophic losses. Accurate assessment of the risk of wildfire on a parcel-by-parcel basis will enable fire departments and homeowners to effectively triage and plan to reduce the risk. We will develop a Wildfire Integrated Modeling, Prediction, and Learning Environment (WIMPLE), a hybrid AI tool for wildfire risk assessment. WIMPLE is based on our Scruff AI framework, which provides integration of different kinds of AI models, sharing and composition of models, with spatiotemporal flexibility in model composition. We will demonstrate WIMPLE by developing a new wildfire risk assessment method that integrates multiple model components such as fire propagation and climate models at different spatial and temporal scales, as well as learning from historical data. We provide a decision-support UI using explainable AI techniques to ensure that predictions and recommendations of WIMPLE can be understood and trusted by users.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

WIMPLE will link work being done at NASA with the end-user community to support decision making about wildfire risk triage and mitigation. Using sources such as NASA Earth Observatory and NASA Visible Earth, and climate models such as the GISS GCM, WIMPLE will provide an avenue for these sources to directly support critical environmental decisions.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

WIMPLE will support wildfire risk assessment at low cost for homeowners working with fire departments, for example through programs such as Marin County's Community Wildfire Protection Plan (CWPP). WIMPLE will enable more rapid and proactive triage and mitigation of wildfire risk than current approaches.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H6.22-2286**

SUBTOPIC TITLE: Deep Neural Net and Neuromorphic Processors for In-Space Autonomy and Cognition

PROPOSAL TITLE: Neuromorphic Electronics that Rethinks Verifiable Efficiency on Spacecraft (NERVES)

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

To meet the NASA need for power efficient algorithms that improve onboard autonomy, Exploration Institute proposes to develop NERVES, an approach for power efficient, verifiable generic calculation and signals processing onboard resource constrained systems using the latest neuromorphic hardware.

Through our substantial experience in applying and developing neuromorphic algorithms for spacecraft systems, we have determined that the performance of our algorithms can be substantially improved if the lowest level substrate, the building blocks, were designed to use the most power efficient traits of neuromorphic hardware. More efficient performance of key mathematical operations in neuromorphic hardware would provide high value to spacecraft developers as they can translate their existing work directly into a vastly more power efficient and faster processing system. NERVES is driven by a practical need and the pipeline to commercialization is already established through Exploration Institute's track record and current work.

NERVES directly maps conventional algorithms to any neuromorphic processor, combining the benefits of more capable, well known algorithms with the power savings of a neuromorphic architecture. A neuromorphic chip like Intel's Loihi has a computational power density of more than 1000x that of a CPU or GPU for some tasks. Based on our initial analysis, Exploration Institute predicts that NERVES will enable these kinds of power savings (or conversely, computational capacity increase for the same power) which will greatly improve NASA's capacity for onboard autonomy.

As an added bonus, NERVES provides a more verifiabile approach to neuromorphic computing in space, by allowing the use of verified computing approaches (non-neuromorphic, conventional) on neuromorphic hardware with all the power savings that can entail. This enables more likely adoption and infusion into NASA programs.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

For a given power budget, using NERVES in concert with neuromorphic hardware, NASA could run significantly more complex processing onboard that will enable more onboard autonomy. With such a general, infrastructure-level additional capability, the potential applications are numerous, including: safer human habitation modules, faster onboard autonomy for navigation and other applications, more automated onboard Fault Management, and a foundation to build onboard cognitive computing to support general operations.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

NERVES is specifically designed for spacecraft systems such as Gateway, planetary robotics, and government and commercial satellites in general, but also applies to any autonomous system, particularly autonomous vehicles, and is especially useful for applications that are power constrained and mobile (for example: agricultural and automated platforms).

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z8.10-1283**

SUBTOPIC TITLE: Modular Systems for Cost-Effective Spacecraft Missions

PROPOSAL TITLE: On Demand Printing of Stretchable Electronics

Small Business Concern

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Printing electronics is a new and quickly growing alternative to traditionally manufactured electronics wherein an additive method is used to produce electronic circuits, passive circuitry, displays, sensors, utilizing conductive and sometimes dielectric materials. Advances have been made in electronic printing technology in recent years bringing it closer to scalable manufacturing. Flexible PCBs (FPCB) provide the same processing capability as a standard PCB, with added flexibility, and are better suited for space applications. FPCB's are more reliable, can bend without breaking / sustaining damage, can withstand greater stress and harsher conditions, and can be adapted to smaller spaces due to thin copper and insulating layers.

ChemCubed (C3) provides additively manufactured (AM) printing solutions for electronics. One of the key advances in recent years in AM electronics has been in the conductive inks for inkjet printing. This advance is a main reason why scalable printed manufacture PCBs is now within reach. C3 leads the way in particle-free reactive silver inks, providing the highest conductive performance, sintering efficiency and printing reliability available in the market. C3 has developed the best conducting ink available, and a system of products to use inkjet technology to print F/PCBs.

A nanocomposite dielectric material is needed to serve as (a) insulating layers between the circuits, (b) masking material for soldering, and (c) support at connection points. This material will be develioed to have the following properties: a) high tear and strain resistance, b) compatible with silver ink, c) dielectric constant between 3 to 4, d) good printing performance through a prize inket head, and e) electrical insulating properties. This work is in the development stages already, and will be fully addressed in the proposed project phases I & II. The goal for this Phase I is to develop and produce an ink-jettable metal ink.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed innovation will enable wearable electronics, RFID antennas, satellite communications, navigation and passive detection systems, radio communications, LED lighting systems, temperature sensors, power converters, control tower systems, IOT devices, and other in space applications for NASA. In-space manufacturing market value is expected to reach $7.5 billion by 2030. From 2020- 2030 the market is expected to grow at a CAGR of 17.26%.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Broader impacts include defense, national security, & supply chain improvements. Lack of a secure domestic supply chain for PCBs poses a national security risk. Additionally, the proposed innovation would enable novel warfighting capabilities and reduce sustainment costs of military

weapon systems. Finally, the solution enables seamless health sensor integration into clothing and other wearables.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.05-1527**

SUBTOPIC TITLE: Computational Tools and Methods

PROPOSAL TITLE: High-Resolution Unstructured Mesh Refinement Framework for Aircraft Icing Predictions

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Ice accretion on aircraft can trigger flow separation and degrade aerodynamic performance by reducing lift and stall angle-of-attack, increasing drag, and in severe cases causing complete loss of aircraft control. Modeling and quantification of icing effects on aircraft performance therefore plays a critical role in aircraft design and certification. High-fidelity CFD analyses of

aircraft with imposed ice shapes are impeded by time-consuming manual pre-processing and mesh generation that are difficult to automate. Given the desire to adapt the mesh to optimize a given output functional (e.g. aircraft CLmax), these challenges are particularly important as the mesh quality in the vicinity of complex ice shapes directly impacts the accuracy of CFD solution error estimates. The objective of this project is to develop, demonstrate, and deliver a high-resolution automated unstructured mesh refinement framework for aircraft icing predictions. The capability will interface with existing NASA CFD solvers and provide access to high-resolution icing data in a manner consistent with established procedures for accessing CAD geometry, while locally disambiguating between CAD and ice shape. Grid quality improvements will be made near the complex ice geometry to improve error estimates. In Phase I, the capability will be developed in FUN3D using metric-based anisotropic mesh refinement to achieve optimal CLmax prediction for an iced aircraft configuration. Mesh refinement at the ice surface will be augmented to leverage the new API to query the true ice shape to improve the resolution of the surface discretization. Accuracy and efficiency of the developed capability will be demonstrated for a canonical wing geometry as proof of concept. Phase II efforts will further develop and mature the capability, and demonstrate on more complex topologies including high lift geometries and perform uncertainty quantification to understand and improve solution sensitivity and accuracy.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This technology has applicability not only for fixed wing aircraft icing predictions, but also for rotor blade icing predictions for rotorcraft and eVTOL configurations. Direct applications reside in several of NASA's programs such as the prediction of performance degradation for fans, ducts, propellers, and airframes, due to the presence of ice accretion. Impacted NASA programs and projects include Advanced Air Transport Technology, Commercial Supersonic Technology, Revolutionary Vertical Lift Technology, and others.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

NOAA deploys aircraft during inclement weather. Commercial transports and business jets fly at conditions where in-flight ice accretions occur frequently. Aircraft fly to service oil rigs in the North Sea, Alaskan coast, etc. Commercial and military UAVs are more susceptible to icing due to their size, flight regime, and speeds. These examples show enormous market for improved icing predictions.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z8.13-1573**

SUBTOPIC TITLE: Space Debris Prevention for Small Spacecraft

PROPOSAL TITLE: Self Propelled Energetic Electron Dispensers (SPEEDs) for Deorbit Applications

Small Business Concern

Firm: **Physical Sciences, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

Physical Sciences Inc. (PSI) proposes to develop passive and active enhancements to existing heritage electrodynamic tether smallsat deorbit systems. Passive coatings based on flexible materials with negative electron affinity-enhanced TP electron emitters will enable deorbit of smallsats and other payloads at end-of-life at altitudes up to at least 1200 km by increasing the passively generated current through electrodynamic tethers. The active component of PSI's system, embodied by a robust, self-powered and self-regulated cold cathode electron gun, will further increase deorbit rate and altitude while also giving a host satellite control over deorbit parameters. This active deorbit system is entirely electric and requires no propellant, dramatically reducing their size, weight and power requirements versus traditional active deorbit systems and services.

Both the active and passive deorbit components leverage past work PSI has performed for the US Space Force and for NASA. PSI is also partnering with Tethers Unlimited Inc. (TUI) to adapt the passive and active electrodynamic tether enhancement to their existing, heritage terminator tape (TT) deorbit systems. In Phase I, PSI will demonstrate proof of concept for the new tether enhancement technologies. In Phase II, PSI will apply the new technologies to TUI's TT system, producing flight-ready prototypes available to NASA for deployment on demonstration missions following the Phase II program.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The innovation is applicable to smallsats, and possibly larger objects such as spent rocket stages having terminal altitudes up to at least 1100-1200 km. The application is controlled, rapid, propellantless deorbit of payloads in order to minimize further pollution of low Earth orbit (LEO) and mitigate the risk of spacecraft collisions. Further development may allow propellantless station keeping in LEO, as well as propellantless maneuver of spacecraft around other planets with natural magnetic fields such as Jupiter and Saturn.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The innovation is applicable to all smallsats, and possibly larger payloads such as spent rocket stages. The application is controlled, rapid, propellantless deorbit of payloads, minimizing further pollution of low Earth orbit and mitigate risk of spacecraft collisions. This innovation will also enable cost-effective compliance with regulations designed to mitigate space pollution.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z14.02-1779**

SUBTOPIC TITLE: Extraterrestrial Surface Construction

PROPOSAL TITLE: Brick Ubiquitous and Itinerant Lunar Deposition System

Small Business Concern

Firm: **Astrobotic Technology, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Extreme temperature fluctuations throughout the lunar day and night combined with the economic and environmental challenges of cislunar launch, transit, and deployment have impeded America's ability to create the critical infrastructure needed to support in-situ construction and a sustained human and robotic presence on our nearest neighbor. The establishment of the Commercial Lunar Payload Services (CLPS) and Artemis programs are channeling growth and investment into the nascent lunar economy, which is building demand for lunar activities. Critical infrastructure pieces must be established to support this growing demand, however, such as power, communication, and construction technologies. Consequently, Astrobotic proposes its Brick Ubiquitous and Itinerant Lunar Deposition (BUILD) system to

produce, retrieve, and place building block elements for small to medium sized construction activities on the lunar surface.

The BUILD system is complementary to NASA's Moon-to-Mars Planetary Autonomous Construction Technology (MMPACT) project. Whereas MMPACT is focused on harvesting materials from the lunar surface and using them to produce structures such as landing pads in the near term, Astrobotic can utilize the waste slag produced as a byproduct of molten regolith electrolysis used from oxygen production to create CAST (ceramic aggregate structural and thermal) elements. These CAST elements can then be used to construct structures such as small berms for blast shielding and thermal and radiation protection. The target requirements of the CAST elements produced in this project are as follows:

- Structural integrity capable of supporting bearing pressures of > 150 kg/m^2
- Compressive strength of > 12.7 kPA
- Modular size of 19 cm x 9 cm x 8 cm
- Slag composition inclusive of $CaO\text{-}Al_2O_3$, $K_2\text{-}SiO_2$, $MgO\text{-}P_2O_5$.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The BUILD system is an ideal technology for enabling in-space construction as a service, which would allow domestic and international government agencies, as well as lunar infrastructure companies to construct lunar surface structures. Astrobotic's BUILD system has utility for NASA programs that require blast protection near launchpads or thermal and radiation shelters for robotic assets or human habitation.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial lunar mining would benefit from simple walled structures that provide thermal and radiation shielding to enable long duration missions. International space agencies could commission the resulting construction services for blast protection near planetary bases. Astrobotic will also look to offer the resulting retrieval and placement system as a product for other robotic applications.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z8.02-2283**

SUBTOPIC TITLE: Communications and Navigation for Distributed Small Spacecraft Beyond Low Earth Orbit (LEO)

PROPOSAL TITLE: Lunar Inter-Spacecraft Optical Communicator

Small Business Concern

Firm: **Chascii Inc.**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

Chascii is proposing the development of an inter-spacecraft omnidirectional optical communicator (ISOC) that will provide fast connectivity and navigation information to small spacecraft forming a swarm or a constellation in cislunar space. The ISOC proposed for cislunar applications operates at 1550nm, employs a dodecahedron body holding 6 optical telescopes and 20 external arrays of detectors for angle-of-arrival determination. The proposed ISOC will provide full sky (4π steradian) coverage and gigabit connectivity among smallsats forming a swarm or constellation. It will also provide continuous positional information among these spacecraft including bearing, elevation, and range. We also expect the ISOC to provide fast low-latency connectivity to assets on the surface of the moon such as landers, rovers, instruments, and astronauts. During Phase I we propose to conduct a thorough study of the cislunar ISOC including key factors that affect angular accuracy and available ranging techniques suitable for ISOC accurate range calculation. We will also perform a conceptual design of the ISOC that will lead to successful prototype construction and testing during Phase II. We believe the ISOC, once fully developed, will provide commercial, high data rate connectivity to future scientific, military, and commercial missions around cislunar space and beyond.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed ISOC will allow ultrafast wireless data transfer for many space applications. Among the NASA applications include short range inter satellite communications such as formation flying and constellations of spacecraft. A key application of the ISOC is to enable constellations of spacecraft in cislunar space such as the proposed Lunanet. It should also allow connectivity around planetary bodies and on the surface of those bodies as well. It should also enable new larger instruments via synthetic aperture formation as well.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial development of space is imminent. A key opportunity is to use space to provide internet services across the globe. There are 7.9B people on Earth from which 3.7B (47%) have no internet access. We believe that, once fully developed, the ISOC should be able to provide a viable solution to the global connectivity market.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.03-2374**

SUBTOPIC TITLE: Extreme Environments Technology

PROPOSAL TITLE: Silicon Carbide High Temperature Solid State Memory

Small Business Concern

Firm: **CoolCAD Electronics, LLC**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The proposed work covers an initial feasibility analysis of high temperature tolerant memory cells. Additionally, the proposed work covers an exploratory set of small-scale

experiments and a proof-of-concept demonstration. The project targets a well-rounded approach of "design for manufacturing" and "design for reliability" for temperature hardened memory electronics.

A high temperature tolerant memory technology is needed for sensing and logging operations in harsh environments. To this end, silicon carbide offers a mature semiconductor technology that is akin to silicon in many aspects of its processing.

A dynamic random-access memory (DRAM) is a crucial part of many silicon electronics. It provides a fast high-capacity storage solution in many applications due to its relatively small cell structure. The most compact DRAM array is based on one capacitor one transistor (1C1T) memory cell.

Even though the 1C1T memory cell is volatile in silicon due to the relatively high leakage currents at its p-n junctions, it is speculated that such a cell would be "practically" non-volatile and static if fabricated in silicon carbide. This is due to the fact that the reverse biased leakage currents in SiC p-n junctions is minimal, drastically cutting the loss rate of the stored charge, or increasing the time constant of the charge storage system.

The longest possible time that DRAM holds onto its data before losing it to leakage is called the charge retention time. Charge retention times in silicon are small, requiring constant refresh cycles, which are not very power-aware. The initial experiments in silicon carbide indicate such times are very long in SiC, making its 1C1T cell "practically" a non-volatile and static memory unit.

In this project, we plan to design and fabricate SiC DRAM and SRAM memory cells, and investigate their potential for use in harsh environments, to pave the way for advanced logging and metrology in extreme environments.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Exploration of inner planets such as Venus and Mercury require electronics that can operate at high temperatures. The peak temperature on Mercury is as high as 430 C, while the lowest temperature is as low as -180 C. Additionally, even though Venus is further away from the Sun, it is significantly warmer than Mercury. Lastly, gas giants (for example Jupiter) and some solar probes also require electronics that can operate at temperatures above the reach of silicon electronics. The proposed work provides a high temperature electronics solution.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

High temperature electronics include components ranging from the drill logging and sensing devices needed for the commercial oil, gas, and geothermal exploration activities to the active components, controls, and sensors needed for jets and hypersonics. Temperature hardened electronics are a gamechanger for energy exploration, energy conversion, and propulsion to name a few technical areas.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H6.23-1197**

SUBTOPIC TITLE: Spacecraft Autonomous Agent Cognitive Architectures for Human Exploration

PROPOSAL TITLE: TRACS -- A Cognitive Architecture for Deep Space Missions

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Future deep space missions will require artificial cognitive agents are able to interface with onboard systems and take over time-consuming routine tasks, thus reducing crew cognitive and work load. In addition, they should continuously monitor critical onboard systems and alert crew about any off-nominal operation, quickly responding to them according to predetermined procedures in cases where the crew is overloaded or would be endangered. We propose our fully implemented Thinking Robots Autonomous Cognitive System (TRACS) architecture at TRL5 as the basis for a cognitive agent for future NASA deep space missions. TRACS is open, modular, makes decisions under uncertainty, and learns in a manner that the performance of the system is assured and improves over time. It deeply integrates natural language capabilities and one-shot learning from instructions, observations, and demonstrations. TRACS allows for

easy integration with commercial off-the-shelf components and third-party modules, components, and software libraries, and has extensive integrated fault detection, fault exploration, and recovery methods. TRACS has also been successfully used in several projects with NASA collaborators at NASA Langley and NASA Ames. In this project, (1) the fully implemented and operational interactive cognitive TRACS architecture, extended by episodic memory for long-term interactions and additional annotation mechanisms for facilitating assurance, together (2) with the results from a feasibility study in NASA-funded simulation environment demonstrating the full operation of the architecture in interactive human-subject experiments, and (3) a detailed plan for the application domains, system integration, and evaluations in Phase II based on NASA objectives to be developed in collaboration with NASA.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The TRACS cognitive architecture will have broad application in NASA contexts, from cognitive advisors in cockpits, to control architectures for autonomous robots working remotely on the Mars habitat. Because TRACS can be easily integrated with existing systems, it can also be used just as an intelligence user interfaces on top of existing software which enables natural task-based interactions with humans.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The TRACS cognitive architecture will also be widely applicable in social and assistive robotic domains (e.g., office assistants that are given new tasks on the fly), but also in collaborative manufacturing or any other areas where humans need to interact with systems in natural language and be able to configure, adapt, and task such systems online.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.04-1977**

SUBTOPIC TITLE: Unpiloted Aerial Platforms and Technologies for NASA Science Missions

PROPOSAL TITLE: S-HALE Stratospheric HALE LTA Aircraft

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA has outlined several goals and objectives regarding cost-effective long-duration access to the stratosphere for environmental observation and scientific research. The High-Altitude, Long-Endurance (HALE) mission is to fly a payload weighing 22 or more pounds for at least 30 days at or above 60,000 ft altitude, while maintaining position within 100 nautical miles of a target point on the ground. In order to balance these mission objectives with important operational factors such as cost of deployment, end to end logistics, and global reach, Moonprint Solutions and Gossamer Aerospace propose the use of a solar powered, super-pressure airship, building on recent advances in materials and commercial components, to create the S-HALE system (Stratospheric-HALE). S-HALE will employ novel lightweight structural concepts in conjunction with proven stratospheric airship technologies to meet NASA needs. Advanced methods of vehicle handling and launch will also be employed to minimize risk.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

S-HALE will cost-effective long-duration access to the stratosphere for environmental observation and scientific research. This includes climate impact studies, crop performance, communications relays, and weather monitoring.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

S-HALE has numerous military applications including ground moving target identification, persistent surveillance, and targeted reconnaissance. Numerous commercial applications exist including disaster relief, internet access, and crop performance tracking.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z4.07-2773**

SUBTOPIC TITLE: Advanced Materials and Manufacturing for In-Space Operations

PROPOSAL TITLE: Solid State Welding for Space

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

TGV proposes to build a modular testbed that can scale ultrasonic additive manufacturing and test multiple material combinations in vacuum conditions. A lighter smaller sonotrode will be developed which will be tracable to testing on ISS or future space platforms but can serve to mature solid state welding designs and concepts in the current era

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This is an enabling technology for large structure, deep space missions or lunar bases.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

This is enabling technology for large civilian commercial space stations

Duration: **6**

PROPOSAL 22-1- **H6.22-2237**

NUMBER:

SUBTOPIC TITLE: Deep Neural Net and Neuromorphic Processors for In-Space Autonomy and Cognition

PROPOSAL TITLE: Neuromorphic Processor with radiation tolerant MRAM

Small Business Concern

Firm: **Numem Inc**
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Phone: **(408) 836-8795**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 6

Technical Abstract (Limit 2000 characters, approximately 200 words):

Space missions require high-performance, reliable computing platforms and can function in challenging environments. The von Neumann bottleneck constrains performance due to the time and energy consumed during the required data exchange between main memory chip sets and the processor. Neuromorphic computing could emerge as a game changer for space applications where mission success relies on fast and autonomous analysis of a vast array of incoming information from multiple sources.

The future space applications will drive the need for

- Reduced size, weight, and power constrains
- Data retention
- On-board adaptive learning capability
- Autonomous, onboard, and fast data analysis

Neuromorphic processors aligns with the above capabilities. Neuromorphic architectures are inherently fault tolerant, and several hardware implementations have high-radiation tolerance. In addition, neuromorphic algorithms are well-suited to classes of problems of interest to the space community.

Present Neuromorphic solutions for Space applications require FLASH memory for boot and weight storage in case of power loss or intermittent power failures. The FLASH memory has limitations on speed and life-time is limited by about 1M cycles of memory operations due to its endurance. For Deep Space Missions where continuous learning is required with updates on the non-volatile memory, a robust radiation tolerant memory with SRAM like performance but still with non volatility and high endurance is required. MRAM which offers 2.5X to 3.5X density advantage over SRAM, 1000X better endurance over FLASH, high radiation tolerance above 100Krad to 1Mrad and ultra-low power standby leakage which is critical for long battery life between solar recharge is a big advantage for these critical SPACE missions. **Numem proposes in Phase-I to create a interface system with MRAM which can connect with AKIDA Neuromorphic Processor from Brainchip to either limit or replace FLASH operations with MRAM.**

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Object Identification and Change Detection - Neuromorphic Computing could enable more efficient on-orbit data processing and storage

Autonomous Control - As activities in space become more remote and automated, without a human in the loop, this advantage could improve the satellite's ability to analyze onboard sensor data with better autonomous decisions.

Cybersecurity - Neuromorphic Computing onboard a spacecraft would provide a trusted protection mechanism

It can resolve a fundamental time-energy problem with fast low cost results.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Artificial Intellligence applied at Edge for ultra low power IOT applications,Large Scale Operations & Product Customization with vast amount of data-sets,Medicine and Drug discovery for faster analysis and iterations,Imaging & Vision Sensors for classification and detection, Autonomous Operations in Drones and Cars, Robotics Technologies,Defense - Hypersonic and Ballistic Missile Technologies

Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.01-1245**

SUBTOPIC TITLE: Lidar Remote-Sensing Technologies

PROPOSAL TITLE: Single Mode Ultra Large Mode Area Fiber Lasers with large energy storage (HE-ULMA)

Small Business Concern

Firm: **Optical Engines, Inc.**
Address: **842 South Sierra Madre Street, Suite D, Colorado Springs, CO 80903**
Phone: **(815) 301-5922**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

To meet the NASA need, Optical Engines (OEI) proposes to develop a new HE-ULMA, that will deliver high energy pulses with near diffraction limited beam quality from a single gain fiber. It is based on the technological concept of OEI commercial products and will also employ our understanding of advanced glass processing to create fiber lasers and amplifiers with distributed signal mode filtering with efficient pump power passing.

The proposed development of HE-ULMA will leverage of OEI's experience in world class fiber glass processing to create novel fiber laser structures to enable single mode near diffraction limited operation of Ultra Large Mode Area (ULMA) fiber lasers with multi mj pulse pulse storage and pulse output capabilities, Achieving this high energy performance will allow NASA to create remote sensing systems with more efficient Non Linear conversions to address more essential remote sensing wavelength bands and to sense a much larger distances and sensitivities.

In Phase 1 OEI will perform critical modelling, simulations and experiments to determine the fiber device requirements and amplifier design architectures for making a typically multimode, commercially 100/400um Yb doped gain fiber operate in a single mode diffraction limited operation. In addition OEI, will develop double fiber mode filters (DFMF) that will allow only the fundamental LP01 mode to propagate while allowing the pump light to pass effiently through the DFMF.

At the end of Phase II, a TRL 4 level pulsed fiber laser will be demonstrated with 7-10m of single mode 100/400um gain fiber (over 300mj of energy storage) in a high average power counter pumped configuration. This laser will be operated both in high extraction energy (pulse widths of ~100ns) and in high peak power (pulse width of less than 2ns) regimes. This laser will be delivered to the indicated NASA facility for additional testing.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed innovation will apply directly to current NASA missions and instruments (Doppler wind lidar, IPDA, LAS) and accelerate commercial development and availability of practical ground-based and airborne systems (e.g., compact airborne CO2 concentration-measuring instruments) at BP and elsewhere.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Verification of CO_2 sequestration and reduction of CH_4 leakage, for example, CO2 sensing for mission-critical sites such as aircraft cockpits, detecting CH4 leakage in oil refineries, and locating natural gas leaks. It is far more sensitive and accurate than any commercial system that measures either CH_4 or CO_2, is not significantly heavier than any competing system.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H4.07-1033**

SUBTOPIC TITLE: Low Volume, Power and Mass CO2 and Humidity Control for xEMU

PROPOSAL TITLE: CO2/H2O Sorbent Development for the xEMU

Small Business Concern

Firm: **Paragon Space Development Corporation**
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Phone: **(520) 903-1000**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

Regenerable sorbents have been gaining increased attention for direct carbon capture to sequester atmospheric CO_2 for terrestrial applications. Since the development of SA9T for the Rapid Cycle Amine (RCA) system in the 2000s, studies have continued to investigate a multitude of new sorbents with enhanced performance specifications. These new sorbent candidates in many cases have direct application to closed environment CO_2 removal (space-based vehicle and submarines). New regenerable sorbent formulations have the potential to benefit current space-based applications that rely upon the current state of the art (SOA) candidate. Sorbents with improved CO_2 and H_2O capacity can also result in potential reductions in mass, volume, and pressure loss in new systems. Paragon, through internally funded research activities, has developed the sorbent manufacturing expertise to develop new candidates that meet and exceed the key performance metrics laid out in this SBIR solicitation. These new sorbents will be chemically tuned and experimentally investigated with the goal of achieving higher working capacities for CO_2 and H_2O. In addition, the test facility and required hardware to accurately evaluate sorbents in a simulated atmospheric environment for space-based applications has also been developed and operated by Paragon.

As clearly defined in the SBIR Topic H4.07 description, NASA has a need for new technology alternatives to the RCA in order to establish a robust suit program. The sorbent development proposed herein is in direct response to this application. Paragon is positioned well to leverage its current sorbet development and meet the requirements laid out in the SBIR solicitation.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The technology developed through this SBIR effort will be well-suited for systems that rely on vacuum desorption during extravehicular activity operations. Promising sorbents will also be potential candidates for thermally regenerated systems in spacecraft cabins. Enhanced regenerable sorbents for CO_2 and H_2O control will enable reductions in overall system specifications, which will be a significant advantage as NASA begins to explore beyond Low Earth Orbit.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial space efforts will benefit from the use of new sorbents for CO_2 and H_2O control, particularly as they begin to support larger crew sizes over longer durations. Another area of particular interest is in the development of atmospheric revitalization for the Navy, and such a sorbent will be a promising solution for CO2 and H2O control onboard submersibles.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A2.02-1558**

SUBTOPIC TITLE: Enabling Aircraft Autonomy

PROPOSAL TITLE: Flexible Aerial Systems Testing with the Reconfigurable and Expandable Payload (FAST-REP)

Small Business Concern

Firm: **American GNC Corporation**
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Phone: **(805) 582-0582**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The rigorous verification and validation (V&V) as well as certification of new and complex systems and algorithms for use in the National Airspace System (NAS) is of utmost importance to support Advanced Air Mobility (AAM) missions. Novel hardware and software architectures are needed to provide a cost-effective and unified way for testing new advanced technologies for Unmanned Aerial Systems (UAS). To facilitate V&V activities at NASA Armstrong Flight Research Center (AFRC) and beyond, American GNC Corporation (AGNC) and Penn State University's Applied Research Laboratory (PSU-ARL) are proposing the Flexible Aerial Systems Testing with the Reconfigurable and Expandable Payload (FAST-REP) System. This system will provide NASA with a flexible scheme to conduct two types of testing: (1) recording sensor data in flight and then performing V&V afterwards in an offline way using the acquired data and (2) running candidate software in real-time and capturing the outputs and decisions to see if they match expectations of the developers and customers. The latter test allows to incorporate effects of sensor sampling rates, latencies, resolutions, program execution times, etc. in documenting the performance of the algorithm under test. To enable this, FAST-REP will consist of: (i) an expandable and reconfigurable structure mounted to a flight vehicle; (ii) power delivery module with optional battery; (iii) single board computer or microprocessor running application code with

flash memory for data storage; (iv) supporting electronic circuits for multi-sensor data acquisition and interfacing ports; and (v) suite with different types of sensors (motion, vision, ranging, thermal, magnetic, etc.). The system is reconfigurable to different UAS types and sensors, both in terms of the embedded system as well as the mechanical structure.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA is leading the nation in research for Urban Air Mobility (UAM) to enable a safe and efficient air transportation architecture capable of operating above populated areas. Armstrong Flight Research Center (AFRC) supports this objective by engaging in identification, development, and testing of technologies and procedures for enabling UAS' to operate in an airspace occupied by human-piloted aircraft. FAST-REP will ensure progress toward that vision by providing a reconfigurable and scalar payload architecture for testing legacy and new UAVs.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

It is widely expected that the UAV industry will continue to grow, placing the FAST-REP in a desirable position for widespread use. Applications include inspection, agriculture, remote sensing, surveying, delivery, photography, etc. with many of these such as package delivery involving operation in urban locations that require a high level of safety assurance and rigorous V&V of new technologies.
Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.07-1644**

SUBTOPIC TITLE: Cryogenic Systems for Sensors and Detectors

PROPOSAL TITLE: High-Efficiency Modified Collins Cycle Cryocooler

Small Business Concern

Firm: **Triton Systems, Inc.**
Address: **200 Turnpike Road, Chelmsford, MA 01824**
Phone: **(978) 250-4200**

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

Technical Abstract (Limit 2000 characters, approximately 200 words):

Existing space qualified cryocoolers are typically Stirling and pulse-tube type cryocoolers that achieve compactness and reliability by adopting mechanically simple cold head configurations, at the expense of thermodynamic efficiency. Large terrestrial cryogenic refrigerators achieve higher thermodynamic efficiencies but use mechanically complex designs that are not feasible at a small scale. The ideal space cryocooler would have the efficiency of a large terrestrial machines, but with the compactness and reliability of a pulse-tube or Stirling cryocooler.

A cryocooler concept approaching this ideal has been investigated and achieves compactness and reliability by using microelectronics to enable complex valve timing in a mechanically simple and efficient design. It is based upon a modification of the Collins cycle. Key component technologies include floating piston expanders and electromagnetic Smart Valves have been demonstrated in a prototype low-temperature cryocooler stage.

Cryocoolers are an enabling technology for space missions viewing in the infrared, gamma-ray and x-ray spectrums, providing the necessary environment for low temperature detectors and sensors, as well as for telescopes and instrument optics on infrared observatories. Detectors and sensors provide better imaging performance at lower temperature. The Mid Infrared Instrument (MIRI) of the recently launched James Webb Space Telescope includes a 7K cryocooler for detector cooling. The next generation of space telescopes include the LYNX (X-ray surveyor) and Origins Space Telescope (far IR surveyor) that are planned for launch in 2030.

A 4K 4-stage pulse tube cryocooler from Lockheed Martin is the current baseline design for the LYNX mission, with expected electrical power is 10,000 W per Watt of cooling at 4K. The proposed Modified Collins Cycle is expected to reduce the power draw for 4K cooling to about 2,000 W per Watt of cooling

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The next generation of space telescopes, including the LYNX (X-ray surveyor) and Origins Space Telescope (far IR surveyor) that are planned for launch in 2030, will require cooling to 4K and will benefit from development of this technology. Successful development will result in 4X to 5X reduction of power for cryogenic cooling.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The principal non-NASA application is cooling of low-temperature superconducting magnets used in MRI and NMR imaging machines. Other applications include cooling low-temperature superconducting electronics, including quantum computing. This is an ideal technology for cooling devices using magnesium diboride superconductors.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.02-1592**

SUBTOPIC TITLE: Quiet Performance - Aircraft Propulsion Noise

PROPOSAL TITLE: GPU-accelerated LES framework for aeroacoustic predictions of integrated systems

Small Business Concern

Firm: **CASCADE Technologies, Inc.**
Address: **2445 Faber Place, Suite 100, Palo Alto, CA 94303**
Phone: **(650) 521-0243**

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

To achieve the targets of efficient fuel burn, low pollutant emissions and low noise radiation, new engine design concepts have been developed for next generation aircraft. These designs leverage a more compact engine-airframe integration to reduce drag and distributed turbofans with smaller diameters to control noise. These tightly coupled systems have posed a greater challenge to numerical prediction tools, especially for problems such as aeroacoustics that requires high-fidelity simulations. While high fidelity simulations (e.g., wall modeled/wall resolved large eddy simulations) have demonstrated predictive capabilities for separated boundary layers, transitions, and turbulent wakes, they are often infeasible in design contexts due to their high computational costs, and only limited to component level analysis. This SBIR project will incorporate recent technical advances Cascade has made in low dissipation, compressible flow discretizations and wall modeling for large eddy simulations, as well as an innovative approach

for treating stationary-moving interface which is conservative, numerically stable, and computationally efficient. The proposed framework is implemented to exploit cost-effective throughput afforded by modern accelerated architectures (e.g., GPUs). This will finally result in an approach for these turbomachinery flow and aeroacoustic calculations that are both accurate and feasible (with less than 1 day wall clock turnaround times). This affordable approach will eventually provide a high-fidelity computational solution for system level designs.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The GPU-accelerated LES framework will benefit NASA's turbomachinery research by providing an efficient and high-fidelity simulation approach for turbomachinery flows and associated noise problems. Due to much reduced turnaround time, it can also benefit NASA's next generation aircraft design, such as the design of SUbsonic Single Aft eNgine (SUSAN) aircraft concept, by providing a high-fidelity alternative to the existing RANS based computational tools.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The successful completion of Phase I & II will produce an efficient and affordable solution for high-fidelity numerical predictions of aeroacoustics, turbomachinery and integrated wing-engine configuration at reduced computational cost. These advances are highly aligned with the demand of Cascade's commercial licensees in the aerospace industry (e.g. Boom, Boeing, Solar Turbines & GE).
Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.08-2196**

SUBTOPIC TITLE: Aeronautics Ground Test and Measurement Technologies

PROPOSAL TITLE: Multiparameter Laser Absorption Tomography System for High-Speed Flows

Small Business Concern

Firm: **Innovative Scientific Solutions, Inc.**
Address: **7610 McEwen Road, Dayton, OH 45459**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

Characterization of hypersonic flow in a large-scale ground test facility is challenging due to the extreme thermodynamic and fluid dynamic environment, which exhibits drastic spatio-temporal variations. Physical probes can be inserted into the flow, but point data is insufficient and the probe will invariably alter the flow field, potentially affecting the quantities of interest by changing the flow pattern, quenching key reactions, or acting as a catalyst. Optical diagnostics are non-intrusive, but existing techniques cannot provide robust velocity data in a high enthalpy flow, let alone surrogate parameters like temperature, species, and pressure. Therefore, there is a need for diagnostics that can measure these thermo-fluid properties over the wide field-of-view typical of large-scale supersonic and hypersonic applications. ISSI proposes to address this need using Linear Absorption Tomography with Velocimetry (LATV). LATV is based on laser absorption spectroscopy, a molecular diagnostic that is directly sensitive to the absorbance of a target fluid along the measurement path. The diagnostic utilizes a network of laser beams and tomographic reconstruction algorithm to produce 2D measurements of velocity, temperature, species, and pressure in a tilted plane. This diagnostic has been demonstrated for internal supersonic reacting flows as well as jet plumes. Our implementation is unique in that it utilizes Bayesian physics-informed neural networks to conduct data assimilation with built in uncertainty quantification. Use of the LATV technique at hypersonic flight conditions requires application-specific considerations, which will be explored in the Phase I effort. Quantifying spatio-temporally resolved exit conditions in NASA's 8 ft. hypersonic tunnel using this technique is a long-term goal of the Phase II program. Accuracy and precision will be assessed by comparing LATV measurements to conventional probe data in a controlled setting.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The LATV diagnostic can be used to probe internal and external flows of both reacting and non-reacting fluids. As such, the diagnostic has a wide range of potential ground and flight test applications. One application of LATV is real time characterization of NASA's extreme condition wind tunnels. The ability to quantify and time resolve flow field parameters such as velocity, temperature, species, and pressure in real time could drastically improve online interpretation of results and decision-making during test campaigns.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The final product from this program will be a system capable of producing 2D tomographic reconstructions of velocity, temperature, species, and pressure for high-speed wind tunnels. This technological capability is of interest to ISSI's current commercial, research, and military wind tunnel customers. ISSI expects to aggressively market this capability to these customers.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H5.02-1883**

SUBTOPIC TITLE: Hot Structure Technology for Aerospace Vehicles

PROPOSAL TITLE: Nano Nucleation of Unique Long Range Order Materials via Seed Crystals

Small Business Concern

Firm: **Applied Sciences, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

Technical Abstract (Limit 2000 characters, approximately 200 words):

This Phase I SBIR proposal seeks to create polycrystalline ceramics using nanomaterials as seed crystals to promote the formation of well-ordered crystalline domains of ceramic materials that are more resistant to high temperature oxidation and capable of higher strain than conventional ceramics. The rationale is that fine micrograins, containing well-ordered, uniform atomic lattice crystals, materials will exhibit less brittle fracture and resist oxidation and ablation. In other words, they will behave more like high temperature metals. This proposal takes the view that refractory carbides such as hafnium carbide are the best high temperature ablation resistant materials possible, and their ultimate performance depends upon a well-ordered atomic lattice in a uniform, micro-dispersed grain structure.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The number one application is high temperature hypersonic shielding materials, but the methodology has application to any type of structural ceramic material when high performance is required. High temperature oxidation resistance and ductility are the main properties that are

sought, but generally high-performance, lightweight structures will result from enhanced long range order in the atomic lattice, and the creation of highly dispersed micro-dimensioned grains.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Aerospace is the intended application, but any application that demands high performance, especially at high temperature, benefits from improved materials. The main trade-off is that nanomaterials add cost. Civilian aerospace is the most direct benefactor, but high temperature electronics and sporting goods also can support the necessary premium for high performance.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z5.04-1924**

SUBTOPIC TITLE: Intravehicular Robot (IVR) Technologies

PROPOSAL TITLE: Gateway Robot Autonomous Planning Execution and Situation Awareness

Small Business Concern

Firm: **Stottler Henke Associates, Inc.**
Address: **1650 South Amphlett Boulevard, Suite 300, San Mateo, CA 94402**
Phone: **(650) 931-2700**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Stottler Henke proposes to develop **Gateway Robot Autonomous Planning Execution and Situation Awareness (GRAPES)**, an operational concept, system architecture, and integrated set of software components for autonomous intra-vehicular robotics, focusing on the Astrobee and/or Robonaut on the Lunar Gateway. GRAPES will enhance the capabilities of Gateway operations such as payload operations, system health management, and inventory management by providing autonomous robot services. GRAPES will also include modeling tools for specifying the planning/scheduling, task execution, situation awareness, impact assessment, and goal management knowledge used by components in the GRAPES run-time system. The development of GRAPES will leverage Stottler Henke's autonomous systems experience and technologies, its Aurora scheduling system, and its SimBionic intelligent toolkit for adaptive task execution. During this project, we will identify and analyze system requirements, develop a concept of operations and high-level system design, develop test scenarios, and implement a prototype that illustrates key elements of the operations and design that we envision.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary NASA application will be autonomous payload operations and caretaking on board Gateway. However, the resulting technology can also be used to provide long-duration autonomy for other manned and unmanned spacecraft and space habitats as well as for ground-based operations.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- Long-duration vehicle autonomy for next generation military command, control, reconnaissance, surveillance
- Facility/infrastructure surveillance (buildings, factories, roads & bridges, pipelines, power lines)
- Reconnaissance & Surveillance (disaster response, urban, wildfire, search & rescue)
- Agricultural surveillance (over/under-watering, disease, pests, nutrients levels)
- Long haul freight

Duration: **6**

PROPOSAL NUMBER: 22-1- **H4.06-2650**

SUBTOPIC TITLE: Low-Power Multi-Gas Sensor for Spacesuits

PROPOSAL TITLE: Compact, Low Power, Multi-Parameter Astronaut Life Support Sensor (M-PALSS)

Small Business Concern

Firm: **Makel Engineering, Inc.**
Address: **1585 Marauder Street, Chico, CA 95973**
Phone: **(530) 895-2771**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

Makel Engineering, Inc. (MEI) proposes to develop a highly compact Multi-Parameter Astronaut Life Support Sensor (M-PALSS) for use in the portable life support system (PLSS) component of the new Exploration Extravehicular Mobility Unit (xEMU). M-PALSS will consist of an array of low power chemical microsensors for oxygen, carbon dioxide, water vapor, and pressure to monitor the major constituents in the gas stream circulated by the PLLS and/or exhaled from the astronaut in the rebreather loop. Highly miniaturized chemical microsensors will be packaged with compact electronics with a compact physical envelope and low power consumption. Phase I will develop and test a prototype system at PLSS operating conditions. The M-PALSS incorporates a mix of proven solid-state sensors developed by MEI for applications such as aircraft life support systems and for Navy divers using rebreathers. These chemical sensors will be combined with humidity and pressure sensors to provide a compact sensor suite with multi-parametric sensing capabilities, suitable for integration with the PLSS on the xEMU. Phase II will deliver units for use in NASA testbeds and for integration into prototype xEMUs.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary NASA application for the technology is to support human exploration activities by providing enhanced sensing capability to new generation of space suit life support systems including xEMU and the PLSS module. The technology is also applicable to ISS, Gateway, and future lunar outpost life support systems.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non-NASA Applications include commercial and military diving rebreathing systems which have similar sensing requirements. Medical applications for the technology are portable oxygen generators and respirators.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z14.02-2297**

SUBTOPIC TITLE: Extraterrestrial Surface Construction

PROPOSAL TITLE: Lunar Articulating Mirror Array

Small Business Concern

Firm: **Blueshift, LLC**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA is requesting technologies for constructing lunar and Martian infrastructure using in situ resources to radically reduce the cost and increase the scope of future space exploration. Blueshift, LLC dba Outward Technologies proposes to develop a novel Lunar Articulating Mirror Array (LAMA) for constructing landing/launch pads, roadways, habitats, and other infrastructure structural elements using in situ resources. The proposed LAMA system and associated construction method will be able to rapidly construct thick structures with material properties similar to concrete from minimally beneficiated lunar regolith. Benefits of the proposed innovation include a complete lack of earth-based consumables, very low electrical power needs, and lower material handling requirements as compared to polymer stabilization, lunar concrete, sintered bricks, or microwave sintering. The system utilizes a lightweight deployable design that further minimizes launch costs and includes design elements to enable long-term operation on the Moon with minimal to no maintenance requirements. The proposed hardware and related feedback and control systems are uniquely suited for in situ process monitoring for construction verification and qualification. The Phase I effort will focus on developing a representative

numerical model to verify feasibility of the full-scale system, producing prototype hardware of a small-scale LAMA, and characterizing the mechanical behavior of infrastructure elements produced by the proposed construction method.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary application within NASA's technology roadmap for LAMA is TX12.X: Other Manufacturing, Materials, and Structure. The technology also is applicable to TX07.2.2: In Situ Manufacturing, Maintenance, and Repair as well as TX07.2.3: Surface Construction and Assembly, and TX03.3 Power Management and Distribution. The LAMA system will support infrastructure development through the rapid construction of non-pressurized structures such as landing pads, roadways, and blast shields.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed construction technology will benefit other federal agencies interested in surface construction in extraterrestrial environments. Terrestrially, LAMA could be adapted for construction in remote locations where sunlight is readily available, where building materials are limited, and where communities are underserved by currently available construction methods.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H5.02-2416**

SUBTOPIC TITLE: Hot Structure Technology for Aerospace Vehicles

PROPOSAL TITLE: Boron Nitride Nanotube-Enhanced Hot Structure Technology for Aerospace Vehicles

Small Business Concern

Firm: **BNNT, LLC**
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Phone: **(757) 369-1939**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Boron nitride nanotubes (BNNTs) are a breakout reinforcement, structurally and thermally, needed for hot structures from 1650-2000 °C. BNNTs advance the state-of-the-art being as strong as carbon nanotubes plus superior oxidation and chemical resistance. The highest-quality BNNTs, which we recently started producing at industrial scale by methods improved from what earned our founders NASA Invention of the Year, now embody key performance parameters of being ultra-strong (63 GPa or above), highly flexible, lightweight, pure, highly crystalline (low-defect), molecular ceramic fibers.

BNNT offers the strongest and lightest high-temperature reinforcement for ceramic matrix composite (CMC) hot structures, where, protected from oxidation, service temperature of BNNTs is at least 2000 °C. State-of-the-art BNNT reinforcement has significantly improved ceramic, e.g., SiCN, to 3.5x toughness, 2x hardness, 1.3x flexural strength (also SiON and ZrO2). This project adds hafnium oxide (HfO2) to SiCN/BNNT, so HfSiO4 forms a protective coating and protects within the volume to raise temperature thresholds.

Project objective is to use BNNTs as sturdy, self-supporting, 3-D shapes infused with the pre-ceramic polymer precursor, SiCN doped with hafnium oxide (HfO2), and pyrolyzed to form a new polymer-derived ceramic (PDC) composite, BNNT/SiCN/HfSiO4. Phase I will develop techniques to fabricate reinforced ceramics for hot structures based on prior proofs-of-concept in other ceramic matrices. Coupons will be delivered for thermal and mechanical tests, arc-jet tests, hot-fire/combustion flame tests, plus complex shapes for additional tests.

NASA applications start with uncooled propulsion components, combustion chambers, nozzles, and load-carrying aeroshell structures, leading edges, and heatshields subject to oxidizing environments and/or temperatures of 1650-2000 °C. Defense applications follow, starting with RF-transparent matrices for radar domes on aircraft traveling above Mach 5.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Uncooled propulsion system components, including hot gas valves, combustion chambers, nozzles, and nozzle extensions, and primary load-carrying aeroshell structures, control surfaces, leading edges, and heatshields, subject to oxidizing environments and/or temperatures in the range of 1650-2000 °C.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Defense applications will reinforce RF-transparent ceramics for radar domes, and identical ceramics as for NASA can develop leading edges, control surfaces, and engine components for platforms exceeding Mach 5. Commercial applications need CMCs beyond current SiC/SiC (1400 °C), especially complex rotating shapes for aviation and power-generating turbines where CMCs are still viewed as too brittle.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H5.05-2174**

SUBTOPIC TITLE: Inflatable Softgoods for Next Generation Habitation Systems

PROPOSAL TITLE: Flexible multifunctional Structural Health Monitoring systems for inflatable space habitat structures

Small Business Concern

Firm: **Acellent Technologies Inc.**
Address: **835 Stewart Drive, Sunnyvale, CA 94085**
Phone: **(408) 745-1188**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

Inflatable structures are being pursued as candidates for long-term habitats in space. The ability to monitor and assess the structural health of an inflatable module is an important factor in determining the feasibility of using inflatable technologies for habitat requirements, especially in the presence of micrometeoroid and orbital debris (MMOD) threats. There is therefore a need for Structural Health Monitoring methods to perform detection, localization, and quantification of damage to structural layers throughout the structure's mission. This capability must be accomplished within real constraints for sensor volume, mass, and crew resources, including being able to perform effective damage monitoring of the inflatable habitat layers from the interior during a mission either on a routine basis or as a quick- response basis. Acellent has extensive experience in developing space and field-ready Structural Health Monitoring (SHM)

diagnostic systems. This program will focus on development, maturation, assembly and automation of "**Flexible multifunctional Structural Health Monitoring systems for inflatable space habitat structures**". The program will enable the low-cost manufacturing of integrated sensing capabilities in inflatable softgoods material systems that are needed to monitor the structural performance of the material in situ, measure load/strain on softgoods components, detect damage, and predict further degradation/potential failures. The Phase I effort would focus on developing an approach for SHM for inflatable softgoods, testing a laboratory proof of concept of the preliminary design, which integrates the SHM approach into inflatable habitat test articles.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

*NASA is currently looking for SHM technologies that are **small and lightweight** to provide **onboard monitoring capabilities** and are **easy to install**.* The proposed system has several critical future exploration applications including support of technologies for self-assembly, in-space assembly, in-space maintenance & servicing, and highly reliable autonomous deep-space systems. These technologies have the potential of significantly increasing safety, reliability, affordability, and effectiveness of NASA missions.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed SHM system can be used in several different platforms including Aircraft, Mining, Bridges, Buildings and other platforms.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H4.06-1488**

SUBTOPIC TITLE: Low-Power Multi-Gas Sensor for Spacesuits

PROPOSAL TITLE: Advanced Multi-Gas Sensor

Small Business Concern

Firm: **Mesa Photonics, LLC**
Address: **1550 Pacheco Street, Santa Fe, NM 87505**
Phone: **(505) 216-5015**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Space suit Portable Life Support System (PLSS) is critically important for the successful support of the International Space Station (ISS) and future human space exploration missions for in-space micro-gravity extravehicular activities (EVA) and planetary surface operations. As the design for the new Exploration Extravehicular Mobility Unit (xEMU) is developed, there are obvious gaps in technologies that need to be fulfilled to meet the new exploration requirements. In particular, the currently employed gas sensors are functionally limited and draw significant power.

The proposed advanced spacesuit gas sensor addresses the critical need of developing a reliable, compact, rugged and low-power multi-gas sensor as a part of the PLSS for the current and future Extravehicular Mobility Units (EMU). The goal is to develop a moisture tolerant, drop-in replacement for the current sensor. The performance characteristics of the multi-gas sensor will meet the requirements for spacesuit gas detection.

In Phase I, a laboratory bench prototype of the multi-gas sensor will be designed, built and characterized over a wide range of gas mixture compositions, total pressures and temperatures including condensing moisture conditions. The engineering challenges of miniaturizing and ruggedizing the instrument will be addressed, and a general design of the Phase II prototype will be outlined. In Phase II, the prototype gas sensor will be built, tested, and delivered to NASA.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed multi-gas sensor is relevant to the new Exploration Extravehicular Mobility Unit (xEMU), International Space Station (ISS), future NASA Moon and Mars missions (e.g., Artemis III), as well as commercial space companies.

Another potential NASA application is measurement of major atmospheric constituents in spacecraft cabin. The sensor will provide complete characterization of cabin atmosphere composition by measuring O_2, N_2, CO_2, and water vapor.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The multi-gas sensor can be used as atmospheric analyzer for submarines. Upon some modifications, the technology can be adapted for monitoring oxygen and nitrogen levels in On-Board Oxygen Generation Systems (OBOGS) in military aircraft and for monitoring hydrogen and methane in natural gas within pipelines.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.04-2285**

SUBTOPIC TITLE: Nontraditional Airspace Operations and Aerial Wildfire Response

PROPOSAL TITLE: Unmanned Aircraft Systems Traffic Management (UTM) System for Wildfire Response

Small Business Concern

Firm: **Aeris, LLC**
Address: **1021 Main Street, Louisville, CO 80027**
Phone: **(303) 250-7233**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Aeris proposes to develop an Unmanned aircraft systems Traffic Management (UTM) airspace operations capability specifically designed to support Urban Air Mobility (UAM) Advanced Air Mobility (AAM) wildfire response operations. This wildfire UTM system will ingest continually updating information on environmental/fire conditions, dynamically evolving air traffic demands comprised of both UAS and traditional firefighting aircraft, microscale weather information and then leverage graph analytics machine learning methods to provide ***tactical*** UAM/AAM UTM capability that can provide ***dynamic and real-time*** aircraft route planning and scheduling recommendations for wildfire response stakeholders. The innovation proposed here will enable combined situational awareness between operations centers and in-theater assets during an active fire response by dynamically aggregating data pertaining to fire location, ground-based personnel, asset locations, staging sites, vertiports, and aerial traffic of traditional manned and unmanned systems. This capability will allow for the dynamic scheduling of aircraft and the deconfliction of the airspace as users enter sortie requests in real time, it will accommodate on-demand coordination of aircraft regardless of their performance capabilities (ie, everything from a small camera drone up to a manned heavy airtanker). The focus of the Phase I effort proposed here will be to provide the user of this wildland fire UTM system with a detailed and deconflicted route selection and flight schedule that optimizes efficiency of flight operations and ensures safety.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

A core mission of the National Aeronautics and Space Administration (NASA) is to support the development of technologies that enhance the safety and efficiency of aviation operations in the United States National Airspace System. The technologies proposed in this Phase I SBIR will demonstrate a core capability and provide a novel solution for scheduling unmanned aircraft responding to an active wildfire to ensure safe an efficient Unmanned Aircraft Systems Traffic Management (UTM) operation.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The notional wildfire UTM architecture concept currently envisioned by NASA will provide a key piece of operational software that can be implemented by state and local agencies responding to an active wildfire. The system will provide a common operating picture fort UTM operations for use by local fire departments requiring a wildfire response capability.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.06-2757**

SUBTOPIC TITLE: Earth Science Decision Support Tools Focused on the Mitigation of Climate Change Impacts

PROPOSAL TITLE: Estimating groundwater dynamics from artificial intelligence and InSAR

Small Business Concern

Firm: **Geolabe LLC**
Address: **3802 Ridgeway Drive, Los Alamos, NM 87544**
Phone: **(505) 876-7412**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Groundwater represents about a third of global water withdrawals, and approximately half of global irrigation water. In many arid and semi-arid regions, groundwater is rapidly being depleted, which is affecting agricultural productivity over the long term. The over-exploitation of groundwater due to the current drought episode in South-Western U.S. has already led farmers to fallow hundreds of thousands of acres of farmland.

Informed assessments and policies related to groundwater supplies can only be made on the basis of large-scale, precise estimates of depletion and recharge. However, current technologies have poor resolution in time and/or in space. We propose to leverage very recent advances in artificial intelligence applied to Interferometric Synthetic Aperture Radar (InSAR) in order to study groundwater depletion and recharge. Variations in groundwater levels induce deformation at the surface of the Earth, which can be captured by satellite-based InSAR measurements. Our technology allows to lower the detection threshold of surface deformation in InSAR time series by about an order of magnitude compared to the state-of-the-art; the associated resolution in space is a few km with a time resolution of roughly a week, thereby potentially offering a new tool for groundwater management decisions.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The tools proposed in this Phase I proposal will rely extensively on NASA data, by analyzing partly processed InSAR data available on NASA's Earth Data portal. NASA is also about to launch a new InSAR constellation (NISAR) in 2023, and we will rely on these data for Phase II of this project.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The market of groundwater estimates is centered around two major types of clients: agricultural businesses wanting to perform groundwater exploration and assess whether they are using their groundwater resources in a sustainable way, and local and state governments seeking to better quantify and understand local and regional water resources.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S12.04-2190**

SUBTOPIC TITLE: X-Ray Mirror Systems Technology, Coating Technology for X-Ray-UV-OIR, and Free-Form Optics

PROPOSAL TITLE: Wide Range Chromatic Interferometric Probe

Small Business Concern

Firm: **OptiPro Systems, LLC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

From flagship observatories to small earth-observation satellites, many NASA missions require high performance optical components that are also cost-effective to manufacture and launch. Freeform optical components can reduce a telescope's size and weight (reducing launch costs), but are challenging to test and validate with traditional metrology tools due to their lack of symmetry and large changes in curvature (increasing manufacturing costs). Improved metrology systems for freeform optics have potential to improve performance and reduce manufacturing costs by avoiding prescription-specific null correctors or holograms. Metrology systems for freeform optics require a challenging combination of capabilities: high-resolution (ideally sub-nanometer) measurement of large deviations from a planar surface and steep surface slope. At OptiPro Systems, we have recently developed (in part through NASA SBIR projects) a chromatic interferometric probe capable of sub-nanometer metrology of optical surfaces, which is essential for precision optical components such as telescope mirrors. The probe's range is currently limited to small surface sag ("measurement range") and shallow surface slope ("acceptance angle"), preventing direct application to freeform optics.

We propose fundamental enhancements to the chromatic interferometric probe to enable cost-effective metrology of freeform optics: wide measurement range and acceptance angle, while maintaining sub-nanometer performance. Such improvements require understanding unproven concepts and potentially major redesign of the probe optical system. The Phase I project aims to verify these concepts, using bread-board level proof-of-concept demonstration and computer simulations, and deliver a report detailing a clear path toward implementing these improvements in prototype probes and their use in metrology of high-performance freeform optics.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Potential NASA applications include metrology of freeform and other optical components for NASA missions, including flagship/decadal missions, small satellites, and everything between. Some specific applications:

- Origins Space Telescope (OST) and Large UV/Optical/IR Surveyor (LUVOIR), which may use freeform optics.
- Lynx, Advanced X-ray Imaging Satellite (AXIS), and other X-ray telescopes.
- Large telescope mirrors, such as those for the Habitable Exoplanet Observatory (HabEx), OST, and LUVOIR, requiring sub-nanometer metrology.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed metrology probe would benefit many applications, including:

- Metrology of high-precision optical components for commercial products
- Metrology of x-ray and neutron mirrors (Department of Energy)
- Vibration analysis of mechanical components and machines

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z12.01-1686**

SUBTOPIC TITLE: Extraction of Oxygen, Metal, and Water from Lunar Regolith

PROPOSAL TITLE: Ionic Liquid-Assisted Electrochemical Extraction of Metals and Oxygen from Lunar Regolith

Small Business Concern

Firm: **Faraday Technology, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA's *in-situ* resource utilization (ISRU) mission is to put in place a sustainable infrastructure that will allow human habitation on with Moon with minimal support from earth. One particular resource available on the lunar surface is regolith which consists of metals (Fe, Al, Si, …) bond to oxygen in the form of metal silicates. Extraction and recovery of metals and oxygen from the regolith could be used to support human life on the moon. For instance, recovered metals could be used to forge tools and components require for daily life, while the oxygen could be used life support and for propellants. Faraday Technology and RoCo Global will demonstrate an ionic liquid-assisted electrochemical extraction process to recover metals and oxygen from lunar regolith. The advantages of this method include: High-rate regolith digestion; High purity metal recovery; High purity oxygen recovery; Low temperature operation < 150°C; Low energy requirement; and, Scalable manufacturing platform. In Phase I, Faraday and RoCo will optimize the ionic liquid to rapidly digest metal silicates like feldspar. Next, Faraday will demonstrate and optimize the electrochemical recovery of metals and oxygen from the ionic liquid containing the digested metals and water. Finally, the electrochemical process will be used to regenerate the ionic liquid for digestion of additional metal silicates. The results of this study will provide a basis for transition planning, safety analysis, and an alpha scale semi-continuous system design. Alignment of this technology for future NASA (Artemis) and commercial missions (Xelene) is critical for future integration and with the help our team we will assess safety and system robustness metrics required for Phase IIE/III. In Phase II we will build the semi-continuous ionic liquid-assisted electrochemical extraction system and optimize the recovery and regeneration parameters based on the input from NASA and our commercial partners.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The ability to utilize available resources on planets and moons is critical during extended space exploration. The proposed technology would support longer-term activities and eventual establishment of facilities on the lunar surface capable of supporting human missions, while reducing launch costs of excess materials. Oxygen recovered through this technology could be used to feed life support systems or as propellants. Simultaneous metal reclamation could be used to facilitate the formation of structures, tools, or components from Lunar soil.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The potential terrestrial customer could be in the metal smelting industries. Aluminum ore is transformed to Al by the Hall-Héroult which simultaneously outgasses large quantities of CO_2. The ionic liquid-assisted electrochemical extraction process has the potential to eliminate greenhouse gas emission from Hall-Héroult. If successful the global Aluminum market size was $194 billion in 2021.
Duration: **6**

PROPOSAL NUMBER: 22-1- **H6.22-2330**

SUBTOPIC TITLE: Deep Neural Net and Neuromorphic Processors for In-Space Autonomy and Cognition

PROPOSAL TITLE: Adaptive Neuromorphic Processors for Cognitive Communications

Small Business Concern

Firm: **Brisk Computing, LLC**
Address: **1191 Red Ash Court, Centerville, OH 45458**

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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

The objective of this work is to develop highly Size, Weight, and Power (SWaP) efficient neuromorphic processors that can train deep learning algorithms. The training phase for deep learning is very compute and data intensive. Being able to train a network on the satellite eliminates the need to send large volumes of data to earth for training a new network. However, this requires an extremely energy efficient deep learning training processor. We will develop resistive crossbar neuromorphic processors, with the primary target being to train deep learning algorithms. Although our system would work for any type of data, we plan to focus on networks for cognitive communication applications. We will also look at processing networks for other data sets. The key outcomes of the work will be the processor design, processor performance metrics on various applications, prototype system, and software for the processor.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Potential NASA applications include various deep learning training and inference tasks on satellites. These include cognitive communications, processing sensor outputs, and scientific experiments. Additionally, the developed system could be used for UAVs.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The non-NASA market would be primarily for edge processing, where power is highly limited. The market includes both the DoD and the commercial market. DoD applications include cognitive communications, sensor processing, cognitive decision making, and federated learning. Commercial applications include communications systems, automobiles, consumer electronics, and robots.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z8.02-1723**

SUBTOPIC TITLE: Communications and Navigation for Distributed Small Spacecraft Beyond Low Earth Orbit (LEO)

PROPOSAL TITLE: Adapting 100G Optical Comm to Unique NASA Small Satellite DSM Applications

Small Business Concern

Firm: **Fibertek, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

Our proposal addresses expanding the bandwidth of free space optical (FSO) communications to 100G for lunar and Lagrange points while using available low-cost and low size, weight, and power (SWaP) technologies. We propose to develop 100G space laser transceiver technology using terrestrial optical fiber communications (fibercom) 100G, photonic integrated circuits, coherent modules for long-range space-based free space optical (FSO) links. Our link budget indicates that 100G-200G is feasible with a ground station telescope of 1-6 meters in diameter,

with smaller 10-20 cm satellite telescopes, and can support lunar, L1 and L2 ranges. The SBIR enables extending DSM optical communication to Mars, Venus, Asteroids and planetary bodies and Lagrange points.

- Key enablers to expand NASA human spaceflight operations, telerobotic, astronaut HD video and SMD science for Lunar missions.
- Enables NASA Heliophysics vision for affordable, sun-sensing SmallSat constellations at L1, L2 for space weather, astronaut safety missions and SMD heliophysics science.
- Technical approach leverages terrestrial fibercom photonic integrated circuit (PIC) providing advanced technology at low cost for space.
- Ready for program insertion in 2025.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- NASA state-of-the-art mesh networked lasercomm capability to support SCaN deployment of optical communications.
- Deep Space & Heliophysics – Space weather, Sun studies out to L1, L2 at 100 Gbps
- Near Earth science missions – Increased data rate for SmallSat sensors
- Near Earth and cis-lunar, lunar orbital, Lagrange Point L1, L2
- Future NASA SmallSat and CubeSat constellations with science missions that need optical coms to support high data rates including multispectral imaging sensors and radar

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- DoD and U.S. Government for intelligence imagery. GEO, MEO, LEO
- CLPS commercial lunar payload services companies
- High data-rate, low cost commercial optical communications from LEO/GEO satellites

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z8.09-2420**

SUBTOPIC TITLE: Small Spacecraft Transfer Stage Development

PROPOSAL TITLE: Solar Electric Propulsion Transfer Ring (SEPTR)

Small Business Concern

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

farSight Technologies proposes a Solar Electric Propulsion Transfer Ring (SEPTR) to fill the technology gaps identified on several NASA programs: The Flight Opportunities Program, The Small Spacecraft Technology (SST) and The Launch Services Program. These programs have all identified the need for lunar/cislunar transfer capabilities, novel propulsion systems (e.g. Dual Mode) and to serve as a precursor mission for gateway future planetary exploration. SEPTR is a small spacecraft boost and support stage that is built into the payload mounting ring for venture class launch vehicles. It will provide Direct-to-Earth tethered communication and basic PNT utilizing space tested avionics, solar panels, batteries, sun sensors and star trackers. SEPTR leverages high I SP/low thrust electric propulsion to open access to a wide range of orbits to smaller space craft that they would not be able to achieve on their own. It can be used not only as a 3rd stage booster but also configured to provide additional support including power, multi-mode propulsion, communications and station keeping for as long as the spacecraft needs or desires. SEPTR offers a short-term solution to the problem of small spacecraft reaching higher altitude orbits and opens access to missions in lunar and cislunar space for this segment.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA applications: 1) Moon to Mars, 2) Artemis, 3) Commercial Lunar Payload Services (CLPS) – a program the PI supported and 4) NASA Flight opportunities. To support these missions, farSight

envisions a model that will open up the TLI market to small entrants by offering pre-staged “Pony Express services” that include propulsion and mission services delivered on the NASA-matured Venture
Class LEO launch capability provided by Relativity Space, Firefly Space Systems, and Virgin Orbit;
substantially reducing costs for small spacecraft.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non-NASA applications: 1) Shipboard ADNS DTN enabled router for Enterprise level Naval Networks and unmanned C2, 2) United Launch Alliance with it’s cislunar economy initiatives, 3) Astrobotics; projected to be the first commercial company to land on the moon and 4) Local and State level Disaster Recovery Agencies where ground communications infrastructure is space or Non-existent.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S12.04-2252**

SUBTOPIC TITLE: X-Ray Mirror Systems Technology, Coating Technology for X-Ray-UV-OIR, and Free-Form Optics

PROPOSAL TITLE: Low-cost Ultra-high Precision X-Ray Mirror Surface Deterministic Finishing

Small Business Concern

Firm: **A-Z INNOVATIVE SOLUTIONS LLC**
Address: **59 Apsley Street Suite #2, Hudson, MA 01749**
Phone: **(508) 635-7870**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

A-Z Innovative Solutions proposes to develop a computer- numerical-controlled deterministic polishing machine specialized for X-ray mirror surface finishing. The proposed new technique is particularly suiting for large cylindrical X-ray mirrors (between 100 and 1,000 mm in height, 50 to 5000 mm in diameter, varying radial prescription along azimuth, ~2 mm in thickness) for NASA's space X-ray observer by introducing the substrate X-direction step-rotating scan mechanism. By incorporating chemical reactive removal mechanism, this new tool will drastically speed up the deterministic process with much better surface smoothness finishing quality. In this program, we anticipate to achieve:

- Ultra-high precision surface finishing capability of 0.1 arcsec half-power diameter (HPD) with RMS < 0.6 nm
- Radial slope error <0.1 urad
- Shape error out-of-round < 0.4μm for X-ray cylindrical mirrors
- 5 to 10 times better surface smoothness (0.1 nm RMS) is expected over the present deterministic techniques
- With the innovative removal mechanism, 5 to 10 times better surface smoothness is expected over the present deterministic techniques as the chemical reactive removal is at the atomic level, rather than to knock off material as aggregates of molecules by bombardment from FJP, MRF and Ion-Beam Figuring flows.
- High-speed for use on large areas and cost effective

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed CNC deterministic polishing techniques will significantly improve the X-Ray mirror surface figure accuracy to 0.1 arcsec half-power diameter with RMS < 0.6 nm while the current technology can yield 2.5 arcsec HPD on the outside of a mandrel used for replicating shells. The new technology will bring the previous difficult ultra-high precision X-Ray mirror fabrication and impossible arbitrary surface shape/pattern generation into a routine job. This will greatly benefit NASA astronomy telescope optical parts fabrication.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed system will be general optical surface finishing system. It will bring the optical fabrication to a new era with ultra-high precision, arbitrary shape generation and ultra-high surface smoothness.
Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.03-2074**

SUBTOPIC TITLE: Extreme Environments Technology

PROPOSAL TITLE: In-Circuit Energy Storage Device for Extreme Environments

Small Business Concern

Firm: **TDA Research, Inc.**
Address: **12345 West 52nd Avenue, Wheat Ridge, CO 80033**
Phone: **(303) 422-7819**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Future NASA missions will require system operation at extreme environmental conditions with temperatures as low as -180°C. Current state-of-practice is to place the hardware in bulky and power-inefficient environmentally protected housings. Hence, NASA is seeking systems that can readily operate in these extreme environments without needing environmental protection systems.

TDA Research, Inc. will develop a chip-sized hybrid supercapacitor that can operate in extremely cold temperatures (-180°C). The supercapacitor electrodes will use a 3D printed microstructure to provide high areal capacitance and power in a small package suitable for high power delivery and low temperature operation. On-chip micro supercapacitors provide the unique capability to store electrical energy and deliver it very quickly and efficiently, enhancing peak-load performance. They also offer excellent cycling capability (1-2 orders of magnitude better than batteries). The devices developed here would find use as energy storage devices in NASA space systems that operate in the extreme environments of space missions, and will not require special environmental housings. In Phase I, we will prepare the electrode materials and fabricate chip-sized supercapacitors. We will then demonstrate their ability to store energy at temperatures down to -180ºC over 5,000 charge/discharge cycles, elevating the TRL to 4. We will benchmark our 3D printed hybrid supercapacitor against COTS devices and complete a techno-economic feasibility study of the proposed on-chip energy storage device.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

TDA's proposed 3D printed hybrid supercapacitor can withstand extreme low temperature environments found on Titan, the Moon. Mars, asteroids, comets, and other small bodies and can be used during the descent through kilometers of cryogenic ice expected in these planetary survey missions. The applications include supplementing batteries during high power transients: power precision actuators and sensors, high-torque force actuators, radio-frequency (RF) electronics, guidance and navigation avionics and instruments.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Micro supercapacitors can also be used to supplement batteries, enhancing peak-load performance. Other commercial applications could include energy storage in various MEMS sensors that are being used in: (i) Personal Wearable Devices; (ii) Transportation Systems; (iii) Photovoltaic Technologies; (iv) Power Grid Applications; (v) Medical Devices; (vi) Defense.
Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.03-2163**

SUBTOPIC TITLE: Future Aviation Systems Safety

PROPOSAL TITLE: Multi-Objective Risk Prediction and Hazard Evaluation/optimization for Urban air Services (MORPHEUS)

Small Business Concern

Firm: **The Longbow Group, LLC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

In this Phase I SBIR project for NASA, The Longbow Group, LLC (LONGBOW), with Daniel H. Wagner Associates, Inc. (DHWA) as a subcontractor, will demonstrate the feasibility of developing key components of a future In-Time Aviation Safety Management System (IASMS) and commercializing those components as IASMS services, functions, and capabilities (SFCs) within one or more Supplemental Data Service Providers (SDSPs) supporting uncrewed aircraft system (UAS) traffic management (UTM). This proposed Phase I will lay the groundwork for Phase II prototype development of a **Multi-Objective Risk Prediction and Hazard Evaluation/optimization for Urban air Services (MORPHEUS),** which will support (1) pre-flight planning to assess and mitigate risk (e.g., to the populace, infrastructure, airframe/payload/mission); (2) in-flight monitoring and mitigation of risk; and (3) post-flight analysis of risk and model and database updates. MORPHEUS will leverage NASA Langley Research Center's (LaRC) Ground Risk Assessment Service Provider (GRASP), DHWA's experience with AI and Machine Learning (ML) and commercialization of a NASA Langley Phase II SBIR for UAS route evaluation/optimization with respect to weather (RouteCAST), LONGBOW's Space Act Umbrella Agreement SAA1-34272 for uncrewed systems collaborative testing with NASA LaRC. and the team's involvement in a recently awarded Phase II NASA SBIR to develop an Urban Weather Testbed (UWT) for UAS operations in Hampton Roads. By leveraging these other projects, in Phase I we will be able to conduct real-world demonstrations of using MORPHEUS to assess and mitigate risk. Phase II prototype development will result in a functional MORPHEUS system as a Minimum Viable Product (MVP) ready for transition to UTM systems. Benefits to NASA and the UAS commercial enterprise will include safer and more efficient flights in the national airspace system (NAS).

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

MORPHEUS will directly support NASA programs/projects related to UAS/eVTOL safety and risk mitigation such as the High Density Vertiplex (HDV) program, which used GRASP data in a recent FAA COA Safety Case application for BVLOS operations at NASA LaRC, and particularly the AOSP SWS initiative. MORPHEUS would also benefit programs involved in human-autonomy teaming (e.g., the HAT Lab), providing multi-objective optimization for humans to review and understand, accept/reject, and/or modify.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

LONGBOW plans to use MORPHEUS for its own operations and is also targeting its use by other drone and fleet operators, on-demand urban air travel companies, UTM system providers, Supplemental Data Service Providers (SDSP), Aviation/UAS/eVTOL insurance providers, Provider of Services to UAM (PSU), intra-base and base-to-base DOD logistics, and city and state planners for UAS/eVTOL infrastructure.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z7.01-1480**

SUBTOPIC TITLE: Entry, Descent, and Landing Flight Sensors and Instrumentation

PROPOSAL TITLE: Ultra-wide Bandwidth, Nanomembrane-based Pressure Transducers for Entry, Descent, and Landing Applications

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

This NASA Phase I SBIR program would develop ultra-wide bandwidth, nanomembrane based pressure transducers for entry, descent and landing applications, using silicon-on-insulator nanomembrane techniques in combination with nanocomposite materials. The team has developed a wide bandwidth pressure transducer with a bandwidth from DC to 5MHz and has demonstrated these transducers in subsonic, transonic and hypersonic wind tunnels and shock tubes in both university and government facilities. Through this NASA program, the team will develop an improved mechanical and electrical model of semiconductor nanomembrane based sensor performance that will allow quantitative optimization of material properties and suggest optimal methods for sensor packaging and use for in-situ entry, descent and landing applications. The team will fabricate hermetically sealed sensors and internal electronics using optimized materials. Support electronics will be developed to acquire, multiplex, store and process raw sensor array data needed for near real-time entry, decent and landing aerostructure control.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed ultra-wide bandwidth pressure transducers can be used in the entry, descent, and landing applications. Currently, there is no commercially available pressure sensor that meets engineering requirements for such missions. The team will transition the ultra-wide bandwidth pressure transducers from the prototype stage to gauge products of use for the entry, descent, and landing applications.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Primary customers will be university, government laboratory and industry researchers. Customers for ultra-wide bandwidth pressure transducers will be the high-speed vehicle and flight control system designers and manufacturers. Broader commercial sensor opportunities including oil and gas down-hole measurements may be also pursued.
Duration: **6**

PROPOSAL NUMBER: 22-1- **Z5.04-2604**

SUBTOPIC TITLE: Intravehicular Robot (IVR) Technologies

PROPOSAL TITLE: An Affordance Driven, Human-in-the-Loop Perception Framework

Small Business Concern

Firm: **PickNik Inc**
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Phone: **(720) 513-2221**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Despite all the advances in robotics, it has been difficult to deploy robots for non-trivial tasks in unstructured environments in a fully autonomous way. As a result, for such tasks there is often a human in the loop to create supervised autonomy. We are proposing to develop a software framework that enables operators to more easily command robots by leveraging more computer vision. The key innovation of this proposal is to connect a perception pipeline that recognizes instances of known classes of objects with affordances: a description of how an object should be manipulated. For example, given a depth image of a scene, the system will recognize door handles and hinges and annotate the scene to automatically inform the user how a robot could open the corresponding doors. Our work combines automatic recognition of affordances with a user interface (UI) that enables an operator to fine tune affordances if needed. The operator feedback will be used to retrain the system to further improve system performance and decrease the amount of operator input required. This is expected to reduce the cognitive load on robot operators by allowing them to focus on high level tasks including appropriate actions on objects that are relevant to a given task.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The initial focus is on enabling higher levels of autonomy for IVA such as cargo unloading and science experiment tending. The technology may also be applicable to EVA and OSAM-related robotic activities. In the long run, we also envision applications in, e.g., construction and assembly on the moon and other planets.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The same applications that are of interest to NASA are also of interest to the rapidly expanding commercial space industry. Terrestrial applications that are enabled by the proposed work include inspection and maintenance of industrial sites and offshore platforms.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S12.02-2526**

SUBTOPIC TITLE: Precision Deployable Optical Structures and Metrology

PROPOSAL TITLE: Photopolymer Space Parabolic Mirrors

Small Business Concern

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Principal Investigator:

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Business Official:

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Phone: **(858) 775-9363**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

We propose to develop paraboloid mirrors to be made in space. The mirrors would be based on solidifying liquid precursor materials into a paraboloid shape. The paraboloid mirrors would be made in space by spinning the mirror support structure or the entire satellite simultaneously in two orthogonal axes while releasing the liquid precursor into it. Spinning around the first axis generates an artificial gravity, while spinning around the second axis generates a paraboloid surface in the liquid mirror precursor. The precursor is subsequently allowed to solidify thus preserving its paraboloid surface and forming a mirror.

The currently proposed precursor material is a photopolymer which is cross-linked by exposure to an on-board UV source. Alternatively, the precursor materials can be two-part epoxies, metals (K, Na, In), their alloys and thermosetting and thermoforming polymers.

The proposed system also includes a thermo coating system which would deposit a reflective coating onto a formed mirror surface in case the mirror is fabricated of a weakly reflecting precursor.

Additionally, the mirror support structures are proposed to be made of shape-memory materials which would offer high packaging density for launch and which would unfold upon application of heat. Utilizing such structures avoids dedicated actuators and greatly reduces complexity, weight and packaged volume of the system.

There are no fundamental limits to the size of space-made mirrors, since they are fabricated in zero- or microgravity.

The mirrors can be repaired in space by re-deposition of the precursor (or re-melting in case of metals), re-spinning them and solidifying the precursor.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed mirrors would enable new techniques of constructing large- and very large aperture telescopes in space, opening up new opportunities for terrestrial and space exploration.

With relatively few mirror generation steps, this technology would favorably compete with present multi-segment large mirror assemblies, in terms of cost, complexity and reliability, while offering potentially much larger apertures.

In addition, the proposed mirrors can be re-worked while in space, thus extending the useful lifetime of space telescopes.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed technology would enable large aperture space telescopes to be launched with relatively small vehicles, while avoiding complicated assembly in space. The cost of the resulting mirrors is expected to be orders-of-magnitude lower than present ones.

As a result, the cost of high resolution space and terrestrial surveying, cartography and surveillance will be reduced by orders-of-magnitude.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z2.01-1555**

SUBTOPIC TITLE: Spacecraft Thermal Management

PROPOSAL TITLE: A Compact, Gravity-Insensitive Gas Trap for Extreme Temperature Environments

Small Business Concern

Firm: **Creare, LLC**
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Business Official:

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Phone: **(603) 643-3800**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA is actively working towards missions involving crewed habitats for extended stays on the lunar surface and other similar environments in space. Environmental control of these habitats is enabled by use of thermal control systems to maintain conditions within a tight band. These thermal control systems must be highly reliable, lightweight, and able to effectively control cabin and equipment temperatures to within several degrees under varying heat loads. In these systems, the pump is often the only dynamic component and thus poses the greatest risk of failure. To address this need, Creare has developed a compact, gravity-insensitive gas trap capable of passively sequestering, then venting non-condensable gas buildup in liquid coolant loops. The gas trap is fully welded with metallic wetted surfaces, can be regenerated to eliminate fouling, and is compatible with operation in extreme environments. In Phase I, we will prove the feasibility of this approach by developing a preliminary gas trap design, demonstrating key processes involved in fabrication of the gas trap including development of the superhydrophobic titanium porous tube, and characterizing a subscale gas trap through laboratory testing. In Phase II, we will fabricate a gas trap capable of serving a multi-kW spaceborne thermal coolant loop, demonstrate its performance in a representative thermal environment, and deliver it to NASA for further performance evaluation.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Gas traps are needed for enhanced reliability in thermal control for NASA missions including on-board the ISS. The current proposed effort would enable high reliability coolant loops for use in future lunar habitats or extreme environments circulating low-surface-tension fluids. Other governmental applications (e.g., DoD) are similar to NASA uses, specifically high reliability coolant loops operating in extreme environments for aircraft, ships, and ground vehicles.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The superhydrophobic membrane development has commercial applications for various chemical industries including steam separation and chemical processing with two-phase caustic chemical flows. The gas trap itself has application in high reliability coolant with minimal available maintenance such as in nuclear power plants or in other remote power stations.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.02-1556**

SUBTOPIC TITLE: Quiet Performance - Aircraft Propulsion Noise

PROPOSAL TITLE: A Wall-Modeled Large-Eddy-Simulation Tool for Fan Broadband Noise Prediction

Small Business Concern

Firm: **D&P, LLC**
Address: **3409 North 42nd Place, Phoenix, AZ 85018**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

This SBIR project proposes to develop a wall-modeled large-eddy-simulation (WMLES) tool for fan broadband noise prediction. Since fan broadband noise results from the interaction of turbulence with solid surfaces, it is important to resolve turbulent eddies up to a certain scale in order to achieve an accurate fan broadband noise prediction. Unfortunately the computational cost of the wall-resolved LES approach is found to scale with the Reynolds number as $Re^{2.72}$, similar to $Re^{2.91}$ of the direct numerical simulation (DNS) approach. To obtain a faster tool for fan broadband noise prediction, this SBIR effort will pursue the WMLES approach, in which the inner portion of the boundary layer will be modeled rather than resolved. The approach can reduce the computational cost to $Re^{1.14}$. As a feasibility study, the Phase I outcome will demonstrate the feasibility of the proposed WMLES approach for accurate simulation of NASA 22-in fan noise source diagnostic test (SDT) case. Therefore, it is meaningful to further refine the methodology and develop a computational software tool for commercialization in Phase II.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The Advanced Air Transport Technology (AATT) and Commercial Supersonic Technology (CST) Projects would benefit from the developed computational tool that could be used to predict the

performance and noise impacts of the novel engine installations for noise reduction. The Transformational Tools and Technologies (TTT) Project would benefit from the developed computational tool to enhance the ability to consider acoustics earlier in the aircraft propulsion system design process.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

DoD's High Performance Computing Modernization Program would benefit from this computational tool that could provide them a useful tool for fan broadband noise prediction. Design engineers in engine manufacturers can use the developed computational tool to explore various noise reduction concepts and validate fast, low-fidelity analytical methods for trade-off studies and performance prediction.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.04-1635**

SUBTOPIC TITLE: Nontraditional Airspace Operations and Aerial Wildfire Response

PROPOSAL TITLE: Precision Retardant Delivery

Small Business Concern

Firm: **KIHOMAC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

KIHOMAC proposes to develop a Precision Retardant Delivery system for to improve the safety and efficiency of aerial firefighting. The proposed system will calculate the optimal aircraft vector for a retardant drop taking into account environmental variables, aircraft capabilities and desired retardant effects. The system will calculate and provide steering cues to the air tanker pilot to the calculated release point, ensuring an optimal drop of retardant.

Our proposed system leverages NASA research into ground collision avoidance and furthers the state of the art by implementing a "forward-look" algorithm to deconflict steering cues with known obstacles. The combination of advanced ground collision avoidance with calculated drop vectors will reduce pilot workload and increase safety during critical low-level flight operations.

Our Phase I effort will focus on advancing prior algorithmic work and demonstrating the feasibility of the approach in four key areas:

1. Retardant plume modeling.
2. Optimal path prediction for ground collision avoidance.
3. Algorithm scalability and implementation of off the shelf hardware.
4. Post-drop analysis effectiveness.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Improvement of airspace operations during aerial firefighting through the reduction in re-attacks after missed drops. Improved safety and efficiency of aerial firefighting, resulting in reduced costs, earlier fire containment and lower environmental impact.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Increased efficiency and reduced costs for domestic and international aerial firefighting, both Governmental and commercial. Improved safety for operators of air tankers and lead planes.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H8.01-2197**

SUBTOPIC TITLE: Low-Earth Orbit Platform and Microgravity Utilization for Terrestrial Applications

PROPOSAL TITLE: Rapid, Low-Cost Drug-Discovery in Space

Small Business Concern

Firm: **Sachi Bioworks**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

While the space is nominally considered a “harsh” environment for sustaining life due to its atmosphere, microgravity, and exposure to intense galactic cosmic rays (GCR), causing adverse health effects like accelerated aging, DNA damage, tissue damage, and disease, it also offers unique opportunities for development and screening of therapeutic modalities that can immensely benefit therapeutic development activities for terrestrial applications. Another advantage the unique space environment offers is the effect of microgravity enables facile formation of human organoids 3D *in vitro* models that exquisitely mimic the complexity of our tissues and organs and provide a practical alternative to whole-organism studies in human and can be used to study various pathophysiological phenomena on Earth, for deep space manned missions, and developing personalized medicine. Sachi Bioworks will team up with Space Tango for accelerating the development of therapeutics for neurodegeneration, cancer treatment, and cardiovascular diseases.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed project and rapid drug-discovery and manufacturing in space can lead to “on-the-fly” therapeutic manufacturing, providing “on-demand” therapeutics for different adverse health conditions that can arise during space travel. Moreover, such therapeutics can be personalized to different astronauts (personalized medicine), providing capability for NASA missions to ensure positive therapeutic outcomes to maintain astronaut’s health. This could also lead to availability of effective therapeutics without frequent restocking missions.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

For terrestrial applications, the space-based rapid and low-cost drug-screening in space can result in development of new and effective therapies to treat a wide-range of disease affecting millions of patients. Moreover, by shifting the drug-screening from animal testing to human cell lines and organoids can also ensure successful translation and advent of personalized and effective medicine.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S17.02-1941**

SUBTOPIC TITLE: Integrated Science Mission Modeling

PROPOSAL TITLE: Coverage and Access Analysis in Spaceline

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

We propose to expand Spaceline's capability to perform concept of operations (ConOps) feasibility analysis. Coverage Analysis calculates to what extent a region has been observed by a set of instruments. Access Analysis determines the timespans when entities are within unobstructed line-of-sight to each other. The inputs to Coverage Analysis include orbit, target availability, instrument field of view, downlink, and solar charging opportunities. The proposed addition of Coverage Analysis includes ground coverage for planetary missions and celestial sphere coverage; the proposed Access Analysis will allow Spaceline users to ensure that their spacecraft will fulfill their downlink, communication, and solar charging requirements even with complex data relay setups. The proposed innovation of integrating this utility into Spaceline increases its accessibility to a wider variety of mission proposal teams.

Spaceline can fill a valuable role in providing mission teams a single stable platform to share and communicate all the details associated with designing, planning, and analyzing a mission. Interviews with members of the spaceflight sector pinpointed several issues that Spaceline will address: (1) Spaceline will enable the rapid development of mission concept of operations, (2) Spaceline will provide a robust and flexible schema allowing for the design and review of plans in multiple coordinate systems, and (3) Spaceline will greatly reduce the overhead to communicate complex mission plans among team members. The proposed innovations of Coverage and Access Analysis to Spaceline will provide increased utility across all three use cases. Early in the lifecycle of a mission, while the ConOps is still in development, users will execute the analysis tools to calculate a baseline efficacy of a mission plan to support their proposal efforts. This baseline can then be used as a reference point for comparison against more complicated plans.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Our proposed addition of coverage and access analysis in the Spaceline ecosystem will directly facilitate NASA in their goal of developing Mission Design Analysis tools to increase the accuracy of science modeling and enable design of future observing systems by predicting and optimizing their impacts on science data collection. By allowing users to experiment with observation designs earlier in the design cycle of a mission, teams have the opportunity to develop a more advanced ConOps, supporting mission success.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Spaceline would support commercial Earth orbiting constellations as well as Space Situational Awareness applications. Spaceline can test the efficacy of constellation-based sensors which monitor the activities of other spacecraft and provide a training tool for operations team members. The visualization portions of Spaceline will be easy to insert into third-party web sites or museum kiosks.
Duration: **6**

PROPOSAL NUMBER: 22-1- **H3.09-1890**

SUBTOPIC TITLE: Human Accommodations

PROPOSAL TITLE: Ultra-Fast Ultrasonic Clothes Washer/Dryer Combination for Moon, Mars and ISS Applications

Small Business Concern

Firm: **Ultrasonic Technology Solutions**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA's Life Support and Habitation Systems Focus Area seek key capabilities and technology solutions that enable extended human presence in deep space and on planetary surfaces such as the moon and Mars, including Orion, ISS, Gateway, Artemis, and Human Landing Systems. One of the critical technological gaps listed includes clothing washer/dryer combination for use on the moon (1/6g) or Mars (1/3g) that can clean up to 4.5kg of cotton, polyester, and wool clothing in less than 7 hours using <50kg machine mass, <0.3m^3 external machine volume and <300W electrical power (Note: 101.3kPa habitat pressure may be assumed for prototype development).

The P.I. invented the transformative "direct contact ultrasonic drying" back in 2015 at ORNL and improved the technology over five years. In 2020, the lead inventor decided to leave ORNL and focus on the commercialization of this technology at UTS and further improving it. UTS exclusively licensed this platform technology from ORNL. Our team demonstrated five times higher drying energy efficiency for clothing (1/5th of the energy input) and two times faster drying rates compared to the state-of-the-art residential clothes dryers.

Here, we are proposing to develop a transformative combo washing and drying machine for space application where the ultrasonic components are the backbone of the technology**.** We are proposing to use mechanical washing methods using ultrasonic cleaners for the washing cycle. Also, we are going to use our direct contact ultrasonic drying for the drying cycle.

For a single garment, a 30×40×10cm assembly weighing less than 5kg should be able to wash and dry a pair of jeans in 6-12 minutes with an average power draw of 40 Watts during the wash cycle and 30-200 Watts during the drying cycle.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The improvement in human comfort will be essential for the future of space missions. The more Earth-like conditions we can create in space life, the more opportunities we will have to explore space beyond Earth life possibilities. In addition to improved sanitation, hygiene, and comfort of the astronaut's clothing, the proposed technology can result in significant weight savings from reductions in discarded clothing.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

UTS intends to further develop the technology for consumer use on Earth. One of the direct markets for such a tabletop size product will be for student housing, dorms, rental properties, hotels, and hospitals. Another niche market for such a product will be personal use in hotels, vacation homes, mobile devices and battery powered systems to be used outdoor.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.06-2440**

SUBTOPIC TITLE: Vertical Lift Technology for Urban Air Mobility -Electric Motor Fault Mitigation Technology

PROPOSAL TITLE: Automated Machine Learning Prediction of Motor Degradation (AMP MD) for eVTOLs

Small Business Concern

Firm: **Greensight, Inc.**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

GreenSight proposes to develop Automated Machine-Learning Prediction of Motor Degradation (AMP MD), a novel new system to detect motor issues, specifically insulation failures of stators, before the issue results in complete motor failure. The system uses the magnitude of current delivered to each phase of the motor to detect issues, a machine learning algorithm to detect anomalous behavior, and a classifier to inform the operator whether the motors are good, degraded, or have encountered a severe fault. The system uses machine learning models to characterize data from motor tests, outputs from a digital twin, and GAN augmented data to build a robust data set for the models to train effectively. The final system will consist of current sensors as well as a data acquisition system and machine learning software project that can seamlessly integrate on future Urban Air Mobility platforms to provide operators with actionable information about safety critical systems lending itself to a clearer path toward flight certification and authorization. GreenSight brings extensive experience in UAS flight control software and automation powered by machine learning to produce high reliability systems.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed AMP MD work fills critical gaps outlined in 2022 SBIR topic area A1.06. AMP MD by providing new methods to detect safety critical faults before cascading failures. This system can integrate seamlessly into an eVTOL's electronic speed controllers and embedded control system. The technique will enable rapid progress towards NASA objectives for Urban Air Mobility (UAM) and Advanced Air Mobility (AAM), to meet the high assurance levels required for aviation certification.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

AMP MD fills an industry requirement to improve reliability of safety critical components prior to authorizing the future Urban Air Mobility vehicles for commercial operations. This system can easily be adapted for commercial and military unmanned aircraft systems that require FAA approval prior to more widespread adoption of the available aircraft.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H3.08-2852**

SUBTOPIC TITLE: Challenges in Carbon Dioxide Removal and Reduction: Carbon Particulate and Thermal Management

PROPOSAL TITLE: Combined Sub-Micron Particle Separators for Carbon Removal System

Small Business Concern

Firm: **Mainstream Engineering Corporation**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

Mainstream proposes to develop a high-efficiency carbon removal system to safely collect and dispose of sub-micron carbon particulates generated from oxygen recovery systems. A cyclone separator reduces the total particulate matter loading while collecting larger particles (i.e., 1–10 μm, >10 μm). The remaining sub-micron particles (i.e. 0.1–1 μm) are then removed using an electrostatic precipitator (ESP), which drives particles entrained in the gas stream onto a collection electrode. Mainstream will optimize the geometry, electrode material, and key operational parameters to achieve a very high efficiency (>99%) for particles down to 0.1 μm. Collection electrodes can be regenerated in place through gas reaction or removed and scraped for safe storage and reuse or disposal, retaining all carbon particles. In Phase I, Mainstream will leverage our existing CFD and design toolsets to experimentally demonstrate sub-micron particulate separation with a combined cyclone and ESP system. Regeneration of electrodes would occur in-place or be used for safe disposal of carbon. Using process model designs and experimental data, Mainstream will design a carbon removal system and detail system size, weight, and power requirements. In Phase II, we will fabricate and validate a full-scale prototype system and advance system development for rapid integration.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA applications for the proposed carbon removal system for sub-micron particulates separation include integration with oxygen recovery systems for future long-duration manned missions such as Gateway and Mars. Additionally, this technology is applicable for both general air purification of the main cabin of the manned spacecraft as well as the removal of planetary dust from main cabins and airlocks of the planetary habitat.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non-NASA applications are numerous including automotive, thermal oxidizers, incinerators, industrial separators, commercial/medical/residential air purification, and particulate concentrators. With respect to additional manned spacecraft, non-government commercial entities such as Space-X, Blue Origin, Bigelow Aerospace, and others include space tourism as a future goal

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z2.01-1656**

SUBTOPIC TITLE: Spacecraft Thermal Management

PROPOSAL TITLE: Intact.Generative: A Plug&Play Approach for Topology Optimization of Thermal Control Systems

Small Business Concern

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

With funding from DARPA, Intact Solutions (**IS**) has developed Intact.Generative (**IG**), a plug-and-play topology optimization (**TO**) toolkit for structural and heat conduction based problems. In this project, we will extend IG into a robust commercial strength toolkit for TO of thermal/fluid components in thermal control systems. The innovative features of this project include:

- A modularized plug-and-play framework for multiphysics where users can customize the modules, e.g., plug-in turbulence models or add new physics. More importantly, users can plug-in their physis-based manufacturing modules to account for the rapidly evolving manufacturing techniques.
- Our algorithm does not rely on meshing the fluid and/or solid geometries. This paves the way for setting up an automated TO workflow which does not require user intervention for defeaturing and clean-up. Furthermore, it allows for interoperability with widely used simulation software such Abaqus/Ansys/NASTRAN/MFEM.
- We employ a CAD aware design methodology using implicit modeling, where the raw output geometries yielded by TO algorithm can be seamlessly exported to a typical CAD/CAE software in an automated way for downstream applications such as validating/certifying the optimized designs.

The current state of the art (**SOA**) topology optimization tools need to address several challenges before TO based approaches can become standard practice in the design of thermal/fluid and other components involving multiple physics simulations. Most of these challenges are related to modularization, meshing, automation, and interoperability. Our innovation, IG, adopts a plug-and-play approach based on a decoupled geometry-simulation framework and implicit modeling to seamlessly address these challenges. Consequently, IG will be the perfect tool that can help designers in the development of high-performance thermal control systems that can produces using modern manufacturing techniques.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Intact.Generative can be used to design and optimize thermal/fluid and other components that require multi-physics simulations, in applications such as

- Heat exchangers in small satellites and cubesat components
- Heat pipes and heat exchangers for spacecraft, e.g., lunar landers/rovers
- Aircraft structures such as wing panels/spars, fuselage chassis, etc.
- Design of active/passive thermal cooling systems for electric aircraft such as the NASA X-57
- Load carrying battery packs, which require coupled structural/thermal/flow simulations

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Designers can use Intact.Generative to improve the efficiency of multi-functional components, such as that are typically designed for multiple physics considerations, such as aircraft wings, rotorcraft blades, as well as load bearing structures (brackets, chassis, etc.,) in aerospace and automotive applications, and heat sinks & heat exchangers typically used in electronics.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z10.01-1870**

SUBTOPIC TITLE: Cryogenic Fluid Management

PROPOSAL TITLE: Compressor for Efficient On-Orbit Gas Transfer

Small Business Concern

Firm: **Creare, LLC**

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

On-orbit transfer of gaseous propellant is a critical technology for extending the useful life of satellites. A key component needed for on-orbit refueling is a compressor that can efficiently move gas from a resupply vessel to the propellant tank on board a satellite. High efficiency requires a very high pressure ratio, and operation on orbit requires that the compressor be compact, lightweight, and highly reliable. We propose to develop a miniature, high pressure ratio compressor that meets these requirements. Our technology can efficiently transfer gas to a high-pressure receiver tank using a highly reliable compression mechanism. In Phase I, we will prove feasibility through demonstration testing of key components and materials, analysis and assessment of key design tradeoffs, detailed conceptual design, and predictions of performance. In Phase II, we will build and demonstrate a full-size, flight-like prototype compressor.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary NASA application will be to replenish gaseous propellant for ion drives used by orbiting satellites. Creare's compressor is compact, lightweight, and low power. Its high pressure ratio will enable the most efficient use of resupply gas. It has a modular configuration that can be scaled to a range of refueling applications.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial spacecraft operators face the same need for on-orbit propellant resupply as NASA. Creare's compressor will enable commercial spacecraft operators to extend the lifetime of their orbiting spacecraft.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A2.01-2072**

SUBTOPIC TITLE: Flight Test and Measurement Technologies

PROPOSAL TITLE: A Strap-On System Indentification System for Model Validation and Certification of VTOL Vehicles

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

The advanced air mobility (AAM) marketplace is currently experiencing a proliferation of novel Vertical Takeoff and Landing (VOTL) concepts. Prototypes are currently being flown and several are in early stages of the certification process with the Federal Aviation Administration (FAA) even as the FAA continues to develop the means of compliance methods that will be used for the Part 23 aircraft. The emerging certification methods will rely not only on flight test but also piloted simulation. In this scenario, the generation of system and parameter identification data via flight test will be critical for the extraction of key parameters that will be used to characterize the aircraft system and further to validate the simulation models that will be used for aircraft development and certification credit. For the military aircraft industry and the traditional airframers, fully instrumented aircraft are common. The many new companies that are

developing aircraft for the first time are also developing flight test equipment and knowledge infrastructure for the first time. To support the generation of high-quality system identification data in flight, Systems Technology, Inc. (STI) and Bolder Flight Systems Inc. (BFS) propose to develop the Aircraft System Identification Measurement System (ASIMS) that will feature a strap-on inertial measurement unit and novel architecture installations for inceptor position sensors coupled with a tablet-based display that will guide the end user through the generation of appropriate test inputs and provide after action analysis reviews and synthesis of the processed data in flight. To demonstrate efficacy of the proposed approach in Phase I, key elements of the system including the inceptor position sensing device and candidate features of the tablet display will be demonstrated via piloted simulation using the STI flight simulator.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

ASIMS applies to several NASA projects. The technology applies directly to the ARMD Flight Demonstrations and Capabilities projects. Specifically, ASIMS can support the growing number of flight test activities including the UAM Grand Challenge by providing a means to easily and repeatedly perform flight test system identification evaluations. ASIMS also applies to the RVLT Project, where the system supports the goal to “develop and validate tools, technologies and concepts to overcome key barriers for vertical lift vehicles.”

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The target market for ASIMS is the UAM market. According to HTF Market Intelligence, the estimated market size will be $15.2 billion by 2030. The study considered entries by traditional and non-traditional airframers. All will need to go through a certification process thereby defining the market, which will be introduced as the tablet-based system and as productized service to support is use.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.06-1962**

SUBTOPIC TITLE: In Situ Instruments/Technologies and Plume Sampling Systems for Ocean Worlds Life Detection

PROPOSAL TITLE: Methane Isotopes Analyzer for Enceladus Plume Flythrough

Small Business Concern

Firm: **Opto-Knowledge Systems, Inc. (OKSI)**
Address: **19805 Hamilton Avenue, Torrance, CA 90502**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

We propose a low SWaP Capillary Absorption Spectrometer (CAS) to analyze Methane during an Enceladus plume flythrough. The system will contain a Plume Capture and Delivery System (PCDS) which transports plume molecules to the CAS to be analyzed for 13C/12C carbon and D/H hydrogen isotope ratios. Although Enceladus's plume is thought to have created Saturn's E-ring, the plume particles are expected to be sparse at flythrough altitudes. With a very small sample, the CAS produces high-precision measurements, making it ideal for a plume flythrough. This proposed effort will design a PCDS and develop the CAS further to strengthen the D/H analysis with the constraints of relatively low-abundance of deuterated methane, along with the need to also measure 13C/12C isotopes jointly. The proposed measurements in an Enceladus plume flythrough would answer crucial questions about Enceladus's methane origin, giving insight into the possibility of life on Enceladus.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Ocean worlds discovered pose an exciting possibility of finding habitable regions, and more information must be learned. The CAS is a novel technology that analyzes small sample amounts to produce high precision data. This is imperative when traveling to a new planet/moon, where the flythrough environment is uncertain. The CAS can take measurements to guide future knowledge and missions with insight into the possibility of life on Enceladus. This technology is being proposed for Enceladus, however, could be extended for other worlds as well.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

By expanding the CAS capability to measure D/H ratios in methane, the technology will be attractive for a range of greenhouse gas and environmental sensing applications. In addition, there are energy related applications for the technology, specifically by enabling the improved analysis and characterization of underground geothermal sources and undersea hydrothermal seeps.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.01-2181**

SUBTOPIC TITLE: Advanced Air Traffic Management System Concepts

PROPOSAL TITLE: Machine Learning Approach for Predicting Persistent Contrails Formation Region

Small Business Concern

Firm: **Crown Consulting, Inc.**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3

Technical Abstract (Limit 2000 characters, approximately 200 words):

The proposal is motivated by the need for models for predicting the environmental impact of planned operations to enable aircraft operators to make tradeoffs between the benefit of reducing the negative environmental impact and the cost of deviating from fuel optimal routes and altitudes. These models will also provide metrics for policy makers to assess long term impact of the policies for reducing the environmental impact of aviation. Modeling of two major sources of environmental impact of aviation: (1) persistent contrails and (2) emissions have been proposed. A machine-learning approach is proposed for forecasting regions of persistent contrails formation using features derived from atmospheric data and satellite images. Compared to earlier models that are point-based, our proposal is a region-based prediction methodology with reduced uncertainty in the prediction of regions of persistent contrails formation using clustering techniques. For improving the emissions estimates, we propose a computational procedure for estimating the takeoff weight considering in part information provided in the flight plan. Simulation of trajectories with the estimated takeoff weight along with regions of persistent contrail formation predicted by the machine-learning model provide environmental impact in terms of expected emissions and contrail formation.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed machine-learning model for forecasting regions of persistent contrails formation, and the takeoff weight estimation method for improving emissions estimates integrated into NASA's air traffic management (ATM) simulators such as the Future ATM Concepts Evaluation System and the ATM-Testbed will enable environmental impact assessment of technologies and concepts for improving safety, efficiency, capacity, and throughput, and of implementation of NASA technologies in the current and future NAS.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The machine-learning model, along with trajectory simulation integrated into a web-enabled cloud-based tool will enable the FAA and the aircraft operators to determine environmental impact in decision-making. These models can provide information to policy makers about relative merits of environmental horizons (10 yrs vs 20 yrs) and efforts to reduce the impact of emissions and contrails.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H3.09-1873**

SUBTOPIC TITLE: Human Accommodations

PROPOSAL TITLE: ZeoWash: High Efficiency Low Power Washer Dryer

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

For longer duration stays in space, a compact low power washer dryer system is a critical element for reducing consumable mass of clothing. Not only does it save on launch mass, clean clothes can improve crew morale. More importantly, cleaning clothes regularly helps to reduce the growth and proliferation of bacteria, allergens, and fungi that may irritate or even cause skin diseases for the crew. But space vehicles and habitats are limited in usable power and volume, therefore the design of a combination washer-dryer system must accommodate these extreme constraints. The ZeoWash Laundry System offers a solution for a combined cycle (Wash/Sanitize and Dry) system which consumes 300W of power to clean and dry 4.5 kg of laundry within 3 hours. The system uses a novel **T**hermo-**e**lectric condenser and **c**onvection **D**esiccator water **R**emoval technolog**Y** (TecDry) for achieving an extremely low power, fast drying, self-contained laundry system.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- Planetary habitats (moon, Mars) for long duration stays
- Spaceflight missions with access to partial gravity

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- Space constrained habitation with expensive or low power access such as: off-grid houses, recreational vehicles, small yachts, apartment dwellers, remote research stations/outposts, remote military bases, refugee camps and tiny homes
- Regular households that want minimal power appliances

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z13.04-1862**

SUBTOPIC TITLE: Lunar Dust Filtration and Monitoring

PROPOSAL TITLE: Lunar Dust Filtration and Collection System

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Numerous space exploration missions to planetary bodies have noted significant deleterious effects due to fine particulates which can foul mechanisms, alter thermal properties, and obscure optical systems. NASA is seeking advances in the removal, management, and monitoring of airborne particulates and external dust to address the intrusion into and containment of lunar dust within the pressurized habitable volumes and compartments in crewed spacecraft systems. Under this SBIR project, Analytical Scientific Products is proposing the development of an efficient, compact, low-power, autonomous, low-maintenance, regenerable dust filtration and collection device for cabin air and airlock compartments during lunar missions. This filter takes in the dust laden gas from the target region, removes and collects the particles, and releases the clean gas back into the compartment. This device is unique because it is equally effective in filtering all dust particles irrespective of their origin (i.e., both lunar dust and cabin dust), it has no moving parts, and it imposes an extremely small pressure drop for fluid flow. The technology development will occur in three phases. In Phase I, we propose to perform numerical modeling to design the key components of the device, construct a breadboard device, and perform tests to demonstrate the effectiveness of this device in filtering and collecting dust particles. In Phase II, we will mature the technology through more detailed analysis and fabrication and testing of an alpha-prototype to fully characterize the performance before the construction of a beta-prototype that will be delivered to NASA. We will field test and commercialize the device in Phase III.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary intended application of the proposed technology is in the space industry where the deleterious effects of particulates are well known and can compromise the safety and functionality of various systems. It can be used to remove the dust particles and clean the air in spacecraft cabins and airlock compartments during the future missions to various planetary bodies including the moon and Mars.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed dust filtration and collection device can be used in any system that requires both separation and collection of particles from the carrier gas, is sensitive to pressure drops, and there is potential for exposure to hazardous particles/gases. Examples include nanoparticle manufacturing units and smokestacks.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.07-2081**

SUBTOPIC TITLE: Energy Storage for Extreme Environments

PROPOSAL TITLE: Nondestructive Instrumentation for Real-Time On-Demand Battery State Monitoring

Small Business Concern

Firm: **Storagenergy Technologies, Inc.**
Address: **1990 S Milestone Drive, Suite A, Salt Lake City, UT 84104**
Phone: **(801) 803-1303**

Principal Investigator:

Name: **Dr. Jared Liao**
E-mail: **liao@storagenergy.com**
Address: **1990 S Milestone Dr. Suite A, UT 84104 - 6553**
Phone: **(801) 386-8555**

Business Official:

Name: **Lynn Zhang**
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Address: **1990 S Milestone Dr. Suite A, UT 84104 - 6553**
Phone: **(801) 803-1303**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

Battery health monitoring is particularly crucial for space applications since battery shutoff or complete drain can be catastrophic. The battery management system (BMS) is vital to avoid such instances. Conventional on-board BMS are currently limited to the monitoring of extrinsic parameters including voltage, current, and temperature. From these, battery's state of charge (SoC) and state of health (SoH) are merely approximated using state-estimation software and algorithms. Almost all the state-of-the-art techniques for battery health monitoring have serious limitations. In order to address the current challenges for battery state monitoring, Storagenergy Technologies, Inc. proposes novel nondestructive and field-deployable technique for real-time on-demand battery SoC and SoH monitoring. The successful realization of the proposed concept will enable the practical use of battery state monitoring for space battery applications. The

outcome will be widely applicable for current and future commercial, science and exploration missions and offer benefits to other national needs.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed nondestructive battery state monitoring technique has shown promise that fit NASA's interest for battery state monitoring for future science and exploration missions such as: missions using electric propulsion, space vehicles, robotic missions, lunar exploration missions to NEO and MARS, crewed habitats, astronaut equipment, robotic surface missions to Venus and Europa, polar Mars missions and Moon missions, and distributed constellations of micro-spacecraft.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed nondestructive battery monitoring technology also offers benefits to other national needs. This includes national defense systems such as unmanned aerial vehicles, unmanned underwater vehicles, and soldier portable power systems. Benefits to the terrestrial energy sector include all-electric and hybrid cars, grid-scale energy storage systems, smart grid, and off-grid power systems.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z13.01-2507**

SUBTOPIC TITLE: Active and Passive Dust Mitigation Surfaces

PROPOSAL TITLE: Nanomaterials-enabled Electrodynamic Dust Shield

Small Business Concern

Firm: **Innosense, LLC**
Address: **2531 West 237th Street, Suite 127, Torrance, CA 90505**
Phone: **(310) 530-2011**

Principal Investigator:

Name: **Dr. Yifan Tang**
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Phone: **(310) 530-2011**

Business Official:

Name: **Kisholoy Goswami**
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Address: **2531 West 237th Street, Suite 127, CA 90505 - 5245**

Phone: **(310) 530-2011**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA needs an advanced technology for dust mitigation relevant to its critical exploration missions. Electrostatic discharge (EDS) coatings will prevent build-up of charge and adhesion of dust on the surfaces of moon, Mars or Near-Earth Objects. InnoSense LLC (ISL) will develop a nanomaterials-enabled EDS (DustRepel™) for use on transparent and flexible surfaces in support of 2020 NASA Technology Taxonomy TX07.02 - Mission Infrastructure, Sustainability, and Supportability (TX07.2). DustRepel will be engineered to provide effective dust shielding capability. Being optically transparent and flexible, it can be deployed on various substrates in different form factors. The design, materials and fabrication processes will render DustRepel versatile and durable. In Phase I, ISL will formulate the electrode ink materials, fabricate DustRepel coupons, evaluate the optical, electrical and physical performances. Phase I feasibility will be validated by demonstrating effective dust shielding effect. In Phase II, we will optimize the design, materials and process, fabricate prototypes and perform rigorous characterizations.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

DustRepel EDS technology will provide effective active dust shielding on flexible transparent surfaces. It will: (1) mitigate dust on solar panels, optical systems, viewports, thermal radiators and other mission-critical infrastructures; (2) reduce maintenance needs; and (3) ensure stable performance of mission-critical infrastructures. DustRepel's versatility will also allow its application on other surfaces or equipment required to meet NASA's exploration needs.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

DustRepel, a transparent and flexible shield, will provide versatile and effective active dust mitigation. It can protect surfaces against dust/particle accumulation for: (1) solar panels, (2) construction vehicles, (3) eye protection devices, (4) military vehicle windshields, and (5) optical devices that are deployed in the desert.
Duration: **6**

PROPOSAL NUMBER: 22-1- **H5.02-2035**

SUBTOPIC TITLE: Hot Structure Technology for Aerospace Vehicles

PROPOSAL TITLE: Localized 3-D Fiber Reinforcement in C-C and Ceramic Composites

Small Business Concern

Firm: **North Country Composits LLC**
Address: **17 Marquis Drive, PO Box 408, Colebrook, NH 03576**

Phone: **(603) 996-1054**

Principal Investigator:

Name: **Frederick Lauten**
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Address: **10 Brechin Terrace, NH 01810 -**
Phone: **(978) 884-4701**

Business Official:

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Address: **10 Brechin Terrace, NH 01810 -**
Phone: **(978) 884-4701**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

North Country Composites (NCC) is teaming with Lancer Systems to modify Lancer's commercial ceramic matrix composite (CMC) manufacturing methods to produce affordable very high performance rocket engine components. The components would operate in highly oxidative and corrosive environments to temperatures up to 3600^{o}F for long durations (many hours) and 4600^{o}F for shorter durations. This will occur without the use of expensive coatings. Through the utilization of low cost ISO 9001 controlled manufacturing methods, affordable, high performance components can rapidly be transitioned for commercial use. In addition, NCC will utilize 3D reinforcement of the fiber preforms to significantly increase (3X) interlaminar strength properties with only a mild decrease in plane properties.

The high strength, light weight and high temperature capabilities of these structures will significantly increase the performance of rocket engines by increasing the thrust to weight, operational temperatures, and pay-load capabilities.

The purpose of the Phase I program is to demonstrate the feasibility producing ultra-high temperature (UHT) CMCs for use as chambers and nozzle extensions in liquid rocket engines. During Phase I the NCC team will produce a nozzle extension for hot fire test in LOx/Methane. In addition we will produce thermo-mechanical test specimens with optimized interlaminar strength properties. After high temperature, oxidative exposure, they will present strength retention of greater than 85%.

In the Phase II program we will work with engine suppliers to perform the technical maturation work for a specific engine system nozzle extension that will result in use of the NCC components in Phase III and other programs. As a result of developing a significantly cost and time reduced UHT-CMC manufacturing process, NASA and other customers will garner the performance increases for rocket propulsion and other advanced vehicle applications.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Human Exploration & Operations Mission Directorate (HEOMD) would benefit by utilizing the technology in spacecraft and launch vehicles to provide improved performance and to enable advanced missions with reusability, increased damage tolerance and durability. Potential NASA users of this technology exist for a variety of propulsion systems, including:

- Upper stage engine systems, such as those for the Space Launch System.
- Lunar/Mars lander descent/ascent propulsion systems.
- Propulsion systems for commercial space companies supporting NASA

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The CMC technology would be enhancing to systems already in use or under development and enabling for missions that necessitate improved high temperature composite technology. The Air Force is interested in such technology for its Evolved Expendable Launch Vehicle, ballistic missile, and hypersonic vehicle programs. Other non-NASA users include Navy, Army, and the Missile Defense Agency.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.02-1831**

SUBTOPIC TITLE: Quiet Performance - Aircraft Propulsion Noise

PROPOSAL TITLE: Advanced Phased Array Instrumentation and Processing for Engine Inlet Measurements

Small Business Concern

Firm: **Interdisciplinary Consulting Corporation**
Address: **5745 Southwest 75th Street, #364, Gainesville, FL 32608**
Phone: **(352) 283-8110**

Principal Investigator:

Name: **David Mills**
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Address: **5745 Southwest 75th Street, #364, FL 32608 - 5504**
Phone: **(812) 204-9206**

Business Official:

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Address: **5745 Southwest 75th Street, #364, FL 32608 - 5504**

Phone: **(407) 697-3697**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The Interdisciplinary Consulting Corporation (IC2), in partnership with OptiNav, Inc., proposes to develop advanced phased array instrumentation and processing capabilities for aircraft engine-inlet measurements. High channel-count, high-density, reduced cost-per-channel microphone arrays, using microelectromechanical systems (MEMS) piezoelectric microphones with backside contacts and advanced packaging technology, will be integrated into model-scale inlet design/build efforts to revolutionize engine-inlet array-measurement capabilities through increases in array density and channel count while significantly reducing the cost per channel. These measurement advances will be coupled with development of advanced processing techniques to take full advantage of the enhanced measurement capabilities, including handling of the three-dimensional (3D) problem related to non-uniform inlet geometries.

One focus of this project is to combine proven design principles and established device structures to develop, package, and install high channel-count, high-density arrays of MEMS piezoelectric microphones into model-scale engine inlets. Back-side contact piezoelectric MEMS microphones combined with advanced packaging methods will enable ultra-smooth sensor installation to avoid flow disturbances that would perturb the conditions inside the inlet and/or reduce the effectiveness of the measurement due to extraneous flow noise generated by the sensor.

A second focus of this project is to develop innovative processing algorithms to take advantage of the newly-enabled, high-fidelity data-acquisition capabilities. The increased sensor density and lower-cost sensors will enable measurements with higher modal density and dynamic range than previous measurement campaigns have been able to achieve. An even more significant advancement is the enabling of source-diagnostic capabilities in non-uniform inlets that require new algorithm development to account for the more complex geometry.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed advanced phased array instrumentation and processing technology has the potential to be transportable across multiple NASA facilities such as the newly renovated 9' x 15' Low Speed Wind Tunnel. The new DGEN Aeropropulsion Research Turbofan (DART) is an excellent candidate for inlet phased array tests. NASA’s Commercial Supersonic Technology Project will need research testing of exotic inlets, and NASA has Space Act Agreements with numerous companies developing Advanced Air Mobility (AAM)/Urban Air Mobility (UAM) vehicles.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial turbofan engine manufacturers have long wanted in-duct testing of real engines to reduce cost and increase information return compared with far-field static engine testing. External customers for the technology include government agencies as well as commercial engine manufacturers such as GE, Pratt & Whitney and Rolls Royce, and commercial AAM/UAM developers.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A2.02-1200**

SUBTOPIC TITLE: Enabling Aircraft Autonomy

PROPOSAL TITLE: Autonomy Platform Hover, Inc Proposal

Small Business Concern

Firm: **Hover, Inc**
Address: **909 5th Avenue, Seattle, WA 98164**
Phone: **(817) 675-8042**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Detect And Avoid (DAA) is an essential capability for autonomous and semi-autonomous Advanced Air Mobility (AAM) and Urban Air Mobility (UAM) aircraft operating Beyond Visual Line of Site (BVLOS) within the National Airspace System (NAS).

The capability presented in this proposal will overcome the following barriers to entry: cognition and multi-objective decision making, cost-effective, resilient, and self-organizing communications and verification and validation technology and certification approaches. Our research will benefit detect and avoid algorithms, sensor fusion techniques, robust trajectory planners, and

contingency management systems that can enable AAM and higher levels of UAS integration into the NAS.

For a DAA algorithm to be certified for use within the NAS, the computing platform which includes all the software and hardware necessary for it to be executed also needs to be certified. Furthermore, different sensors for detecting intruder aircraft do not perform as well as each other under all operating conditions and utilize technologies that are not equally certifiable. The capability to execute two DAA functions (see examples below) and other autonomy functions concurrently supports the integration of these sensors and technologies enabling aircraft autonomy.

The current state of the art does not offer a low Size, Weight and Power (SWaP) certifiable computing platform suitable for AAM and UAM aircraft that provides this capability.

The computing platform offered by this proposal provides this capability

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA applications that require DAA functions and other autonomy functions for integration into the national airspace system

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non-NASA applications that require DAA functions and other autonomy functions for integration into the national airspace system

Duration: **6**

PROPOSAL NUMBER: 22-1- **H8.01-2777**

SUBTOPIC TITLE: Low-Earth Orbit Platform and Microgravity Utilization for Terrestrial Applications

PROPOSAL TITLE: Space Enhanced Crystals (SPECS)

Small Business Concern

Firm: **DSTAR Communications**
Address: **4531 Dulcinea Court, Woodland Hills, CA 91364**
Phone: **(805) 501-9399**

Principal Investigator:

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Business Official:

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Phone: **(818) 512-8802**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 6

Technical Abstract (Limit 2000 characters, approximately 200 words):

To meet NASA's goal of commercial in-space production of materials with a level of quality and performance superior to that on Earth, DSTAR Communications Inc. proposes to develop Space-Enhanced Crystals (SPECS). This customer-driven development is based on initial sales of Minimal Valuable Products (MVPs). The technology uses the microgravity-driven enhancement of crystal formation in microgravity in combination with a set of novel process controls to establish commercially sustainable manufacturing on board of the International Space Station (ISS). Phase I program is set to establish the feasibility of SPECS. Phase II program targets commercial crystal fabrication on ISS for the needs of the identified commercial customers. The program leverages a unique modular ISS manufacturing platform to maintain U.S. leadership in the area of commercial in-space production.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- Long wavelength infrared sensors and probes
- Exoplanet exploration instruments
- Thermal imaging and situational awareness systems for robotic and space platforms
- Pigtailed quantum cascade lasers for remote environmental sensing

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- High power CO and CO2 laser delivery for screen glass processing
- Medical endoscopes and diagnostics equipment
- Environmental sensing platforms

Duration: **6**

PROPOSAL NUMBER: 22-1- **A2.03-1800**

SUBTOPIC TITLE: Advanced Air Mobility (AAM) Integration

PROPOSAL TITLE: Extraction of Supplemental Meteorological Data

Small Business Concern

Firm: **Intellisense Systems, Inc.**
Address: **21041 South Western Avenue, Torrance, CA 90501**
Phone: **(310) 320-1827**

Principal Investigator:

Name: **Mr. Chris Ulmer**
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Address: **21041 S. Western Avenue, CA 90501 - 1727**
Phone: **(310) 320-1827**

Business Official:

Name: **Selvy Utama**
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Address: **21041 S. Western Avenue, CA 90501 - 1727**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA is seeking to supplement low-altitude meteorologic information to enable Advanced Air Mobility (AAM) service. AAM is a concept for safe, sustainable, affordable, and accessible aviation (e.g., passenger transport, aerial work, and cargo transport) both locally and intraregionally. The use of data from sensors that are not currently aviation-approved to identify local conditions along the route of transit, rather than making broad assumptions from sparsely distributed sensors, would allow for more effective use of the airspace, enhance safety, and improve operational efficiency by providing improved real-time wind, cloud ceiling, and visibility data. To address this need, Intellisense Systems, Inc. (Intellisense) proposes to develop the new Extraction of Supplemental Meteorological Data (EXTRA) system to provide fine-granularity weather data based on (1) direct measurement from low-cost, widely distributed meteorological sensors, (2) artificial intelligence (AI) data extracted from nonmeteorological sensors, (3) central data collection, (4) extrapolation of overhead conditions from ground conditions, and (5) go/no-go determination based on safety criteria. The system will result in very fine-scale data to fill the gaps in legacy weather-sensing equipment in order to enable the emerging transformation of the skies that AAM will bring about. EXTRA operates on the principle of multi-sensory integration by which data sets from a range of disparate sources (such as direct readings from weather sensors or AI analysis of traffic camera imagery) are collected in order to synthesize a detailed map (down to a resolution on the order of 100 ft) and to subsequently extrapolate from that weather map to the wind field above the location of the sensors (i.e., winds aloft) and ultimately make go/no-go recommendations. This technology directly supports the NASA Aeronautics Research Mission Directorate (ARMD) AAM mission.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The EXTRA system has direct applicability to NASA research, specifically to the NASA Aeronautics Research Mission Directorate (ARMD) Advanced Air Mobility (AAM) mission to accelerate applications of passenger transport, aerial work, and cargo transport. Among the three pillars of the AAM ecosystem (vehicle, airspace, and community), weather is a critical aspect of the airspace component and the EXTRA technology addresses this critical need with a minimal-footprint, low-cost solution.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Advanced Air Mobility (AAM) will revolutionize transportation and delivery with an enormous impact expected on the commercial aerospace industry. Safe operation of all aircraft including new electric and hybrid aircraft (e.g., Joby Aviation, Wisk Aero) requires monitoring of the weather, and the EXTRA system will be an essential element of the overall AAM system.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.08-2059**

SUBTOPIC TITLE: Aeronautics Ground Test and Measurement Technologies

PROPOSAL TITLE: Robust Optical Interrogators for Electric Propulsion Applications

Small Business Concern

Firm: **Luna Innovations, Inc.**
Address: **301 1st Street Southwest, Suite 200, Roanoke, VA 24011**
Phone: **(540) 769-8400**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

A new generation of aircraft is being researched at NASA through the Electrified Aircraft Propulsion Technologies (EAPT) project that will use electric motors powered by batteries for propulsion instead of fuel-burning engines. Electrified Aircraft Propulsion (EAP) air vehicles present a challenging environment for measurement and instrumentation systems due to the presence of strong Electromagnetic Interference (EMI) created by the powerful high voltage motors. Fiber optic sensors are an ideal solution to this problem given their light weight, ability to make distributed multi-parameter measurements with a single optical fiber and their native immunity to EMI. However, the associated optical interrogation electronics are not fully immune to EMI and may not operate properly in the presence of these high electric and magnetic fields. This problem demonstrates a need for ruggedized, EMI hardened optical interrogators to support critical testing needs for ground and flight based EAP applications.

Luna Innovations has partnered with magniX, a leading manufacturer of electric propulsion units (EPUs) for electric-powered aircraft to address this problem by developing and testing an EMI hardened version of its proven Hyperion® platform of fiber optic sensor interrogators. The Hyperion is a versatile optical sensing platform, compatible with a variety of sensor types, including fiber-Bragg-grating based temperature and strain sensors that can simultaneously monitor as many as 1,024 sensors at up to 5kHz. The existing commercial product has an optical bandwidth greater than 80 nm and a spectral resolution of 1 pm. The proposed innovation will validate the performance of the modified unit under high levels of EMI exposure through laboratory testing and will demonstrate performance in a relevant operational environment by testing around existing electric propulsion units.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed research will directly address NASA's need for an optical interrogator that is immune to EMI. This system will find potential applications in electric powered aircraft such as the X-57 Maxwell and other vehicles being developed under the Revolutionary Vertical Lift Technology (RLVT) and Electrified Aircraft Propulsion Technologies (EAPT) projects. It may also be useful for ground testing at the NASA Electric Aircraft Testbed (NEAT) or for other applications under the Advanced Air Transport Technology (AATT) umbrella.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed EMI-hardened Hyperion will find a ready market for instrumentation in emerging commercial electric aircraft designs. Besides aviation, large scale electric propulsion platforms in the transportation sector would be a likely market, such as locomotives, electric semi-trucks, and electric boats. With some cost reduction the system could also be applied to the electric automobile market.
Duration: **6**

PROPOSAL NUMBER: 22-1- **Z2.02-2779**

SUBTOPIC TITLE: High-Performance Space Computing Technology

PROPOSAL TITLE: Design and Formal Verification of a Fault-Tolerant RISC-V Processor Core Augmented to Accelerate Image and Science Data Processing

Small Business Concern

Firm: **Aries Design Automation, LLC**
Address: **2705 West Byron Street, Chicago, IL 60618**

Phone: **(773) 856-6633**

Principal Investigator:

Name: **Miroslav Velev Ph.D.**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

In this SBIR Phase I project, we will design and formally verify a fault-tolerant processor core implementing the RISC-V Instruction Set Architecture (ISA), augmented with arrays of reconfigurable processing elements and possibly other mechanisms to accelerate image and science data processing. The proposed work will achieve fault tolerance, high performance, high reliability, and low power consumption in a very agile architecture that can be reconfigured dynamically for optimal or near optimal performance for many applications. Also, by using processor cores implementing the free open-source RISC-V ISA, NASA will benefit from the constant stream of innovations in the extremely active R&D field of this architecture, which is being vigorously developed by tens of companies and hundreds of researchers worldwide.

We have made critical contributions to formal verification of complex microprocessors. We will apply our extremely efficient tool flow for formal verification of pipelined/superscalar/VLIW processors that outperforms other approaches by orders of magnitude, while requiring minimal manual intervention, and scales for mathematically proving of both safety and liveness for a wide range of microprocessor architectures with many architectural mechanisms. Another application of our tool flow is the formal verification of correctness and cybersecurity properties of executable code for a given ISA with a formally defined specification.

The need for formal verification of digital avionics for aerospace applications cannot be overemphasized after the Boeing 737 MAX crisis, with its high cost in lost human lives (346 people died in the two fatal crashes), and economic damage to both the manufacturer (more

than $18.6B loss for Boeing, not including potential future economic losses from damaged reputation), and its customers (billions of dollars loss for the airlines that had purchased airplanes from this model that had to be grounded for more than 1.5 years).

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed processor will accelerate many applications at NASA, such as image and science data processing, e.g., signal/sensor processing, AI methods, and edge computing, including astrophysics, planet weather modeling, etc. Compared to other designs, it will have higher reliability and lower power consumption, allowing much faster solutions of problems that can be solved with current processors, and enabling solutions of larger problems. NASA can use this processor in spacecraft, satellites, rovers, robots, spacesuits, and embedded devices.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed work will similarly benefit all aerospace, defense, engineering, pharmaceutical, e-commerce, financial, and other companies that require fault-tolerant image and science data processing, as well as those developing medical devices, equipment for nuclear power stations, automotive, and other safety-critical applications. We will commercialize both physical chips and IP processor cores.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z4.07-1146**

SUBTOPIC TITLE: Advanced Materials and Manufacturing for In-Space Operations

PROPOSAL TITLE: Basalt Fiber-Reinforced Sulfur Polymer Matrix Composites

Small Business Concern

Firm: **Cornerstone Research Group, Inc.**
Address: **510 Earl Boulevard, Miamisburg, OH 45342**
Phone: **(937) 320-1877**

Principal Investigator:

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Business Official:

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Phone: **(937) 320-1877**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

To facilitate the goals of a sustained lunar presence, there will be a need for the efficient utilization of indigenous resources. The ability to make composite articles would be hugely advantageous for the fabrication of structures having high tensile and flexural strength. Articles with such properties are required for applications such as beams for cranes. The lunar environment lacks the hydrocarbons necessary to formulate organic polymeric matrices. However, sulfur is the eleventh most abundant among the elements in average lunar mare rocks. In 2016, a process called inverse vulcanization was developed that results in chemically stable and processable sulfur-based polymers. The process is straightforward and yields a dynamic covalently crosslinked thermoset. Though, it requires a small amount of an organic molecule having multiple points of unsaturation, of which there is not an abundance on the Moon. Urobilin, formed from the natural break down of red blood cells and found in healthy urine and feces, may fit the requirements for the necessary unsaturated organic molecule. Extraction from astronaut waste could be implemented in the Universal Waste Management System (UWMS) for collection. Given the processing characteristics of sulfur polymers it may be possible to utilize basalt fiber and sulfur polymers to produce polymer matrix composites using automated composite processing techniques such as pultrusion—a technique that allows structural composite materials to be made affordably by implementing automated processing. Utilizing novel polymer systems and reinforcements derived from lunar resources combined with proven automatable composite processing techniques should result in materials having enhanced tensile and flexural strength relative to wholly mineral based materials.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- The first product will be a sulfur-based polymer matrix capable of being processed into a composite material reinforced with basalt fibers.

- The first, and likely only, customer is expected to be NASA.

- The end users for this product are expected to be the astronauts that will be building the first structural habitats on the lunar surface.

- The proposed product conveys key benefits of reduced upmass compared to those in previously published literature by creating plastic material using indigenous lunar mare rocks.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- This niche technology addresses a need unique to space exploration and no plastics have been produced in an extraterrestrial environment to date, so estimating additional markets is speculative

- Potential customers may include SpaceX or U.S. Space Force

- Provides potential route to processable plastics on the Moon: adhesives, elastomers, moldable plastics, films, battery materials

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.03-2746**

SUBTOPIC TITLE: Extreme Environments Technology

PROPOSAL TITLE: Rapid, Cost Affordable Manufacture of Bulk Metallic Glass Components

Small Business Concern

Firm: **Transition45 Technologies, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

A novel hybrid fabrication process combining features of additive manufacturing and metal injection molding (MIM) has been conceived and shown to be low cost yet still capable of making highly complex, fully 3D objects for structural metals as titanium and nickel-base superalloys. The technology uses a modification to the conventional MIM process that provides substantial benefits, including the ability to make low to medium volume parts affordably without the need for design compromises or expensive hard tooling, with a reduction in the machining, multiple setups, and labor hours typically associated with producing such complex parts. The 3D-MIM process offers an intriguing fabrication method for making components of bulk metallic glasses (BMGs) that are ideal for use in extreme temperature deep space environments in small spacecraft. Not only is this fabrication approach relatively inexpensive, its technique uses sintering to bond the metal at temperatures lower than the melting point, a significant benefit when it comes to retaining the amorphous properties of BMGs.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Potential NASA Applications are heater-less planetary and strain-wave gearbox configurations for extreme cold environments (icy planets) where bulk metallic glass gears could offer a unique material solution. Other potential NASA applications are foam BMGs as a material for building future spacecraft for long-term space flight, as well as castable mirrors and mirror assemblies. The latter includes optics for spacecraft and satellites, mirror components for telescopes, mirrors for lasers, sensing and solar energy collection.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Potential Non-NASA applications are high efficiency transformers at line frequency and some higher frequency transformers, electronic article surveillance (e.g., theft control passive ID tags), enclosures and cases for electronics, warhead penetrators for munitions, biomedical implants, and sporting goods.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A2.02-1647**

SUBTOPIC TITLE: Enabling Aircraft Autonomy

PROPOSAL TITLE: Verification and Validation Software for Autonomous UAS Certification

Small Business Concern

Firm: **VISIMO, LLC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

VISIMO, a HUBZone small business, and University of Cincinnati will advance the verification and validation of Unmanned Aircraft Systems (UAS) by developing a testing environment (TE) that supports certification through the evaluation of safety and stability of artificial intelligence (AI) models used for autonomous flight. Utilizing a 3D simulation, the TE will test complex sensor fusion and ML decision-making routines. This system allows for testing of non-deterministic, “black-box” models by evaluating their performance in a realistic setting integrated with flight software and hardware. By carrying out failure modes in the TE, the certification tests can expand to include cascading failures in emergency scenarios, simulating rapid changes in operating conditions such as incoming storms, sensor failures such as obscured camera views, and hardware failures such as a bad Inertial Measurement Unit sensor (IMU). The high-level architecture of our solution contains a test management system. This system provides a way to design test suites, evaluate test results, and decide on further tests to pin down the complex, subtle failures that can occur in multi-sensor AI systems. The flight simulators that currently allow failure injection do not contain this useful post-test analysis. This test management system will also run parallel tests faster than real time, greatly surpassing the speed of current single-instance user-run tests. The purpose of the proposed Phase I work is to advance state-of-the-art to create a TE capable of certifying that complex nondeterministic algorithms used in autonomous UAS flight are safe for integration into the wider NAS environment; and (in Phase II) to subsequently develop tools to validate algorithms for prognostics, vehicle health, sensor fusion, decision-making, and cooperative planning using the Phase I TE. Phase I work will result in a technology demonstration and final report detailing the TE proof-of-concept.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The solution supports NASA’s Advanced Air Mobility Mission by enabling a consistent, rigorous certification process that will increase UAS integration into the National Airspace System (NAS). Relevant NASA applications include the Airspace Operations & Safety Program, Integrated Aviation System Program, Transformative Aeronautics Concepts Program, Scalable Traffic Management for Emergency Response Operations, and Transformational Tools and Technologies.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Improved certification will advance use of UAS across a variety of markets including healthcare, search and rescue, delivery, and agriculture. VISIMO will target prime contractors developing advanced UAS technology to integrate our proposed technology into best-practice certification standards.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H6.22-1780**

SUBTOPIC TITLE: Deep Neural Net and Neuromorphic Processors for In-Space Autonomy and Cognition

PROPOSAL TITLE: Adaptive Deep Onboard Reinforcement Bidirectional Learning System

Small Business Concern

Firm: **Intellisense Systems, Inc.**
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Phone: **(310) 320-1827**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA is seeking innovative neuromorphic processing methods and tools to enable autonomous space operations on platforms constrained by size, weight, and power (SWaP). To address this need, Intellisense Systems, Inc. (Intellisense) proposes to develop an Adaptive Deep Onboard Reinforcement Bidirectional Learning (ADORBL) processor based on neuromorphic processing and its efficient implementation on neuromorphic computing hardware. Neuromorphic processors are a key enabler to the cognitive radio and image processing system architecture, which play a larger role in mitigating complexity and reducing autonomous operations costs as communications and control become complex. ADORBL is a low-SWaP neuromorphic processing solution consisting of multispectral and/or synthetic aperture radar (SAR) data

acquisition and an onboard computer running the neural network algorithms. The implementation of artificial intelligence and machine learning enables ADORBL to choose processing configurations and adjust for impairments and failures. Due to its speed, energy efficiency, and higher performance for processing, ADORBL processes raw images, finds potential targets and thus allows for autonomous missions and can easily integrate into SWaP-constrained platforms in spacecraft and robotics to support NASA missions to establish a lunar presence, to visit asteroids, and to extend human reach to Mars. In Phase I, we will develop the CONOPS and key algorithms, integrate a Phase I ADORBL processing prototype to demonstrate its feasibility, and develop a Phase II plan with a path forward. In Phase II, ADORBL will be further matured, implemented on available commercial neuromorphic computing chips, and then integrated into a Phase II working prototype along with documentation and tools necessary for NASA to use the product and modify and use the software. The Phase II prototype will be tested and delivered to NASA to demonstrate for applications to CubeSat, SmallSat, and rover flights.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

ADORBL technology will have many NASA applications due to its low-SWaP and increased autonomy. It can be used to enable autonomous space operations beyond Low Earth Orbit to establish a lunar presence, visit asteroids, and extend human reach to Mars. ADORBL can be directly transitioned to the NASA Glenn Research Center to address the needs of the Cognitive Communications Project, the Human Exploration and Operations Mission Directorate (HEOMD) Space Communications and Navigation (SCaN) Program.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial applications of ADORBL include remote sensing, geophysical and planetary surveying and prospecting, atmosphere, water, and land pollution monitoring, space flights and space exploration. Multispectral sensor data fusion can be used in aviation security and mine and explosives detection. Wider applications include machine vision, robotics, telemedicine, spectral medical imaging.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.07-1168**

SUBTOPIC TITLE: Cryogenic Systems for Sensors and Detectors

PROPOSAL TITLE: Three-Stage Cryocooler Cold Head for Advanced Heterodyne Sensors

Small Business Concern

Firm: **CU Aerospace, LLC**
Address: **3001 Newmark Drive, Champaign, IL 61822**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Future advanced heterodyne sensors for submillimeter-wave receivers require 50 to 100 mW of cooling at 15 to 20 K for the sensor, and 1 to 2 W cooling at 80 to 120 K for the local oscillator, with size and input power suitable for use in a Small Sat. A 3-stage pulse tube cryocooler is well-suited for this type of application, offering a simple, reliable option with TRL 5 heritage in a larger cryocooler size, and allowing a design optimized to the sensor's cooling and temperature requirements. CU Aerospace (CUA) will use innovative materials and low cost cold head design and assembly, coupled with Lockheed Martin's (LM) industry-leading multi-stage pulse tube expertise, to provide NASA with a compact, affordable cryocooler for submillimeter detectors. Our team proposes to:
1) Perform a thorough thermodynamic trade study of 2-stage and 3-stage cold head configurations optimized to provide simultaneously 50-100 mW cooling at 15-20 K and 1-2 W cooling at 80-120 K, to achieve high efficiency, low mass, and compact packaging. Different regenerator materials and heat exchanger configurations will be included in the trade study.
2) Additively manufacture using Direct Metal Laser Sintering an optimized finned heat exchanger and demonstrate its capability to survive thermal cycling when press-fit into a cold head flange.
3) Generate a solid model of the cold head during Phase I so that it is ready for procurement, assembly, and testing in Phase II.
4) Continue the process of qualifying CUA to provide flight cold head subassemblies for future LM Space programs as a way to reduce cost and schedule. This work will leverage the MDA SBIR Phase II as well as CU Aerospace's past flight hardware development and delivery on programs such as Propulsion Unit for Cubesats (PUC) delivered to the Air Force.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Three-stage cryocoolers are generally required when cooling to 15-20 K as required by heterodyne sensors. Staged pulse tubes are ideally suited for space applications because adding stages does not add moving parts, such as with Stirling or Brayton coolers, so reliability remains high. NASA heterodyne sensors, as well as other instruments requiring temperatures from 10-30K would benefit from a low-mass, reliable 3-stage pulse tube cryocooler to improve mission capability.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Multiple-stage cryocoolers can benefit all cryogenic space applications by cooling secondary components and intercepting parasitic heat loads at higher temperature, reducing power and

mass. Applications including remote sensing satellite constellations, weather satellite constellations, earth science instruments, and deep space astrophysics instruments can all benefit from multiple-stage cooling.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H3.09-1442**

SUBTOPIC TITLE: Human Accommodations

PROPOSAL TITLE: Multipurpose Omni-Gravitational Wet Vacuum for Space

Small Business Concern

Firm: **IRPI, LLC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Human accommodations requirements will eventually dictate the necessity of simple, safe, routine, robust, ergonomic, and effective means for a broad variety of human accommodations clean-up activities in a broad variety of spacecraft. A low-g wet/dry vacuum provides one such

solution. If such a low-g accommodating device could be delivered to NASA with the quality, durability, and performance of terrestrial vacuums, a significant contribution could be made in that the device might have significantly broader impact value to the crew.

In this Phase I research we propose to develop a cross-cutting 'vacuum' device for clean-up activities in space and more. We intend to exploit recent advances in low-gravity liquid-solid-gas transport and separation systems to develop a multiphase vacuum for spacecraft capable of a cross-cutting variety of tasks, from the mundane to the mission critical. Our solution is a 3-phase omni-gravitational vacuum cleaner. Our breadboard design approach will employ a current commercial chassis but replace the body with a novel capillary fluidic element that exploits recent advances in passive low-g phase separation technologies where geometry, wetting, and surface tension forces are harnessed providing a no-moving-parts solution to the liquid, particulate, and bubble separation.

We will provide test data from the proof-of-concept study, with projections for system size, mass, power draw, and crew time for use and maintenance. Our report will detail the path toward a high- or even flight-fidelity prototype delivered to NASA in Phase II, after or during which proof of concept demonstrations could take place aboard the ISS for highest TRL.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

A low-g wet/dry vacuum provides simple, safe, routine, robust, ergonomic, and effective means for a broad variety of human accommodations clean-up activities in a broad variety of spacecraft. Applications for NASA may include routine dry, wet, and wet/dry clean-up, spot laundering, bio-sample collection, stubborn particulates such as lunar dust, hygiene liquids, and others.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The device is expected to have commercial applications for human spaceflight, including private spaceflight operations, and serve as a multipurpose device for low-gravity and partial gravity environments. The enabling technology may also be applied to a variety of applications with certain components enhancing terrestrial systems.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z4.05-1204**

SUBTOPIC TITLE: Nondestructive Evaluation (NDE) Sensors, Modeling, and Analysis

PROPOSAL TITLE: Nondestructive Evaluation (NDE) for In-Space and Additively Manufactured Materials/Structures

Small Business Concern

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

Despite enormous progress in metallic additive manufacturing (AM) process, one of the most notable needs is the industry agreement for the development of proper in-situ sensing methods and implementation of in-process sensors (monitoring/controlling) for product acceptance. Even though the usage of different signal processing techniques has greatly improved the defect tracking-learning-detection and classification performance, seldom are these methods robust and reliable enough to meet in-space standards and customers satisfaction. In order to develop reliable NDE in-process sensing and monitoring technologies for AM processes used to produce critical components for in-space applications, smart optical monitoring system based on spectroscopy is adopted and following technical challenges will be addressed by performing; (1) Understand the mechanism on how different composition, phase transformation and manufacturing defects affect the characterization of the laser/arc induced plasma; (2) Design effective algorithms and a seamless hardware digital signal processing unit that are able interpret the plasma signal for manufacturing quality prediction with high accuracy and reliability; and (3) Design a in-process monitoring / control system to adjust the manufacturing parameters to guarantee manufacturing quality. The approach to tackle these challenges is to use a good balance between understanding how different manufacturing defects, compositions and phase transformations affect the plasma characterization and the use of effective algorithm to interpret the change of plasma to reflect the defects. The successful execution of the tasks proposed will help us develop a smart sensor far beyond the available state-of-the-art technologies to provide in-situ and reliable prediction of composition, phase transformation and manufacturing defect that meets in-space application standards.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

It has a multifaceted value proposition. The first is the reduced manual inspection, along with the associated timesaving's from eliminating these inspections, which provides the greatest cost reduction. A second source of value addition is the decreased cycle time associated with detecting defects earlier in the manufacturing process, enabling waste reduction by eliminating redundant work on defective parts. The final portion of the value proposition comes from elimination of potential liability costs by steadily improving product quality.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

SenSigma has established connection with customers and plans to go into the market through successful field tests. We have already completed field tests at Caterpillar, GE, Trumpf, ABB Robot, and Lincoln Electric. We are currently for field tests with NRL. Potential customers are in metal manufacturing industries, including automotive, heavy equipment manufacturing, and aerospace industries.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.05-2053**

SUBTOPIC TITLE: Suborbital Instruments and Sensor Systems for Earth Science Measurements

PROPOSAL TITLE: Compact and rugged mid-infrared multi-gas open path sensor

Small Business Concern

Firm: **Pendar Technologies LLC**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 6

Technical Abstract (Limit 2000 characters, approximately 200 words):

We propose a turn-key in-situ gas sensor that can reliably perform continuous measurements on airborne, ship-based, or other mobile platforms. Specifically, we emphasize that the proposed system is compact, lightweight, power efficient, and therefore can be mounted on small to mid-sized un-crewed aircraft systems. The sensor features a small (centimeter scale) exposed beam path that allows ambient air circulation without active gas sampling. The proposed sensor is based on mid-infrared absorption spectroscopy using Pendar's proprietary distributed feedback quantum cascade laser array (QCLA) technology. Our monolithically integrated chip-scale coherent source can withstand harsh operating conditions while offering superior wavelength and intensity stability compared to other broadband mid-infrared sources. Broadband spectral coverage (up to 500 cm^{-1}) combined with high frequency resolution (~100 MHz) enable a multi-tasking sensor capable of detecting a multitude of gases including toxic industrial chemicals, chemical warfare agents, greenhouse gases, and volatile organic compounds. The laser source can rapidly tune over a large bandwidth to provide fast spectral measurements, enabling >100 Hz time response. Absorption measurements in the mid-infrared fingerprinting region ensures that a small pathlength is sufficient to reach uncertainty levels of <1% even when operating on moving platforms. By the end of Phase I, we will have built a prototype sensor and experimentally demonstrated that the sensor can reach targeted sensitivities under simulated flight conditions.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed sensor can be directly adopted for airborne missions such as on NASA's Airborne Science aircraft fleet, un-crewed aircraft systems and balloons to provide lower cost atmospheric gas measurements. The CO_2 sensing capability can be utilized to augment the space-based measurements of CO_2 dry air mole fraction under the OCO-2 project. The TEMPO project can also benefit from additional ozone and NO_2 measurements.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

We believe our proposed sensing solution can be adopted for chemical threat detection, which would be of interest to the Department of Homeland Security. The broadband sensing capability is also applicable to selective volatile organic compound detection in the air, which is of interest to markets targeting air quality measurements.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.05-2850**

SUBTOPIC TITLE: In Situ Instruments/Technologies for Lunar and Planetary Science

PROPOSAL TITLE: Low Size, Weight, and Power, High Gain 2D Material-Based Detectors for Mass Spectrometers

Small Business Concern

Firm: **Guardion, Inc.**
Address: **151 South Bedford Street, Unit 108B, Burlington, MA 01803**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

This project will assess the feasibility of using low power, high intrinsic amplification 2D material ion detectors for mass spectrometry to lower mass, power, and volume of mass spectrometers. Guardion's proposed solution is to eliminate the need of high voltage electron multipliers utilizing patented 2D material-based ion detectors that provide intrinsic charge to current amplification values ranging between 1E6-1E9 A/C, and only require an operating bias of 0.1V. It further distinguishes between positive and negative ions, and works from atmospheric pressure through ultra high vacuum. Unlike conventional methods of detection used in mass spectrometry, our sensors will exploit a low-bias intrinsic quantum gain mechanism in nanomaterials to amplify the signal from trace amounts of ions. This eliminates the need for external amplification, eliminates high voltage requirements, and significantly reduces power consumption.
We will first develop test devices in an ultra high vacuum compatible assembly. We will then modify an existing mass filter to direct ions towards our detector assembly and compare against a commercial off the shelf residual gas analyzer. We will then modify a standalone single quadrupole mass spec to accommodate our device assembly to test higher mass ranges. We will then evaluate sensor response to mass range, sampling rate, charge state, and ion energy. Finally, we will generate a report assessing the sensor performance, benefits, and limitations with suggestions on what types of mass spec and missions would be benefitted for sensor adoption.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This innovation will directly impact NASA planetary, lunar, and terrestrial missions that rely on mass spectrometry. Successful development of this technology will eliminate the high voltage requirements, eliminate potting, and provide an amplification mechanism that works at various pressures. By lowering the SWaP of mass spectrometers and potentially reducing the requirements on pumping systems, NASA will be able to pursue more ambitious mission concepts, improve analytical capability, and instrument durability.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Mass spectrometry is a critical analytical tool in a diverse set of industries - from drug discovery, forensic toxicology, clinical research, and homeland security. These new sensors will enable the next generation of mass spectrometers to be more portable, efficient, and resilient, opening up new market opportunities terrestrially and new mission capabilities in space.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.03-1732**

SUBTOPIC TITLE: Extreme Environments Technology

PROPOSAL TITLE: Additive Manufacturing of Radiation Tolerant Bearings

Small Business Concern

Firm: **Polaronyx, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

This NASA SBIR Phase I proposal presents an unprecedented method to make radiation tolerant bearing for deep-atmospheric probes to the giant planets. With our successful history in a variety of AM processing, this proposal has a great potential to succeed. A proof of concept demonstration is to be carried out at the end of Phase 1. A prototype will be delivered at the end of Phase II.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

In addition to NASA's robotic components manufacturing, the proposed short pulse high power fiber laser AM and SM process can also be used in other applications, such as space vehicle, aircraft, and satellite manufacturing. PolarOnyx will develop a series of products to meet various requirements for NASA/military deployments.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

3D printing uses various technologies to build products for all kinds of applications from foods, toys to rockets and cars. The global 3D printing market is projected to reach $49 Billion by 2028, registering a CAGR of 21.8%. North America was the highest contributor to the global market, and is estimated to reach $16.8 Billion by 2028, registering a CAGR of 20.8% during the forecast period.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H10.01-1879**

SUBTOPIC TITLE: Advanced Propulsion Systems Ground Test Technology

PROPOSAL TITLE: Non-Intrusive Cryogenic Flowmeter for Existing Piping Infrastructure

Small Business Concern

Firm: **Luna Innovations, Inc.**
Address: **301 1st Street Southwest, Suite 200, Roanoke, VA 24011**
Phone: **(540) 769-8400**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Rocket propulsion test facilities and test articles are highly instrumented to enable a comprehensive analysis of performance and to ensure propulsion system risks are mitigated for spaceflight. NASA desires to advance propulsion ground test technologies to minimize test program time, cost, and risk while meeting safety requirements. To address this challenge, Luna Innovations, in collaboration with National Technical Systems, will develop a non-intrusive cryogenic fluid flow meter for existing piping infrastructure at rocket engine test facilities. The system uses a fiber optic cable attached to a pipe wall to measure the flow induced vibrations distributed along a section of piping. The implementation is non-intrusive and does not contain any electrical components making it inherently safe and robust for rocket engine fuel flows. The system will provide high fidelity flow rate measurements with low initial and operational costs.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

A cryogenic flow meter will directly support liquid rocket propulsion development. A variety of systems exist that use liquid oxygen to combust with a variety of fuels including liquid hydrogen, kerosene, or liquid methane. In addition, the technology can be used in monitoring flow rates and piping health in space station components. Aero-propulsion applications would benefit from improved engine performance and structural health monitoring while eliminating heavier traditional sensors.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The automotive and commercial aircraft industry can use the sensing technology in critical piping to detect the onset of hardware failure. Flow sensing in high pressure and extreme temperature fluid systems in nuclear power, oil and gas, and industrial applications can be used to optimize processes and monitor hardware failure in remote or inaccessible locations.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.03-1089**

SUBTOPIC TITLE: Technologies for Passive Microwave Remote Sensing

PROPOSAL TITLE: Ultra High Speed Digitizer with Integrated Synchronized Clock Source and Rad Hard SPI

Small Business Concern

Firm: **Advanced Science and Novel Technology**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

To enhance the design of backend spectrometers included in NASA's microwave radiometers, ADSANTEC will develop a wide bandwidth (>30 Ghz) radiation-hard digitizer with more than 6 effective bit resolution utilizing *a space qualified US located semiconductor foundry.* The scalable digitizer with a sampling rate up to 25 Gs/s will be able to directly interface to space-qualified Xilinx Versal FPGAs using a patented FPGA compatible reverse pseudo-synchronization algorithm and rad hard SPI control interface.

The proposed FPGA interface integrates the proprietary synchronization protocol that minimizes the data transmission overhead. The utilization of advanced a wide temperature range (up to -200 Degree C) SiGe 9 HP technology developed by IBM will help to achieve the wide temperature range of operation and low power consumption of the digitizer, which will incorporate internal already proven extremely low noise clock source. The company's proprietary space qualified packaging will enable fabrication and testing of the prototype to TRL 8 by the end of Phase II.

The developed digitizer will support the advanced requirements of NASA's microwave radiometers development, next Generation of Laser Communication Relay Demonstration program, DoD's program for GPS Block IIIF payload development, and numerous worldwide radio astronomy programs such as SKA and ALMA. ADSANTEC offers more than 200 space qua Application Specific Integrated Circuits including ADC ASNT 7113 A developed during NASA SBIR Program in 2012 and commercially available as a space qualified ASIC.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed approach will revolutionize the future radar and radiometer systems required for multiple Earth and planetary science applications. Spectrometer back ends for microwave radiometers will specifically benefit from the features of the new ADC. The designed ADC will be easy to integrate into high performance measurement systems due to the simple output interface compactable with RT FPGA transceivers.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The developed product will also be useful for the next generation of laser satellite communication and multi-sensor flight control systems, as well as for many commercial application including: wireless ground stations, long-haul fiber optic communication, ultra-high-speed measurement instrumentation, space-based radar, CDROM testing systems, and a variety of other applications.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H9.01-1621**

SUBTOPIC TITLE: Long-Range Optical Telecommunications

PROPOSAL TITLE: Ground based uplink and beacon laser for long range communications

Small Business Concern

Firm: **Physical Sciences, Inc.**
Address: **20 New England Business Center , Andover, MA 01810**
Phone: **(978) 689-0003**

Principal Investigator:

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E-mail: **bpati@psicorp.com**
Address: **20 New England Business Center , MA 01810 - 1077**
Phone: **(978) 738-2283**

Business Official:

Name: **Dr. William Marinelli**
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Address: **20 New England Business Center , MA 01810 - 1077**
Phone: **(978) 738-8226**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

For deep space optical communications at astronomical distances such as Mars and beyond, a multi-kW average power laser that can be coded to send data is needed. Optical communication will revolutionize space-based science and exploration capabilities by supplying data rates up to 100 times faster than the currently used radio frequency based systems. New science will be enabled as missions become capable of hosting instruments that require substantial bandwidth, such as hyperspectral imagers and instruments with high definition in spectral, spatial, or temporal modes. The key to efficient optical communication encompasses the ability to generate the optical power efficiently, aim the narrow beam accurately enough to illuminate a receiver on Earth, and to collect and detect the received optical signal with minimal loss after passing through the atmosphere. A fundamental concept of operation is that the deep space transceiver uses an uplink beacon from Earth as a reference for pointing the downlink. This is done to minimize the mass and power of the subsystem on the spacecraft that accurately points the downlink laser beam.

In response to NASA's solicitation to develop a multi-kW laser to use as a ground beacon and uplink laser transmitter, PSI is proposing to develop a simple and innovative fiber design that can produce > 3 kW of average power and 6 kW of peak power at 50% duty cycle. The laser will be modulated with user interface to encode data. In the phase I PSI will design a special fiber laser amplifier for efficient, compact and low cost communication system. The laser will be modulated using pulse position modulation technique to encode data.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed technology is applicable to NASA for communicating between satellites, space crafts or to the ground. The LCRD mission will demonstrate the first two-way rely optical communication. Future Psyche mission, which is a journey to Psyche-16 between Mars and Jupiter, will test this new technology that encodes data in photons to communicate between a probe in deep space and Earth. In this mission, deep-space optical communications technology using lasers will demonstrate link length extending from 0.1 to farther than 2 AU.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non NASA applications are in cutting, drilling, machining, Lidar, and elemental analysis using LIBS. Our low Size Weight and Power laser with narrow-linewidth is suitable for coherent beam combination to generate 100s kW average power for directed energy weapons. When operated to generate very short pulses, the laser can be in the scientific laboratories to interrogate high energy physics.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z13.04-1240**

SUBTOPIC TITLE: Lunar Dust Filtration and Monitoring

PROPOSAL TITLE: Magnetic Dust Filtration System

Small Business Concern

Firm: **Pioneer Astronautics**
Address: **11111 West 8th Avenue, Unit A, Lakewood, CO 80215**
Phone: **(303) 984-9346**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

The Magnetic Dust Filtration System (MDFS) is designed to collect and remove lunar dust or particulate matter with grain size ~30μm (exceeding the solicitation requirements) and below from airlocks, suit preparation compartments and other enclosed areas and pressurized compartments. JSC-1A lunar dust simulant used by NASA is highly magnetic (especially so for the small grain size fraction). Both experimental and theoretical studies on soils brought back by Apollo missions suggest that lunar minerals are even more magnetic than their terrestrial analogs and fine fractions of lunar regolith (below 30 μm) are virtually impossible to separate by magnetic means because all fine grains are attracted by magnets. The MDFS will employ either a permanent, electro- or electropermanent magnets used as an additional step of air filtration for small pressurized compartments to eliminate/minimize lunar dust transfer between compartments and to main cabin areas. Currently the airlock systems used on ISS have been decompression pump for removing air from airlocks (up to ~13 kPa) prior to EVA and it is proposed that airlocks are purged with air after the EVA and decompressed to allow the lunar dust particles tracked in to be captured by the magnetic air filter. The MFS functioning will require minimal or no power and will not require frequent replacements.

In the proposed program, a full-scale working model of the MDFS will be built and tested at Pioneer Astronautics lab.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The MFS system is one of the key technologies for establishing human presence on the Moon for the Artemis program. Air filtration and clean breathing air are absolutely necessary for any manned mission, additionally it will protect interior surfaces of the spacecraft and many delicate components from harmful effects of harsh lunar dust.

This technology will can be a resource for future dusty planetary destinations in space exploration

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

With the advance of commercial spaceflight this technology will be applicable for all manned missions to dusty planetary destinations.

In addition to that, the basis of this technology can become useful in some terrestrial applications where elemental iron-rich particulate can be present: mining that involves naturally occurring magnets and iron containing minerals.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S14.01-1684**

SUBTOPIC TITLE: Space Weather Research-to-Operations/Operations-to-Research (R2O/O2R) Technology Development

PROPOSAL TITLE: Robust and Autonomous Space Weather Charge Mitigation

Small Business Concern

Firm: **Faraday Technology, Inc.**
Address: **315 Huls Drive, Englewood, OH 45315**
Phone: **(937) 837-7749**

Principal Investigator:

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Business Official:

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Address: **315 Huls Drive, OH 45315 - 8983**

Phone: **(937) 836-7749**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

This program will address the stated need from the National Space Weather Strategy and Action plan to “enhance the Protection of National Security, Homeland Security, and Commercial Assets and Operations against the Effects of Space Weather”. Specifically, we will develop and deploy robust and autonomous space weather charge mitigation technology by applying durable and highly emissive composite coatings onto spacecraft components such as solar arrays. In Phase I we will optimize and develop a scalable electrophoretic deposition approach to apply tunable erosion resistant and highly emissive passive coatings consisting of mixtures of low work function material and hard/conductive boron doped diamond materials. The coating properties will further be tuned according to the technical constraints and needs specific to the locations of interest on the spacecraft that require high emissivity and erosion resistant coatings, which will be identified in the beginning of Phase I. The coating development activities will be guided by an evaluation of the electron-emitting properties of the coating before and after Xenon ion sputtering, across a broad range of energies, and identify first and second crossover energies, maximum yields, and energies of maximum yields. Finally, we will estimate the feasibility of transitioning this technology to pertinent spacecraft components of interest to NASA and our Phase II commercialization partners. In Phase II, Faraday, USU, and commercial partners will apply the optimized coatings to testable components and expose them to simulated launch conditions, space weather, ionospheric charging, and ion sputtering erosion and deliver a prototype to NASA. Success in meeting these criteria will provide technical/economic validation and accelerate transition toward establishing commercial adoption of the technology to meet NASA and other commercial applications within Phase III.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This next generation space weather mitigation technology will enable the local and selective application of autonomously emitting, erosion resistant coatings onto spacecraft components and improve their resilience to space weather events. This lightweight, erosion resistant composite coating for autonomous electron emission could be applied to various spacecraft platforms include spacecraft skin, solar arrays, circuit boards, and emitters such that their lifetime, effectiveness and durability within LEO/GEO environments events can be enhanced.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The commercial global space economy is almost $300B and growing. Initial applications will focus on improving the resilience of commercial solar cells due to ongoing relationships with solar cell manufacturers. Subsequent applications will be targeted towards space charge mitigation needs for maintaining power grids, communications, environmental monitoring, remote sensing and national security.
Duration: **6**

PROPOSAL NUMBER: 22-1- **A2.03-1182**

SUBTOPIC TITLE: Advanced Air Mobility (AAM) Integration

PROPOSAL TITLE: Developing Local Knowledge for Advanced Air Mobility (DLK)

Small Business Concern

Firm: **Architecture Technology Corporation**
Address: **9971 Valley View Road, Eden Prairie, MN 55344**
Phone: **(952) 829-5864**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3

Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA has identified a clear and pressing need for education of both local decision makers and the local flying and nonflying public to enable AAM operations to commence in a timely manner. The goal of this research effort is to develop a robust and cost-conscious capability to support local organizations and local decision makers with materials that support community education, engagement, and outreach for AAM. Our effort titled Developing Local Knowledge (DLK) for AAM will build on 1) our long history supporting NASA and FAA aviation research; 2) our knowledge of NASA, FAA, academic, and industry research for AAM; and 3) our longstanding ties to the local community. DLK will enable and enhance the ability for local, regional, and state agencies to provide community education, engagement, and outreach for AAM tailored for their constituencies.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The DLK effort directly supports NASA Aeronautics Research Mission Directorate (ARMD) AAM mission its contributing projects. While the focus of this work is on developing materials to support local community education for AAM, the methods, tools, and materials also support education of the public regarding NASA's role in aviation research and development, and aviation research being conducted under ARMD programs and projects.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

NASA is seeking energize small-business involvement in supporting local community AAM planning efforts. The target market for our Phase I DLK effort will be a local community partner

(public agency) that is a stakeholder in the AAM ecosystem. We will also identify and engage with a regional AAM stakeholder during the Phase I effort.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.01-1744**

SUBTOPIC TITLE: Photovoltaic Power Generation and Conversion

PROPOSAL TITLE: TRAP (Thermo-Radiative Assisted Photovoltaic) Cell to Simultaneously Harvest Incoming Solar and Outgoing Thermal Radiation

Small Business Concern

Firm: **Advanced Cooling Technologies, Inc.**
Address: **1046 New Holland Avenue, Lancaster, PA 17601**
Phone: **(717) 205-0628**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Advanced Cooling Technologies, Inc. (ACT) proposes to develop a TRAP (Thermo-Radiative Assisted Photovoltaic) Cell technology to simultaneously harvest the incoming solar and outgoing thermal radiation in a single integrated device, with goals to achieve total efficiency

>35% in the near-term (~2 years) and > 45% in the mid- to far-term (5-10 years). ACT's TRAP Cell leverages the "dark" photovoltaic (i.e., thermo-radiative (TR) cell) technology that ACT has developed in two previous successful NASA SBIR programs. A TR cell can be viewed as the reverse mode of a PV cell. In a PV cell, the electrical power generation can be viewed as a result of the imbalance of incoming radiation from the sun and outgoing radiation from the PV cell. Conversely, the electrical power generation in the TR cell is a result of imbalance of the outgoing thermal radiation and negligible incoming radiation (from deep space), which creates a charge carrier motion resulting in electric power generation. Our proposed TRAP Cell will consist of three layers: a conventional space photovoltaic cell as the top layer, a mid-infrared transparent solar absorber as the middle layer, and a "dark" photovoltaic cell as the bottom layer. When producing electrical power, the conventional PV cell needs to face the sun, while the "dark" photovoltaic cell needs to face the ultra-cold deep space. To address the challenges when combining them together, we introduce a mid-infrared transparent solar absorber layer (e.g., undoped germanium layer) between the solar cell and the "dark" photovoltaic cell. Due to the mid-infrared transparent nature of the solar cell (top layer) and solar absorber (middle layer), the bottom thermo-radiative cell layer is only radiatively coupled to the ultra-cold deep space, while the top and middle layers will utilize the entire solar spectrum by either generating electricity directly or converting unused solar radiation into heat to provide thermal energy for the bottom layer

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

One application is to produce more electrical power during the lunar day due to the enhanced system efficiency, while also continuously generate electrical power by the thermo-radiative cell part using the waste heat during the lunar night. This enhances and extends the performance for lunar missions. Another potential application is attaching TR cells to the radiators of RPS to significantly increase the electrical power output and boost the overall system efficiency of many deep space missions

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Our TRAP Cell technology could be used as the residential solar panels in the future. In the daytime, the panel could produce much more electrical power than that produced by conventional solar panel alone. In the nighttime, the bottom TR cell layer can still produce electrical power. Therefore, our system could continuously generate electricity for residential use throughout the day and night

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.03-2094**

SUBTOPIC TITLE: Extreme Environments Technology

PROPOSAL TITLE: High Temperature Additively Manufactured ROM for Venus Surface Operation

Small Business Concern

Firm: **Ozark Integrated Circuits, Inc.**
Address: **700 West Research Center Boulevard, Fayetteville, AR 72701**
Phone: **(479) 935-1600**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA has demonstrated a resolve to land instruments on the corrosive, high-pressure (~100 bar), high-temperature (470°C) surface of Venus. NASA Glenn Research Center's JFET-R technology is the only one that has shown 1000's of hours operation under Venus surface conditions. NASA desires computational analyses on the surface of Venus. Ozark IC is currently working on a NASA Phase II to create an all-SiC based RISC-V microprocessor in parallel with a rugged high-density packaging system. For this computational system to achieve maximum potential, access to a high temperature read only memory is critical. Companies like Cerfe and UPenn are creating high temperature thin film non-volatile memory (NVM) technologies. In this project, Ozark IC will utilize its extensive experience in rugged additive manufacturing to create a macro scale thick-film HT ROM technology as an alternative technology.

This proposal's objective is an all-additive ROM that will integrate well with the JFET-R technology or accompany, off chip, a microprocessor module.

The project will design, simulate, package, and characterize an all-additive ROM technology based on materials that were qualified up to TRL-5 in previous NASA SBIR programs. This work will first attempt to create an all-additive ROM structure in which each bit is created, or "programmed" during manufacturing. Ozark IC will also investigate using this technology for programming the ROM once, after manufacturing. Each design will be tested at 500°C to validate feasibility of Venus surface operation. Parallel work will investigate SiC thin film options for ROMs as well as all the necessary read-out electronics using JFET-R for any of these ROM structures. The body of this work will culminate in a scalable ROM structure that can accompany the SiC RISC-V chipset in a single heterogenous package.

Ozark IC is well positioned to determine and address the requirements of these ROM memory structures from its work on the RISC-V microprocessor.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed HT additive ROM is the next logical development step for enhancing computational power on the corrosive, high-pressure (~100 bar), high-temperature (up to 500˚C)

Venus surface. The system will also be useful for other high temperature environments, such as Mercury, as well as high temperature avionics, re-entry, and propulsion sensing and controls.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Any application that needs very high temperature data collection is a potential market. Some examples include: geothermal exploration to improve drilling efficiency, jet engine sensing and actuation for distributed engine controls, avionics for high temperature sensing and actuation in hypersonic aircraft and health monitoring of molten salt reactors.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H12.07-1482**

SUBTOPIC TITLE: Protective Pharmaceutical Packaging

PROPOSAL TITLE: Thoraeus Rubber Shielding MOF Scavenging Space Pharmaceutical Packaging

Small Business Concern

Firm: **Nanosonic, Inc.**
Address: **158 Wheatland Drive, Pembroke, VA 24136**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA's Human Research Program (HRP) has identified a need for state-of-the-art pharmaceuticals packaging to enable long-duration human exploration missions. NanoSonic is a small, advanced materials company that specializes in gas/moisture impermeable membranes and both space radiation shielding and durable materials. In this program, innovative packaging for long-term medication storage shall be developed in support of HRP's Research Operations and Integration (ROI) initiative for all human crewed spacecraft or pre-deployed human missions. NanoSonic shall specifically develop new graded atomic number (*Z*) radiation shielding packaging layers for use within our impermeable polymer membranes lined with oxygen, moisture, and CO_2 scavenging constituents for testing alongside Aclar® and Mylar® foil-based industry standards. The new packaging materials shall be developed for a radiation study conducted by the PI at the Brookhaven National Laboratory (BNL) NASA Space Radiation Laboratory (NSRL). The materials shall be evaluated for predicted lifetime via dynamic mechanical analysis (DMA) and time-temperature-superposition (TTS) studies in moisture, oxygen, and CO_2 environments. During Phase I, we shall repackage medication to retain its active pharmaceutical ingredients (API) and offers lifetime improvements over the current 59 - 82% median drug failure for 2–3-year missions. The new packaging material shall be based on NanoSonic's graded-Z Thoraeus Rubber radiation shielding design and implemented within low gas and moisture polymer membrane barriers suitable for lining with oxygen scavenging particles, such as the metal organic frameworks (MOF). The packages would be purged with inert gas for deployment. NanoSonic shall conduct one round of radiation exposure to assess initial lifetime predictive mechanical and sealing behavior as functions of moisture, oxygen, and radiation pre- and post- radiation exposure.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Potential NASA applications for the pharmaceutical packaging include technology development that benefits the Exploration Medical Capability Element (ExMC) of the NASA Human Research Program (HRP). Pharmaceutical repackaging technologies developed herein shall address risks of ineffective or toxic medications during long-duration exploration spaceflight and adverse health outcomes and decrements in performance due to inflight medical conditions.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The new packaging shall address current HRP Gaps including: a) optimal packaging/storage for medications in space that mitigates toxicity, preserves effectiveness, and minimizes resource costs. The API degradation profiles shall be characterized in a radiation exposure study to understand safety and effectiveness for exploration missions.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z13.03-1913**

SUBTOPIC TITLE: Technologies for Spacesuits in Extreme Surface Environments

PROPOSAL TITLE: Exploration Labyrinth Dust Seals (xLiDS)

Small Business Concern

Firm: **Paragon Space Development Corporation**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

On the Moon's surface, regolith is a well-known environmental hazard, both endemic and destructive to materials and mechanisms. Lunar dust fouling was a critical issue for Apollo spacesuits, causing abrasive wear that led to pressure leaks, impaired visibility, scratched gauges, and penetration into deeper layers. Dust mitigation was not an engineering design driver for the performance of the Apollo Extravehicular Mobility Unit (EMU), because the number of extravehicular activities (EVAs) were limited. However, the future exploration EMU (xEMU) will have to remain usable for a much longer period, thereby necessitating more emphasis on dust mitigation. In particular, the Pressure Garment System and Portable Life Support System (PLSS) must be ready to withstand the elements, protecting not only the astronauts, but their own internal hardware from regolith migration and intrusion. Apollo missions' human health effects included inhalation and irritation, which emphasize the importance of keeping astronauts safely isolated from dust. Paragon intends to develop Exploration Labyrinth Dust Seals (**xLiDS**) to improve astronaut safety and prolong equipment. For the xEMU PLSS (xPLSS), NASA has identified six components that will need gas flow to or from the surrounding ambient environment. Each component will require a specialized cover to prevent dust infiltration without impairing their flowrates. Without those covers, critical xPLSS functions could be disrupted, such as cooling, purge capabilities, and seal integrity . Paragon has developed a unique method of casting complex, labyrinth-like geometries that allow gas to flow while still preventing regolith migration into critical life support systems. **xLiDS** can be customized to fit the needs of every xPLSS port. Paragon's extensive experience with spacesuit components, dust mitigation strategies, and rapid prototyping will quickly advance the desired mitigation technology through the iterative design and fabrication process.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The **xLiDS** concept is a customizable dust mitigation solution for any planetary surface technology. It protects mission equipment from being fouled or clogged by regolith dust, enabling sustained operations for lunar and Martian habitation. In addition to mitigating dust for the xEMU xPLSS, **xLiDS** technology can scale to larger infrastructure and/or mechanisms that have

various degrees of regolith exposure and/or geometries. Custom **xLiDS** can handle varying types of flow for consumables, data, and/or power (ex: in-situ resource utilization).

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

xLiDS offers a versatile approach to mitigating dust issues for commercial companies that are interested in lunar surface infrastructure, including spacesuits, softgoods (ex: expandable habitats), and human-spacecraft-robotic interfaces. **xLiDS** could also apply to terrestrial industries like mining, construction, pharmaceutical, sandblasting, agricultural, and ruggedization of desert equipment.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z4.05-2504**

SUBTOPIC TITLE: Nondestructive Evaluation (NDE) Sensors, Modeling, and Analysis

PROPOSAL TITLE: In-Process X-ray Sensor for Additive Manufacturing

Small Business Concern

Firm: **Advanced Analyzer Labs, Inc.**
Address: **3982 Old Columbia Pike, Ellicott City, MD 21043**
Phone: **(301) 708-7759**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The demanding of innovative Non-Destructive Evaluation (NDE) in-process sensing technology on AM is cross-cutting and spans instrumentation, materials, processing, quality assurance, testing and modeling disciplines. X-ray imaging and X-ray Diffraction (XRD) are traditional and standard NDE methods to detect defects and measure materials microstructure properties and other physical characteristics. This SBIR Phase I proposal is to study the feasibility of using X-ray imaging and XRD based sensor to in-process monitor the quality of AM parts during the printing process and develop a solid quality assurance mechanism.

X-ray imaging is an excellent tool to reveal internal features of materials, such as its application in dental clinical to detect tooth cracks. XRD is a standard method to identify crystalline structures and to measure the structure and physical state of materials. X-ray imaging can be used to directly detect pores and cracks for AM applications. XRD can provide important microstructure information of the AM samples: such as crystal orientation, residual stress, chemical phase inhomogeneity, stacking faults and their arrangement, and concentrations of other defects. It is well known that the performance of functional materials (components) is dependent on their microstructure. The growth and formation of these materials are also closed related with their compound and microstructure. In principle, XRD can identify the root causes of the pores and cracks revealed by X-ray imaging. Compared to non-contacting optical techniques, such as laser scanning with major goal for geometrical confirmation, this proposed in-process X-ray sensor has the potential to directly detect the defects and provide critical information related to the quality and performance of AM parts. Furthermore, the real-time in-process sensor also brings the opportunity for effective process control and shed light on understanding the AM processes.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Additive Manufacturing (AM) techniques can produce complex, high-value parts, such as propulsion components. NASA plays a strong role in developing AM technologies for propulsion components, materials, and supplemental processes to infuse into NASA and other government missions as well as commercial space missions.

This proposed in-process X-ray sensor for Additive Manufacturing to rapidly evaluate the quality of AM parts meets the NASA demanding of innovative Non-Destructive Evaluation (NDE) in-process sensing technology.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercialization of metal Additive Manufacturing (AM) has moved beyond the Maker Movement, research institutions, and service bureaus, onto the production floor of leading manufacturing companies. The manufacturing industry is now investing heavily into this promising field.

The proposed innovative in-process sensor meets the need of industry advanced manufacturing to apply AM in a widespread way.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.01-1600**

SUBTOPIC TITLE: Robotic Mobility, Manipulation and Sampling

PROPOSAL TITLE: Sediment Sequestration for Hot Water Drilling Cryobots

Small Business Concern

Firm: **Stone Aerospace Inc.**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

This proposal responds to Focus Area 4: Robotic Systems for Space Exploration; subtopic S13.01: Robotic Mobility, Manipulation, and Sampling describes a need for technologies that provide improved robotic mobility for ocean world deep drilling and water access. This proposal addresses this need with a solution for sediment buildup in the melt stream of ocean world ice penetrating robots (cryobots) that descend via hot water drilling. Ocean worlds remain of critical interest for astrobiology but cryobots require deep drilling to reach areas of interest on Europa or the poles of Mars. Previously built and tested prototype cryobots such as Stone Aerospace's THOR system demonstrate high efficiency using downward-pointing closed cycle hot water drill (CCHWD) jets on the nose cone of the vehicle, however debris released from the ice could potentially obstruct a cryobot and it will accumulate as refreezing ice behind the cryobot excludes salt and sediment. Our proposed solution mitigates silt, solids, and salt accumulation using HWD jets in new ways. It uses the two-pronged approach of A) control of meltwater circulation, speed, and flow using jet orientation or mechanical rotation plus B) obliquely-oriented HWD jets to create Sequestration Side-Pockets (SSPs) in the surrounding ice. This system is

part of an extended plan for using CCHWD jets to manage sediment for cryobots called MJOLNIR (Managing Jets of Liquid for Nullifying Ice Refuse). Control of vectored HWD jets equipped for selectable spray and variable pressure will hollow out SPPs on the side-periphery of the nose cone of a cryobot. These SSPs will accept and accumulate brine and sediment. Controlling jet pressure, angle, spray, and orientation gives precise control of meltwater circulation and speed for sediment transport and deposition. This allows sediment to settle out when appropriate, by centrifugally driving it into pre-cut pockets of still water.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

MJOLNIR allows ice penetrating cryobots such as THOR to breach debris-laden ice (ice fraction >50%), providing steady state debris mitigation over long descent distances. Potential NASA mission application include:

- Mars polar cap (2-3 km) subsurface access and sampling
- Europa's 10-40 km ice crust with ocean access
- Ganymede's rocky ice crust for strata and sampling studies
- Enceladus's estimated 10-40 km thick ice crust with ocean or cryovolcanic access
- Other icy ocean worlds

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The MJOLNIR system may be implemented on terrestrial hot water drill rigs to manage sediment for glacial and astrobiological investigations:

- Basal access to bedrock layer through heavily debris-laden ice at base of ice sheets in Antarctica and Greenland
- Heavy debris alpine glacier penetration for strata-based sampling, and access to subsurface water conduits
- Volcanic caldera glaciers

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.02-1179**

SUBTOPIC TITLE: Increasing Autonomy in the National Airspace System (NAS)

PROPOSAL TITLE: Vertiport Human Automation Teaming Toolbox

Small Business Concern

Firm: **Crown Consulting, Inc.**
Address: **1400 Key Boulevard, Suite 1100, Arlington, VA 22209**
Phone: **(703) 650-0663**

Principal Investigator:

Name: **Dr. Paul Krois**

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

A mature advanced air mobility (AAM) system envisions hundreds of vertiports supporting high-density operations in complex environments. It is commonly recognized that vertiports will be the bottleneck of regional vertiport networks, thereby constraining the flow of traffic and impacting the financial bottom line. While it is also acknowledged that vertiports will require elevated levels of automation, the role in which the vertiport manager plays in teaming with automated resource scheduling systems has yet to be studied in detail. We propose to develop Vertiport Human Automation Teaming Toolbox (V-HATT), a simulation capability focused on vertiport airside operations with direct human vertiport manager oversight.

In Phase I, we will develop vertiport manager user interface requirements, investigate vertiport surface and airspace design variables, evaluate vertiport surface resource scheduling algorithms, and develop a proof-of-concept simulation capability. In Phase II, we will build the vertiport manager user interface, develop terminal airspace separation and queuing algorithms, develop the integrated simulation capability, validate interfaces with human-in-the-loop for select use cases, and demonstrate contingencies in bottleneck analysis.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The High Density Vertiplex Subproject (HDV) may plug-in their vertiport automation technologies into V-HATT to test the effectiveness with HITL. Similarly, Air Traffic Management Exploration (ATM-X) Project has several Subprojects with potential applicability including: UAM Airspace Management, Digital Information Platform (DIP), and Extensible Traffic Management (XTM). Additionally, V-HATT may be of interest to NASA Ames Human Systems Integration Division as a toolkit amongst others developed evaluating the human's role in AAM.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

V-HATT can be utilized to evaluate tradeoffs against vertiport design, scheduling algorithms, and human-machine interactions for both public and private organizations who require an understanding of vertiport operational performance to aid in realistic planning and investment decisions. V-HATT may be transformed to a commercial vertiport operational software serving any ownership and usage model.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.02-2135**

SUBTOPIC TITLE: Technologies for Active Microwave Remote Sensing

PROPOSAL TITLE: Coupled Resonator Power Combiner (COREPOWER)

Small Business Concern

Firm: **Nu Waves, Ltd.**
Address: **132 Edison Drive, Middletown, OH 45044**
Phone: **(513) 360-0800**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3

Technical Abstract (Limit 2000 characters, approximately 200 words):

NuWaves' proposed COupled REsonator POWer combinER (COREPOWER) is an innovative approach to significantly reducing the size of high-power solid state amplifiers. The COREPOWER RF splitter/combiner allows for the matching network, harmonic filter, and power combiner to exist in a single small footprint package.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Synthetic Aperture Radar Satellites, Deep space communications

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Electronic Warfare, Tactical Training, Base stations, Commercial Synthetic Aperture Radar Satellites

Duration: **6**

PROPOSAL NUMBER: 22-1- **S15.01-1352**

SUBTOPIC TITLE: Plant Research Capabilities in Space

PROPOSAL TITLE: Miniaturized Reagent Regenerative Ion Analyzer for Elemental Analysis

Small Business Concern

Firm: **Lynntech, Inc.**
Address: **2501 Earl Rudder Freeway South, College Station, TX 77845**
Phone: **(979) 764-2200**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA has been developing Bioregenerative Life Support Systems (BLSS) to contribute to life support, supplying food and oxygen, while removing carbon dioxide as complement of physical and chemical life support systems for the future space exploration, Martian missions, and the

construction of lunar bases. As plant-growing systems mature and expand for future exploration missions, the ability to generate, analyze, and manage nutrient solutions is required. Thus., an in-situ capability is needed to analyze plant nutrient solutions or feed water to better understand and manage plant nutrient delivery on a near-real-time basis. The technology would need to be robust and miniaturized, operate with low power, and have minimal consumables to augment plant growth and research capabilities for the future missions. The system would also need to be safe for operating in spaceflight environments.
Lynntech has previously developed a reagent-regenerative, microgravity-compatible, low-power ion analyzer (ion chromatograph). In addition to its advantages of high sensitivity and requiring neither sample preparation nor reagent resupply, it could be operated in microgravity and partial gravity. By adapting engineering advances carried out in Lynntech's electrochemical devices, a miniaturized, robust, safe, ion analyzer will be developed that can be operated inline, eliminating the need for sample injection by astronauts. In the Phase I Lynntech will demonstrate the feasibility of the proposed approach with a breadboard system. An automated prototype will be delivered to NASA during Phase II.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Direct NASA applications of the reagent-regenerative, microgravity-compatible, miniaturized ion analyzer (RMMIA) include the on-board elemental analysis device to analyze plant nutrient solutions or feed water to better understand and manage plant nutrient delivery on a near-real-time basis. The multi-analyte capability of the proposed technology will expand to measurements of ionic species in condensate, potable water, wastewater, byproducts of water treatment for manned space exploration missions beyond low Earth orbit.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Successful development of the reagent-regenerative, microgravity-compatible, miniaturized ion analyzer (RMMIA) as a portable device will have a high commercial applicability to a wide range of industries where water quality assurance and control is important, and where water quality analysis of inorganic pollutants in both environmental and potable water sources is critical.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z12.01-1662**

SUBTOPIC TITLE: Extraction of Oxygen, Metal, and Water from Lunar Regolith

PROPOSAL TITLE: Pyrometer for Regolith-extracted Oxygen

Small Business Concern

Firm: **Hedgefog Research, Inc.**
Address: **1891 North Gaffey Street, Suite 224, San Pedro, CA 90731**
Phone: **(310) 935-2206**

Principal Investigator:

Name: **Dr. Daniel Engelhart**

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Business Official:

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Phone: **(310) 935-2206**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Hedgefog Research Inc. (HFR) proposes to develop a multicolor Pyrometer for Regolith-extracted Oxygen (PyRO) for use in vacuum-pumped foundries designed to extract oxygen from lunar regolith on the surface of the moon. The flexible design of the sensor will allow for accurate temperature determination for systems with well-known emissivity values as well as accurate high-temperature measurement for systems in which the temperature- and wavelength-dependent emissivities are unknown. Crucially for this application, the sensor will be constructed to operate in a hermetic, non-outgassing package under significant radiant heating loads and a highly corrosive environment without polluting extracted oxygen/water/metals. While optimized for several methods of resource extraction from lunar highland regolith, PyRO is adaptable for non-contact temperature measurement of any practical system. The vacuum-compatible design and low size, weight and power requirements will allow for a portable version to be developed for use by human or robotic settlers beyond Earth. In Phase I, HFR will design system components of PyRO, evaluate their performance in non-contact temperature measurement, and down-select key components and enabling technologies for future development. We will also conduct a preliminary design for the fully-packaged PyRO prototype optimized for temperature stability and corrosion resistance.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Accurate non-contact temperature measurement is a ubiquitous requirement in all types of material processing. Any long-term extraterrestrial human settlement must necessarily have well-developed facilities for in-situ resource utilization. Optimizing these utilization processes requires careful control of all experimental parameters, including temperature. In addition, a compact, extremely rugged non-contact temperature sensor will find use in non-destructive component inspection and performance evaluation for high temperature devices.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

A pyrometer optimized for harsh vacuum operation will find use in an array of material processing and laboratory environments requiring high temperature measurements in vacuum. Commercially available pyrometers are custom tailored for chosen industrial processes. The inherent flexibility of PyRO and its tolerance to a variety of process conditions will make it an attractive commercial technology.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.05-1543**

SUBTOPIC TITLE: In Situ Instruments/Technologies for Lunar and Planetary Science

PROPOSAL TITLE: Deep UV Raman Spatial Heterodyne Spectrometer for Depth Resolved Core Analysis

Small Business Concern

Firm: **Physical Sciences, Inc.**
Address: **20 New England Business Center , Andover, MA 01810**
Phone: **(978) 689-0003**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Physical Sciences Inc. (PSI) will develop a compact, solid-state ultraviolet spatially offset Raman sensor with a diagnostic core retrieval system. The UV Raman sensor, currently under development at PSI, utilizes a UV laser (266 nm) that has been developed by Q-Peak (a division of PSI) for a previous NASA SBIR. The Raman sensor will also use a high throughput spatial heterodyne interferometric spectrometer (SHS). The SHS is 10^4 more sensitive to Raman photons than a conventional diffraction grating based slit-spectrometer operating with the same

spectral resolution in the UV. In addition, the proposed UV Raman system utilizes the Rayleigh scattering law for Raman scatter at shorter wavelengths. The current UV Raman design will be modified to include a digital micromirror device (DMD) in order to collect spatially offset Raman signal (SORS) at varying penetration depths within a material. This system will be paired with a small core retrieval system in order to measure depth resolved Raman spectra within samples. This will allow for initial diagnostic testing of areas on small bodies, such as comet nuclei, to determine where larger cores should be collected and returned to Earth. Depth resolved measurements will be more indicative of volatiles trapped within the material that might vaporize off the surface during collection and avoids contamination that can occur at the surface. The Phase I effort will focus on functional testing of the SORS breadboard with the UV laser. In parallel, the Phase I will design a prototype core retrieval system, in order to better inform the final design for a Phase II prototype.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The DUV-SORS system can be applied to NASA missions in which the goal is to retrieve sample cores that are to be transported back to Earth. This includes small body missions, as well as missions to Mars and the Moon. The DUV-SORS system will indicate areas of interest, prior to large core collection, by collecting small diagnostic samples and analyzing in situ. In addition, SORS will allow for depth resolved Raman spectra, eliminating the measurements of volatiles reacting at the surface, or contamination from collection methods.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The DUV-SORS system is applicable to the defense and law enforcement community for chemical detection where Raman is measured through interfaces (such as glass or plastic containers) that emit Raman and fluorescence signals. This specifically would be of interest in security applications such as the Transportation Security Administration (TSA) where measurements are taken through containers.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.02-2786**

SUBTOPIC TITLE: Spacecraft Technology for Sample Return Missions

PROPOSAL TITLE: Improved Design, Fabrication, and Testing of an Ascent Vehicle Reaction Control System

Small Business Concern

Firm: **Ultramet**
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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Sample return missions generally have the largest velocity change (ΔV) requirements for a mission to a given body, especially bodies with large gravity wells. For every gram of liftoff mass removed from the return vehicle, the incremental reduction in gross liftoff mass from Earth is several orders of magnitude greater. Consequently, any technology that can reduce the mass that must be lifted out of the target body's gravity well will have a huge impact on the amount of mass that must be lifted off the Earth's surface. For an ascent vehicle, regardless of whether a solid, liquid, or hybrid rocket is used, thrusters will be needed for the reaction control system. Studies have shown that above a certain threshold, monopropellant systems become more mass-efficient than cold gas systems. An in-house trade study has shown that for total impulses above 140 N·s, a traditional hydrazine system has less mass than a cold-gas system. The same study also showed that if a foam-based ignition system is used with hydrazine instead of a granular catalyst and external heaters, the breakeven point drops to just 44 N·s. Furthermore, as the total impulse requirement increases, the mass advantage of the foam-based hydrazine system increases significantly. In this project, Ultramet will build upon a recently completed effort in which a foam-based ignition system for hydrazine was designed, fabricated, and hot-fire tested. In particular, modifications will be made to the design to facilitate testing, and more extensive hot-fire testing will be performed.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Virtually any spacecraft or launch vehicle using monopropellant hydrazine can benefit directly from this technology. Applications include attitude control systems on spacecraft, reaction control systems on launch vehicles, and primary propulsion systems on smallsats and cubesats. Because the technology is fundamentally propellant-agnostic, it can be applied to virtually any monopropellant or non-hypergolic bipropellant system. Other applications include air heaters for hypersonic wind tunnels.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non-NASA applications include attitude control thrusters on satellites, reaction control thrusters on launch vehicles, and primary propulsion systems on smallsats and cubesats. DoD applications include missile propulsion systems and air heaters for hypersonic wind tunnels. Other potential applications include auxiliary power units and emergency power units on aircraft.
Duration: **6**

PROPOSAL NUMBER: 22-1- **Z2.01-1386**

SUBTOPIC TITLE: Spacecraft Thermal Management

PROPOSAL TITLE: LIGHTWEIGHT MICROTUBE PHASE CHANGE MATERIAL HEAT EXCHANGERS

Small Business Concern

Firm: **Mezzo Technologies**
Address: **10246 Mammoth Avenue, Baton Rouge, LA 70814**
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Principal Investigator:

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Business Official:

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Phone: **(225) 324-2674**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 2

Technical Abstract (Limit 2000 characters, approximately 200 words):

The primary goal of this program is to develop the significant weight-saving potential of phase change material (PCM) microtube heat exchangers for NASA spacecraft thermal management. Mezzo will utilize microtube heat exchanger technology along with topography optimization and 3D printing to allow for cutting-edge performance and weight savings.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

PCM heat exchangers assist in the smoothing out of thermal energy during part pulse or cyclic operation and allow for short-term thermal storage. This ability allows for thermal systems to be designed around non-peak operating conditions which allows for a smaller thermal system.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

One market is the quickly growing directed energy market, which could greatly benefit from the load-leveling capabilities of microtube PCM heat exchangers. The directed energy weapon market was valued at $4.3 billion in 2021 and is projected to reach $10.1 billion by 2026.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H3.08-1031**

SUBTOPIC TITLE: Challenges in Carbon Dioxide Removal and Reduction: Carbon Particulate and Thermal Management

PROPOSAL TITLE: Carbon Separation and Storage for Continuous Operation of a Bosch Reactor

Small Business Concern

Firm: **UMPQUA Research Company**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Closure of the oxygen loop will be a critical requirement during future, long-duration, manned missions. The current carbon dioxide reduction assembly recaptures oxygen as water via the Sabatier reaction, in which, four moles of H_2 and one mole of CO_2 react to form one mole of CH_4 and two moles of H_2O losing half of the input H_2. In contrast, the Bosch reaction produces H_2O and elemental carbon with the recovery of all H_2, while closing the oxygen loop. Historically, Bosch reactors have been embodied as batch type reactors where the catalyst is initially loaded and the reactor is operated until the carbon product blocks the gas flow producing an unacceptable back pressure. A Bosch reactor designed for continuous operation requires the addition of make up catalyst and separation of the carbon from the recirculating gases with no down time. The proposed catalyst introduction system and carbon separation and storage system will utilize a semi-continuous feed of catalyst and mechanically assisted removal of the carbon product and spent catalyst from the reactor to allow for continuous operation. This Phase II effort will focus on the development, testing, and delivery to NASA of a continuous flow reactor system that removes and stores the product carbon. These efforts will aid NASA in meeting the NASA Technology Roadmaps - TA6: Human Health, Life Support and Habitation Systems air revitalization goal of 100% oxygen recovery.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed Bosch Reactor technology has a strong potential for use by government and the private sectors. The government application will be as Flight Hardware for deployment in support of future long duration exploration objectives beyond Low Earth Orbit (LEO) where closed loop air revitalization will play a critical role in reducing Environmental Control and Life Support System (ECLSS) logistics. In addition, such a system can be used to recover oxygen from the carbon dioxide present in the Martian atmosphere.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Ground based applications include mitigation of industrial carbon dioxide emissions into the atmosphere that add to the burden of greenhouse gases. The Bosch technology is also capable of decomposing methane into carbon and hydrogen. Additionally radioactive hydrogen-carbon compounds can be decomposed to easily storable carbon.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z2.02-1613**

SUBTOPIC TITLE: High-Performance Space Computing Technology

PROPOSAL TITLE: Fault Tolerant RISC-V Flight Computer with Coprocessor Support

Small Business Concern

Firm: **Resilient Computing**
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Phone: **(406) 451-8138**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

This project aims to mature an innovative approach to advance the state-of-the-art in high performance space computing through the development of a fault tolerant RISC-V flight computer with coprocessor support. This project builds on over 14 years of NASA-funded research at Montana State University (MSU) on strategies to provide fault tolerance in space computers through the implementation of a novel self-repairing computer architecture on Commercial-off-the-Shelf (COTS) Field Programmable Gate Arrays (FPGAs). The MSU technology, called *RadPC*, was licensed to Resilient Computing in 2021 to move it closer to commercialization. Under funding from a 2021 NASA SBIR Phase I award, Resilient Computing conducted customer discovery on the RadPC concept and refined the computer concept to be closer to a viable product through an in-depth feasibility study on how software-implemented fault tolerance (SIFT) could be automated in the RadPC approach. In this project, we seek to study the feasibility to automating SIFT for a RISC-V computer system implemented on the RadPC fault-tolerant, FPGA-based flight hardware. We further seek to refine the architecture to support the seamless integration of RISC-V coprocessors that both accelerate computation and are fault-tolerant using the same RadPC strategy implemented on the primary RISC-V computer. The outcome of this Phase I effort will be a conceptual design for a RISC-V flight computer with coprocessor support that will be prototyped in a subsequence Phase II project.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- Replacing ~20 year old rad-hard processors with a lower-cost, higher performance, commercial-based technology.
- Computationally intense algorithms such as real-time science data processing, autonomy, and navigation.
- Control & data handling for NASA small satellites.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- Small satellites needing increased reliability and performance, but at a price-point below current rad-hard computers.
- Earth image processing (climate monitoring, disaster mitigation, agriculture).
- Communication networks.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z12.01-1322**

SUBTOPIC TITLE: Extraction of Oxygen, Metal, and Water from Lunar Regolith

PROPOSAL TITLE: Non-Water Lunar Ice Mining

Small Business Concern

Firm: **Paragon Space Development Corporation**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 2

Technical Abstract (Limit 2000 characters, approximately 200 words):

Non-water volatiles (NWVs) found co-located with water in lunar permanently shadowed regions (PSRs) are both a potential source of risk to water processing equipment and a potential source of value to spaceflight applications. Paragon seeks to refine and analyze process technology and architecture concepts to separate and handle lunar NWVs, along with processes to concentrate ammonia from the NWVs and generate useful products such as refrigerant, propellant, and fertilizer. This project, titled Ammonia and Volatiles Accumulation in Lunar Architectures for Non-Water Capabilities furthering Human Exploration (AVALANCHE), targets the capture, concentration, and utilization of ammonia as the primary NWV with the highest potential impact value to sustained human lunar surface operations and generation of a lunar resource economy. While ammonia is the primary target, the separation and handling of other NWVs, such as mercury, and solid precipitates resulting from the possible reactions of NWVs

with one another, such as ammonium sulfite, is considered a vital part of this proposal. This proposal approaches the solution space from the In-Situ Resource Utilization (ISRU) system architecture-level, which allows for the opportunity of evaluating technology and process concepts that would otherwise be non-viable as standalone solutions. Components and architectures will be simulated to evaluate their performance in a trade study that will allow assessment of the costs, risks mitigated, and value-added by various configurations. This, along with a feasibility study and down-selection, will result in design and experiment plans for resulting component(s) and architecture to be developed and demonstrated within Phase II of the AVALANCHE project. The top-down system analysis methodology and the potential benefits resulting from these concepts to other systems is enabled by Paragon's unique position as an industry leader in ISRU technology.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed technologies, processes, and architectures are applicable to the handling, separation, and concentration of NWV's and the processing of ammonia to value-added products on the Moon. Potential NASA applications of technologies and concepts from the AVALANCHE project include risk mitigation to lunar water processing, provision of consumables for TCS refrigerant recharge, provision of propellant and make-up inert gas for habitats, and provision of fertilizer for crop production.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The technologies, processes, and architectures of the AVALANCHE project may be included in any commercial lunar or in-space mining and resource utilization plants. Ammonia refrigerant may be used to recharge thermal control systems of commercial surface or in-space vehicles or habitats. Hydrazine generated from the resulting system could be used to service or re-supply commercial in-space assets.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.05-2406**

SUBTOPIC TITLE: In Situ Instruments/Technologies for Lunar and Planetary Science

PROPOSAL TITLE: Windspeed Sensor for Planetary Science Applications

Small Business Concern

Firm: **Sporian Microsystems, Inc.**
Address: **515 Courtney Way, Suite B, Lafayette, CO 80026**
Phone: **(303) 516-9075**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

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. To address this need, Sporian is developing a harsh environment wind speed and direction sensor targeted toward future Venus probe spacecraft. The proposed technology will be beneficial to NASA's planetary science mission by facilitating environmental chamber testing & validation, and wind speed and direction measurements in the Venus atmosphere and on the surface. The Phase I effort will focus on heavily leveraging prior harsh environment, in-situ instrumentation development and, with input from current/prior NASA partners, will construct, test, and characterize prototype sensor suites. If successful, Sporian will be well prepared for Phase II efforts focused on producing full demonstration units for application-relevant testing and addressing integration strategies.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

A harsh environment sensor that can provide real-time wind speed and direction information has the potential to provide major advancements in planetary science. The technology will target the Glenn Extreme Environment Rig and its capability to mimic planetary conditions such as those on Venus, but be directly applicable to both current and future NASA programs/directorates, and facilitate innovations in vehicle performance monitoring, environmental testing, and atmospheric characterization of planetary bodies.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Land-based power generation systems, including nuclear and solar power plants, would benefit from a small flowmeter allowing for visibility of the conditions in supercritical CO2 Thermal Energy Storage (TES) and Heat Transfer Fluid (HTF) lines. Additional potential market areas include marine propulsion, rail locomotives, automotive, oil and gas refining, and government and academic laboratories.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.03-1456**

SUBTOPIC TITLE: Guidance, Navigation, and Control

PROPOSAL TITLE: Optical gyroscopes and accelerometers: enhanced response and squeezed noise

Small Business Concern

Firm: **Lenzner Research, LLC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

We propose the development of a novel laser-based gyro and accelerometer, pushing the sensitivity to the fundamental limit. The device is based on two correlated frequency combs of the same repetition rate, generated in a single laser cavity. Because of this correlation, while the bandwidth of a tooth of each comb is in the Megahertz range, the bandwidth of the interference is less than 0.1 Hertz. Dispersion control of the circulating laser pulses leads to a further increase in sensitivity of this intracavity phase interferometer.

In addition to the boost in sensitivity, we will reduce the noise. The classical noise limit will be reached by classical means like a high repetition rate of the measurement and additional control loops. Applying the technique of squeezed light will then be used to approach the fundamental limit of sensitivity.

The results achieved in Phase I on a discrete-components OPO will be applied to two fiber-OPO prototypes. These devices are expected to be competitive with the LIGO in terms of sensitivity.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Potential NASA applications include all future inertial navigation systems for which SWaP reduction is critical. A lightweight expandable gyro and miniaturized accelerometer have

application in commercial navigation. Because the fiber laser can be made of very large perimeter and is of unprecedented sensitivity, it can have applications in monitoring the motion of tectonic plates. Furthermore, the ring laser gyro and linear accelerometer can be used in aerospace navigation either stand-alone or as part of Inertial Measurement Units (IMU).

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Aerial and naval navigation, especially if included in IMU's. Emerging market segments are for instance micro- and nano- satellites (SpaceX), commercial space flight (Blue Origin, Virgin), and autonomous road vehicles. Due to the high sensitivity, the gyroscope can also have applications in basic research, for direct observation of effects in General Relativity like the Lense-Thirring precession.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z1.06-2089**

SUBTOPIC TITLE: Radiation-Tolerant High-Voltage, High-Power Electronics

PROPOSAL TITLE: Single Event Burnout Hardened High-power Diamond Devices

Small Business Concern

Firm: **Euclid Beamlabs, LLC**
Address: **5900 Harper Road # 102, Solon, OH 44139**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Electrical power management designed for use in space requires electronics capable of operating without damage in the galactic cosmic ray space radiation environment under severe temperature swings. Unfortunately, the adoption of SiC and GaN technology into space applications is hindered by their susceptibility to permanent degradation and catastrophic failure from single event effect heavy-ion exposure. This degradation occurs at <50% of the rated operating voltage, requiring the operation of SiC/GaN devices at de-rated voltages.

Diamond is one of the candidate materials for the next-generation WBG semiconductor devices capable of overcoming the current limitations of SiC/GaN technology. In addition to having the highest breakdown field, it has the highest p-type conductivity, making it a unique p-channel material for power electronics applications. It also holds a solid hope to be hardened against single event burnout (SEB) due to its superior thermal conductivity and ability to maintain an excellent crystalline structure under heavy ion exposure.

Euclid Beamlabs, in collaboration with Rensselaer Polytechnic Institute, will develop a new quasi-lateral diamond power MOSFET that will overcome current limitations by combining the inherent advantages of diamond material, SEB hardened transistor design with advanced 3D femtosecond laser writing capabilities of micrometer-scale conductive structure fabrication inside the diamond. The project's primary focus is developing SEB tolerant diamond transistor design with a 2D boron-doped conductive channel and graphitized embedded connections. The targeted specifications are 3,300+ V voltage rating with 2.8 Ohm-cm^2 specific on-resistance.

In Phase I of the project, we will focus on the optimal transistor design simulations. Also, the customized ionization software will evaluate SEB performance for diamond devices. We will also electronically characterize diamond substrates and test the optimum fs-laser writing procedure.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The technology has immediate application for radiation-hardened power electronics circuits in exploring atmospheric planets, Moon to Mars, and Commercial Lunar Payload Services (CLPS) missions. It has a strong potential to advance current state-of-the-art electronics on revolutionary spacecraft design with reduced size, weight, and power while increasing overall system efficiency, longevity, and performance.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The developed technology can be commercialized for a wide set of purposes with hostile environments and high-temperature operation regimes. It will overcome the limitations of current state-of-the-art high-temperature, cost-effective power electronics technology. The all-carbon technology will find its applications in military electronics, high energy physics, and medical radiology.
Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.03-1266**

SUBTOPIC TITLE: Low Emissions/Clean Power - Environmentally Responsible Propulsion

PROPOSAL TITLE: A Software Toolkit to Develop OpenNCC Chemistry Models On-Demand Targeting Sustainable Aviation Fuel Blends with Soot Precursors

Small Business Concern

Firm: **Combustion Research and Flow Technology**
Address: **6210 Keller's Church Road, Pipersville, PA 18947**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The innovation proposed is a major capability upgrade to CRAFT Tech's Multi-Time-Scale (MTS) Flamelet/Progress Variable (FPV) Software Toolkit (operational in NASA's National Combustion Code, OpenNCC) to enable the on-demand generation of chemistry models targeting blends of conventional aviation fuels (CAF) such as Jet A and sustainable aviation fuels (SAF) that are directly usable in Computational Fluid Dynamics (CFD) analyses of gas turbine engine combustors. These on-demand chemistry models are envisioned to be inclusive of the underlying blend-specific soot precursor chemistry driving the formation of nonvolatile particle matter (nvPM). The quantification of nvPM/soot has recently gained significant traction due to its negative effects on global warming and public health. With the growing interest in replacing part of the CAF typically used with SAF to limit life-cycle greenhouse gas emissions and nvPM, the proposed innovation addresses key technical challenges currently preventing the routine application of high-fidelity computational design support tools to guide the selection of optimal SAF candidates and definition of optimal CAF-SAF blending ratios: (i) the limited availability of computationally-tractable chemical kinetic models for SAF blends and, even when available, (ii) their inherent complexity in terms of capturing the evolution of Polycyclic Aromatic Hydrocarbons (PAH) soot nucleate species needed when using higher-fidelity soot formation models. In order to attain the maximum level of dimensionality reduction, the MTS-FPV approach is leveraged by new tools to directly deploy large detailed kinetic models during the FPV table generation process and exploit time-scale separation for the fuel pyrolysis and the soot precursors. The significance of the innovation is that it addresses NASA's core needs for an economically

feasible and environmentally acceptable propulsion technology suitable for subsonic and supersonic commercial aircrafts.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This product addresses (i) NASA's core needs for an economically feasible and environmentally acceptable Commercial Supersonic Transport propulsion technology, (ii) NASA ARMD needs for enabling safe and reliable operation of next-generation (N+3 and beyond) ultra low-emission conventional gas-turbine engine and hybrid electric aircraft propulsion, and (iii) core needs of NASA's vision for next-generation aircraft systems with hybrid integrated wing/body systems with significant improvements in engine performance, emissions and noise reduction.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The commercial market includes the broad aerospace, power-generation and defense industry. Commercial aircraft gas turbine engines are the primary driver for this product. Other applications encompass power-generation turbines and IC/HCCI/diesel engines. DoD applications include gas-turbine engines, scramjets, RDEs, augmentors, UAVs propulsion systems and rocket engines

Duration: **6**

PROPOSAL NUMBER: 22-1- **H10.02-2523**

SUBTOPIC TITLE: Autonomous Operations Technologies for Ground and Launch Systems

PROPOSAL TITLE: Autonomous Operations Technologies for Ground and Launch Systems (SBIR)

Small Business Concern

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

To support NASA's Kennedy Space Center (KSC) in the generation of innovative autonomous operations technologies (AOT) for ground and launch systems, American GNC Corporation (AGNC) is proposing the “Semiautonomous Anomaly Monitoring and Early Detection (SAMY)” System to advance NASA operations and maintenance (O&M) infrastructure while increasing ground systems availability to support mission operations. Typical health monitoring systems focus to Failure Detection and Identification (FDI) of fully developed and known fault conditions. SAMY goes beyond this traditional approach, where in addition to FDI the SAMY system focus to: (a) detecting newly emerging health behaviors that could correspond to incipient faults; (b) tracking the fault growth process; and (c) identifying system changes that may correspond to system deterioration to deeply understand and assess the availability status of NASA ground systems. Based on these capabilities Phase I address a comprehensive design of the anomaly detection and prognostics framework (in addition to FDI), which is embedded within cutting edge sensor network. Core technologies are: (1) approximate bayes discriminant by Multilayer Perceptron for anomaly analysis and prognostics; (2) AGNC-LaTech’s Variogram for change detection; (3) incremental learning based on AGNC’s eCLE; (4) health monitoring by Deep Neural Network (DNN) with optimized footprint for integration within hardware platforms with minimized Size, Weight, and Power Consumption (SWaP); (5) top layer with ensemble of reasoning applications; and (6) smart sensor network based on cutting edge ISA100 technology and Zigbee. Successful completion of Phase I will result in the implementation of an innovative smart sensor network with embedded incremental learning system for detection of anomalies and new emerging health behaviors to better understand operational status in NASA ground systems. Phase II is expanded this foundation for an enterprise implementation.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The SAMY system supports NASA’s ground and launch systems by advancing autonomous operations technologies (AOT) to reduce operations and maintenance (O&M) costs while increasing safety and system reliability. Direct applications include ground launch systems (e.g., rocket engine test facilities, and autonomous propellant management) as well as planetary and lunar surface-based infrastructure used to transition launch vehicles to flight operation. SAMY’s integral monitoring can be deployed in a broad variety of NASA applications.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

SAMY is a very versatile system, where some potential markets include Condition Base Maintenance, smart sensors, and health monitoring for the military, aerospace, and industrial sectors. Applications include: (i) aircraft avionics equipment monitoring; (ii) robotic/unmanned systems; (iii) IoT; (iv) military assets in ships and submarines, among many other commercial and military systems.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H8.01-1840**

SUBTOPIC TITLE: Low-Earth Orbit Platform and Microgravity Utilization for Terrestrial Applications

PROPOSAL TITLE: Novel Additively-Manufactured Ultra-High Temperature Composite with Microgravity Improved Grain Structure (NACE HHS MICRO)

Small Business Concern

Firm: **Nanoarmor, LLC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 7
Technical Abstract (Limit 2000 characters, approximately 200 words):

Nanoarmor has developed an advanced polymer-based ceramic precursor feedstock that can be used to fabricate high-temperature carbide ceramic parts at high densities, without the traditional extreme processing parameters associated with carbide ceramics. Furthermore, the Nanoarmor feedstock has been proven to be effective in certain additive manufacturing processes, allowing carbide ceramics to be explored for applications that were previously not possible due to processing constraints.

Nanoarmor's critical advantage over state-of-the-art approaches is its unique ability to structure nano-reinforcements into ceramic matrix composites (CMCs) without degradation during processing through low-temperature reaction bonding.

This technology is ideal for application in reusable aerospace vehicles and hypersonic platforms and offers exceptional potential tactical and strategic advantages for NASA, the DoD, and other public and private organizations seeking to manufacture reusable, reinforced materials for hypersonic application in orbit or in low-gravity environments.

For emerging thermal protection systems to enable next-generation hypersonic vehicle designs, novel materials and design architectures must exhibit high thermal conductivity, resist oxidation and ablation, withstand thermal shock during rapid heat flux, and survive tensile and compressive stress under dynamic and unpredictable loads. Nanoarmor's unique ability to form lightweight, reinforced CMCs with superior performance capabilities already provides a critical advantage over state-of-the-art ceramics.

The proposed research and development initiative is to advance Nanoarmor's patent-protected process and technique for manufacturing ultra-high temperature ceramic matrix composites (UHT-CMCs) that facilitate dissimilar material integration (e.g. zirconium carbide (ZrC) with toughening additives such as boron nitride nanotubes (BNNTs)), non-extreme processing parameters, and additive manufacturing.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Reusable aerospace vehicles and hypersonic platforms offer exceptional potential tactical and strategic advantages for NASA. The survival of such TPS systems during atmospheric re-entry is paramount to vehicle survival, crew safety, and mission success. UHT-CMCs are desired for implementation on the nose tips, leading edges, air intake systems, and other high-loaded regions of hypersonic aircraft and re-entry vehicles in space applications, due to the utility and high-temperature resistance of these materials.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

UHT-CMCs are desired by the DoD for implementation on the nose tips, leading edges, air intake systems, and other high-loaded regions of commercial spacecraft and re-entry vehicles due to the utility and high-temperature resistance of these materials. Nanoarmor carbides are also prime candidates for applications in high-temperature turbines, industrial processing, and energy production.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z7.03-2524**

SUBTOPIC TITLE: Entry and Descent System Technologies

PROPOSAL TITLE: Lightweight and Low Cost Pyrotechnic Gas Generator for HIAD

Small Business Concern

Firm: **Storm Castle Technical Products, Inc.**
Address: **Box 461 , Manhattan, MT 59741**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

Entry, descent, and landing systems with capability beyond current state-of-the-art are required for a number of missions. These missions represent an immediate need for return of orbital payloads, and include larger milestone objectives up to a manned flight to Mars which requires landing a payload many times beyond that achieved to date. In this Phase I SBIR, Storm Castle Technical Products intends to produce a lightweight and low-cost gas generator based on pyrotechnic reaction. To achieve this objective, the company will procure chemical cores based on a successfully demonstrated technology and engineer the generator system around those cores.

The generator system will be based on a composite overwrapped pressure vessel concept. In addition to mass and cost savings over other demonstrations, this new architecture is expected to feature very low particulate concentration and enhanced temperature control in the outlet gas stream. Technical work will include rigorous analysis of candidate materials systems, productions of preliminary drawings, and demonstration of small-scale generators. At the end of Phase I, a refined design concept with complete materials selection and in situ demonstration will be completed.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This project is designed to directly address the needs of hypersonic aerodynamic inflatable decelerators (HIADs). This innovation could serve a number of applications where pressurized gas is required for inflation or pneumatic systems, but storing compressed gas is impractical on a mass basis.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Iterations of this technology are ideal for inflating payload carrying balloons from locations or in environments where compressed gas is not practical for inflation. These applications exist in the meteorological and defense areas. Iterations of this technology are applicable to gas generation for power production in remote areas.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.03-2154**

SUBTOPIC TITLE: Low Emissions/Clean Power - Environmentally Responsible Propulsion

PROPOSAL TITLE: Humidity probe for contrail-cirrus avoidance

Small Business Concern

Firm: **Aerodyne Research, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

In this SBIR project we will develop a new compact laser-spectroscopic instrument to measure humidity in the upper troposphere under conditions favoring the formation of persistent aircraft-induced contrails and contrail-cirrus clouds. Aircraft-induced contrail-cirrus clouds account for the major share of aviation's climate impact by way of radiative forcing. It is therefore critical to try and minimize the occurrence of contrails and contrail cirrus to reduce the climate impact of the global aviation fleet.

Our system will make active contrail-cirrus avoidance possible by the real-time measurement of the humidity state of the atmosphere and hence allow for active cirrus-contrail mitigation strategies.

The system we propose will measure atmospheric humidity using laser spectroscopy and will provide a better detection limit than presently available commercial technology. It will have low-power consumption, and will be compact enough to be a permanent asset including data downlink on commercial aircraft for continuous humidity monitoring at cruise altitude as well as during the ascent/descent profiles. To minimize the climate impact of global aviation we need aircraft equipped with our technology that fly on intercontinental routes along the busiest flight corridors.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Accurate humidity measurements are crucial for almost any scientific study of Earth's atmosphere. A simple-to-integrate, highly compact, and maintenance free water vapor instrument for NASA aircraft campaigns would be a great asset for many scenarios. This includes satellite validation where a NASA aircraft would perform profile measurements co-located with satellite observations.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Precise, compact, and low-power trace-gas sensors – not just for humidity – are relevant in many scientific and industrial applications, e.g.

- Aircraft campaigns

- remote field sites

- industrial process control

This project will be a key step in developing a new instrument platform for a wide range of applications in existing and new markets.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z7.03-2439**

SUBTOPIC TITLE: Entry and Descent System Technologies

PROPOSAL TITLE: GasPak: A High Output, Clean Gas Generator for Large Volume Deployable Aerodynamic Decelerators

Small Business Concern

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

A large majority of commercial and NASA spacecraft mission types would benefit from the ability to have deployable aerodynamic decelerators. Beneficial applications include spacecraft returning to Earth from low Earth orbit, exploring other planetary bodies (e.g. descent to Mars, Venus, and Titan), and reducing the cost of access to space by enabling the recovery of launch vehicle assets.

Current deployable aerodynamic decelerators are constrained by existing blowdown system limitations including mass efficiency, and long term storage of high pressure gas. Hydrogen, while an ideal candidate for its storage capacity, has high leak rates when considering long duration missions and transits. Gas generators provide a solution that has a higher density than cryogenic liquid hydrogen, however, these hydrogen generators are yet to be a space qualified technology.

In this effort, Outpost Technologies Corporation (Outpost) will develop GasPak which is a low mass and clean gas generator that will be used for hypersonic inflatables on space missions. In order to achieve this goal Outpost will leverage its relationship with Dutch company TNO to procure commercial off the shelf nitrogen gas generators to be used in a feasibility study and benchtop prototype. From these steps a hydrogen gas generator will be designed and brought to a PDR-level by the end of Phase I. By the end of Phase II, the gas generator will reach TRL-8 by being demonstrated on an orbital Outpost mission with Earth return.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary NASA application will be Hypersonic Inflatable Aerodynamic Decelerators (HIADs) as planned for use on missions to planets and moons with atmospheres as well as returning payloads to Earth. Additionally, GasPak may be used in substitution for other single use pressurant systems such as deployment of spacecraft components and planetary landing impact suppression.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Outpost will use the GasPak technology in its own reusable satellites to deploy the heat shield for re-entry. Commercially, Outpost is enabling a new means of Earth return that allows satellites to be brought back to Earth and refurbished for future missions.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.07-2071**

SUBTOPIC TITLE: Energy Storage for Extreme Environments

PROPOSAL TITLE: Solid-state Rechargeable Batteries for Extreme Lunar Surface Environments

Small Business Concern

Firm: **TDA Research, Inc.**
Address: **12345 West 52nd Avenue, Wheat Ridge, CO 80033**
Phone: **(303) 422-7819**

Principal Investigator:

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Phone: **(303) 940-2341**

Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Future science missions to the Lunar surface and other planets and their moons will require advanced secondary battery systems that can operate at extreme temperatures. Advancements that address battery operation at extreme temperatures, combined with high specific energy and

energy density are critically needed. Conventional rechargeable Li-ion cells operate within a narrow temperature range of -20 to 40 ºC, and they particularly suffer from capacity loss at lower temperatures. Improved batteries that minimize the need for strict thermal management, which adds mass to the spacecraft, are critically needed.

The solution to making rechargeable lithium-ion batteries that operate in extreme temperature environments is to develop a solid electrolyte that does not suffer from poor solid-solid lithium conductivity. New materials and methods for tailoring these solid-solid interfaces are needed. It is also critical to combine this modified solid electrolyte with high voltage cathodes and stable anodes to produce the high energy density batteries that NASA needs. In this project TDA Research will develop surface modified solid electrolytes and surface modified electrodes that combine to make high voltage lithium rechargeable batteries suitable for the Lunar environment.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The targeted NASA application is for energy storage (batteries) that do not require excessive thermal management on the Lunar surface. NASA has specifically identified this need, and it is the primary target application. Similarly, extreme temperature tolerant batteries would serve NASA for additional missions (Mars, Titan, etc.).

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

There is an immense dual-use commercial market for solid batteries on Earth. Electric vehicles, electric aircraft and numerous other energy storage applications would greatly benefit from being able to work below -40 ºC, and safety would be greatly enhanced by solid-electrolyte batteries that were not flammable and could survive temperatures above 100 ºC (for example, vehicle fires).

Duration: **6**

PROPOSAL NUMBER: 22-1- **H5.01-2879**

SUBTOPIC TITLE: Lunar Surface 50 kW-Class Solar Array Structures

PROPOSAL TITLE: Motorless Expandable Solar Array (MESA)

Small Business Concern

Firm: **Dynovas, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Dynovas' Motorless Expandable Solar Array (MESA) system provides a novel solution that specifically addresses NASA's call for technologies enabling structural and mechanical innovations for a 50-kW-class solar array that can be relocated and deployed at least 5 times. This solution was developed based on previous technologies that have proven track record such as inflatables and bistable composites and new technologies for deployment and packaging that specifically address the unique mission requirements for large deployable solar arrays. The MESA system is unique in that uses multiple technologies developed by Dynovas personnel to achieve this innovation. These include:

1. Bistable Composites – Lightweight composite materials that provide motorless deployment force and strong structural support when deployed. Because this technology has no moving parts it is naturally dust resistant.
2. Inflatable Technologies – These are lightweight and motorless deployment systems that house the solar arrays. The use of gas pressure provides **deployment AND retraction** forces, making the need for no motors. With no moving parts, the inflatable is inherently dust resistant.
3. Mechanical and Structural – Use of self-tensioning guy wires and ratcheting system provide a safe and repeatable system for deployment and stowage. These are necessary to stabilize an array of this size on an uneven terrain.
4. Novel Packaging Solutions – By packaging the arrays within the base structure, the system is compact and modular for launch, deployment, stowage and relocation.

Using these technologies together, Dynovas was able to develop a solution for a deployable solar array that meets the requirements for the next generation 50-kW deployable solar array that can be lifted 10m high to avoid shadowing

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The MESA system builds on near term NASA initiatives: Vertical Solar Array Technology (VSAT) project, Watts on the Moon Challenge, and Artemis Lunar Landings. The increased scale of MESA to 50 kW enables application to large power stations, habitats, recharging stations, and power substations. The robust inflatable boom can also apply to surface conforming arrays for the moon and Mars exploration and habitation.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The NASA specific lunar missions will also have parallel commercial efforts to which MESA applies. In addition to lunar exploration other dual use applications exist, including: refueling

stations; orbiting debris removal; and terrestrial pop-up power and communications towers.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S17.03-1917**

SUBTOPIC TITLE: Fault Management Technologies

PROPOSAL TITLE: Damage Propagation Assessment - A Causal Model Approach for Design and Operations

Small Business Concern

Firm: **Qualtech Systems, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

Qualtech Systems, Inc. (QSI) in collaboration with Dr. Stephen B. Johnson of Dependable Systems Technologies (DST) proposes a novel, causal-model based systematic methodology for assessing damage propagation due to one or multiple originating faults and how the propagation affects and damages other components. In fault propagation, downstream components from the root-cause fault which rely on its function, may also fail. When the root cause is mitigated, those

downstream components resume their normal operating behavior. During damage propagation, the originating fault's damage, leads to the failure effects in which physical damage to downstream components is a consequence, such that those components can no longer function nominally. Even if the originating fault recovers or is replaced or bypassed, the downstream damaged components do not recover and continue to remain in a failed state.
This proposal aims to create new capabilities for QSI's TEAMS® tool suite to represent the differences between components in which failure effects 'pass through' or cause only functional impairment versus those that can cause physical damage. During TEAMS® model design, this new capability will enable the modeler to represent the activation of a downstream component failure mode when a specific failure effect (a TEAMS® 'function') arrives at the component. This will signify that though the failure effects begin with a single fault (cause, failure mode), a second fault will now exist in the relevant downstream component so that if the first fault is removed the second fault will remain unless another repair is made. During operations when TEAMS® is used to perform diagnosis, TEAMS® will alert operators that a second independent fault may exist as a consequence of the effects of the first fault. The impact of this new capability on the TEAMS® fault management metrics modeling and generation capability will be explored during the course of the SBIR project.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed technology is aimed at facilitating effective usage of model-based systems engineering for improving fault tolerance and mitigation response capability during design, and the concomitant software tool for supporting its implementation, will allow NASA to better design, plan and execute future Space Missions. The proposed technology is positioned for direct applications for NASA missions that deploy complex equipment such as the Lunar Gateway, the Space Launch System, the Human Lander, Europa Clipper and rovers such as the VIPER.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

We envisage the proposed technology to be of significant interest for DoD's Mission planning and Rapid design of space missions/satellites where model-based design processes will be used for supporting infrastructure Space services capabilities. QSI is currently working with the Army for fault management design of the Remote Combat Vehicle (RCV) and plan to apply this technology for that effort.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z10.01-1069**

SUBTOPIC TITLE: Cryogenic Fluid Management

PROPOSAL TITLE: Film Condensation Modeling in Cryogenic Tank Applications

Small Business Concern

Firm: **Combustion Research and Flow Technology**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

To support NASA's Cryogenic Fluid Management (CFM) design and operation initiatives, computational fluid dynamics (CFD) models of cryogenic condensation/liquification are required to allow for efficient trade studies to be conducted on real systems over a range of conditions that may be prohibitive with laboratory testing. In the Phase I effort, a validated subgrid CFD model of cryogenic film condensation on a vertical flat wall will be developed which is capable of capturing the formation and growth of a cryogenic condensation layer and its movement along a wall boundary. A systematic test campaign will be undertaken to investigate the downflow film condensation of various cryogenic fluids of CFM and In-Situ Resource Utilization (ISRU) relevance. The Phase I effort emphasizes experimental visualization of the onset of film condensation, understanding of relative importance of heat transfer processes, quantification of key film characteristics, including liquid film thickness, vapor thermal boundary layer, and condensation heat flux, and identification of governing parameters that influence cryogenic film formation and growth. The experimental data will be used for fundamental validation of a subgrid cryogenic film condensation CFD phase-change model, setting the stage for a Phase II validation program on prototype CFM geometries. The Phase II effort will extend the validation to tank geometries and incorporate the validated film condensation model into commercial CFD tools used by NASA. The validated predictive simulation tools will help in identifying better designs and protocols related to cryogenic propellant transfer and ISRU thereby mitigating risk in outer space hardware deployment and operational strategies.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Cryogenic Fluid Management (CFM) is in the critical path of nearly all NASA's future space exploration missions. A validated CFD cryogenic film condensation model will provide a unique simulation capability for tools being used by NASA for CFM design and operational initiatives including In-Situ-Resource-Utilization (ISRU) and in-space refueling for long-duration space exploration missions, which are currently a high priority area as NASA looks to return to the moon and explore Mars on an accelerated time frame.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Cryogenic Fluid Management affects many space-exploration initiatives and as the commercial space launch market continues to grow the market for high-fidelity cryogenic simulation software will expand to support design and operational strategies. Industries involved in liquefied gases,

hydrogen as a green fuel, and the petroleum industry with liquefied natural gas also provide a potential market.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S17.03-2479**

SUBTOPIC TITLE: Fault Management Technologies

PROPOSAL TITLE: Autonomously Maintaining Mission Objectives using Fault Management

Small Business Concern

Firm: **Singularity - Intelligence Amplified, LLC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Singularity-IA proposes the development of a proof-of-concept software application to design fault detection and mitigation functions into complex systems using modelling, simulation, intelligent design automation, and requirements-based constraints to assist with the design of optimal Fault Management (FM) solutions.

FM solutions are an important enabler of autonomous operation. They help reduce operations costs by reducing the number of required monitoring personnel and help increase the chances of success by ensuring a rapid response to faults.

NASA's science program has over 100 spacecraft in operation or development. Many of these platforms are autonomous, or uncrewed, and many other agencies (both government and commercial) around the world are launching spacecraft of their own. The industry for autonomous vehicles is growing rapidly and expected to transform all aspects of travel on the ground, in the air, and in space. FM technologies are necessary to keep people safe and to keep things running.

The design process needs to integrate FM concepts from the beginning, and we plan to develop a proof-of-concept tool that makes this easier. Our plan is to replicate an analogous spacecraft power system on a real-world test stand and develop the tools and capability to model and simulate this test stand with various fault conditions. We will use this ability to determine the ideal design to achieve FM objectives, then build a real-world version of the FM system and test it in the real-world power test stand.

This approach ties a modelling and simulation capability to a real-world system, which allows us to assess performance of the approach. We will leverage existing tools and capabilities where possible, and add new features where required. Broad simulation testing and intelligent design automation will simplify and accelerate the design process ensuring that engineers can create more reliable and fault tolerant systems in less time than before.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA can incorporate this toolset and capability into the design of all the crewed and uncrewed systems they are developing. It will provide value in reduced operations costs for the uncrewed systems, and it will provide reliability and safety improvements for crewed systems. This means the crew can spend less time monitoring and maintaining the vehicle and more time focusing on exploration and ground-breaking science. Sudden unexpected failures shouldn't leave people stranded and FM technologies can help get them home.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The toolset and capability to seamlessly integrate FM technologies is important for designers of autonomous vehicles in both the defense and commercial industries. The fast-growing market for self-driving cars provides a fantastic opportunity to roll out these technologies on a large-scale and demonstrate improved vehicle robustness and reliability.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A2.03-2875**

SUBTOPIC TITLE: Advanced Air Mobility (AAM) Integration

PROPOSAL TITLE: Electronic Community AAM Toolkit

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Our innovation is NASA inspired by a Model Based System Engineering (MBSE) approach but adopted to describe the functional elements of an electronic Community AAM Toolkit (eCAT) that is adaptable, scalable, and tailorable to fit the information needs of the adopter community. This systematic approach will be location agnostic but will provide templates to be adapted for the unique requirements of the AAM adopter community. Elements of the adopter stakeholder community can be decomposed as the ecosystem contributors. This provides a template that is adaptable to meet the unique needs for a given community. The eCAT will serve as a repository for bi-directional exchange of AAM knowledge. This repository can hold information gathered from community stakeholders and data gained from research and distribute information across the community of actors. Information would be distributed in various formats to include digital downloads, audio/visual (such as community podcasts/YouTube videos) as well as virtual space for moderated community discussions. The Toolkit would be hosted on the internet or via cloud-based service architecture. All Azimuth Solutions would act as a governance entity that would gather the community inputs and ensure veracity of information compiled. The eCAT houses seven central elements known as effort repositories that interact within the described system. Within these areas are housed education material, a system demonstration playbook and decision support tools for community planning strategies. The seven effort repositories that interact within this system are:

1. Common dictionary of terms/Taxonomy/Educational Material
2. Vision and Guiding Principles
3. Concepts of Operations (Conops) and use cases
4. Guidance Material and Decision Support tools
5. Applicable Standards and Regulations

6. Requirements

7. System Architectures

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

eCAT transfers to other AAM efforts within the ARMD AAM Mission Portfolio. Elements maybe adapted to High Density Vertiplex subproject, AAM National Campaign, Advanced Air Mobility Project, and AAM Ecosystem Working Groups to include, but not limited to Community Integration and Crosscutting WGs.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The eCAT will be of value to all AAM community stakeholders. There currently does not exist a complete system of community AAM resources readily available for communities of all sizes, levels of engagement and resources. This new system is also ideally suited to provide AAM education and outreach materials, demonstrations as well as providing a complement of decision support tools.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z1.08-1353**

SUBTOPIC TITLE: Space-Rated Fuel Cell Technologies

PROPOSAL TITLE: Unitized High Pressure Regenerative Fuel Cell Stack for NASA Applications

Small Business Concern

Firm: **Lynntech, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Unitized regenerative fuel cells (URFCs) are promising candidates for power sources for future Mars and crewed lunar missions, as they offer added benefits of reduced mass and footprint compared to the traditional regenerative fuel cell (RFC) systems. NASA seeks development of high pressure reversible or unitized proton exchange membrane RFC stacks that can meet (i) 2,500 psig balanced pressure operation, (ii) Round-trip efficiency of > 48% based on higher heating value measured at 500 mA/cm^2 in fuel cell mode and 1,500 mA/cm^2 in electrolyzer mode, and (iii) > 170 cycles with a target of up to 366 hours of operation per cycle in each mode (meaning ~ 62,000 hours operational durability!). To address these requirements, Lynntech will leverage its prior URFC stack design, catalyst and membrane materials experience, and develop advanced URFC stacks with emphasis on materials selection for high-pressure hydrogen and oxygen compatibility, amphiphilic corrosion resistant diffusion layer for reversible oxygen electrode, and stack design for balanced high-pressure operation. In the Phase I project, Lynntech will target the demonstration of stack and components at the single or short cell stack level and establish the stack design for a multi-kW URFC stack for the Phase II prototype demonstration.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

URFC technology can be used by NASA for future surface exploration of the Moon and Mars. RFCs provide a lightweight alternative to batteries, especially to support energy storage requirements for long lunar nights. RFCs provide the possibility of integration with ISRU systems, as it involves the same feedstocks/products such as water and oxygen used for the life support systems. URFCs provide a more compact and lightweight version of RFCs where the system can be significantly simplified with elimination of several balance of plant systems.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The specific energy of URFCs can easily beat batteries for large energy storage requirements. Hence URFCs can find applications in stationary energy storage systems using renewable energy where the specific energy for the URFC systems is much greater than 200 Wh/kg, or that of current battery systems

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.05-1169**

SUBTOPIC TITLE: In Situ Instruments/Technologies for Lunar and Planetary Science

PROPOSAL TITLE: Automated Recovery and Isolation of Extraterrestrial Lipids (ARIEL)

Small Business Concern

Firm: **Leiden Measurement Technology, LLC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Leiden Measurement Technology (LMT) proposes to build the Automated Recovery and Isolation of Extraterrestrial Lipids (ARIEL) instrument. This instrument will be created to autonomously isolate and concentrate amino acids and fatty acids from samples delivered to the instrument. These chemical species have long been chemical targets of NASA missions and may be indicative of life. More specifically, ARIEL is a sample processing instrument that will extract ions, amino acids, fatty acids and non -polar organic molecules from either solid, liquid, or mixed samples. The ARIEL sample chamber will be equipped with an ultrasonic horn which not only increases the extraction efficiency of the target analytes, but also lyses any cellular material, thus making it available for further characterization. ARIEL will autonomously carry out a pair of sequential extractions, the first of which removes ions, amino acids and small fatty acids. The second extraction dissolves medium and long chain fatty acids as well as any non-polar organic compounds present in the sample. ARIEL's fluidic system will send the first extraction solution to a processing channel equipped with a solid phase extraction (SPE) column that will specifically isolate amino acids and short chain fatty acids. Any other ions in solution will pass through the column. The second extraction solution will be sent to a separate channel containing an SPE column designed to remove medium and long chain fatty acids while other non-polar organic species pass through the second column. Once the target analytes are isolated on two separate

SPE columns they can be washed, eluted with a minimum volume of solvents, and delivered to ARIEL's two separate outputs. These outputs can be designed to interface with derivatization systems and analytical instrumentation used by NASA such as GCMS, LCMS or LDMS.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA is interested in detecting low concentrations of amino acids and fatty acids since they are indicative of life under the appropriate conditions. AREIL uses UAE to efficiently remove amino acids and all fatty acids (including short chain species) from either solid or liquid samples. The de-salted, concentrated analytes are concentrated on solid phase extraction materials at low temperatures and autonomously delivered to on board analytical instruments for characterization.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non-NASA uses of ARIEL include the processing of difficult to handle samples such as soils, minerals or food stuffs which can be either wet or dry solids. ARIEL can also process mixed (solid and liquid) samples such as dairy samples. The isolation and concentration of the target analytes allows for easier detection of species that may be present at very low concentrations.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.03-2143**

SUBTOPIC TITLE: Technologies for Passive Microwave Remote Sensing

PROPOSAL TITLE: Low-power 28GHz Selective Spectrometer

Small Business Concern

Firm: **Pacific Microchip Corporation**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Pacific Microchip Corp. proposes to design a 28GHz spectrometer ASIC which performs channelizing the signal's spectrum. The ASIC includes an 8-bit 56GS/s time-interleaved ADC coupled with a digital backend performing digital poly-phase filter function and parallelized Fast Fourier Transform (FFT). To achieve 28GHz signal bandwidth, we will apply a time-interleaved temporal ADC architecture with advanced minimization of the time-interleaving related parameter mismatches in subADCs. This is expected to result in significant reduction of unwanted artifacts in the output spectrum. The feasibility of implementation of the ADC based on a charge ramping quantizer was already proven within another SBIR project. Instead of overdesigning, when seeking to maximize the performance, the ADC will rely on comprehensive calibration of ADC parameters. On-chip phase locked loops (PLLs) will be used for clock synthesis. For convenient interfacing with field programmable gate arrays (FPGAs), the ASIC will include a high-speed JESD204B standard data interface. Phase I work will provide the proof of ASIC feasibility – critical blocks will be implemented and verified at targeted technology node. In Phase II, a silicon proven spectrometer ASIC will be fabricated and tested.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Spectrometer instruments based on the proposed ASIC are required for current and future space borne and airborne NASA's passive remote sensing missions for exploration of cosmic microwave background, Earth's surface and atmosphere. Specific missions include: A-SLMS, CAMEO, GACM, GeoSTAR, HyspIRI and GEO-CAPE. In addition, the proposed ASIC can find application in space and Earth based radio telescopes used for astronomy.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Spectrometers employed on satellites, aircraft and air balloons are required for remote sensing and surveillance. Environmental research requires spectrometers for space, airborne and ground based remote sensing instruments for temperature, water vapor, pollutant and ozone exploration. Thermal imaging in security systems is yet another area for application of the proposed ASIC.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A2.01-1708**

SUBTOPIC TITLE: Flight Test and Measurement Technologies

PROPOSAL TITLE: Ruggedized MEMS-VCSEL with high speed data acquisition for Fiber Optic Sensing System

Small Business Concern

Firm: **PRAEVIUM RESEARCH, INC.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 9
Technical Abstract (Limit 2000 characters, approximately 200 words):

This work will develop and validate a new wavelength swept laser for fiber optic sensing systems (FOSS). Existing FOSS technology uses external cavity tunable lasers, which are assembled from discrete components with precision intracavity laser alignments. This creates cost and complexity, inhibits volume scaling, and inhibits ruggedization. These factors have in turn inhibited widespread commercial adoption of FOSS in avionics applications and precluded embedding this technology into commercial flight vehicles for continuous in-flight structural health monitoring. Praevium will endeavor to solve these problems by building on its prior work done in developing micro-electromechanical systems tunable vertical cavity surface emitting lasers (MEMS-VCSELs) for swept source optical coherence tomography (SSOCT). Although FOSS employs optical frequency domain reflectometry (OFDR), which is similar to SSOCT, the much longer interferometer delays and much lower wavelength sweep rates employed in FOSS require the effects of Brownian motion on the MEMS actuator to be mitigated. In this work, Praevium Research will minimize the effects of Brownian motion through re-design of the MEMS actuator structure. Additionally, Praevium will develop a low weight and power ruggedized butterfly package based on newly emerging electrically pumped MEMS-VCSELs, eliminating costly and bulky components such as the pump laser, isolator, and wavelength division multiplexer needed in commercial optically pumped devices. Praevium will work with subcontractor Sensuron, who has expertise in FOSS to evaluate the newly developed laser. Sensuron will evaluate the Praevium MEMS-VCSEL in various interferometer configurations, and develop high speed data acquisition and computation to integrate the new laser into a fiber bragg grating based sensor measurement. Results will be compared with existing laser sources.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This work will develop a new cost-effective ruggedized laser technology that will accelerate proliferation of optical frequency domain reflectometry (OFDR) fiber optic sensing of physical parameters such as shape, deflection, temperature, and strain. This will impact the structural engineering and testing of cutting-edge structures and vehicles for land, air, water, and space. This laser technology can also be embedded into vehicles for continuous in-flight structural and health monitoring.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

This work will create a new 1550nm widely tunable laser source which provides continuous single mode tuning with low size, weight, and power dissipation in an economical package. This source has non-NASA applications in metrology and spectroscopy. Additionally, the technology developed here will enable fiber-optic shape sensing for medical applications.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.06-1161**

SUBTOPIC TITLE: In Situ Instruments/Technologies and Plume Sampling Systems for Ocean Worlds Life Detection

PROPOSAL TITLE: Microscope Using Super-resolution for Exploration (MUSE)

Small Business Concern

Firm: **Leiden Measurement Technology, LLC**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Leiden Measurement Technology (LMT) proposes to design and construct the Microscope Using Super-resolution for Exploration (MUSE), a compact luminescence microscope operating from the deep ultraviolet through visible (DUV-VIS) using structured illumination microscopy (SIM) techniques to achieve super-resolution imaging. MUSE will be the first-of-its-kind DUV-VIS SIM fluorescence microscope based on the ICEE-2-funded Europa Luminescence Microscope (ELM) microscope. It will retain ELM's ability to excite fluorescence at four different wavelengths, including the deep ultraviolet (DUV), enabling imaging of both native and stain-induced fluorescence. Further, MUSE will maintain a small form factor (95 mm x 95 mm cross-section) making it suitable for deployment on Ocean World Missions, including the Europa Lander, as well as future plume sampling missions where it will be a powerful tool for life-detection.

MUSE uses LEDs to illuminate a sample with up to four excitation wavelengths: 265nm, 370nm, 470nm, and 530nm allowing it to excite autofluorescence in samples (e.g., proteins, metabolites, minerals) as well as work with a variety of common molecular probes that could identify key biomarkers (e.g., fatty acids, phospholipid bilayers, membrane proteins, RNA/DNA).

Structured illumination microscopy is a well-established method of increasing the resolution of an optical system by up to a factor of two. MUSE will employ this technique for the first time in the DUV to make a very powerful fluorescence microscope capable of imaging structures with resolution better than 0.2μm, making it ideal for detecting and studying small cells or cell fragments.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

MUSE will be ideal for an Ocean Worlds mission. It meets the Europa Lander Science Definition Team requirements for the measurement of cells and other microstructures (down to 0.2μm) for their compositional and/or native autofluorescence properties. Indeed, MUSE is uniquely designed to excite autofluorescence in the DUV, work with multiple molecular probes indicative of structural composition, and, by using structured illumination microscopy, do it all with better than 0.2μm resolution.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

DUV transmission and fluorescence spectroscopy is a powerful tool for life science and medical research, particularly in the fields of histology and cell biology. Similarly, automated inspection of wafers and other sensitive devices could be greatly enhanced with DUV super-resolution microscopy

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.07-2110**

SUBTOPIC TITLE: Cryogenic Systems for Sensors and Detectors

PROPOSAL TITLE: Multi-Lift-Temperature Stirling Cryocooler and Controller for CubeSat Platform

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Our modular double-acting free-piston Stirling cryocooler features three separate cold head acceptors and heat rejection pathways and only one moving part per cold head. While our controller holds the piston amplitudes equal, the temperature presented to each acceptor may be different. Accordingly, the heat lifted by each acceptor can vary to meet load requirements.

Some CubeSat payloads require the cooling of multiple loads at different temperatures. While the Phase I SBIR solicitation does state “a miniature two-stage cryocooler would be ideal for this type of application,” we believe that our single-stage, multi-acceptor cryocooler, and controller potentially provide a simpler solution that is easily adaptable to various CubeSat missions.

Our preliminary estimates show that our proposed CubeSat cryocooler is competitive with existing single-stage “state-of-the-art” space-qualified units in terms of size, mass, and input

power. However, our cryocooler can simultaneously service multiple cooling loads at different temperatures.

The goal of this SBIR Phase I project is to complete the preliminary design for our CubeSat cryocooler and evaluate its multi-temperature performance as part of a simulated system, including a controller and vibration absorber.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Space-based Cryocooling - Our cryocooler can be used to produce cooling in the temperature range of 60 - 200 K. Lower operating temperatures are possible via staging (as is described in our U.S. patent). Cooling applications that require multiple lift temperatures may benefit from using our cryocooler instead of multiple single-stage cryocoolers. The scalability of our machines down to small sizes makes them valuable for miniature “CubeSat” satellite-based sensor cooling.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Cryocooling - Our modular Stirling cryocoolers can be arranged to place heat acceptor surfaces near or surrounding the heat source. This ability to cool a central load and reject heat at the periphery would be ideal for zero boil-off re-condensation of liquid nitrogen, volatile fuels, and other substances or cooling superconducting magnetic bearings in support of flywheel energy storage systems.
Duration: **6**

PROPOSAL NUMBER: 22-1- **H9.03-1333**

SUBTOPIC TITLE: Flight Dynamics and Navigation Technologies

PROPOSAL TITLE: Automated and Visually Interactive Navigation Analysis

Small Business Concern

Firm: **Continuum Space Systems, Inc.**
Address: **600 Playhouse Alley, Pasadena, CA 91101**
Phone: **(765) 464-4883**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Next-generation space missions feature a never-seen design and operational complexity that creates a critical need to perform mission design, navigation, and operation tasks in a modern and responsive environment. Currently, navigation tasks such as orbit determination and statistical maneuver design are a series of disconnected stakeholders, processes, software, and manual human tasks that result in time inefficiencies, high costs, and compound risks for mission success. This type of structure is poorly suited for collaborative activities that are becoming more and more prevalent given the increase of complexity of space missions.

The solution that we propose is to design and provide one ***unified environment for navigation analysis*** that integrates and **a**utomates state of the art NASA software to abstract the complexity and manual nature of these tasks into a collaborative environment, coupled with interactive and visual support to perform the remaining manual tasks. Navigation analysis is a key step in mission planning as analysts must assess trajectory robustness toward various error sources, including uncertainty in the launch state, mismodeling of the dynamics, as well as thruster execution and orbit determination errors. We propose to build a tool that (1) performs a navigation analysis given a reference trajectory by automatically determining the optimal number and the location of statistical maneuvers as well as the type and amount of tracking data needed, and (2) visualizes the data output in a user friendly, visual and interactive environment.

Continuum Space Systems is already building its cloud-based design platform, CTK, for space missions from ideation to completion, so far focused on flight dynamics. The proposed innovation will build upon Continuum's effort to expand the platform into an integrated mission design and navigation framework towards a fully unified design lifecycle and seamless transition to other key subsystems.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This innovation will directly empower all upcoming NASA flight missions, including concepts in development, as any mission that involves deep space navigation will face the challenges this innovation aims to alleviate. Specifically, the upcoming ARTEMIS missions to the Moon, including secondary hosted spacecraft as well as longer term plans for orbital stations, will benefit from this technology. The framework Continuum is developing will act as an agent for sustainable and safe space design and navigation in this challenging environment.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

There are increasing applications for this technology both in the public and private sectors. The cis-Lunar commercial space activity is booming and any venture attempting to reach Lunar orbit or its surface will face the challenges this innovation aims to alleviate. The United States Air Force and Space Force are sensitive to the critical nature of establishing a presence on the Moon.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H6.23-1603**

SUBTOPIC TITLE: Spacecraft Autonomous Agent Cognitive Architectures for Human Exploration

PROPOSAL TITLE: Co-Explore: Adaptive Goal-based Cognitive Architecture for Human

Small Business Concern

Firm: **Metron, Inc.**
Address: **1818 Library Street, Reston, VA 20190**
Phone: **(703) 787-8700**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Metron proposes to develop an adaptive and interactive cognitive system to address the technical challenge of providing onboard mission control decision support in deep space exploration missions where crewmembers must make crucial decisions in the absence of terrestrial mission control oversight. However, communications during deep space missions are challenging and impede mission monitoring and interactions with mission systems and personnel. Communication from ground control may take hours, or longer. We propose to build a modular and adaptive goal-based cognitive system with the understanding of spacecraft operations to provide effective mission management and control during periods of no or low communication.

Our innovative cognitive architecture fuses goal-driven autonomy with an adaptive computational representation of mission control expert-knowledge to generate and prioritize spacecraft operations, produce goals in response to these operations, and communicate crew tasks and objectives to accomplish the goals. This solution will schedule high-level functions normally performed by human operators, such as logistics management, payload management, maintenance, and personnel health. It employs a flexible, intuitive, and explainable knowledge representation and case-based reasoning that enables the introspection necessary for the crew to query task reasoning. Additionally, our cognitive architecture will employ active learning to adapt and improve over time by incorporating crew feedback and experience into its knowledge.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The cognitive solution we are developing would expand the operational envelope of NASA space environment research by providing effective decision support to deep space space habitats and spacecraft, potentially saving lives and infrastructure. Within NASA's projects this work would contribute to the Lunar Gateway or Artemis, as well as on space habitats on the Moon or Mars.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Minimally manned autonomous maritime vessels are an adjacent market for possible commercialization. There is a rise in demand for the transportation of cargo through water ways, which is less expensive for shipping goods as compared to road and air transits as by ships. Our cognitive system could provide efficient autonomous decision support to the skeleton crews onboard these vessels.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.01-1271**

SUBTOPIC TITLE: Advanced Air Traffic Management System Concepts

PROPOSAL TITLE: Decision Support for Reroute Impact and Analysis

Small Business Concern

Firm: **Metron, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 2
Technical Abstract (Limit 2000 characters, approximately 200 words):

We propose to design a data-driven decision support tool that quantifies and predicts the impacts of Playbook reroutes at the strategic level. This will improve the efficiency and throughput of the NAS. Our machine learning model will predict the net effects of US national reroutes in response to severe weather. This will enable faster, more accurate, and longer horizon predictions than traditional methods. Our model will form the core of a what-if analysis tool to enable air traffic managers to rank the Playbook reroute options by suitability and then understand the intended and unintended consequences of issuing such a reroute. The tool enables air traffic managers to take a strategic data-driven approach to choosing reroutes, thereby reducing disruptions to the national airspace. Currently, traffic managers lack data-driven analysis tools and instead rely on years of experience and personal preferences. Our team includes experts in traffic management, machine learning, and airspace data processing.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- Advances NASA ATM research to improve the efficiency and throughput of the NAS.
- Identifies new strategies for assessing quality of Playbook reroutes.
- Integration with NASA's Digital Information Platform (DIP) enables other analytic service providers and Trajectory Based Operations (TBO) algorithms to reason over our predictions.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- ANSP personnel will identify the net effects of traffic flows in response to proposed reroutes, severe weather, and subsequent reactions by local facilities, airlines, and pilots.
- Airlines will anticipate competitor behaviors in response to reroutes and can adjust their operations accordingly.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.02-1694**

SUBTOPIC TITLE: Increasing Autonomy in the National Airspace System (NAS)

PROPOSAL TITLE: Contingency Planning Toolkit for Advanced Air Mobility

Small Business Concern

Firm: **Mosaic ATM, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA's Urban Air Mobility (UAM) and Uncrewed Aircraft System (UAS) Traffic Management (UTM) concepts envision increasing autonomy, artificial intelligence, and machine learning to maintain operational efficiency while ensuring safety. Increasing autonomy while maintaining or improving efficiency and safety will require effective teaming between humans and automation in routine and contingency operations. Concepts for highly automated future air transportation, like UAM and UTM, describe procedures for addressing contingencies, implicitly assuming automated services will be able to coordinate well enough to address contingencies, with little or no human input, if procedures are pre-defined. However, if traditional air traffic operations are to be a guide, humans will need to be involved in coordinated contingency planning for UAM/UTM operations.

To address the need for coordinated contingency planning in UAM/UTM, we propose a ***Contingency Planning Toolkit for Advanced Air Mobility (CPT AAMO),*** whose architecture appropriately distributes work among system organizations and agents (human and automated).

Its design is based on a ***systematic analysis of potential allocations*** of contingency planning functions. The analysis is not just about allocating functions between humans and automation, but also the allocation of responsibilities across organizations in the system. Metrics include function allocation coherency, operational tempo, and coordination load. The analysis enables us to assess each candidate architecture according to system properties like safety, resilience, equity, integration, and resistance to cyber-attack. Our approach allows NASA to move beyond function allocation to task design, providing a systematic assessment of what will and will not work as a procedure/task. This effort ***fills a gap in AAM concept development***, providing appropriate architectures and function allocations for contingency planning in a highly automated system.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- Support validation of contingency planning roles, responsibilities, and procedures for Advanced Air Mobility (AAM) concepts in tabletop, simulation, and field evaluations.
- Refine requirements for AAM participants to meet standards of participation
- Toolkit for performing contingency planning functions in a distributed work system

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- Toolkit for Urban Air Mobility (UAM) and Uncrewed Aircraft System (UAS) Traffic Management (UTM) fleet operators, Providers of Services to Urban Air Mobility (PSUs), and UAS Service Suppliers (USSs) to participate in coordinated contingency planning and contingency management
- Capability to support FAA participation in coordinated contingency management for UAM and UTM operations.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.03-2646**

SUBTOPIC TITLE: Guidance, Navigation, and Control

PROPOSAL TITLE: Optical Telescope Pointing Milli-Arcsecond Control System

Small Business Concern

Firm: **Relative Dynamics, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The key innovations in OTP MACS are:

1. Integrated data-driven control algorithms for improving performance and disturbance rejection
2. Low Size, Weight, Power, and Cost (SWaP-C) - new configuration with Koester prism sensor and nanometer actuators:
    - 1 milli-arcsecond (5 nanoradian) angle sensor. Modified arrangement of Hubble Space Telescope fine guidance sensor provides much higher resolution.
    - Nanometer precision ultra-high-vacuum compatible piezo-electric-transducer (PZT) actuators with nanometer resolution position encoder.
3. Moving guide star testbed for large telescope image stabilization.
4. Use sensor fusion with combined fast-steering-mirror and PZT actuators with hierarchical control loop algorithms for image stabilization

The OTP MACS innovations described above addresses several critical gaps defined in the subtopic description:

- OTP MACS uses highly integrated, low-power, low-weight, radiation-hard component sensor technologies, and multifunctional components.
- OTP MACS uses sensor fusion with robust sensing and control algorithms.

The main sources of spacecraft disturbances are mechanical vibrations, sensor, and actuator noises, as well as slew residuals. The most critical disturbance is the jitter. A key idea is to use integrated data-driven feedback control algorithms to reject the repetitive and periodic disturbances. We will use two modeling approaches. The first approach is based on the first principles modeling paradigm and COMSOL Multiphysics software. The second approach is based on data-driven modeling paradigm and system identification techniques. The performance of the used techniques will be tested on the experimental setup. In the laboratory experiment, representative disturbance spectra and stochastic models on a computer will be transferred to a moving guide star simulator. The control algorithm fuses the information from two sensors to two actuators to provide milli-arcsecond image stabilization.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Our RDI proposed OTP MACS innovations will enable large telescope image stabilization (e.g., LUVOIR) and other high-precision optical instrument platforms (e.g., LISA and GRACE-2). High-precision pointing control is also important for long-distance optical communication systems. The data-driven, feed-forward, and stochastic control algorithms can be applied to a class of spacecraft control problems. Similarly, the low-cost Koester prism sensor and nano-precision actuators can be used for low-cost fine guidance of small spacecraft.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Our RDI proposed OTP MACS innovations will enable similar platform stabilization for commercial satellites. Precision fused sensors and the associated control algorithms are important for robotic assembly, autonomous driving, unmanned aerial vehicles, missile munitions, and many other applications. These innovations benefit all industries that rely on precision metrology for absolute measurements.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.08-1912**

SUBTOPIC TITLE: Atomic Quantum Sensor and Clocks

PROPOSAL TITLE: A very simple set of auxiliary lasers for a deployable strontium ion clock

Small Business Concern

Firm: **Stable Laser Systems, Inc.**
Address: **4946 63rd Street, Boulder, CO 80301**
Phone: **(303) 542-0427**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

A very compact, very simple set of auxiliary (repumper, clear-out and cooling) light sources for the operation of a mobile strontium ion clock is proposed. The proposed repumper and clear-out sources will operate without the need for any stabilization and will be based on mature laser technologies. The cooling laser will be stabilized to a rubidium cell and will be built in a compact, uniform package.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Precision time-keeping

Frequency references

Deep space navigation

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Optical frequency references

Optical clocks

Duration: **6**

PROPOSAL NUMBER: 22-1- **S17.04-1586**

SUBTOPIC TITLE: Application of Artificial Intelligence for Science Modeling and Instrumentation

PROPOSAL TITLE: Predicting 3D atmospheric structure from geostationary satellites

Small Business Concern

Firm: **GeoLens LLC**
Address: **19 Buena Vista Road, Arlington, MA 02476**
Phone: **(978) 314-4847**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

3D atmospheric wind is a key missing observable in NASA's Earth Observation System (EOS) and presents large initial condition uncertainties in data assimilation systems. Atmospheric motion vectors (AMVs), which track cloud/water vapor movement and assign a height, provide key passively sensed initial condition information for numerical weather prediction. However, data produced by current operational AMV algorithms are sparsely available and contain high uncertainties in the vertical direction. Comparison with radiosonde profiles indicates that AMV height assignment errors comprise 70% of uncertainty. Our work aims to fill EOS gaps by learning a mapping between high-temporal resolution GOES-16/17 geostationary satellites operated by NOAA/NASA and radiosonde observations. We use our WindFlow model that applies deep learning based optical flow techniques to track clouds and water vapor in sequences of geostationary images to produce direction and speed data. WindFlow provides an efficient approach to generate dense and accurate wind vectors. Outputs of WindFlow, paired with thermal infrared imagery, provides information content to directly predict wind speed, humidity, and temperature at varying pressure levels. This proposal aims to generate a 3D atmospheric product from geostationary satellites validated against radiosondes and lidar observations.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Applications of 3D atmospheric winds are numerous throughout NASA Earth science research and development. Assimilation of our data with systems operated at the NASA's Global Modeling and Assimilation Office (GMAO) has the potential to improve analysis and forecast products, including short-term and sub-seasonal. Dense atmospheric winds will also have implications to wildfire monitoring and subsequent air quality issues.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercially the developed technology has applications to aviation, renewable energy, finance/insurance, and forecasting. In aviation, surface level and atmospheric winds have great economic value to airlines in terms of safety and potential operating cost savings. Renewable energy markets are largely powered by weather conditions and must be estimated for stable operation of the power grid.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z7.04-2586**

SUBTOPIC TITLE: Landing Systems Technologies

PROPOSAL TITLE: Reconfigurable Plenoptic Objective for Snapshot Multimodal Flow Diagnostics

Small Business Concern

Firm: **Nanohmics, Inc.**
Address: **6201 East Oltorf Street, Suite 400, Austin, TX 78741**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Obtaining detailed flow measurements during a realistic hot-fire experiment is of the upmost importance for characterizing the complicated flow physics that occur during plume-surface interactions, and for providing high-fidelity data to the modeling community for code validation. The proposed research program will help close the information gap by advancing state-of-the-art optical techniques for measuring high-speed, high-temperature, chemically reacting plumes under full-scale test conditions. Nanohmics, Inc., working in partnership with the Stevens Institute of Technology, proposes to develop and demonstrate a modular imaging system for performing non-intrusive, time-resolved flow measurements for PSI test environments. The proposed system will include a reconfigurable plenoptic objective (i.e., photographic lens) that will convert a standard high-performance camera into a multispectral high dynamic range polarimetric imaging system. Customizations afforded by the plenoptic objective will allow end-users to configure the system for different quantities of interest by trading spatial resolution for dynamic range, spectral content, or polarimetric information. The system will include a set of standard configurations and post-processing algorithms to provide turn-key measurement capabilities for hot-fire plumes of propellants commonly used in Lunar and Mars landers (e.g., LOX/H2, LOX/LCH4, and hypergolic propellants), and include functionality for generating quantities of interest for comparison with computational fluid dynamics models. Low-cost implementations of the plenoptic objective will be scalable across a wide range of reduced- and

full-scale ground test environment and systems, and may be used as a new standalone measurement system or as a component upgrade to existing measurement systems.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA's MSFC and LaRC are a good initial market for the technology as there is already a heavy concentration of ground testing for lunar and Mars landers in support of NASA's Space Technology Mission Directorate (STMP) Game Changing Development (GCD) Plume-Surface Interaction (PSI) project. These and other NASA laboratories developing lunar lander technologies in support of NASA's Artemis and Human Landing System (HLS) programs will also benefit from improved PSI diagnostics for ground tests.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Improved PSI ground testing and model validation for commercial lunar lander developed in support of NASA's HLS and Commercial Lunar Payload Services (CLPS) programs. Landing site optimization for terrestrial space launch service providers using reusable rockets. General snapshot multispectral, high dynamic range, and polarimetric imaging for scientific, industrial, and defense applications.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z1.06-1533**

SUBTOPIC TITLE: Radiation-Tolerant High-Voltage, High-Power Electronics

PROPOSAL TITLE: Radiation-Tolerant High-Voltage GaN Devices for Space Power Applications

Small Business Concern

Firm: **CFD Research Corporation**
Address: **6820 Moquin Drive NorthWest, Huntsville, AL 35806**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Power electronic components with high operating voltages are desirable in NASA Power Management and Distribution (PMAD) systems as they result in reduced mass and higher efficiency at the system level. Gallium nitride (GaN) offers significant advantages over state-of-the-art silicon (Si) technologies for power electronic applications including higher breakdown voltage and power density, faster switching, and lower switching losses. High-voltage (HV) enhancement mode GaN-on-Sapphire multi-channel lateral Schottky barrier diode (SBD) technology has recently been demonstrated up to 10 kV breakdown voltage (BV), the highest in GaN devices till date. This GaN device technology is scalable for voltage. Other commercial GaN power device technologies are known to show heavy-ion induced radiation susceptibility with leakage and catastrophic damage seen well below their rated voltages. A thorough investigation of the heavy-ion response of this emerging, HV GaN SBDs and underlying mechanisms is essential to developing radiation tolerant devices for space applications. We propose to use an integrated experimental and physics-based modeling approach to address this challenge. In Phase I, we will perform heavy-ion testing of the HV GaN SBDs to generate radiation response data. Detailed TCAD modeling of heavy-ion induced single-event effects (SEEs) will be performed for the SBD structures to investigate physical mechanisms driving the observed radiation response. In Phase II, we will perform additional heavy-ion and total dose testing as a function of temperature and bias. Extensive TCAD-based modeling will be performed to determine radiation and temperature-dependent physical mechanisms, and to investigate device design changes for improved radiation tolerance. Promising solutions will be prototyped and characterized via electrical and radiation testing. Participation by a commercial vendor of GaN devices in Phase II and beyond will ensure space qualified GaN power diodes.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Radiation tolerant, high voltage/high temperature GaN power electronics is an enabling technology for power management and distribution in spacecrafts and scientific instruments. It directly supports NASA goals for Lunar and Planetary Surface PMAD and the Kilopower program. It also benefits Remote Sensing Instruments and Sensors related to NASA Science and Exploration missions. The modeling and analysis tools for electronic qualification will be a Cross-Cutting Technology for all NASA missions requiring high voltage power electronics.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Radiation tolerant GaN power electronics are applicable in DoD space systems (communication, surveillance, missile defense), commercial satellites, and nuclear power systems. High-voltage/high-temperature tolerant GaN power devices have applications in power conditioning systems (avionics and electric ships), solid-state drivers for heavy electric motors, PMAD and control electronics.
Duration: **6**

PROPOSAL NUMBER: 22-1- **H9.07-1564**

SUBTOPIC TITLE: Cognitive Communication

PROPOSAL TITLE: Configuration, Optimization and Management of DTN via Artificially Intelligent Decentralized Systems (COMMANDS)

Small Business Concern

Firm: **EpiSys Science, Inc.**
Address: **13025 Danielson Street, Suite 106, Poway, CA 92064**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

We propose **C**onfiguration, **O**ptimization and **M**anage**m**ent of DTN via **A**rtificially **In**telligent **D**ecentralized **S**ystems (COMMANDS). COMMANDS offers a decentralized AI-based solution to configure, optimize and manage communications for NASA's lunar networks. It will provide significant improvements in throughput, end-to-end latency, overhead and resource consumption in delay/disruption tolerant networks (DTN) backed by our previous NASA's SBIR program, LEARN. COMMANDS is based on our tactical AI design and builds a multi-agent deep reinforcement learning (MADRL) framework that enables the lunar network to sense, adapt, act and learn from its experiences and unknown environment autonomously. This automates and optimizes mission operation and resource efficiencies without necessitating involvement from a mission operations team. We propose to deploy graph-based machine learning that enables neural comprehension of all available network parameters and conditions into a node embedding. Next, our tactical AI uses a hybrid approach to combine expert systems and AI to bring robustness and intuition designs.

COMMANDS extends our Python-based simulation of DTN Lunar communication for the training, testing, verification. We further use the CORE network emulation tool to demonstrate

the validation and performance gains of the COMMANDS as a novel network traffic management software service.

We propose an alternative approach for training graph neural network (GNN)-based design. To efficiently train GNN, first, we find the centralized solution to the network routing, resource allocation and control, bundle scheduling and fragmentation. The centralized solution will be formulated as mixed-integer linear programming (MILP). We propose to solve neural combinatorial optimization (NCO) to solve this centralized problem. The outcome is a centralized solution, which will help us in the design of a decentralized GNN-based solution.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

COMMANDS technologies, when fully developed and demonstrated, will offer commercially viable, cost-effective delay-tolerant networking solutions to deploy intelligent overlay network solutions over commercial communication services for future space missions, such as Artemis. In addition, they will substantially reduce the operational complexity for mission engineers by automating, with high confidence, various tasks of planning, scheduling and managing communication resources across multiple heterogeneous networking assets.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Space-based broadband internet services such as Starlink and Amazon Kuiper demand terrestrial-grade service quality despite many spacecraft participating in data forwarding. We expect our AI-based DTN technology to further advance such systems by seamlessly allowing the addition of new communication assets, e.g. unmanned aerial systems, to quickly adapt to varying user demands with little planning

Duration: **6**

PROPOSAL NUMBER: 22-1- **S12.03-1490**

SUBTOPIC TITLE: Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical and Infrared Telescope

PROPOSAL TITLE: Low Viscosity, High Strength Adhesive Materials with Low CTE

Small Business Concern

Firm: **Nanosonic, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

NanoSonic shall develop and demonstrate a novel low viscosity, UV curable adhesive that will possess high strength, high glass transition temperatures (Tg), and low coefficient of thermal expansion (CTE) for precise bonding. NanoSonic will validate the proposed cycloaliphatic epoxy silane adhesive material that is molecularly engineered for rapid, near room temperature photocuring and display low shrinkage during cure for precision alignment of Zerodur® and related low CTE ceramics for construction of telescopes. The proposed HybridSil low CTE epoxy silane adhesive will be molecularly tailored and formulated to possess the following properties: shear strength >4,000 psi; tensile strength >6,300 psi; glass transition >60 °C with near-room-temperature cure; viscosity ~12 Poise; and low outgassing. NanoSonic will develop low viscosity, crosslinked hybrid organic – inorganic UV cured epoxy adhesives that are molecularly engineered for exceptional adhesion to low CTE ceramics without high temperature processing, which may damage and cause stress increases leading to cracking. The silane crosslinking reactions can be used to introduction inorganic silicate nanoparticles in situ to modify the CTE, possibly eliminating the need for the typical high filler loading approach. The proposed HybridSil UV curable epoxy silane adhesive shall be engineered to rapidly set in minutes to afford submicron precision alignment of a telescope without prolonged support of placement equipment. The developed adhesive material shall be characterized for its chemical, thermal, and mechanical properties via real-time FTIR, rheometry, DSC, DMA, TMA, and Instron load frame.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA needs low viscosity, UV curable adhesives with high strength, high glass transition temperatures and low coefficient of thermal expansion for precise bonding of Laser Interferometer Space Antenna (LISA) and other stable structure applications. These UV curable adhesives are used as potting and encapsulant materials in electronics.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Aliphatic UV curable materials are used as wood finishings, adhesives, UV stable coatings, automotive protectant coatings, optical fibers coatings and cable jackets. Epoxy adhesive and resins with low CTE properties are used widely in optical and electrical components.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.04-1233**

SUBTOPIC TITLE: Nontraditional Airspace Operations and Aerial Wildfire Response

PROPOSAL TITLE: MRFEE - Self Organizing Ad-Hoc Air Traffic Control Radar

Small Business Concern

Firm: **WinterWinds Robotics**
Address: **1910 Pike Road, Suite A, Longmont, CO 80501**
Phone: **(970) 632-1890**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

MRFEE is a hyper-portable air traffic control (ATC)-Radar System that can be established in an area, self-organize, and be automatically mobilized where fire suppression efforts are most likely to require aerial support. This is accomplished through a combination of the fusing of several IC based technologies, all of which are relatively low power (can be battery powered) and available as a low SWaP component.

By combining these technologies with purpose built algorithms to localize both authorized aerial assets as well as unauthorized assets, the following issues can be addressed:

1. Not all aerial assets in the airspace are controlled, and unplanned drones have forced aerial assets to shut down during critical operations in at least 100 known cases. Any ATC system needs to be able to operate even if "undesired or uncontrolled" assets are operating. We cannot assume that all assets are tracked, or that onboard sensors alone will ensure safe operations.

2. Onboard sensors on the SUAS that are authorized to operate can be communicated with UTM but are a single point of failure (in case of loss of communication) and only account for systems under the control of the incident command group. This also requires full integration of any system in use with UTM, which can limit flexibility significantly in which assets can be used and under what conditions.

3. Any system used for the localization of aerial assets in a systematic way must be lightweight, portable, and be easy to power and use as wildfires move extremely quickly, and the location of the system must be considered to be semi-mobile to fully mobile.

4.

MRFEE is a particularly important concept because the enablement of wildfire response can reduce the impact that wildfires have on the burgeoning climate crisis, wildfire response staffing shortages, and the billions of dollars of property loss each year, particularly in western states.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This is intedned to be a direct extension of NASA's UTM, and STEReO systems and would be extremely useful in that capacity. In general this technology would be an ideal way to coordinate mobile resources wherever a lack of steady infrastructure is available, such as during early lunar and martian operations. The MRFEE system can just as easily coordinate ground assets as well as aerial assets.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The most immediate use for such a system, specialized as it is towards supporting aerial wildifire response, will largely be used in that capacity initially. There are several

relevant “customers” for such as system including but not limited to the National Interagency Fire Administration (NIFA), United States Forest Service, as well as significant State Wildfire departments.
Duration: **6**

PROPOSAL NUMBER: 22-1- **A2.02-2461**

SUBTOPIC TITLE: Enabling Aircraft Autonomy

PROPOSAL TITLE: Resilient Autonomous Flight Systems using Sensor Fusion and Enhanced Emergency Operations

Small Business Concern

Firm: **Avilution, LLC**
Address: **115 Houston Goodson Way SouthWest, Huntsville, AL 35824**
Phone: **(256) 694-4569**

Principal Investigator:

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Phone: **(256) 694-4569**

Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

There is an increased need for autonomy in aircraft for tasks that are dangerous or not well suited to human pilots. These tasks are generally long duration, repetitive, highly precise, or

require high speed response. All of these tasks are well suited to computer automation but current autonomous systems struggle to perform without human oversight and intervention, especially in off-nominal conditions.

Avilution proposes to solve this problem by providing resilient sensor fusion using its eXtensible Flight System (XFS) modular avionics software framework and high level decision capability through the X-Avionics' Xavion application. XFS is a commercially available product that enables the rapid integration of disparate sensors and components into an integrated system. Avilution will expand upon this foundational capability by providing synthetic airspeed to data consumers that is derived using disparate sensors. Additionally, Xavion has an emergency glide path functionality that currently provides a pilot with an optimal route to a safe landing in the event of an engine failure. In this proposed effort, Avilution will combine the data aggregation and sensor fusion capabilities of XFS with the emergency glide path routing of Xavion into a robust system for autonomous aircraft.

The ultimate goal of this proposed effort is to increase both the reliability of autonomous aircraft systems and their high level decision capabilities. This technology will allow autonomous vehicles to better respond to abnormal conditions and increase overall system survivability. Avilution intends to market this technology for use on both manned and unmanned aircraft with applications for both commercial and DoD customers.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA has an increasing fleet of autonomous vehicles including the Global Hawk, Predator and Tiger Shark. These types of vehicles all have the potential to benefit from the improved fault tolerance and survivability of sensor fusion and the autonomous landing capabilities of Xavion to help preserve the vehicles, life, and property in the event of an engine failure.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

This technology, delivered as software on Avilution's XFS platform, can assist across the spectrum of automation of aircraft including both piloted vehicles and fully autonomous aircraft. The sensor fusion can improve data both for pilot displays and autonomous systems, while the landing assistance can provide guidance during emergency situations.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z8.13-1205**

SUBTOPIC TITLE: Space Debris Prevention for Small Spacecraft

PROPOSAL TITLE: Quick Turn Pulsed Plasma Thruster (QT-PPT) for Deorbiting Applications

Small Business Concern

Firm: **CU Aerospace, LLC**
Address: **3001 Newmark Drive, Champaign, IL 61822**

Phone: **(217) 239-1703**

Principal Investigator:

Name: **Curtis Woodruff**
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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

CU Aerospace (CUA) proposes the development of the Quick Turn Pulsed Plasma Thruster (QT-PPT) with 2400s specific impulse that will provide CubeSat deorbit capability at end-of-life for LEO missions. While classic PPT technology is mature, it has historically been limited by its size and propellant load. CUA developed the Fiber-fed PPT (FPPT) and developed miniaturized several electronics subsystems including high-density energy storage via MLCC capacitors (life tested), low erosion discharge geometry, regenerative carbon igniters with negligible erosion, compact power electronics, and electromagnetic thrust vectoring. QT-PPT seeks to further the miniaturization of the subsystems, but with a 70g Teflon disc (no fiber). In this Phase I, CUA will leverage the technology improvements from FPPT to build a more accessible QT-PPT system with lower size, weight, power, and cost (SWaP-C). The entire system including PPU is tightly integrated onto a stack of PCBs approximately 0.5U in size which offloads most of the manufacturing and quality control to the specialized PCB manufacturer, and enables the “Quick Turn” PPT system integrated by CUA. The proposed technology is estimated to have a specific impulse of 2400s and a total impulse of 1640N-s, enough to lower a 5 kg CubeSat from 1000 km to 400 km. The total impulse can be increased with additional volume and fuel loading if desired for deorbiting larger CubeSats. CUA’s thrust vectoring technology is slated for integration into the system during the Phase II effort, relieving requirements for separate attitude control systems that may be difficult for small missions to meet. CUA’s long term goal will be to establish the QT-PPT as a mature integrated system solution with standard lead times under 6 weeks. One QT-PPT will be delivered to NASA at the end of the Phase II program.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The practice of responsible space and deorbit capability of LEO satellites is critical for the prevention of an escalation of space debris. With an anticipated 1640N-s total impulse from a 0.5U QT-PPT system, deorbit from 1000 km is possible at end-of-life with only power and

attitude determination available from a CubeSat to guide the thrust-vectored propulsion system (no reaction wheels or magnetorquers required). Unlike drag-based deorbit systems, QT-PPT also provides an “as needed” collision avoidance option for the entire mission.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial interest in nano-/small-satellites continues to grow, and it is more important than ever that these satellites have access to a technology for end-of-life deorbiting. The QT-PPT provides a compact, light-weight, non-hazardous, high total impulse propulsion technology solution available in a family of sizes to meet the differing mission needs of users in DOD/industry/academia.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z10.04-2369**

SUBTOPIC TITLE: Materials, Processes, and Technologies for Advancing In-Space Electric Propulsion Thrusters

PROPOSAL TITLE: Improved Thermo-Mechanical Design of the VASIMR RF Coupler

Small Business Concern

Firm: **Ad Astra Rocket Company**
Address: **141 West Bay Area Boulevard, Webster, TX 77598**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Ad Astra Rocket Company proposes a novel method of manufacturing a VASIMR® coupler. This method intends to increase the surface area in contact between the actively cooled coupler and the plasma facing GCT resulting in a lower heat flux between the components, lower temperature on the GCT, higher operational temperature margin, and ultimately a higher steady-state operational power limit of 100 kW for the VX-200SS™ prototype. This innovation is anticipated to increase the contact surface area by a factor of 3 and lower the temperature of the full-scale Ion Cyclotron Heating (ICH) GCT by roughly 40%. This manufacturing method will first be applied to a small-scale coupler assembly that will then have its thermal performance experimentally verified and compared to a traditionally-manufactured small-scale coupler assembly. At the completion of the Phase I work, Ad Astra will provide a small-scale prototype demonstrating the viability of the manufacturing method and a report that contains experimental data, simulation results, analysis, predicted thermal performance of the full-scale ICH coupler assembly, and a design/test plan for thruster-level integration and demonstration to be implemented in Phase II.

This maturation of the VASIMR® engine will move it closer to commercialization. The VASIMR® engine is a high-power electric propulsion system approaching TRL 5. Past prototypes have exceeded many key performance parameters detailed in the National Academies' "Space Nuclear Propulsion for Human Mars Exploration" 2021 report and are anticipated to exceed them all. The VX-200 VASIMR® prototype operated at 200 kW of electrical power at 72% efficiency and a specific impulse of 4,900 seconds. VASIMR® engines can use many propellants including argon and krypton. The TC-1Q first flight unit is expected to operate at 150 kW electrical power, readily be clustered to exceed 1 MW, have a specific mass of 4 kg/kWe, and have an operation lifetime of 10 years.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Cislunar cargo transfer, space debris removal, Mars mission (cargo, crew), deep space uncrewed missions, asteroid mining/deflection

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

High-maneuverability satellites, in-space manufacturing logistics, lunar settlement cargo delivery, private space station positioning

Duration: **5**

PROPOSAL NUMBER: 22-1- **Z8.09-1430**

SUBTOPIC TITLE: Small Spacecraft Transfer Stage Development

PROPOSAL TITLE: Small Spacecraft Transfer-stage Aluminized Rocket (Small STAR)

Small Business Concern

Firm: **Exquadrum, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 6

Technical Abstract (Limit 2000 characters, approximately 200 words):

During the proposed Phase II research and development effort, the project team will integrate previously demonstrated technologies into a low-cost transfer stage based on a high energy density, aluminized, green monopropellant. The resulting stage will achieve the Mass Fraction and Specific Impulse performance needed to send small-spacecraft payloads in the near term to the cislunar environment, with longer term potential for farther destinations such as near-Earth objects, Mars, or Venus. The stage will be designed to provide support services to the spacecraft post-deployment, such as communications relay or positioning, navigation, and timing (PNT) services. The Phase I program will conclude with a hot-fire demonstration of the propulsion system.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Small spacecraft transfer stage/upper stage propulsion systems for Small Launch Vehicles

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Low cost space lift, exploration missions to the moon and Mars

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.01-1525**

SUBTOPIC TITLE: Aeroelasticity and Aeroservoelastic Control

PROPOSAL TITLE: Configurable Parametric Aeroservoelastic Reduced-order Models for Aerostructural Sensing and Control

Small Business Concern

Firm: **CFD Research Corporation**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The goal of the proposed effort is to develop a framework for configurable reduced-order modeling (ROM) for the development of novel aeroservoelastic (ASE) sensing and control approaches within a broad flight parameter space. Parametric ROM techniques developed by the proposing teams present a considerable opportunity to extract dominant aerodynamic and structural dynamics in a compact form that can be used to evaluate and optimize controllers for suppression of flutter and gust loads. This Phase I effort is focused on facilitating ROM technology adoption by ASE control engineers in NASA by providing (1) ROM techniques cast within a genetic algorithm and superposable platform for automated development of configurable, state-consistent ROMs and (2) the ability to apply the configurable ROMs for design and evaluation of aerostructural controllers. These components will be integrated within a modular software framework to streamline the entire workflow and efficiently transition from the model reduction to control synthesis. In Phase I, the feasibility of the proposed technology will be demonstrated for ASE problems of NASA interest (e.g., suppression of gust response and

flutter). The Phase II efforts will focus on: (1) optimization of the ROM and control synthesis modules in terms of execution efficiency, robustness, and autonomy; (2) further process automation and exact input/output formatting for direct integration of the framework into NASA's controller development workflow; and (3) extensive software validation and demonstration for ASE and flight control design of realistic aircraft of current interest to NASA

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This research will deliver NASA a valuable tool to automate ASE ROM and control synthesis; design advanced aerostructural controllers; and perform real-time ASE simulation; and will markedly improve the process for considering aeroelasticity in controller development through rapid predictions of gust loads, ride quality, and stability and control issues. It will significantly decrease simulation validation and workflow lag time, reduce development costs and time. NASA projects like MUTT, MADCAT, and QueSST will benefit from the technology

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The non-NASA applications are vast, and will focus on aerospace, aircraft, and watercraft engineering for fluid-structural interaction and fatigue analysis, control and optimization, hardware-in-the-loop simulation, and others. The proposed development will provide a powerful tool which can be used for fault diagnostics, optimized design, simulation and experiment design and planning, and more.
Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.02-1965**

SUBTOPIC TITLE: Spacecraft Technology for Sample Return Missions

PROPOSAL TITLE: High-Capability Hybrid Rocket Motor with Novel Restartable Ignition System for Sample Return Missions

Small Business Concern

Firm: **Eos Energetics Inc**
Address: **1295 H Street, Penrose, CO 81240**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Estes Energetics and Utah State University will partner together to develop a hybrid rocket motor for the next generation of sample return missions. This system will incorporate several unique technologies that provide the performance and reliability needed for a sample return propulsion system, including a high-capability electric ignition system; an efficient, safe, and high-performance oxidizer; and 3D printed fuel grains.

The patented electric ignition system utilizes recently discovered unique properties of some 3D printed materials whereby electricity applied to the material carves an "arc-track" through the layered material. The associated Joule-heating pyrolyzes fuel, and as oxidizing flow is introduced, ignition spontaneously occurs. This property is being developed into a power-efficient system, that can reliably cold-start and restart hybrid rocket motors. The resulting system is radically simpler and allows for a large number of motor restarts without the complexity or danger of an ignition train containing energetic materials.

Novel Nytrox oxidizer has the volumetric efficiency of nitrous oxide without its decomposition dangers. It can be stored for long-term missions and has been demonstrated to have a specific impulse greater than 300 s.

3D printed fuel grains enable a large variation in geometry, that in turn enables optimization of the thrust profile when combined with the deep throttle capability of our hybrid. For sample return, the thrust can be optimized for a high launch thrust followed by an efficient cruise phase thrust. Multiple restart capability further optimizes the thrust profile.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Our additively manufactured hybrid motor technology is highly applicable to NASA sample return missions requiring reliable, restartable, controllable, and efficient propulsion systems. If developed successfully it will not only serve as a point solution for these “high gear ratio” applications, but also an ideation point or market stimulus to encourage a greater number of these missions once the technology has been proven successful and costs continue to fall as development is completed.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

This hybrid motor technology solves weight and volume challenges in propulsion system while also improving control and restart capabilities. This includes satellite maneuvering, de-orbit propulsion, defense applications such as the upper stage of missile defense interceptors, and any applications where a traditionally energetic material fuel source poses safety issues.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z8.10-2256**

SUBTOPIC TITLE: Modular Systems for Cost-Effective Spacecraft Missions

PROPOSAL TITLE: Plug-and-Play Modularity for Satellite Manufacturing

Small Business Concern

Firm: **SPACE PRODUCTS AND INNOV.**
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Phone: **(505) 317-2908**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Our company, SPIN, is taking a unique approach to plug and play satellites. Rather than imposing a standard to design to, we have developed a universal adapter to rapidly connect and integrate subsystems with disparate hardware and software interfaces. This adapter is called the Multipurpose Adapter Generic Interface Connector (MA61C). Our approach is to provide an adapter based on hardware and software that is compatible with the wide variety of hardware and software interfaces used in the industry. We have adapter (hardware) modules that are suitable from CubeSat-class up through large satellites, as well as for use as ground support equipment, that provide a full suite of hardware and software interfaces. Software drivers are included that are compatible with many satellite subsystems (currently, about 80% of small satellite subsystem vendors).

In conventional small satellite assembly and integration, there are many point-to-point connections, with most data interfaces routing back to the central flight computer and most power connections routing back to the central power system. Whereas by utilizing MAG1C, much more modular integration is enabled, with MA61C providing all necessary data routing and providing plug and play capability.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The MA61C adapter provides interchangeable HW and SW with standardized interfaces. It enables spacecraft to be built up with a plug-and-play convenience with components that are otherwise not supportive of plug and play by utilizing data analysis . The MA61C device has a Command and Control system that allows localized verification of the devices, greatly reducing the time and complexity of manufacturing. The MA61C adapter turns existing satellites into modular systems that can be altered rapidly to meet shifting objectives and risks.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

MA61C reduces integration time and enables late-stage HW swaps. It also accelerates innovation and eases testing of new technologies and satellite configurations. The MA61C universal adapter will increase the options available to satellite integrators in terms of components they can use. This will increase competition among component manufacturers, driving innovation and reducing costs.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.04-1460**

SUBTOPIC TITLE: Nontraditional Airspace Operations and Aerial Wildfire Response

PROPOSAL TITLE: A Toolkit for UAM Communications Management

Small Business Concern

Firm: **Mosaic ATM, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Our proposed innovation is a two-component system that, combined, constitutes our Toolkit for UAM Communications Management, or TUCM. The first component represents a deep dive into computing the path loss (or equivalently, the signal strength) for AAM flights given the link distance, carrier frequency, surface reflection coefficient, and relative path loss difference between a line-of-sight wave and a multipath wave. Our proposed path loss prediction tool is a machine learning (ML) model that is trained using data from ray tracing software. This first component builds on work that Mosaic ATM has already completed regarding path loss estimation in a UTM environment; the innovation here is to extend it to a higher-altitude UAM environment.

The second component of TUCM is a blueprint that will help the wider aviation community collaboratively develop and mature the architecture of a robust UAM/AAM communications infrastructure. This more general, but comprehensive, view will be useful from UML-4 through UML-6. We envision that such a system would provide ground communication, air-to-air communication, and satellite communication. The combination of these technologies will ensure continuous coverage and robust reconfiguration if the communication link is severed, for example, by providing an ad hoc airborne network that can be rapidly reconfigured.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA can use the tool as part of its ongoing testing of UAM and AAM concepts. NASA can also use the tool in conjunction with its ATM-X UAM testbed simulation environment as a communications coverage service. The UAM and AAM ConOps needs further clarity in air-ground communications, and the communications infrastructure part of this proposal helps fill that gap.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Potential revenue customers are local communities, which include local and state governments. Our strategy is to obtain consulting or direct contracts from these local regions to help them with UAM/AAM communications infrastructure planning and implementation. We also look to government research agencies as natural markets for any research problems that we uncover that we can also help solve.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.07-2597**

SUBTOPIC TITLE: Energy Storage for Extreme Environments

PROPOSAL TITLE: Thermal control for energy storage in extreme environments

Small Business Concern

Firm: **Nanohmics, Inc.**
Address: **6201 East Oltorf Street, Suite 400, Austin, TX 78741**
Phone: **(512) 389-9990**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Robotic science rovers operating on the lunar surface over diurnal cycles face extreme temperature environments (-200 to 120 °C) beyond conventional energy storage batteries operating limits, even with shielded and articulated radiator assemblies. These hot and cold lunar conditions can last several Earth days, because of the slow rotation of the Moon, or permanently in shadowed craters and poses the significant challenges to small, low-power (~100 W or less) payloads, rovers, and landers required for lunar science, and survivability of the rovers electrical power subsystems during lunar day/night becomes a critical issue. As such, one strong technology candidate for meeting future lunar electrical storage thermal management needs are ThermoElectric Coolers (TECs) which are a well-established technology (> $1.1B market in 2021). TECs are solid-state, lightweight, have no moving parts or working fluids, and operate with highly reliable, uninterrupted, low maintenance, and environmentally-friendly cooling. Toward this goal, Nanohmics team proposes to develop a TEC system suitable for lunar electric power subsystems cooling during lunar day, and high-efficiency heating during the lunar night. The proposed Thermoelectric Temperature Regulation Unit (ThermoTruTM) will employ

modular printed circuit boards (PCBs) based TEC devices that can be configured to meet thermal power dissipation shortcomings to address the lunar day cooling needs (radiator T = 30 – 35 °C, ΔT > 15 °C, 10 – 100 W of heat lift) and lunar night heating needs (electronics at > -20°C, ΔT to radiator > 20 °C, and radiator T ~ -50 °C) for small rover EPS survivability. A lunar night heating subsystem for small rovers currently does not exist. Using the combined benefits of compact cooling (day) and efficient heating (night) in a single, all-passive (i.e. no mechanical thermal switch) has numerous benefits for lunar rover and other lunar surface systems.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed work will develop high efficiency thermoelectric convertor (TEC) systems which will increase the survivability of lunar rovers' battery storage during day/nighttime by cooling/heating operations and extend the NASA mission times. These modular and conformal TECs can be used in many NASA missions, which require localized cooling/heating needs. Furthermore, the highly efficient TEC designs will also enable to use thermoelectric technology for many other space cooling and power generation missions.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Efficient TECs provide a means to meet next generation smart cooling needs which can reduce the CO2 and greenhouse gases emission compared to competitive cooling systems. These mass-marketable TECs can replace most multistage TECs and compression-based systems in other applications such as automotive, defense, biomedical, and waste heat recovery markets which are worth more than a billion dollars.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.01-1459**

SUBTOPIC TITLE: Lidar Remote-Sensing Technologies

PROPOSAL TITLE: Novel Ultraviolet Laser Source for Ozone Differential Absorption Lidar

Small Business Concern

Firm: **TIPD, LLC**
Address: **1430 North 6th Avenue, Tucson, AZ 85705**
Phone: **(520) 250-4405**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

280-300 nm spectral region is part of ozone absorption spectrum, and lasers operating in this region might be used for lidar measurements. For example, the pulsed UV laser system is used by NASA for the Langley mobile ozone lidar (LMOL) operates in precisely that region. This system output is a train of alternating pulses at two distinct wavelengths from 285-300 nm spectral range. The laser active medium is a Ce:LiCAF crystal pumped by a quadrupled radiation from a Q-switched Nd:YLF laser. Such a laser scheme is bulky and has low efficiency: with 0.2 W of UV output power the system consumes 2 kW, so overall wall-plug efficiency is 0.01%. TIPD proposes to develop a simple, compact, robust, and efficient laser source based on GaN diodes and Tb-doped gain materials to satisfy NASA's requirements. In this phase I program, we will demonstrate the feasibility of our proposed laser source by developing a novel efficient Tb-doped oscillator.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Space exploration applications include follow on applications to NASA's Lidar Atmosphere Sensing Experiment (LASE) program, ablation and spectroscopic tools for the New Frontiers mission to the Jovian moons, and enhanced capabilities for the SHERLOC instrument package. The UV-B laser could be used in the search of life in the extra-terrestrial by detecting organic/inorganic molecules.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial applications including advanced R&D and industrial manufacturing such as in the microfabrication of transparent materials such as GaN wafers, massless lithography for circuit boards and electronics. UV-B light offers improved sensitivity over visible lasers atomic and molecular spectroscopy and chemical dynamics.
Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.01-1703**

SUBTOPIC TITLE: Aeroelasticity and Aeroservoelastic Control

PROPOSAL TITLE: Mid-Fidelity CFD-Based Aeroservoelastic Analysis Method for Supporting Design and Testing

Small Business Concern

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Phone: **(609) 538-0444**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Ongoing work in ultra-efficient subsonic and supersonic air-vehicles clearly shows the potential of evolutionary and revolutionary concepts to meet the performance goals of future aircraft. With their incorporation of lightweight flexible structures, such configurations may require active/adaptive control systems for load redistribution, flutter suppression and gust load alleviation to ensure reliability and safety. Unfortunately, contemporary analysis methods are unsuitable for aeroselastic and aeroservoelastic analysis of such configurations. Design tools are dependent on low-fidelity approaches that are inadequate for reliably analyzing advanced configurations, whereas CFD coupled to finite element structural models require significant user input to define and support advanced configurations, not to mention extensive computational resources. A new efficient approach that automates the geometry setup, mesh generation, and assembly of fluid-structural coupling interfaces is needed for aeroselastic/aeroservoelastic analysis of conventional and new concepts. To address this critical need, Continuum Dynamics, Inc. proposes the development of a mid-fidelity CFD-based aeroservoelastic analysis to support vehicle design, active/adaptive control effector design and integration, as well as control system development and flight and wind-tunnel testing. Building on CDI's legacy in the relevant disciplines, the project emphasizes technology development to streamline workflows and eliminate user involvement associated with mesh generation and fluid-structural model interfacing to efficiently and accurately undertake full flight envelope vehicle evaluation and optimize when and where to utilize high-fidelity models.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed effort directly supports several NASA projects: the Advanced Air Vehicle Program's Advanced Air Transport Technologies (AATT) project developing the next generation of subsonic and supersonic civil aircraft; the Transformative Aeronautics Concepts Program's Convergent Aeronautics Solutions (CAS) and Transformational Tools and Technologies (TTT) Projects, the integrated Aviation Systems Program's (IASP's) Flight Demonstrations and Capabilities (FDC), as well as the X-56, X-57 and X-59 aircraft.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed effort will produce an aeroelastic/aeroservoelastic analysis to design and evaluate advanced air-vehicle concepts that use structural flexure, novel control effectors and propulsion arrangements for performance enhancement and control. Substantial commercialization opportunities are anticipated from licensing the software and providing related support and engineering services.
Duration: **6**

PROPOSAL NUMBER: 22-1- **Z12.01-2721**

SUBTOPIC TITLE: Extraction of Oxygen, Metal, and Water from Lunar Regolith

PROPOSAL TITLE: Feed and Removal of Regolith for Oxygen Extraction

Small Business Concern

Firm: **Blueshift, LLC**
Address: **575 Burbank Street, Unit G, Broomfield, CO 80020**
Phone: **(850) 445-3431**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Blueshift, LLC doing business as Outward Technologies is an early-stage startup developing critical In-situ Resource Utilization (ISRU) technologies for terrestrial and extraterrestrial applications. Outward Technologies proposes to develop a regolith feed and removal system for oxygen extraction from regolith with non-contact reaction temperature measurement and rapid oxygen content measurement in regolith upstream and downstream of the reaction zone. The proposed regolith feed system may be integrated with multiple oxygen extraction methods to enable continuous feed of material into and out of the reaction zone while maintaining a pressure sealed reactor chamber. This Feed and Removal of Regolith for Oxygen Extraction (FaRROE) system implements two innovations that utilize the regolith itself for sealing the inlet and outlet of the reactor chamber while maintaining continuous flow. Benefits of the proposed innovation include reactor chamber sealing using in situ materials (regolith) and minimal moving parts, non-contact reaction temperature measurement that can be used to control and optimize the oxygen extraction process, real-time O2 measurements that can indicate efficiency of the process and signal whether servicing is required, continuous processing of regolith for oxygen extraction rather than requiring a batch process, extraction process agnostic design for wide adaptability, and secondary resource utilization of extruded slag for part fabrication, long duration thermal energy storage, or for smelting and secondary refining. The Phase I effort will focus on system design, prototype development of the regolith feed and removal subsystems, and feasibility demonstrations through prototype characterization testing, system analysis, and component evaluation.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary application within NASA's roadmap is lunar and Martian oxygen production by enabling a continuous regolith feed and real-time process monitoring for oxygen extraction reactors (TX07.1). Additionally, once oxygen has been extracted from the regolith, FaRROE enables continuous extrusion of the processed slag which can then be used in mass production of mechanical and structural components in an extrusion-style 3D printer or casting process (TX07.2), and for thermal energy storage and transfer (TX07.1).

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Companies, federal agencies, and research institutions are exploring methods for industrial decarbonization by replacing fossil fuel power sources with concentrated solar power in traditional industrial processes. FaRROE supports these efforts by providing a low-cost, low-maintenance, and continuous feed system for high-temperature industrial processes fueled by concentrated solar power.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z1.06-1046**

SUBTOPIC TITLE: Radiation-Tolerant High-Voltage, High-Power Electronics

PROPOSAL TITLE: SiC MOSFET WITH RADIATION-RESISTANT GATE OXIDE PERFORMANCE TO 600V

Small Business Concern

Firm: **scdevice llc**
Address: **3359 NorthWest 123rd Place, Portland, OR 97229**
Phone: **(503) 449-4193**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 2

Technical Abstract (Limit 2000 characters, approximately 200 words):

Enhanced capabilities of Silicon Carbide (SiC) power semiconductor technology permit new ultra-high voltage and current applications and offer attractive options for power electronics in satellites, space stations and space exploration. However, the space environment has multiple radiation sources that interact with the SiC crystal and can damage the circuit. Studies show that when heavy ions impinge on an operating SiC power device, the device degradation may range from no discernable damage to increased leakage to catastrophic failure. In SiC MOSFET devices subjected to high-energy ion bombardment in the OFF-state, single-event burnout (SEB) and single-event gate rupture (SEGR) are two major failure types. Commercial SiC power devices have been observed to incur catastrophic failure at biases below 40% of their nominal blocking voltage, and irreversible degradation (SEGR) at biases well below 10% when exposed to ions with a Linear Energy Transfer (LETs) at 10 MeV-cm^2/mg. Latent gate damage that precedes SEGR significantly limits the safe operation area of SiC MOSFETs for space applications. To avoid SEB failures, derating schemes are proposed like reducing the operating voltage to less than half its rated value. Similarly, to minimize SEGR, the operating voltage is reduced to less than one quarter of its rated value. Such de-rating penalty not only diminishes the SiC technology advantages of performance, cost and weight in space but may lead to costly field failures. SCDevice is developing a patented self-aligned device design for high-voltage SiC MOSFETs, with the goal of achieving reliable gate oxide performance up to 600V (state of the art MOSFET survives about 100V) for ion striking with LET=40 MeV-cm^2/mg. Goal of Phase-I is to (a) Optimize device design for performance and (b) Demonstrate electric field across gate oxide below 4MV/cm for the ion strike at bias of 600V in the off-state.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Radiation-tolerant SiC MOSFET devices could have significant impact on satellite launch costs due to reduced weight of overall sub-systems, smaller satellites, or satellites with greater useful functionalities for a given weight and volume.

Example use in Space Electric Propulsion: When utilized in place of Si MOSFET in satellite electric propulsion power supply, SiC MOSFETs have been shown to improve power efficiency of Hall thruster Power Processing Units (PPU) from 94% to 97% and Ion thrusters from 92% to 95.8%

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The burgeoning private satellite industry in the United States will be the single most promising market for SCDevice's radiation-tolerant SiC MOSFET. Satellites, aerospace and automotive applications will greatly benifit from (a) low-loss switching of SCDevice's MOSFET due to low gate-drain capacitance compared to commercial MOSFET and (b) Low drain-source leakage for high temperature applications

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.02-2438**

SUBTOPIC TITLE: Spacecraft Technology for Sample Return Missions

PROPOSAL TITLE: Extraterrestrial Sample-return Chemistry for Advanced Propulsion Experiment (ESCAPE)

Small Business Concern

Firm: **Exquadrum, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 6

Technical Abstract (Limit 2000 characters, approximately 200 words):

During the proposed Phase I research and development effort, the project team will develop a long-term storable, hybrid propulsion system with the highest possible specific impulse for sample return missions from large-body, extraterrestrial destinations including., the Moon, Mars, Vesta, Ceres, Phobos, and Europa. The proposed solution uses advanced chemistry to achieve mass-efficient sample return that minimizes the ascent vehicle's gross liftoff mass (GLOM). The proposed project team will develop a plan for a follow-on flight demonstration program. The Phase I program will conclude with a hot-fire demonstration of a prototype propulsion system.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Small spacecraft, sample return, rocket propulsion

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Low-cost space lift, exploration missions to the moon and Mars

Duration: **6**

PROPOSAL NUMBER: 22-1- **H4.07-2816**

SUBTOPIC TITLE: Low Volume, Power and Mass CO2 and Humidity Control for xEMU

PROPOSAL TITLE: MOF based Adsorbents for Carbon Dioxide Removal Assembly

Small Business Concern

Firm: **Mainstream Engineering Corporation**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Carbon dioxide and moisture removal is critical for maintaining the sustained and efficient operation in extravehicular exploration. Stable and high performance, low pressure drop CO_2 and moisture removal sorbents are therefore a critical part of the space suit life support system and there is a need for alternative high performance adsorbent systems. Mainstream proposes to integrate highly tailorable metal organic frame work molecules (MOFs) which provide a highly selective, high-capacity carbon dioxide and water vapor absorbent levels into the vacuum swing CO_2 absorbent system. Since MOFs are however impractical to integrate directly in a low pressure drop system, Mainstream will fabricate the MOFs into a high stability, high porosity polymeric beads with readily controllable sizes. Our process forming the beads allows full access to their extraordinarily high surface area and gas storage capacity, while allowing the integration into a low pressure drop packed bed adsorbent cartridge. Thus, they can be readily integrated into the adsorbent bed as a drop-in replacement for the current adsorbents.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed sorbent could be used not only as a drop-in carbon dioxide absorbent bed for the xEMU space suit but is relevant to all manned NASA spacecraft. Additionally, as a large variety of MOFs exist with various applications the technologies can be applied to almost all the reactors that make up the ISS's Air Revitalization System. The ability to integrate the MOFs in bead form will also mean that these systems will run more efficiently with reduced pressure drop.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Beyond NASA, applications exist for almost all catalytic or adsorbent processes which would receive many of the same benefits as NASA, including enhanced adsorption and reduced pressure. Applications are seen in the fields of exhaust emissions control, air pollution control and pharmaceutical production. The technology could also be applied in both point source and direct air capture of CO_2.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H3.08-1984**

SUBTOPIC TITLE: Challenges in Carbon Dioxide Removal and Reduction: Carbon Particulate and Thermal Management

PROPOSAL TITLE: Advanced Heaters for Sorbent Systems

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 6
End: 9

Technical Abstract (Limit 2000 characters, approximately 200 words):

In this project, we propose to develop zeolite X13 and branched poyethyleneimine (PEI800) (60% loading) alginate polymer gel with fluffy carbon nanotubes as nanoscale heaters that is capable to be printing and coating on highly electrically and thermally conductive, porous carbon foams. The developing printable polymer gel can form spheric beads embedded in carbon foams after drying. The polymer beads with microscopic structures allow for good vapor permeability through adsorbent bed, also host zeolite X13 and PEI800 CO_2 absorber as well as hygroscopic salts for water absorption. This innovative carbon foam supported adsorbent bed powered with electricity can generate resistive heat on carbon nanotubes and directly transport the heat to its gust's zeolite X13 and PEI800 to remove CO_2 and water for regeneration

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Spacecraft carbon dioxide (CO_2), water, and trace contaminant (organics) removal systems

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Other potential markets will be coal-fire or nature gas-fired plants, as well as other chemical refinery plants for CO_2 clean up

Duration: **6**

PROPOSAL NUMBER: 22-1- **S17.02-1504**

SUBTOPIC TITLE: Integrated Science Mission Modeling

PROPOSAL TITLE: Architecture Decision Modeling & Automated Tradespace Formulation

Small Business Concern

Firm: **Aureus Innovation, LLC**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The innovation proposed is a graphical method to codify decision classes, script-based operators and enumeration schemes to significantly reduce the time associated with formulating and reusing tradespace studies often associated with systems architecture, mission architecture, product planning, technical strategy and business strategy.

Aureus will develop an automated technique to generate a rich architectural tradespace directly from a descriptive systems model. In order to do this, the architecture decision patterns and objective, or value, criteria will be captured in a SysML-capable tool from which a tradespace and pareto front will be generated, enabling teams to more quickly and more thoroughly compare candidate architectures. This will allow the NASA team and other development teams to focus on drawing insights from the tradespace rather than manually deriving the architecture problem for each mission. Aureus believes that these insights and improved decision making overall are the main value facilitated by this innovation. Related values of the innovation include gaining the ability to capture and preserve decision histories throughout a project and / or systems lifecycle by better incorporating high level decision models into NASA's model based systems engineering (MBSE) ecosystem.

The primary end user is a NASA system / mission architect or systems engineer. For Phase I, a laboratory environment (TRL 4) demonstration will be conducted within commercially available tools. The Phase I proof-of-concept demo will largely be an integration of existing tools & libraries with minor customizations to deploy the specific, novel points of the innovation.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The NASA applications mentioned in S17.02 including those at the concept/ feasibility level should directly benefit from the proposed scope of work. These include the Large Ultraviolet Optical Infrared Surveyor (LUVOIR), Origins Space Telescope (OST), Habitable Exoplanet Observatory (HabEx), and Lynx. This proposed method would become immediately beneficial for rapid generation and navigation of the architectural tradespace.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Aureus believes that this method and innovation can be adopted by organizations that are developing medium to high complexity products especially those with high up front costs and long life cycles. Industries that are especially applicable are aerospace, defense, automotive, and pharmaceutical / medical devices.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.01-1991**

SUBTOPIC TITLE: Robotic Mobility, Manipulation and Sampling

PROPOSAL TITLE: Compatible High-res 3D Vision System

Small Business Concern

Firm: **Boulder Nonlinear Systems, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

The proposed effort is to develop a low power/mass vision system that provides in real-time high-resolution (HR) three-dimensional (3D) data over wide angles for quickly detecting hazards and obstacles in the path of planetary rovers. The objective is to build a compact camera package that meets the low size, weight, and power (SWaP) requirements of the application. The 3D sensor will provide better than 0.4 milliradian resolution over a 96-degree by 80-degree field of regard and better than 2.5 cm distance accuracy at 3.75 meters with distance accuracy improving at shorter ranges. This 3D imaging capability is achieved using a unique electro-optic step and stare scanner that provides the largest angle-aperture product of any non-mechanical scanning technology.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed low-SWaP HR 3D vision system will have application in NASA missions needing real-time 3D information such as fixing and refueling spacecraft, autonomous vision-based guidance and control for robotic systems, internal/external spacecraft inspection, 3D environmental mapping and hazard avoidance for autonomous land, air, and sea vehicles. Also, a low-SWaP gimbal replacement would be useful for other space-borne applications including active remote sensing and satellite-to-satellite communications.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial applications include hazard/collision avoidance for autonomous automobiles and unmanned vehicles such as drones. Other potential large markets are 3D imaging for factory automation, noncontact structure analysis, topographical mapping, and gesture recognition for augmented reality systems. Additionally, the scanner technology is being deployed on lidars for wind turbine control.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z1.05-1439**

SUBTOPIC TITLE: Lunar and Planetary Surface Power Management and Distribution

PROPOSAL TITLE: High Temperature, High Energy Density Capacitors for Power Management and Distribution Systems

Small Business Concern

Firm: **TPL, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

The innovation is the application of a high temperature, modified fluorenone polyester (MFPE) dielectric for link capacitors and other capacitive functions, critical components in the high power, high temperature power management and distributions (PMAD) systems being developed for lunar and planetary applications. TPL has solved the leakage current issue which has plagued FPE. MFPE capacitors have demonstrated > 200 ^{o}C performance at a significant operating voltage. A multi-layer film approach will also be investigated to enhance breakdown strength. MFPE capacitors represent an advance with respect to temperature, power density and energy density over state-of-the-art capacitors.

The NASA Technology Roadmap, TA 3: Space Power and Energy Storage, identify the need for improvements in capacitor performance, i.e. TA 3.3.3 Distribution and Transmission – "high-voltage power distribution passive components and high temperature capacitors"; and TA 3.3.5 Conversion and Regulation – "high-temperature, high voltage capacitors critical to new converter designs". NASA's requirements are challenging: power requirements > 100 kW; voltages range from 450 VAC to > 1,500V; temperatures listed range from 150 ◦C to > 300 ◦C; and the power conversion system applications involved suggest that high capacitance values are needed.

TPL, in collaboration with NASA, will review required capacitor applications; develop design specifications for several applications; design capacitors for one or more power conversion systems; and fabricate and test MFPE film under appropriate conditions to indicate the feasibility of achieving the established design specifications. The result of the Phase I investigation will be a detailed product development proposal to be conducted as a Phase II effort.

The application of MFPE capacitors to lunar and planetary power capacitor requirements will achieve major advances in power density and energy density at high operating temperature and voltages.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The Power Energy and Storage Focus Area has numerous needs for capacitors with higher performance capabilities such as **Dynamic Power Conversion** and **Lunar Power Management and Distribution** involving power conversion. All **aircraft electrification** programs where filter, snubber, and link capacitors are involved have a need for high temperature, high voltage capacitors.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

DOD efforts in **aircraft electrification**, F-35, F-25, F-18, and advanced aircraft along with commercial aircraft such as Boeing's 787; **next gen electric grid** with its use of renewables and their reliance on power conversion systems; **high value, hybrid electric vehicles**; and **oil and gas industry –** in deep well, high temperature environments - drilling motors, logging tools, fluid pumping systems.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S14.01-2129**

SUBTOPIC TITLE: Space Weather Research-to-Operations/Operations-to-Research (R2O/O2R) Technology Development

PROPOSAL TITLE: Enhancement of the Geomagnetic Cutoff Models inside SIRE2

Small Business Concern

Firm: **Fifth Gait Technologies, Inc.**
Address: **835 Puente Drive, Santa Barbara, CA 93110**
Phone: **(805) 964-1496**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

The enhancement of the geomagnetic cutoff models inside of the Space Ionizing Radiation Environments and Effects (SIRE2) tool will evaluate and expand on our geomagnetic cutoff modeling as an extension of our previous work. This proposal will also adapt the current geomagnetic cutoff modeling software to be driven by the Dst index rather than the Kp index to better reflect the ring current effects. These improved geomagnetic cutoff modeling timelines will be compared to geomagnetic cutoff measurements for a selected Solar Particle Event (SPE).

This proposal is submitted to the Space Weather Research-to-Operations/Operations-to-Research (R2O/O2R) Technology Development subtopic and will provide key research that can be used to improve future geomagnetic cutoff models. Specifically, this research can be included in the next iteration of the Smart Shea model (circa 2025) to enhance the geomagnetic cutoff modeling of the SIRE2 toolkit. This will provide mission designers, planners, and mission operators with advanced geomagnetic cutoff modeling techniques. Once incorporated into a tool like SIRE2, these advancements will provide improved modeling of the **energetic particle environment within the Earth's magnetosphere**.

This Phase I proposal will result in demonstrations that illustrate the improvements that can be made to the geomagnetic cutoff models by driving the model by the Dst index rather than the Kp Index and using finer Dst levels to create the cutoff grids. In addition, these improvements of the geomagnetic cutoff modeling timeliness will be compared to geomagnetic cutoff measurements for a selected SPE to illustrate the improvements in these techniques.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

When the goals of this Phase I effort are complete, NASA will have a better understanding of improvements that can be made to the current geomagnetic cutoff models. These improvements will provide better modeling capabilities of the energetic particle environment inside of the Earth's magnetosphere. The current NASA programs, projects, or missions that could greatly benefit from this Phase I effort are any satellites or missions that operate inside the Earth's magnetosphere, including the International Space Station, Space Launch System, etc.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Companies like SpaceX and Blue Origin can utilize this Phase I/II work to support future space adventure plans. Enhanced geomagnetic cutoff models would provide these companies with

more accurate particle environments. There are also numerous DoD and DoE programs that exclusively operate within the Earth's magnetosphere and would benefit from enhanced geomagnetic cutoff models.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.07-1786**

SUBTOPIC TITLE: Cryogenic Systems for Sensors and Detectors

PROPOSAL TITLE: Low Cost Cryocooler Control Electronics for Space Missions

Small Business Concern

Firm: **Creare, LLC**
Address: **16 Great Hollow Road, Hanover, NH 03755**
Phone: **(603) 643-3800**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

Many NASA and commercial space science missions require high performance electronics within strict budgetary limits. Many of these missions; therefore, use commercial grade electronic products despite significant technical risk due to lack of radiation hardness. Creare proposes to evolve our commercial-grade, three-phase Brushless DC motor drive electronics for missions

which require radiation hardened cryocoolers at reasonable cost. During Phase I, we will develop a drive electronics design which meets cost and radiation hardness requirements for lunar and planetary missions. We will ensure compatibility for upcoming missions by working closely with a leading developer of low-cost cryocoolers with nearly100 space flight coolers delivered to date. During Phase II, we will work closely with our partner to fabricate and qualify an integrated and low-cost cryocooler solution. Successful completion of this program will enable advanced sensor systems for space-borne science, surveillance, and reconnaissance missions.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The successful completion of this program will provide mission planners with high performance and low-cost cryocooler control electronics that satisfy radiation hardness requirements for small platform missions. The primary NASA application will be for cooling detectors, sensors, shields, and telescopes for planetary science missions.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed cryocooler control electronics are ideal for small, cost-constrained satellite missions such as LEO cubesats. Military applications include space-based surveillance for Operationally Responsive Space missions and Unmanned Aerial Vehicles.
Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.03-2199**

SUBTOPIC TITLE: Extreme Environments Technology

PROPOSAL TITLE: Deep UV Lasers for Raman & Fluorescence Spectroscopy in Extreme Environments

Small Business Concern

Firm: **Photon Systems, Inc.**
Address: **1512 Industrial Park Street, Covina, CA 91722**
Phone: **(626) 967-6431**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

This proposal addresses the need for next generation deep UV (NGDUV) lasers for detection and spatial chemical mapping of trace amounts of organic, pre-biotic, or biological material as well as inorganic compounds and water embedded in a mineral matrix using non-contact deep UV resonance Raman and native fluorescence spectroscopy. Detection of these materials and their spatial distribution within a mineral matrix are fundamental capabilities required to meet NASA strategic goals. Benefits of this method have been demonstrated on the Mars 2020 SHERLOC instrument, which successfully landed on Mars on 18 February 2021. NGDUV lasers address the need of increasingly miniaturized next generation chemical and biological detection instruments for deep UV Raman and fluorescence detection in extreme environments including lander missions to Titan and other ocean worlds with temperatures of -200 ^{0}C, or below, as well as shadows on the Moon, asteroids, comets, and other small bodies.

Specifications for a deep UV laser for operating in these extreme environments, with the performance and size, weight, and power consumption compatible with these missions, was studied as part of the Mars Perseverance SHERLOC development. The prospect for suitable lasers includes a long list of laser types, each of which has a long history of development and different potential for applicability. Fundamental to all laser types is the need for an excitation wavelength below 250 nm to minimize fluorescence background from targeted samples and enable unambiguous Raman and fluorescence spectra of simple organic molecules. The second requirement is for a laser emission linewidth and line stability, independent of ambient temperature less than about 0.01 nm. The laser types which could potentially satisfy these needs includes semiconductor, fiber, solid state, and gas lasers. Each of these laser types will be evaluated and a path forward proposed for the most likely prospects.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NGDUV lasers have application to increasingly miniaturized NASA instruments to detect trace organic chemical and biological materials on surfaces from small fixed-landers and rovers. This technology is also applicable for terrestrial field applications including Antarctica and the Artic as well as other harsh environments where the NGDUV laser can enable miniature deep UV Raman and fluorescence measurements from unmanned ground or aerial vehicles (UAVs).
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non-NASA applications of NGDUV lasers include increasingly miniaturized hand-held or ground or aerial robot mounted situational awareness sensors to detect surrounding chemical, biological, and explosives hazards for first responders in both military and civilian environments. The same technology is applicable to pharmaceutical, food, and chemical manufacturing and environmental monitoring.
Duration: **6**

PROPOSAL NUMBER: 22-1- **Z2.02-2344**

SUBTOPIC TITLE: High-Performance Space Computing Technology

PROPOSAL TITLE: High Multi-speed Time-Triggered Ethernet

Small Business Concern

Firm: **Lewiz Communications, Inc.**
Address: **738 Charcot Avenue, San Jose, CA 95131**
Phone: **(408) 836-4226**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Time critical data requires low latency and deterministic transfer. Sensor, command and control data of mission-critical, high-reliability, real-time applications such as collision avoidance, avionics require on-time delivery. Images from a camera of an autonomous spacecraft to its processing system must be communicated deterministically and low latency for the system to function correctly.
Ethernet is ubiquitous. It's being used everywhere from small devices to high performance computing system. Its large ecosystem of products and services provides key advantages - low cost, high availability, wide range of available developers and support. However, data transferred via Ethernet is "best-effort" and may be buffered. This causes significant jitter and non-deterministic in information delivery timing. Packets transferred may be dropped by Ethernet switches, routers and delivery is not guaranteed.
Time-triggered Ethernet (TTE) has been specified and standardized by SAE International as AS6802 for aerospace applications overcoming time critical issues in Ethernet and supports fault tolerant (synchronization, handshake, etc.). However, solution for the upper Ethernet speeds with radiation tolerant does not exist. NASA SBIR topic Z2.02 requests for IP core for TTE for use in onboard networks with >10Gbps. Proposed is a TT IP core with speed 10Gbps and beyond for TT Ethernet with radiation tolerant. It uses a novel architecture that can span multiple speeds, allowing software reuse, ultra-low jitter, implementable in FPGA or ASIC. Designers can configure the design to suit specific application (e.g., routers, switches, high performance endpoints) or available technology. Several immediate applications in NASA and non-NASA have been identified for commercialization. For the long term, this solution is suitable for use in

space vehicles, satellites, aircrafts, drones, etc. - applicable to NASA, DoD and others

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Space vehicles, satellites, space telescopes, aircraft, drones, rovers, robots, autonomous systems

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

hypersonic vehicles, space systems, satellites, aircrafts, drones, weapons, ground/sea vehicles

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.05-1746**

SUBTOPIC TITLE: Thermal Control Systems

PROPOSAL TITLE: Hybrid Manufacturing Process of Loop Heat Pipe Evaporator

Small Business Concern

Firm: **Advanced Cooling Technologies, Inc.**
Address: **1046 New Holland Avenue, Lancaster, PA 17601**
Phone: **(717) 205-0628**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

In response to the FY 2022 NASA SBIR Solicitation Topic S06.15 Scope “Advanced Manufacturing of Loop Heat Pipe Evaporator”, Advanced Cooling Technologies, Inc. (ACT) and FormAlloy Technologies, Inc. (FormAlloy) propose to develop a hybrid manufacturing process for loop heat pipe (LHP) evaporator. Such a hybrid manufacturing process combines conventional sintering and additive manufacturing (AM) technology. The process can retain the ~1-micrometer pore size of the current primary wick while eliminating the knife-edge seal (KES) that may fail under long exposure to thermal cycles and vibrations. In Phase I, ACT and FormAlloy will continue the process optimization, and perform LHP operation demonstration with evaporators fabricated by the proposed hybrid process.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The potential applications for the proposed process are NASA missions and commercial space flights where high-performance and high-reliability LHPs are adopted. Specifically, Ice, Cloud, and Land Elevation Satellite (ICESat), ICESat-2, Swift, Aura, Geostationary Operational Environmental Satellite (GOES), Geostationary Operational Environmental Satellite-R Series (GOES-R), Surface Water and Ocean Topography (SWOT), and future Science Mission Directorate (SMD) missions can greatly benefit from the proposed technology.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The program is also applicable to all military and commercial satellites that use Loop Heat Pipes. In Other civil or military applications such as LED luminaire, solar water heaters, thermoelectric power generators, etc. can all benefit from LHP with improved reliability

Duration: **6**

PROPOSAL NUMBER: 22-1- **H8.01-2210**

SUBTOPIC TITLE: Low-Earth Orbit Platform and Microgravity Utilization for Terrestrial Applications

PROPOSAL TITLE: Microgravity-assisted growth and defect engineering of 2D materials for terrestrial applications

Small Business Concern

Firm: **GOEPPERT, LLC**
Address: **2200 Arch Street, Unit 504, Philadelphia, PA 19103**
Phone: **(267) 713-2662**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA seeks to advance NASA's objective of leveraging the unique capabilities (microgravity, exposure to space) of the ISS to maintain and strengthen the U.S. leadership in the area of commercial in-space production of materials, technologies, and industries of the future that will be critical to our economic prosperity amid increasing global competition. Here we propose to meet these requirements by taking advantage of microgravity to carry out two-dimensional (2D) molybdenum disulfide (MoS2) material growth with engineered defects to meet various applications, from semiconductors and dry lubricant industry where defects are undesired and should be minimized, to biomedical diagnostics and water desalination where the thin, small (<1 nm in diameter) defects or nanopores are necessary for single molecule detection and characterization. We will design a CVD-based furnace for MoS2 growth and perform a series of terrestrial-based parameter setting studies to optimize the MoS2 growth conditions prior to leveraging the ISS facilities for a subsequent test under simulated microgravity environment in Phase II and beyond. Our innovation is directly related to the subtopic and could lead to valuable terrestrial applications and foster a scalable and sustainable demand for commercial markets in low earth orbits. The main technical objectives include 1) Develop and optimize recipes and devices for 2D MoS2 growth, and 2) Characterize the 2D MoS2 with optical microscopy, atomic-force microscopy (AFM), Raman spectroscopy and analytical TEM (bright field, HAADF and SAED).

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

MoS2 materials are widely used in spacecraft bearings as a solid, inorganic, dry lubricants that can tolerate prolonged exposure to the vacuum of space. Use of the ISS will facilitate validation of MoS2 growth and enable development of a US-led commercial product at reduced cost in order to attract significant capital and lead to growth of new and emerging LEO commercial markets.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

MoS2 is primarily used in the automotive industry as greases for lubrication of various parts. In the defense industry, MoS2 is used for the manufacturing of premier warheads, nozzles, and shaped charge liners. The porous MoS2 membranes with defects have beneficial applications for molecular sensing, water desalination applications, energy harvesting, supercapacitors and semiconductor electronics.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.01-1479**

SUBTOPIC TITLE: Advanced Air Traffic Management System Concepts

PROPOSAL TITLE: Weather Intelligence Support Environment

Small Business Concern

Firm: **Sigmatech, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

Recent years have witnessed a flourishing aviation industry as global air traffic continues to increase with scheduled airlines, general aviation activities, unmanned vehicles, and military aircraft alike. Just in the U.S. alone, the Federal Aviation Administration (FAA) provides air traffic service to more than 45,000 flights and 2.9 million scheduled airline passengers traveling within the National Airspace System (NAS). The day-to-day activities of managing this increasing complexity with the movement of air transportation, coupled with an expected doubling of air traffic operations over the next ten years, will place unprecedented safety and capacity demands

on the NAS. To meet these challenges, the National Aeronautics and Space Administration (NASA), FAA, and industry have long introduced research initiatives aimed at developing advanced technologies and capabilities that can dramatically improve safety, efficiency, and capacity in the future NAS. However, as new operational capabilities are being introduced through modernization efforts such as the Next Generation Air Transportation System (NextGen), maintaining air operations safety in such a dynamic and growing environment becomes even more challenging.

We put forth a novel innovative approach that enhances weather situational awareness (WSA) for NAS stakeholders called WISE – the **W**eather **I**ntelligence **S**upport **E**nvironment for aviation operations. WISE is a multi-agent system (MAS) decision support application that continuously monitors multiple planned flights for all phases of flight. WISE will acquire current and forecast weather data relevant to the flight route, factor in variables interdependent with the weather (aircraft performance data, regulations, airport data, pilot limitations), and provide NAS stakeholders with alerts and notifications on aircraft at risk in response to current and forecast weather events.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA (Aviation Systems Division) is one of several U.S. government agencies that play a crucial role in helping to develop and implement the NextGen program by developing advanced automation concepts and technologies that provide NAS stakeholders (air traffic controllers, pilots, and other airspace users) with more accurate real-time information on air traffic flow, weather, and routing. The proposed innovation directly supports NASA's ongoing research and development efforts in the area of air traffic management.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

A commercial version of the innovation will serve as an autonomous flight dispatch service for stakeholders in the general aviation (GA) community by monitoring flights and providing enhanced weather decision support similar to flight dispatch services found in airline operational control centers – a service not readily in the GA community.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S12.06-1403**

SUBTOPIC TITLE: Detector Technologies for Ultraviolet (UV), X-Ray, and Gamma-Ray Instruments

PROPOSAL TITLE: Soft X-ray sCMOS Detectors for Space Exploration

Small Business Concern

Firm: **Sydor Instruments, LLC**
Address: **78 Schuyler Baldwin Drive, Fairport, NY 14550**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

The discoveries made in astronomy and astrophysics rely on continued scientific advances in detector technology. Recent advancements like detecting gravitational waves and imaging distant galactic bodies in search of life have taken advantage of decades of progress in scientific instrumentation. To continue these advancements, the Astronomy and Astrophysics survey for the 2020's identifies the need for high resolution x-ray imaging and an increase in small scale missions to support long term scientific goals. The gap in the soft x-ray detector market place is difficult for smaller budget missions to manage as they must choose between cheaper sub-par detectors or those designed for class C and above missions, costing many millions of dollars each. By selecting commercially available sensors for this application, cost per detector decreases and smaller missions will be included in the rapid development cycle of terrestrial detectors that includes larger area arrays and smaller pixels. This will directly impact the size and cost requirements for small scale projects as focusing distance to obtain sub arcsecond resolution decreases. This proposal will leverage Sydor's commercial off the shelf scientific CMOS imager designed for soft x-rays, verify the space readiness, and design a camera system specifically targeted at class D space missions. The sensor used already has > 90% quantum efficiency at 100 - 1000 eV, can image at 48 Hz, and has **11** µm pixels, making it a good candidate for astrophysics applications. In collaboration with researchers at the MIT Kavli Institute polarimetry beamline, the Sydor sCMOS detector will be tested and wavelengths and under conditions relevant to NASA missions including thermal effects on noise, quantum efficiency, radiation damage, and vibration testing. At the completion of this work, a development plan will be in place to bring a low cost, flexible design soft x-ray detector to the astrophysics community in Phase II

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This soft x-ray sCMOS detector will benefit polarimetry and high resolution imaging for small scale, class D NASA research applications. Larger array sizes and smaller pixels continually result in breakthroughs in fields like observing quasar jets, gravitational lenses, and supernova remnants. This imager has the potential to further improve resolution this below the 0.5 arcsec obtained with Chandra, and decrease expensive and large focal length requirements associated with larger pixel sensors, all while maintaining low detector cost.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Beyond astronomy applications for NASA, this technology has potential in laboratory soft x-ray experiments like absorption spectroscopy and high resolution imaging. This includes measurements at facilities with benchtop soft x-ray sources and synchrotron facilities. Development for these areas will feed into the design of NASA applications resulting in faster design and function improvements.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H3.09-1562**

SUBTOPIC TITLE: Human Accommodations

PROPOSAL TITLE: Vortex Dust Removing Attachment

Small Business Concern

Firm: **Vivonics, Inc.**
Address: **175 Great Road, Bedford, MA 01730**
Phone: **(781) 373-1930**

Principal Investigator:

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Address: **175 Great Road, MA 01730 - 2730**
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Business Official:

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Phone: **(781) 373-1930**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

In Phase I we are planning to demonstrate the ability of the proposed attachment radically improve the performance of a vacuum cleaner used on a spacecraft/space station in collecting dust and particulate matter from various surfaces and objects. The original technology was developed by the project PI for transportation security applications to collect explosives trace, including tiny ng-mass particles of explosives from the surface of checked-in baggage and carry-on items. The proposed Dust Removing Attachment generates a pulsed air flow, dislodging particles from a 2-6" (5-15cm) distance from the cleaned surface while generating a strong vortex airflow, which delivers the detached particles to the entrance port of the Vacuum Dust Collection (VDC) system. To utilize this technology for space programs applications, the original TSA application-oriented design needs to be scaled down and optimized. After fabrication and assembly, the process parameters must be adjusted, and the breadboard performance should be verified with representative dust/particles and surfaces.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Following successful breadboard design and performance demonstration, we plan to develop a Vortex Dust Remover module as a replacement attachment for a commercial vacuum cleaner currently deployed on a spacecraft/station in conjunction with an equipment manufacturer. In addition to being used as an attachment to a manual VDC system, the dust removal nozzle can be integrated with the VDC system into a fully self-contained autonomous dust collector capable of cleaning the surfaces inside of a spacecraft 24/7 without an astronaut involvement.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed device is very different from other commercially available VDC systems in its ability to remove and collect dust and particulate matter from surfaces that are not accessible to direct contact with the vacuum cleaner nozzle by moving airborne dust directly to the nozzle of the vacuum cleaner. It will have great application in aerosol sample collection and medical facility cleaning.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.03-2180**

SUBTOPIC TITLE: Future Aviation Systems Safety

PROPOSAL TITLE: Predictive Framework for In-Time Safety Monitoring

Small Business Concern

Firm: **Robust Analytics**
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Principal Investigator:

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Phone: **(410) 980-3667**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Our innovation offers NASA and the aviation community a robust, extensible data processing and analysis infrastructure that supports predicting the near-future status of terminal airspace to aid decision-making. The Robust Analysis for Predictive In-time Decision Support (RAPIDS) will generate short-term horizon forecasts (10-20 minutes) for the state of the airspace. RAPIDS combines known procedural structures of the airspace with historical operational data to predict future aircraft trajectories in the terminal airspace. The predicted trajectories will then be used to identify operational/safety stress in the airspace and support mitigation actions. Most of the prevalent research and tools for predictive safety monitoring focus on reactive or tactical predictions (several seconds to minutes ahead). As the forecast horizon increases, the uncertainty in the projected states increases. RAPIDS aims to reduce the uncertainty in the tactical and strategic levels by integrating machine learning algorithms trained on historic operations. Commercial aircraft operational patterns are repetitive due to the highly structured operational procedures used in terminal airspace, thus allowing machine learning models to extract the underlying operational patterns.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

RAPIDS contributes to NASA's aviation safety objectives by providing a framework for generating predictions for terminal airspace states, thus enabling in-time actionable advisories to stakeholders. RAPIDS supports IASMS goals by providing reliable trajectory predictions, which are crucial to effective predictions of the terminal airspace states. The trajectory predictions become relevant for in-time prognostics, allowing the stakeholders to respond with mitigating actions that are key to IASMS.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

RAPIDS has commercial aviation benefits by giving operators an easy to deploy prediction tool to identify operational risks in-time before entering the terminal airspace of an airport. The trajectory predictions will provide sufficient lead-time for the commercial aviation stakeholders to react more optimally to operational challenges thus promising more efficient operations.

Duration: **6**

PROPOSAL 22-1- **S11.02-2206**

NUMBER:

SUBTOPIC TITLE: Technologies for Active Microwave Remote Sensing

PROPOSAL TITLE: Deployable Solid Surface Spiral Wrapped Antenna Technology

Small Business Concern

Firm: **Opterus Research and Development, Inc.**
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Principal Investigator:

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Phone: **(505) 250-3006**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Opterus addresses the small spacecraft reflector challenge with its patent pending Spiral Wrapped Antenna Technology (SWATH). **SWATH is a fully continuous, solid surface deployable parabolic reflector** architecture. The continuous solid surface enables higher frequency operation than mesh systems at lower costs. SWATH leverages Opterus' high strain composite (HSC) material technologies as the primary structural element, this material innovation provides material stiffness within the reflector shell while accommodating high bending strains to stow extremely compactly, readily conforming to CubeSat and SmallSat form factors. Further, SWATH leverages a **mold-based manufacturing** process for low-cost, rapid manufacturability.

NASA has outlined a need for deployable high frequency antenna apertures for V-band (65GHz - 70GHz) for space-based air pressure sensing on earth. Such technologies would address gaps in weather forecasting abilities as a result of inabilities to accurately measure atmospheric

pressure from long ranges, such as over oceans. A proliferated constellation of CubeSats or SmallSats performing sensing operations in the oxygen band would improve weather forecasting capabilities by increasing understanding of current conditions over a larger area to inform predictive models.

The most cost-effective solution for a proliferated space-based sensing constellation requires small or cube satellites. Currently there are no high frequency deployable antenna solutions with spaceflight heritage. Typical high frequency antenna reflectors are rigid structures that do not conform to SmallSat or CubeSat form factors. Current state of the art deployable antennas for small spacecraft are typically mesh-based deployable antennas, these systems are limited in operating frequency to approximately 50 GHz due to mesh leakage and mesh shaping constraints. Mesh antennas also demand extensive touch labor and part counts which causes high costs and long lead times compared to SWATH.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

SWATH enables earth science missions and improves weather forecasting capabilities through enabling space-based remote sensing such as Oxygen Band Radar systems, Differential Absorption Radars. NASA applications extend beyond the subject space-based sensing applications. SWATH benefits the NASA Artemis program by enabling power distribution, communication, and ISRU infrastructures. All lunar surface and deep space operations will require large aperture high gain antennas to conduct direct to earth or spacecraft network communications.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The DoD and NGA have a stated goal of increasing resiliency to support current mission sets by leveraging constellations of small satellites and acquiring needed data from commercial providers of satellite observations. SWATH enables small satellites and entities using small satellite platforms to meet mission requirements for communications, weather forecasting, and remote sensing.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H10.01-1221**

SUBTOPIC TITLE: Advanced Propulsion Systems Ground Test Technology

PROPOSAL TITLE: Monitoring and Advisory System for Solenoid Operated Valves

Small Business Concern

Firm: **D2K Technologies**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The proposed innovation is a monitoring and advisory system for health management of solenoid operated valves (SOV) used in industrial applications. The proposed software application would assist maintenance personnel and equipment owners to optimize system operation and maintenance activities by providing up-to-date information of key health metrics.

The relevance and significance of the proposed innovation lies in the possibility to improve the capabilities to predict and model the behavior of SOV's. More generally, this proposal seeks to develop technology for health determination and fault management, prediction, prognosis, and anomaly detection.

The proposed innovation addresses a gap between academic research and actual available commercial applications for monitoring the health status of real, field-deployed, industrial systems. The few options commercially available require the incorporation of additional hardware (sensors, signal conditioning modules, etc.) with obvious impacts to system cost and complexity.

In relation to this, the proposed approach will make use of non-intrusive, low-cost techniques for measuring a coil's resistance or impedance, which in combination with calibrated models that correlate resistance and temperature, will allow to 1) determine if the coil's insulation has been subjected to operating temperatures higher than its rated class, 2) estimate cumulative damage based on total operating hours, and remaining useful life, 3) detect shorted coils, 4) assess internal leakage of the valve by detecting deviations in measured impedance (ac valves) from nominal values, and 5) provide confirmation of a valve operation in case of limit switch failures (ac valves). Furthermore, the proposed system would allow processing of historical usage data to estimate and maintain reliability curves, thus providing operators with additional insight to better understand and expose risk.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

It is expected that the proposed application would be of interest to most of NASA's research centers, testing centers, and launch sites, given the fact that solenoid valves (SOV) are basic components of most fluid systems. At SSC, there are currently more than 600 SOV's in operation, with a mean time between failures (MTBF) of 75 days. The Gateway Refueling System is another candidate for the deployment of technologies like the ones introduced in this proposal, since SOV's are one of the basic components of its present design.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Given their nature and function, solenoid-operated valves are ubiquitous in industrial applications. In this sense, it is expected that a monitoring and advisory application like the one proposed here could find widespread application throughout a diverse range of industries, as for example oil & gas, nuclear, manufacturing, power generation, chemical, food, and pharmaceutical among others.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.04-2138**

SUBTOPIC TITLE: Sensor and Detector Technologies for Visible, Infrared (IR), Far-IR, and Submillimeter

PROPOSAL TITLE: A Signal Frequency Channelizer ASIC

Small Business Concern

Firm: **Pacific Microchip Corporation**
Address: **3916 Sepulveda Boulevard, #108, Culver City, CA 90230**
Phone: **(310) 683-2628**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

Technical Abstract (Limit 2000 characters, approximately 200 words):

Far-infrared and sub-mm astronomy employs MKIDs for ultimate sensitivity and resolution exceeding 10,000 pixels. Detector array readout requires RF frequency division multiplexing and complex multichannel signal processing. An FPGA based DSP used for frequency band channelizing and power level measuring in each bin suffers of suboptimum size, weight and power (SWaP).

We propose to develop an ASIC which will channelize the spectrum into 1024k frequency bins with 0.95KHz per bin. The ASIC will include two 12-bit 1GS/s ADCs, a data alignment and demultiplexing block, a poly-phase filter bank based FFT core and an accumulation/readout block including a high-speed 16Gbps ESI Stream interface. Additionally, the ASIC will include a PLL for clock synthesis, a debug memory for storing of short duration raw digitized data or the debug data for the FFT core. A digital control subsystem will handle the entire ASIC's operation and communication. In addition to minimized SWaP, the ASIC will tolerate TID and SEE, and will operate below standard -40C temperature.

Within Phase I we will provide the proof of feasibility of implementing the proposed ASIC. Phase II will result in the silicon proven ASIC prototypes.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- Single photon sensitive focal planes from IR to X-ray
- For Earth, balloon and space based telescopes and radiometers
- Mission examples: JPSS-2, 3, 4, PACE and TROPICS
- Spectrometer systems for remote sensing

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- MKID based single photon sensitive imaging for remote sensing and surveillance
- Specialized spectrometers for temperature, vapor, pollutants exploration
- Generic spectrometers and spectrum analyzers
- Infrared, visible light, UV and THz imaging in surveillance and security systems

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.04-2412**

SUBTOPIC TITLE: Contamination Control and Planetary Protection

PROPOSAL TITLE: A Microgravity-Compatible Handheld Squeegee-Aspirator Surface Sampler (SASS)

Small Business Concern

Firm: **AI Biosciences, Inc.**
Address: **1902 Pinon Drive, Suite C, College Station, TX 77845**
Phone: **(979) 450-3602**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 6

Technical Abstract (Limit 2000 characters, approximately 200 words):

In this application, AI Biosciences, Inc. (AIBI) proposes to develop and demonstrate the performance of a hand-held, versatile squeegee-aspirator surface sampler (SASS). Our device will aid Contamination Control (CC) and Planetary Protection (PP) implementation and verification. This SASS can perform diverse sampling tasks and help NASA to perform ISS and crew microbial tracking. The SASS operates in wet or dry, on flat or curved surfaces. This proposal will focus on fluid collection mode only. The SASS can deliver and store liquid samples in microgravity-compatible containers which can be stored or immediately tested without the need for post-collection elution steps. The current SASS (non-microgravity compatible) prototype can recover bacteria and fungi from surfaces below 50 CFU and gave positive results enumerated by plate count. It can also sample areas as large as 1 sq ft. Its vacuum function also allows it to sample porous materials (cloth and nylon). Closed environments such as the ISS and spacecraft for other planned interplanetary destinations require sustainable environmental control systems for manned spaceflight and habitation. These systems require monitoring for microbial contaminants and potential pathogens that could foul equipment or affect the health of the crew. Current sampling and post-collection processing are crew-time intensive. Therefore, our proposal is highly relevant to NASA's mission. Phase I will allow us to design and 3D print the microgravity compatible squeegee and its storage containers. Due to the ease-of-use and small size, we anticipate we will be ready to test the sampling operation in drop-tower and zero-g flight to demonstrate a TRL level of 6 at the conclusion of Phase I. In Phase I, we will collaborate with microgravity fluidics experts Mark Weislogel and Ryan Jenson (IRPI, LLC), plus Professor Chris Mason, a microbiome and sequencing expert at Weill Cornell Medicine.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The SASS can effectively collect surface samples inside the ISS or NASA clean rooms. Our tools will enable:

--ISS and crew microbial tracking

--Microbial detection and monitoring in Advanced Life Support Systems

--Pathogen detection for space-grown food

--Long term environmental monitoring

Future applications (dry-vac mode):

--Sample indoor aerosol and particulates

--Monitor radiation exposure (planetary protection/astrobiology)

--Collect lunar and Martian dust
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

There are increased demands for an easy-to-use, effective and sensitive sampling method for the sequencing and nucleic acid testing market. Our technology is highly effective in recovering samples in localized areas using a small hand-held device. It can be deployed in infection control, environmental monitoring, food safety, crime scene investigations, and homeland security at check points.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S14.03-1291**

SUBTOPIC TITLE: Remote Sensing Instrument Technologies for Heliophysics

PROPOSAL TITLE: 4.7 THz Receivers for Heliophysics

Small Business Concern

Firm: **Virginia Diodes, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

This proposal is responsive to NASA SBIR topic S14.03 Remote Sensing Instrument Technologies for Heliophysics; specifically, the last bullet item related to "*Technologies for precise radiometry at terahertz bands…, particularly at 4.7 THz.*" Through this proposed SBIR effort, VDI will develop the technology to realize an all-solid-state heterodyne receiver at 4.7 THz with suitable frequency resolution, sensitivity, and SWaP for Heliophysics applications in low Earth orbit on SmallSat and CubeSat platforms. The Phase I work is a combined simulation/experiment design study to prove the feasibility of the technology to achieve the SBIR topic requirements and generate the exact plan to achieve these requirements through Phase II. The receiver will be based on a Schottky diode mixer with a local oscillator (LO) source based on high frequency power amplifiers and a chain of frequency multipliers. By the conclusion of the Phase II effort, a prototype receiver system will have been developed and characterized in a laboratory environment (TRL 4) and delivered to NASA for use as a prototype or engineering model (EM) for future Heliophysics missions. This prototype will also be designed to be suitable for space-qualification and will become the basis for a commercial line of receivers for SmallSat and CubeSat applications across the 1 – 5 THz range.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary NASA application is Heliophysics, specifically the measurement of the OI line in Earth's atmosphere through limb sounding at 4.7 THz. The Schottky receiver will have sufficient frequency resolution, sensitivity, and SWaP for this important application. When combined with the recent demonstration of compact heterodyne receivers at 870 GHz and 2.5 THz for IceCube and SSOLVE, respectively, this effort will demonstrate complete coverage from below 1 THz through 5 THz for NASA's atmospheric research programs.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

There is an emerging market for SmallSat/CubeSat-based atmospheric remote sensing technology. Compact receivers with advanced functionality can also benefit imaging systems for portal security. Higher frequency receivers will also extend the frequency range of commercial test & measurement equipment, for example frequency extenders for spectrum and signal analyzers.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S12.04-1446**

SUBTOPIC TITLE: X-Ray Mirror Systems Technology, Coating Technology for X-Ray-UV-OIR, and Free-Form Optics

PROPOSAL TITLE: Binary Pseudo-Random Array (BPRA) standards for Inspection and Calibration of Cylindrical Wavefront Interferometry

Small Business Concern

Firm: **HighRI Optics**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

High-accuracy metrology is vitally essential in manufacturing and optimally using ultra-high-quality free-form mirrors designed, for example, for space X-ray telescopes to manipulate X-ray light with nanometer-scale wavelengths. Due to the shorter wavelength, requirements to the surface figure (shape) and finish (roughness) of X-ray mirrors are many orders of magnitude more stringent than for visible-light optics. Metrology technology has not kept up with the advancement in fabrication technologies. The deficiencies in the metrology, rather than in the fabrication technologies, primarily limit the optical quality. We propose to develop a novel “turn-key” technology and methodology for high precision calibration and sophisticated data processing directed to advance the Cylindrical Wavefront Interferometry. Realizing the proposed goals will open a principally new avenue for fabrication and performance characterization of large-area strongly-aspherical grazing-incidence X-ray mirrors that are critical optical elements of the high-performing space X-ray telescopes and beamline systems the modern X-ray facilities.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The technology will enable superior fabrication and performance characterization of large-area & strongly-aspherical grazing-incidence X-ray mirrors for X-ray telescopes by improving the metrology methodology. The capability for a full-dynamic-range ITF characterization of the metrology tool and data reconstruction to recover “true” optical surface has never been available before. The technology can be easily integrated with the existing metrology systems at NASA.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Using sophisticated full-spatial-frequency ITF characterization and beyond-resolution reconstruction of the metrology data, this product will bring existing metrological tools to their highest possible performance level; it will improve the optical quality of optics, reduce the cost of fabrication, and enable faster improvements in future designs of the instrumentation by equipment manufacturers.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.04-1919**

SUBTOPIC TITLE: Nontraditional Airspace Operations and Aerial Wildfire Response

PROPOSAL TITLE: UAS Traffic Management (UTM) Concept Demonstration for 24 Hour Aerial Firefighting

Small Business Concern

Firm: **Trident Sensing LLC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Climate change is increasing the frequency and severity of western wildfires. Threats to people and infrastructure are growing with more population living in the wildland-urban interface. Blindly throwing more resources at the problem while doing things the same way is not a cost-effective solution. Extending manned and unmanned aerial firefighting to 24-hour operations will provide a major increase in firefighting effectiveness and efficiency. During the night, winds die down, temperatures decrease and humidity increases making night time a more productive time to fight fires from the air. But, existing airspace management processes are visual, manual, and not

conducive to UAS participation. Hence, firefighting is largely restricted to manned, daytime, clear air mass visual operations. By applying existing and emerging technology in innovative ways, firefighting can be transitioned to round the clock operations with Unmanned Air Systems (UAS) picking up much of the workload.

UAS Traffic Management (UTM) concepts will be demonstrated including; UAS near real time fire map downlinked to a ground-based Common Operating Picture (COP), ground based UAS mission tasking, uplink of tasking, and precision guidance to the delivery point. Actual retardant drop parameters are downlinked for display on the COP for evaluation of mission effectiveness. The overhead stack of lead plane, tanker, and aerial supervision aircraft is eliminated. Night air operations are de-conflicted through the use of controlled 3D entry and exit corridors to eliminate the risk of mid-air collision. Eliminating the overhead stack at night will improve efficiency by allowing manned/unmanned tankers to drop on arrival vice waiting in the stack. Airspace is freed up for dedicated UAS missions. Near real-time fire mapping and asset tracking are considered key enablers to allow transfer of control of night of air operations to the ground.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed research has multiple NASA applications:
- This research supports NASA's UTM initiative to better integrate UAS functions inside the National Airspace (NAS) as well as firefighting Temporary Flight Restrictions (TFR).
- The technology as envisioned directly supports fire science by providing data on fire intensity, local weather, retardant drop location/density that can be used to evaluate effectiveness.
- Additionally, this research directly applies to NASA's new wildfire initiative.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

• Federal agencies will benefit from to shift to night/24 hour operations with UAS picking up a major portion of the workload
• State/Local Emergency Services will benefit from a real time feed of fire mapping along with knowledge of where the firefighting effort is being concentrated.
• Utilities, Insurance and Media benefit with better information flow.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z10.04-1388**

SUBTOPIC TITLE: Materials, Processes, and Technologies for Advancing In-Space Electric Propulsion Thrusters

PROPOSAL TITLE: High Emissivity Channel Materials

Small Business Concern

Firm: **Advanced Ceramics Manufacturing**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Electric propulsion for space is attractive for NASA, military, and commercial missions. NASA has identified manufacturing issues that have resulted in significant costs to achieve performance repeatability and hardware reliability. To date, these materials have ongoing challenges with performance/hardware reliability related to thermal management. As Hall Effect thruster power is scaled-up for missions with large payloads, thermal management poses a major design challenge for temperature-sensitive areas of the thruster. State-of-the-art Hall-effect thrusters use borosil ceramics for the discharge channel. ACM has identified emissivity modifiers that can be added to conventional channel materials that will create a High Emissivity Borosil (HEB). This will increase the total channel emissivity. Compared to a coating, this method will offer lifetime performance enhancement that will not spall, fail, or outgas due to cyclic power cycles.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The resulting technology will allow more efficient, higher reliability, and longer lifetimes for electric propulsion systems. The technology will find use in NASA Science Mission Directorate (SMD) and Human Exploration and Operations Mission Directorate (HEOMD) and commercial satellites.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The new channel materials will find use in commercial satellite propulsion systems used to maintain orbit.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z10.04-1751**

SUBTOPIC TITLE: Materials, Processes, and Technologies for Advancing In-Space Electric Propulsion Thrusters

PROPOSAL TITLE: Passive Two-Phase Thermal Management System for Hall Thruster

Small Business Concern

Firm: **Advanced Cooling Technologies, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

As NASA envisions to develop higher power Hall effect thrusters for large payload (or even crew member) transportation, thermal management becomes a bottleneck. In response to NASA technology roadmap "*heat rejection system for in-space propulsion*" (TA 2.4.4). Advanced Cooling Technologies, Inc. (ACT) in collaboration with the University of Michigan proposes to develop an innovative thermal management system for hall thrusters utilizing two-phase and passive cooling techniques. Multiple heat pipes constructed with advanced geometry and wick will be integrated strategically in the hall thruster to manage both plasma heating and ohmic heating from magnetic coils. Working fluid and envelope material will be selected based on thermal, electrical and magnetic properties. A proof-of-concept prototype will be fabricated and its thermal performance under the influence of magnetic and electrical fields will be experimentally characterized. A full-scale hall thruster with two-phase cooling system will be designed and its SWaP benefits will be analyzed jointly by ACT and the collaborator.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed hall thruster cooling system is fully-passive, lightweight and highly reliable. This will allow NASA to develop more capable and longer life electric propulsion technologies for future deep space robotic and human exploration missions beyond LEO. Example missions are Psyche, Double Asteroid Redirection Test (DART), CAESAR, and Lunar Orbital Platform Gateway (LOP-G).

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed two-phase hall thruster cooling system will enable smaller, lighter and higher specific impulse hall thruster designs, which will benefit many commercial and military satellites, including CubeSats and SmallSats.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S17.04-1526**

SUBTOPIC TITLE: Application of Artificial Intelligence for Science Modeling and Instrumentation

PROPOSAL TITLE: Improving Data Assimilation in Numerical Weather Prediction of Winter Cyclones using Artificial Intelligence and Machine Learning

Small Business Concern

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Operational numerical weather prediction (NWP) models frequently struggle with track errors for wintertime cyclones which can lead to life threatening impacts and economic disruptions. Data assimilation is an advanced statistical method for preparing relatively low-resolution, high-fidelity sensor information for these NWP models. This method produces a first-guess field that serves as an estimation of the current state of the atmosphere in operational NWP models, which ultimately produce weather forecasts that are essential tools for forecasters. Despite many advances in the field, shortcomings are still very apparent and NWP models still have prediction issues with common weather occurrences, including those that produce extreme weather. The very large data volumes and computational expense of imperfect data assimilation requires unique solutions to improve NWP predictions. With the advance of machine learning (ML) and artificial intelligence (AI), along with other techniques for processing large volumes of data, the possibilities for improving data assimilation are numerous. This proposed effort will take advantage of recent advances in AI/ML in order to generate better initial conditions for NWP models, which will contribute to improved forecasts of extreme events. This effort will begin by gathering large amounts of data prior to and during major winter weather events to create training datasets for proper orthogonal decomposition (POD) reconstruction which will provide an AI/ML approximation of the natural state based on the data collected. We plan to run NWP models using both traditional data assimilation and with POD dynamic modeling for winter cyclones. The new AI/ML technique should present new approaches for future NASA model development and NASA computational groups.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed research will leverage AI/ML advances as a method to improve data assimilation in Earth systems models, specifically weather models. This work has broad applications for developing NASA climate and weather models, along with applications to the development of the NOAA Unified Forecast System, which will be the state of the science over the next decade. This work has broad applications for several NASA groups, including GMAO, ESTO/AIST, CISTO, and NCCS.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Numerous scientific organizations, national laboratories, and universities are aiming to bring together AI/ML talent with atmospheric and climate scientists, and this work is one effort that could provide proof-of-concept. The development of the UFS by NOAA would also benefit from improvements in data assimilation as they continue to develop state of the art tools for Earth systems prediction.
Duration: **6**

PROPOSAL NUMBER: 22-1- **S12.02-2095**

SUBTOPIC TITLE: Precision Deployable Optical Structures and Metrology

PROPOSAL TITLE: Additive Manufacturing of Low CTE Open Isogrid Composite Structure

Small Business Concern

Firm: **Continuous Composites Inc.**
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Phone: **(888) 508-1085**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Continuous Composites Inc. (CCI) has developed and patented a continuous fiber 3-D printing technology known as CF3D®. CF3D has unique capabilities to reduce cost, accelerate design cycles, scale throughput, and create highly tailorable structures (e.g., in terms of design and material properties). By utilizing continuous fiber reinforcement, snap curing aerospace-grade photopolymers, and robotics, CF3D can drastically reduce the time and cost of creating continuous fiber-reinforced composites.

CF3D allows for fabrication of unique structures that would be impractical to produce with traditional methods requiring autoclave or vacuum bag pressure during curing. One such structure is an open iso-grid rib structure. Iso-grid composite structures are not a new technology and have been built and flown on space structures, however traditionally are very expensive to produce.CF3D is very conducive to the manufacturing of iso-grid composite structures, either with a skin or as an open lattice concept. The single carbon fiber tow can be put on a support surface of any shape (e.g., flat, cylindrical, or spherical). Each tow is then stacked on top of the previous tow and UV cured in-situ, resulting in any rib pattern desired for the target strength and stiffness of the structure.

A unique property of the composite open iso-grid structural concept is its bulk thermal expansion properties. As each rib of the iso-grid structure is composed of all unidirectional fibers oriented along the length of the member, the CTE is very low. Published studies on T800 unidirectional laminates show CTE to be in the range of -.4 (10^{-6} X K^{-1}) in the fiber direction. This results in a structure that is overall lightweight and isotropic given the nature of the iso-grid concept with a very low CTE. Using high strength, low-cost intermediate modulus fibers to build a lightweight, low CTE structure has the potential to greatly decrease the weight, cost, and lead time of dimensionally stable structures.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Potential NASA applications include dimensionally stable space structures and light weight space payloads and vehicles structures.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Potential Non-NASA applications include commercial dimensionally stable space structures and light weight space payloads and vehicles structures. In addition, other aerospace applications where lightweight open iso-grid structures can add value to a program such as fixed wing aircraft, helicopter, VTOL, or other high performance aerospace composite structures.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.08-1736**

SUBTOPIC TITLE: Atomic Quantum Sensor and Clocks

PROPOSAL TITLE: Rugged Atomic Sensor Laser

Small Business Concern

Firm: **Opto-Atomics Corp.**
Address: **222 West 6th Street, Suite 400, San Pedro, CA 90731**
Phone: **(310) 920-2431**

Principal Investigator:

Name: **Dr. Jae Choi**
E-mail: **info@opto-atomics.com**
Address: **222 W 6th St, Ste 400, CA 90731 - 3345**
Phone: **(310) 920-2431**

Business Official:

Name: **Dr. Jae Choi**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Atomic systems are adopted in a growing number of field-deployable sensors for time-keeping, inertial navigation, gravity sensing, magnetometry, electric-field (RF/microwave) sensing, and others. Quantum sensing, taking advantage of the quantum mechanical behavior of neutral atoms, is expected to significantly boost the sensitivity of various sensor modalities critical in NASA and other government or commercial applications. Opto-Atomics Corp. (OAC) proposes to develop a Rugged Atomic Sensor Laser (RASL) for NASA's in-space atom-based sensing applications. RASL will offer flight-qualifiable, rugged, long-life laser systems offering narrow linewidth and high tunability. The RASL platform can be used in atom-based sensing with various atomic species of interest to NASA, even multiple species at the same time if needed, thereby serving as a flexible, versatile, compact light source addressing many NASA missions under a shared system architecture and design. In Phase I, OAC will design and assemble key system components of RASL, evaluate their performance, and perform feasibility demonstrations. We will also conduct a preliminary design of the fully-packaged, configurable RASL system for future development.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Quantum sensing has not been widely adopted in field-deployable systems due to system integration and ruggedization challenges. However, with recent development in various enabling technologies, quantum sensors are adopted in a growing number of applications. Various NASA missions and R&D requiring inertial navigation, gravity sensing, timekeeping, magnetic-field sensing, and RF/microwave sensing can benefit from a rugged, versatile laser system developed explicitly for atom-based sensing.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Quantum sensing based on neutral atoms has many potential applications for the military and other governmental sectors. The RASL technology will significantly expedite field deployment of these truly quantum devices by providing a robust, versatile light source that can be used in various quantum metrology applications.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S12.01-2830**

SUBTOPIC TITLE: Exoplanet Detection and Characterization Technologies

PROPOSAL TITLE: Next generation vector vortex waveplates for astronomical coronagraphs

Small Business Concern

Firm: **BEAM Engineering for Advanced Measurements**

Address: **1300 Lee Road, Orlando, FL 32810**
Phone: **(407) 734-5222**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

The objective of the proposal is advancing the technology of vector vortex waveplates (VVWs) into: novel spectral ranges that have been practically prohibited by fabrication tolerance and even fundamental issues; broader spectral bandwidths wherein a single VVW could be used for coronagraphs developed for vastly different parts of spectrum; novel, highly robust VVW architectures that would eliminate or, at least, will dramatically reduce the effects of fabrication errors and ambient conditions on device performance; polarization-insensitive VVWs; reduce size and weight of coronagraphs by providing VVWs with other optical functions and integrating them with other multifunctional planar optical components of 4G optics; reduce cost levels wherein the technology becomes available and affordable for low-cost applications and missions.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Astronomical coronagraphs; free-space optical communication

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Astronomical coronagraphs; free-space optical communication; optical tweezing and micromanipulations; hgih resolution microsocpy, quantum communication, quantum computing

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z13.02-1981**

SUBTOPIC TITLE: Mechanisms for Extreme Environments

PROPOSAL TITLE: Regolith Dust and Radiation-Tolerant Bearing

Small Business Concern

Firm: **MillenniTEK, LLC**
Address: **631 Barbrow Lane, Knoxville, TN 37932**
Phone: **(865) 966-2170**

Principal Investigator:

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Phone: **(865) 966-2170**

Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

A radiation-resistant and superhard material for dust-resistant mechanical bearing applications on the lunar surface will be tested and demonstrated under this project. This highly incompressible ceramic material is able to be formed into intricate bearing geometries directly from powder by utilizing spark plasma sintering to create dense, hard, geometrically precise, and wear-resistant bearing surfaces. This new material is more than 30% lighter than the chrome steel commonly used for bearings, and about 15% lighter than Nitinol, which NASA has been recently investigating for bearing applications. A roller bearing using this new material that is tolerant of regolith dust will be designed and partially fabricated and tested. Specimen coupons of the material will be characterized for tribology properties, coefficients of thermal expansion and friction, and wear resistance during temperature extremes from -240 C to 130 °C. At the

conclusion of the Phase II, a functioning roller bearing would have been tested in the simulated conditions and delivered to NASA for further evaluation.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The new bearing being developed will be immediately applicable to small, precision mechanical bearing applications that can operate reliably without environmental protection housing in the extreme environments of NASA missions. In addition to the lunar environment, other NASA missions can experience temperature extremes ranging from high temperature/high pressure to cryogenic temperatures/vacuum.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The new radiation-resistant and superhard bearing material being developed has significant potential beyond spaceflight applications, including improved performance for industrial bearings. This fully-ceramic bearing material technology has the potential to be utilized in high temperature and corrosive applications in the oilfield, refinery, chemical processing, and metal processing industries.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z2.02-1130**

SUBTOPIC TITLE: High-Performance Space Computing Technology

PROPOSAL TITLE: High-Performance Space Computing Technology

Small Business Concern

Firm: **Space Micro, Inc.**
Address: **15378 Avenue of Science, San Diego, CA 92128**
Phone: **(858) 332-0700**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA needs enhanced high-performance space computing technology for future missions. Current radiation hardened solutions are power inefficient and lack significant computing performance compared to current commercial capabilities. Some modern technology or process nodes have inherent radiation resistance due to the fabrication methods; partially depleted, fully depleted, and FinFET gates; and the use of silicon-on-insulator. Combining processors implemented with these technologies alongside Space Micro's patented upset mitigation techniques, blind scrubbing, and execution checkpoints, yield a space-grade COTS processor with 1000 times more performance than current radiation-hardened processors.

Space Micro proposes the development of a 3U SpaceVPX, radiation-tolerant, high-performance, reconfigurable single board computer (SBC) based on the Xilinx Versal VC1902. Space Micro has named this new SBC the Proton High-Performance Reconfigurable (PHiRe™) SBC. This SBC offers enhanced parallel processing and artificial intelligence power, much to the effect of a supercomputer cluster. The main system would have the ability to reconfigure this SBC to scale up and down performance of the scalar and parallel processing units to limit power dissipation, specifying a specific state depending on the needs of the current task.

The PHiRe™ SBC utilizes the Xilinx 7nm Versal VC1902 which provides dual ARM Cortex-A72 application processors, dual ARM Cortex-R5F real-time processors, 400 artificial intelligence inference engines, 1,968 DSP engines, and 1,968 reprogrammable system logic cells which combine to provide the following figures of merit:

- AI Engine Peak Performance: 8 TFLOPS
- DSP Engine Peak Performance: 3.2 TFLOPS
- Adaptable Engine Peak Performance: 29 TOPS
- Arm Cortex-A72 Peak Performance: 18,942 DMIPS
- Arm Cortex-R5F Peak Performance: 2.672 DMIPS

Potential NASA Applications (Limit 1500 characters, approximately 150 words):
Our cross-cutting space product with enable current and potential NASA space missions, JUICE, WFIRST, NISAR, Lucy, Psyche, IXPE, Restore, Hermes, Whipple, TiME, Hera, Chopper, ectc. which encompass both Discovery-class and SMEX missions. Future NIAC missions such as KST, PuFF, LEAVES, and R-MXAS could benefit. Space Micro will manufacture and market this product to NASA customers, after design verification in Phase II spacecraft primes will be more comfortable with the higher TRL.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The product evolving from this SBIR will accommodate a wide range of space customers including emerging commercial constellations from the likes of TeleSat, Inmarsat, HeliosWire, Saturn, Astranis, Audacy, WorldVu, SpaceX, Iceye, and Blue Origin. There are also a number of DoD space mission applications for small satellites.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z13.03-1180**

SUBTOPIC TITLE: Technologies for Spacesuits in Extreme Surface Environments

PROPOSAL TITLE: Removable xEMU SCC Protective Cover

Small Business Concern

Firm: **Off Planet Research, LLC**
Address: **1130 Marine View Drive Suite A-2, Everett, WA 98201**
Phone: **(253) 391-0293**

Principal Investigator:

Name: **Vincent Roux**
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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Off Planet Research (OPR) will develop a cover for the Service and Cooling Connector (SCC) on the xEMU that will protect the SCC from dust intrusion while operating on the lunar surface. The cover will exclude dust from the entire surface of the SCC, be lightweight, and have high reliability due to the low number of components. The cover will be easy to attach and remove, free from catching during normal EVA activity, and reduce dust adherence on the exterior surface of the cover. Prior to entering Phase 2, proof of concept and risk reduction for the cover will be accomplished through testing and demonstration of the cover design and operation, and through review and feedback by NASA representatives and the xEMU team. Based off of design concepts from previous SBIR awards, our cover technology is currently at TRL 2.

The timing and urgency of providing flight-ready SCC covers may make it necessary for a two-stage approach to address this technology gap; providing first generation covers for the first few Artemis missions that are intended for EVAs over a single mission while developing a second generation cover that will be capable of use on repeated missions. Using information provided by NASA, we will produce a mechanical mock-up of the SCC port in our lab to ensure timely and

effective development of the cover and its operation. Intermediate covers may be sent to NASA for evaluation using the xEMU depending on the design iteration timeline. Recommendations and feedback from the xEMU team will be integrated into revised cover designs.

We will also produce a retaining device to hold and protect the cover as well as keep it clean when it is not installed on the suit. If desired, this retaining device may be designed to be situated within the same location that the umbilical is stored in when not in use. This will provide a secure location away from the potential dust carried into the habitat during donning, doffing, or cleaning procedures.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This cover supports a current and urgent need for future NASA missions to protect the SCC ports from lunar regolith. Protecting these ports to enable recharging the xEMU will help ensure longer duration EVAs. The primary customer is the xEMU team as this is a custom cover designed to integrate into the current suit architecture. We will continue to explore additional application for a similar cover for protecting connectors on rovers and in habitats, ISRU plant interfaces, and control panels.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

We anticipate that a similar type of cover on commercial rovers and landers will be needed that will create a follow-on market for this technology. Economic benefits include increased lifespan of interconnecting systems, such as the xEMUs, rovers, and ISRU plants. The size of the commercial market for a similar product will be determined in later phases through market research.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z4.05-1156**

SUBTOPIC TITLE: Nondestructive Evaluation (NDE) Sensors, Modeling, and Analysis

PROPOSAL TITLE: Advanced Damage Criticality Analysis in Complex Structures

Small Business Concern

Firm: **Antech Systems, Inc.**
Address: **510 Independence Parkway, Suite 100, Chesapeake, VA 23320**
Phone: **(757) 547-2828**

Principal Investigator:

Name: **Dr. Steven Ziola**
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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Antech Systems proposes to demonstrate a) passive Structural Health Monitoring (SHM) systems can quantitatively identify, locate, and characterize defects, such as cracks and delaminations, using 3D image correlation, and b) how this innovative approach provides a path to commercialization through a more efficient FEA calculational approach to automate the analysis. The development will incorporate and commercialize the use of NASA-developed numerical methods software to characterize the source and guide the image analysis. The approach adds another dimension to the numerically derived dispersion curve plots by adding the amplitude of each frequency component of each mode into the plots using the modeling. This gives a 3D time/frequency/amplitude dispersion curve plot to perform the analysis with – a first. These theoretical curves, which now fully describe a source (e.g., depth, orientation), are correlated against the wavelet transform image of the waveform excited by the defect to accurately identify the source – aka, facial recognition for waveforms. This approach takes guided wave signal analysis out of the 2D/phase velocity space, moves it into a 3D group velocity image analysis (the natural analysis space for guided waves), and directly ties theory to the wavelet image of the raw signal.

The numerically guided image analysis enables automated inspections of large or complex aerospace structures, provides reliable rapid assessments of the location and extent of damage or defects, and registers NDE results to precise locations on the structure. Structural components, such as heat shields, can be practically monitored. Micrometeoroid impact damage has been extensively researched by NASA, and it is well known that the guided wave modes excited are controlled by penetration depth. The 3D image correlation approach extracts that detailed information automatically for any number of modes to accurately characterize impact damage with no manual inspection required.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- Passive SHM of payloads in transit from point of manufacture to launchpad to space to final station whether orbiting or operating on a moon or planet where constraints on power, weight, and footprint are paramount.
- Monitor space vehicles and orbiting stations for debris impacts and evaluate the bond line and in-depth integrity of ablative materials, such as heat shields.
- SHM of composite pressure vessels, composite materials, and other large metallic and composite structures, and Lunar Gateway.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- Navy, Coast Guard, and Commercial Shipping – Monitoring hull structures for crack propagation at sea, composite high pressure air tanks.
- Petrochemical Industries – Leak detection in storage tanks and pipeline.
- Requalification of pressure vessels – Integrity of vessels used for alternative fuels (such as compressed natural gas and hydrogen) to ensure public safety.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.01-2209**

SUBTOPIC TITLE: Robotic Mobility, Manipulation and Sampling

PROPOSAL TITLE: High Strain Composite Booms for Robotics

Small Business Concern

Firm: **Opterus Research and Development, Inc.**
Address: **815 14th Street SouthWest, Suite C200, Loveland , CO 80537**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

Technical Abstract (Limit 2000 characters, approximately 200 words):

The proposed innovation is to adapt Opterus' high strain composite boom and deployer technologies and apply the low-mass, low-power dust tolerant technology to robotic arms for low-gravity environments. A boom enabled robotic arm enables surface mobility, manipulation and sampling functions in an extremely compact, low mass sub system. The high structural performance and low mass features of Opterus' booms and deployment mechanisms can support a greater range of end effectors for scooping, drilling, grasping, or otherwise acquiring

and manipulating surface objects. Opterus is also investigating continuous roll-to-roll fabrication methods for kilometer scale HSC booms.

The objective of the proposed work is to analytically evaluate and experimentally demonstrate the technical feasibility of high strain composite booms applied to a variety of robotic mobility, manipulation, and sampling tasks. Opterus will evaluate concepts, demonstrate the feasibility and quantify the benefit of HSC deployable and retractable booms for three objective applications: legged robotic mobility, robotic arms for low-gravity environments to perform surface and near-subsurface sampling, and kilometer scale HSC boom deep drill systems. Each application will be similarly studied during the program. Each application study will consist of traditional analysis, design, build, and test tasks.

Opterus and will employ an iterative development approach using the analysis, design, build, test cycle. In the course of HSC development programs, we have found a balance between build and analysis to be most effective and we expect to achieve 3-5 cycles in this program. New HSC booms often require 10-20 build iterations to achieve desired objectives. Development will be accelerated here because of Opterus' extensive experience with high strain composite booms.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

HSC booms are enabling for NASA's next generation of robotic architectures for multiple small-body and planetary missions such as the Ocean Worlds program with surface and deep drills for Europa, and future missions to Enceladus, Titan, and other planetary bodies with subsurface oceans. Sample-return missions could be supported such as from Ceres, comets, and asteroids. And a renewed interest in return to Earth's Moon, the mobility and sampling technologies could support future robotic missions to the Moon and Mars.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non-NASA markets include similar operations but in-space rather than small bodies or planets. On-orbit servicing, assembly, and manufacturing is a key DoD market for the robotic arm architectures enabled by Opterus' HSC booms.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z1.05-2530**

SUBTOPIC TITLE: Lunar and Planetary Surface Power Management and Distribution

PROPOSAL TITLE: Radiation Hardened High Power "GBID" Ga2O3 Based Isolated DC-DC Converter

Small Business Concern

Firm: **Syrnatec, Inc.**
Address: **95 Pond Place, Middletown, CT 06457**
Phone: **(860) 594-5248**

Principal Investigator:

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Business Official:

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Phone: **(860) 594-5248**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Recently realized radiation-hardened Gallium Oxide (Ga_2O_3) Metal–Oxide–Semiconductor Field-Effect Transistor, (MOSFETs) offers the opportunity to increase efficiency and power density of space DC-DC power converters. The state of the art for space DC-DC power conversion trails its commercial counterparts in terms of power density and efficiency. One challenge that arises when designing for space environment is the harsh environment power converters need to operate in, and limited availability of space qualified components and field demonstrated converter topologies. Another challenge is the manufacturing process and reliability testing of reliable radiation hardened power MOSFETs. Ga_2O_3 MOSFETs not only have better electrical performance than power MOSFETs, they have also demonstrated inherent tolerance to radiation. This results in fewer structural device modifications required to make Ga_2O_3 MOSFETs operate reliably under high radiation compared to their Silicon counterparts. Syrnatec, an ITAR compliant, HUBZone, minority woman-owned small business seeks to utilize its radiation hardened Ga_2O_3 High Power MOSFETs to implement a Fixed Frequency Isolated Phase Shifted Full Bridge DC-DC Converter that supports 10 kW of power over a wide-temperature (-70ºC to 150ºC), provides high-power-density (>2 kW/kg), high-efficiency (>96%) power electronics with associated drivers for voltage regulation.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Proposed 10KW WBG DC-DC converter will address Lunar and Mars base initiatives. This Power Converter will also benefit other NASA Mission Directorates - Science Mission Directorate and Aeronautics Research Mission Directorate. Specific projects that could find value include Gateway, In-Situ Resource Utilization, Advanced Modular Power Systems, In-Space Electric Propulsion, Planetary Exploration and Electrified Aircraft Propulsion Technology. This technology will be used for Mars, Asteroid research and search of life on other planets missions.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- Off-highway, Mining and Construction Vehicles, Power, for Telecom Infrastructure, E-Vehicle Charging Stations, Renewable Energy Conversion Electronics, Combat Ground Vehicle Systems, Aviation Systems, Electrical Power Systems for Telecommunication Equipment

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.04-2561**

SUBTOPIC TITLE: Electrified Aircraft Propulsion

PROPOSAL TITLE: Low AC Loss Cryogenic Aluminum Conductors for Stators in Very High Speed Motors and Generators for Electric Aircraft

Small Business Concern

Firm: **Hyper Tech Research, Inc.**
Address: **539 Industrial Mile Road, Columbus, OH 43228**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

This SBIR proposal is submitted in response to solicitation SBIR Topic A1.04. This project relates to development of cryogenic (rotor and stator) generators required for future thin/short haul aviation or commercial transport vehicles which use turboelectric, hybrid electric, or all electric power generation as part of the propulsion system. Turboelectric, hybrid electric and all electric power generation as well as distributed propulsive power have been identified as candidate transformative aircraft configurations with reduced fuel consumption/energy use and emissions. However, components and management methods for power generation, distribution and conversion are not currently available in the high-power ranges with the necessary efficiency, power density, electrical stability and safety required for thin haul/short haul, or transport-class aircraft. Specifically, motors/generators are desired with >98% efficiency, specific power >13

kW/kg, and total power >200 kW. For generators, high power density can be achieved if the rotational speed is high (15,000-30,000 rpm), however low AC loss conductors are required in the stator. This can be achieved by designing the stator with a high purity aluminum “hyperconductor” at cryogenic temperatures with a cryogenically cooled superconducting rotor.

During the Phase I we will be investigating the use of cryogenic aluminum “hyperconductor” as a low AC loss conductor for stator coils. With the development of low AC loss aluminum “hyperconductor” wire by Hyper Tech, we can achieve high speed cryogenically cooled generators with power densities over 30 kW/kg for aircraft. During the Phase I we intend to demonstrate approaches for manufacturing aluminum “hyperconductor” strands and cables suitable for high speed machines (500-600 Hz, 15,000-25,000 rpm), and analyze the AC losses of the conductors in applied magnetic fields for developing generator conceptual designs with high speed rotors.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Besides electric passenger aircraft, NASA can benefit from many applications where lightweight power components are required such as smaller land-based generators, invertor type transformers, inductors and higher frequency power conditioning equipment.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Hyperconductor aluminum is a solution for manufacturers of invertor transformers, high speed motors and high speed generators (10,000 - 30,000 rpm) requiring high power density who seek lighter weight and higher efficiency 4-20 MW class aircraft turbo-generators, offshore oil platform motors, marine propulsion and generation and portable emergency power systems.
Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.02-2783**

SUBTOPIC TITLE: Spacecraft Technology for Sample Return Missions

PROPOSAL TITLE: Materials for Structural and Thermal Preservation of Sample Return Payload During Earth Entry and Landing

Small Business Concern

Firm: **Ultramet**
Address: **12173 Montague Street, Pacoima, CA 91331**
Phone: **(818) 899-0236**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

Technical Abstract (Limit 2000 characters, approximately 200 words):

To maximize reliability, Earth entry/landing vehicles 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. Lightweight carbon foams are being considered for the crushable layer, but many other foams with different strengths and energy absorption capacities are available. By using foams of different materials with different mechanical properties and different relative densities, the crush behavior of the layer can be tailored. In addition to brittle crushing of carbon foams or ductile collapse of metallic foams, other energy-absorbing mechanisms are available, some of which have been tested at high strain rates for use as underbody armor on military vehicles to mitigate blast effects from improvised explosive devices. In this project, existing foam properties data at Ultramet will be used to guide the selection of candidate impact absorption material systems, which will include both brittle and ductile foams as a key element. The candidate impact absorption material systems will be built up and undergo high strain rate compression testing via the split Hopkinson bar technique. Low density and low thermal conductivity are also desirable characteristics, so density and thermal conductivity measurements will also be made. The resulting data will be used to develop a top-level design for a minimum-mass, low thermal conductivity crushable layer for sample return missions with high impact velocities.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary NASA application will be sample return missions from solar system locations including planets, planetary moons, dwarf planets, asteroids, and comets. Because the energy absorption characteristics of the material system can be tailored, it also has the potential to be used for landing payloads on these bodies. Likewise, for a mission to divert an asteroid from collision with Earth, this type of system could be used to transfer momentum to the asteroid over a tailorable time frame to minimize fracture/fragmentation of the target body.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial applications for lightweight energy-absorbing structures include backing structures for automobile bumpers and underbody armor for military vehicles to mitigate blast effects from mines and improvised explosive devices. Temporary structures in war zones could also be protected against blast effects with this technology.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H9.01-2383**

SUBTOPIC TITLE: Long-Range Optical Telecommunications

PROPOSAL TITLE: Platform Isolation and Pointing Control

Small Business Concern

Firm: **Controlled Dynamics Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

Technical Abstract (Limit 2000 characters, approximately 200 words):

Existing technologies for platform isolation and pointing of deep-space optical communications terminals are sensitive to radiation and rely on sensors that either exceed size/mass/power constraints or are no longer in commercial production. Phase 1 addresses these issues by extending existing design architectures to add robustness to component failure and investigate combinations of and modifications to Commercial Off the Shelf acceleration and angular rate sensors that can meet performance, environment, and size/mass/power constraints. Component testing of sensors will advance the design concept to TRL-3 and establish proof of concept feasibility.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Planetary mission communication using optical relays back to Earth. Deep-space exploration. The design is scalable to a wide range of deep-space missions; from small solar-system probes, to human Moon and Mars missions.

Primary Technology Taxonomy: TX 05.1 Optical Communications.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial Moon and Mars missions that require high bandwidth communications back to Earth. Free-space optical communication in Earth orbit for satellite-to-satellite communication and communication from orbit to ground.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.04-2151**

SUBTOPIC TITLE: Electrified Aircraft Propulsion

PROPOSAL TITLE: Combined Machine and Converter Architecture for Megawatt EMI Control and Weight Savings

Small Business Concern

Firm: **Kaney Aerospace**
Address: **1300 Capital Drive, Rockford, IL 61109**
Phone: **(815) 986-4359**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Commercial aviation is a marvel of the modern world, connecting our society in ways that were unfathomable just over one century ago. Currently, the industry relies on fossil fuels for the energy required to fuel these aircraft. Commercial-scale electrification of aircraft propulsion systems promises a bright future with substantial societal benefits including reduced carbon emissions, greenhouse gas emissions, noise emissions and energy consumption.

Kaney believes that the requisite power density for long distance commercial passenger air service by electric propulsion will only be achieved with considerable systems engineering and integration of many new novel technologies. Such an electric aircraft propulsion system may be comprised of novel thermal management, additively manufactured motor windings, co-packaging of the motor and drive, and perhaps most importantly a control and hardware architecture specifically designed to mitigate electro-magnetic interference (EMI). Kaney proposes maturing a combination of novel control techniques and machine/converter topologies under this Phase I SBIR to be applied in concert with wide bandgap semiconductor devices to enable future power converter power densities of 20 kW/kg while meeting DO-160 power quality and EMI requirements.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed technology applies to megawatt scale Electric Aircraft Propulsion (EAP) systems.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed technology may also be applied to non-aerospace electric propulsion systems such as those utilized in locomotives, marine vessels, and automobiles.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A2.03-1596**

SUBTOPIC TITLE: Advanced Air Mobility (AAM) Integration

PROPOSAL TITLE: Multipurpose Doppler Lidar Measurements

Small Business Concern

Firm: **TruWeather Solutions**
Address: **19A Coachman Square, Halfmoon, NY 12065**
Phone: **(609) 367-6459**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Safe Unmanned Aerial Systems (UAS) operations and airspace management depend on accurate weather data to make critical decisions, plan fleet asset tasking, schedule cargo or people movements, reduce flight uncertainty and meet client expectations. Accurate weather data requires a robust, autonomous and reliable sensing platform capable of detecting multiple weather hazards across urban, suburban and rural domains.

TruWeather Solutions has a NASA Phase 2 Small Business Innovation Research project to develop a Wind Hazard Impact Location Service (WHILS) in Hampton, VA that we will integrate into our In-Time System-Wide Safety Assurance (ISSA) platform. TruWeather seeks to expand beyond “wind” to “weather.” This project seeks to expand the service into the Weather Hazard Information Location Service (WHILS2.) Weather hazards impactful to AAM include wind, turbulence, ceiling, and visibility. The TruFlite suite of services currently includes global, regional and local scale weather products. The goal of WHILS2 is to predict when and where it is safe to conduct a UAS urban mission, where urban corridors can be planned. This project will focus on hazardous weather detection in low-altitude, urban environments enabled by the accelerated deployment of a robust weather multi-sensor platform scalable to urban area in the world.

We will develop algorithms to retrieve different weather parameters from a set of sensors. We will validate the retrieved data against other weather data sets, including modelled data. Once validated, we will assess the influence of the retrieved data on urban routes using our route optimization capability RouteCAST. The goal is to enhance our ISSA platform with WHILS2 to detect and predict “hot spots” that drones should avoid. This project will expand and accelerate identification of weather hazard areas to keep airframes and people safe as we test, demonstrate, and deploy initial UAS operations to achieve Urban Air Mobility (UAM) Maturity Level-4.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This initiative enables NASA applications that depend on highly reliable and persistent non-government space, atmospheric and terrestrial measurements and predictions:

- Commercial space launches and human space travel
- ATM / UAS / UTM / UAM Systems, Industries, and Projects
- Satellite and communication systems

UAS and UAM is a “blue sky” mission area to demonstrate how weather monitoring systems, especially in urban areas, can reduce the impact of hazardous events to mission critical operations.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Our applications for this technology extend to FAA and commercial endeavors of the same mission areas that NASA is working in, namely:

- Commercial space launches and human space travel
- ATM / UAS / UTM / UAM
- Satellite and communication systems

We are also looking at how cities can use urban micro weather data as part of Smart City initiatives by deploying weather sensing platforms.
Duration: **6**

PROPOSAL NUMBER: 22-1- **Z12.01-1907**

SUBTOPIC TITLE: Extraction of Oxygen, Metal, and Water from Lunar Regolith

PROPOSAL TITLE: Alkaline Low-Temperature Aluminum from Waste Slag

Small Business Concern

Firm: **Pioneer Astronautics**
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Phone: **(303) 984-9346**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The ALTAWS (Alkaline Low-Temperature Aluminum from Waste Slag) process proposes to take what is currently process waste from oxygen and iron extraction in the Pioneer Astronautics MMOST (Moon to Mars Oxygen and Steel Technology). Slag and beneficiation waste from MMOST will be targeted as ALTAWS feed, though ALTAWS as a first processing step feeding MMOST will also be examined. Ultimately the ALTAWS technology will enable greater oxygen extraction than the MMOST process alone, while also providing valuable aluminum and silicon feedstocks for a greater NASA lunar presence.

The ALTAWS process consists of two primary steps: 1) Alkaline extraction of alumina and silica, and 2) a molten electrolysis to reduce teh oxides to metals. Aluminum is the primary target material, with side production of oxygen and silicon. Process equipment will be modified from the MMOST program to help validate the ALTAWS process. Process design, modelling, and optimization will also be used to determine both the feasibility of ALTAWS, as well as the most optimized configuration that combines the MMOST and ALTAWS processes to produce a combination of aluminum, silicon, iron, and oxygen from lunar regolith.

The results of the ALTAWS Phase I study will be the equipment, experimental data, and process design simulations fed into a feasibility study to determine the best usage of the technology moving forward in conjunction with MMOST. In Phase II, the process design from Ph I would be developed into an automated vacuum ALTAWS demonstration with the system build to be delivered to NASA. In Phase III, an optimized process would be developed into an ALTAWS flight experiment to be landed on the lunar surface.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The ALTAWS program will provide key technology to NASA for metals and oxygen extraction necessary for manned lunar base and permanent lunar presence. The primary aluminum product is directly relevant as a construction material (structures and reflectors), with secondary oxygen being necessary for habitation and rocket fuel. The silicon will be a valuable feedstock for further purification to be used in electronics and PV applications. The aluminum and silicon would also find use in energy carrier/storage systems.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Waste reduction of existing Bayer processes through water and NaOH recycle being developed as part of ALTAWS. Also, the advancement of the FFC Cambridge electrowinning process in the ALTAWS program could open doors for terrestrial commercial use targeting improvements in energy efficiency and product purity.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z1.05-2158**

SUBTOPIC TITLE: Lunar and Planetary Surface Power Management and Distribution

PROPOSAL TITLE: Array for High Efficiency Power Beaming

Small Business Concern

Firm: **MicroLink Devices, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

In this Phase I program, MicroLink proposes to develop a laser power converter array technology that provides a pathway for kW-level power beaming on the Lunar or Martian surface. NASA's planned human exploration of the lunar surface and as well as Mars will require innovative technologies to transmit high power over long distances. The craters on the lunar poles are of particular interest as they are in permanent shadow and may harbor valuable resources such as water ice. However, the shadowed craters present a challenge for power generation since conventional solar arrays cannot be used for energy collection on vehicles such as rovers. Laser power beaming has been proposed as one method to power a rover directly from an energy source located at the rim of the crater, which could be a solar array or nuclear reactor (Figure 1). In "Laser Power Beaming for Lunar Polar Exploration", Landis notes that the recent emergence of efficient and compact fiber laser sources greatly improves the feasibility of such an approach and identifies 1064 nm as an attractive wavelength based on available fiber lasers. Meter-scale, space-grade laser power converters will need to be developed at this wavelength that can efficiently collect 100s to 1000s of watts. The power converters will need to be compatible with the lunar environment and in a form factor that is lightweight and can be compactly stowed. MicroLink's experience in thin-film III-V semiconductor materials, solar optical devices, and space-grade blanket technologies presents a unique opportunity to develop laser power converters that are high-performance, radiation-hard, stowable and highly enabling for future lunar and Mars missions.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- Lunar human exploration – shadowed craters on the lunar poles are targets for future NASA exploration, particularly the south polar region that has been baselined as a landing site for NASA Artemis human exploration. Providing power to rovers operating in the craters is an ideal application for laser power beaming.

- Mars missions – for human exploration on Mars will require multiple methods to enable surface power transmission over long distances.
- Power beaming to UAVs – for weather monitoring, meteorological applications and remote sensing.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- Unmanned Aerial Vehicles – Commercial and military applications include ISR, communications relays for wireless networks, and remote sensing.
- Power-by-light systems – can be used to power sensors and actuators when conventional copper cables are not feasible, such as for galvanic isolation, high-voltage or lightning protection, electromagnetic interference, or rotating systems.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.03-1904**

SUBTOPIC TITLE: Technologies for Passive Microwave Remote Sensing

PROPOSAL TITLE: High Performance Photonic Oscillator for Cloud RADAR Applications

Small Business Concern

Firm: **OEwaves, Inc.**
Address: **465 North Halstead Street, Suite #140, Pasadena, CA 91107**
Phone: **(626) 351-4200**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

OEwaves Inc. offers to develop and demonstrate a high-performance miniature photonic oscillator [1] suitable for delivering spectrally pure W-band signals. The device will be based on ultra-narrow line self-injection locked lasers and will operate as a local oscillator (LO) in cloud radar front end, and other high frequency systems including radio astronomy, spectroscopy, and communication systems where achieving higher performance is limited by the oscillator noise. The photonic oscillator proposed here is based on integration of an ultra-high quality (Q) crystalline whispering gallery mode (WGM) microresonator [2-4] with multiple photonic and microelectronic components and devices (including lasers, a detector, and waveguides) to produce signals with spectral purity exceeding that of conventional oscillators. This architecture will be implemented on a single platform with micrometer-scale feature sizes. The oscillator will produce 10 mW of output RF power in W-band, and its single sideband (SSB) power spectral density of phase noise will be as low as -10 dBc/Hz at 10 Hz and -160 dBc at 10 MHz and higher Fourier frequencies. This is at least an order of magnitude better than the state of the art for the systems of comparable size, weight and power. The primary carrier frequency to be demonstrated is 96 GHz, along with the capability to operate at any frequency in the range of 92-100 GHz. The photonic LO can be phase locked (PL) to an external reference oscillator. Advanced NASA applications require microwave and mm-wave frequency oscillators generating spectrally pure signals to eliminate the noise associated, for example, with compression of the received radar signals to increase the resolution. For airborne and spaceborne devices, the desired size is smaller than a quarter (25 cent coin), with power consumption significantly less than a Watt. Existing technologies cannot meet these requirements, so new and revolutionary approaches are necessary.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

There is an increasing demand for radar systems with greater sensitivity, and communications systems with higher performance and wider bandwidth and at high frequency, at W-band and beyond. These sets of intersecting requirements represent compelling needs for NASA systems, yet cannot be met with conventional technologies. The present proposal is for demonstration of such capabilities with novel microresonator-based devices that will be used to support development of high sensitivity wide band W-band and G-band receivers and radars.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Civilian: air traffic control (ATC) radar; GPS systems; satellite video mobile arrays;
Military: phased array radar systems, including ship-based multi-functional phased arrays, large phased arrays for national ballistic missile defense, synthetic aperture radar (SAR) for unmanned aerial vehicles (UAV), and mobile arrays for battlefield and regional missile defense systems ECCM and SIGINT systems.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H10.01-1471**

SUBTOPIC TITLE: Advanced Propulsion Systems Ground Test Technology

PROPOSAL TITLE: Computationally Efficient Multiphase Flow Simulation Tool for Propulsion Test Technology Components

Small Business Concern

Firm: **Streamline Numerics, Inc.**
Address: **3221 North West 13th Street, Suite A, Gainesville, FL 32609**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

This project is geared towards a computationally efficient, robust computational fluid dynamics (CFD) tool for simulating unsteady multiphase flows of critical importance to NASA in their ground and launch systems processing technologies. The proposed work seeks significant cost reduction for unsteady simulations via the PIMPLE algorithm in the Loci-STREAM CFD code. The basic PIMPLE algorithm for pressure-velocity coupling has been implemented in Loci-STREAM for incompressible laminar/turbulent flows and a speedup of a factor of three has been demonstrated. The proposed Phase I project will extend the PIMPLE-based methodology to handle compressible flows followed by coupling with the cavitation capability in Loci-STREAM. This will allow unsteady simulations of cavitating flows of interest to NASA with significantly reduced turnaround times. The long-term objective is to extend this unsteady methodology to other selected multiphase applications (such as turbulent combustion) along with enhancements to the overall algorithm in Loci-STREAM, including implementing a fully coupled flow solver, implementing more efficient matrix solvers, etc.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

a. Modeling of cavitation in cryogenic propellant tanks, valve flows, and run lines
b. Modeling of transient fluid structure interaction (FSI) between cryogenic fluids and immersed components to predict the dynamic loads, frequency response of facilities
c. Modeling of water jets for flow tests on the B-2 test stand
d. Water deluge mitigation for rocket launch induced environments
e. Subcritical injector analysis for gas generators, preburners and thrust chambers

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- Multiphase applications for Air Force and Navy applications involving non-reacting & reacting flows.
- Simulation for cavitating flows and reacting flows at companies dealing with space propulsion, gas turbine, diesel engines, etc.
- Loci-STREAM code is being used at Aerojet Rocketdyne for rocket engine combustion simulations

Duration: **6**

PROPOSAL NUMBER: 22-1- **S12.03-1398**

SUBTOPIC TITLE: Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical and Infrared Telescope

PROPOSAL TITLE: Low-Cost, High-Performance Metal Matrix Composite for Advanced Optical Systems

Small Business Concern

Firm: **Outpost Technologies**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Outpost Technologies, Materion, and the University of Alabama (UAH) Center for Applied Optics (CAO) propose a low-cost, stiff, and stable normal-incidence space mirror material that will decrease aerial costs below $500k/m^2. Beryllium and silicon carbide (SiC) mirrors are the gold standard in mirror substrate materials given their specific strength, thermal stability, and stiffness. However, their capabilities come at great cost, especially manufacturing complexity and safety-related overhead expenses for a given telescope program. There is a significant performance gap between beryllium and SiC materials and the lower-cost aluminum substrates. This presents problems for telescope programs unable to afford beryllium systems: though science and engineering seek highly capable optical systems, common and less expensive metals such as aluminum 6061 lack the material properties required to deliver required capabilities. Subject matter experts at Outpost technologies and its partnering organizations, Materion and the UAH CAO, have noted that aluminum's low specific strength/stiffness and high coefficient of thermal expansion have crippled past balloon-based telescope systems due to excessive mass and material limitations. Materion's SupremEX Metal Matrix Composite (MMC) combines the machinability and low cost of aluminum with the stiffness and thermal performance of silicon carbide, yielding a capable optical mirror substrate material for balloon-based platforms.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Outpost's proposal PI has met with numerous NASA civil servant program managers, system engineers, optics scientists, and diamond turning experts. During these meetings, Alex Few met with a program manager and optics scientist at GSFC who has submitted a balloon based telescope system proposal for a 1-m class IR observatory, called BEGINS. Alex and the PM discussed the BEGINS program needs, mirror specifications, and baseline requirements. This effort is aimed to infuse with the BEGINS program and will continue to update requirements.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The manufacturing efforts to mature the SupremEX MMC product to TRL 5 will open doors for existing optics programs to adopt this technology. Current DOD system use more fragile aluminum substrates on mirror systems commonly failing due to G-loading and vibration loads. The MMC's superior stiffness, thermal stability, and wear resistance will trade well in these DOD applications (tanks, missiles).

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z13.02-1178**

SUBTOPIC TITLE: Mechanisms for Extreme Environments

PROPOSAL TITLE: Flexible Dust-Excluding Fiber Seals

Small Business Concern

Firm: **Off Planet Research, LLC**
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Phone: **(253) 391-0293**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

A multi-application solution for excluding dust in planetary regolith must be developed if landed technology is going to operate for an acceptable amount of time. A range of dust management & mitigation innovations must be used for operations on dusty planetary surfaces. This is especially true in dynamic regolith environments like rovers, ISRU plants, excavation, & EVAs where multiple layers of dust protection & exclusion are needed.

We will develop a flexible dust-excluding seal to provide multiple technologies with the protection they need to fulfill their missions. The dust seals will be adaptable for use in static joints, covers, hatches, linear actuators, bearings, rotary joints, hinges, & linkages, & increase system life to provide a greater return on investment. The nature of these dust seals allows for their rapid development for space environment testing. Due to the materials used, producing the dust seals using in-situ resources can be explored for future missions.

The dust seal will not rely on elastomers or polymers that fail due to intense temperatures or volatile depletion in the vacuum of space. The materials are resistant to many chemicals & oxidizers. They will be capable of operating for 10s to 100s of months with little to no maintenance as part of a complete dust strategy.

The dust seals will be made with fine stainless steel and/or basalt fibers that align & interlock when compressed, conforming to the joint surfaces to seal out dust. The fibers have a naturally low friction coefficient on smooth, hard surfaces which makes them ideal for use in dynamic & static applications. The dust seals do not require a solid film or lubrication. The dust seals retain a degree of flexibility & compressibility so they can be re-used. The fibers can also be coated with other materials to impart additional useful properties such as shedding dust.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The dust-excluding seals in this proposal will be usable on any NASA landed mission on the Moon, Mars, and other worlds. The seal features can be adapted for use in a wide range of static joints, covers, hatches, linear actuators, bearings, rotary joints, hinges, and linkages. We anticipate further testing, research, and conversations with potential end users will indicate other uses of these dust seals.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

These dust-excluding seals will be usable on any NASA landed mission on the Moon, Mars, and other worlds. The seal features can be adapted for use in a wide range of static joints, covers, hatches, linear actuators, bearings, rotary joints, hinges, and linkages. We anticipate further testing, research, and conversations with potential end users will indicate other uses of these dust seals.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S14.03-1829**

SUBTOPIC TITLE: Remote Sensing Instrument Technologies for Heliophysics

PROPOSAL TITLE: Compact All Sky Interferometric Doppler Imager (CASIDI)

Small Business Concern

Firm: **Atmospheric & Space Technology Research Associates, LLC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Proposed here is a next-generation Compact All Sky Interferometric Doppler Imager (CASIDI) capable of measuring a thermospheric wind field every few minutes, with a precision of 10s of m/s. The ability to measure the wind field two-dimensionally over the visible thermosphere will provide greater measurement of gravity waves, energy transport, and interaction between the ionosphere and thermosphere.

Equatorial spread-F (ESF), is mainly found within 20° of the magnetic equator and occurs at night. ESF frequently occurs when the eastward electric field is large, and when trans-equatorial neutral winds are small. ESF onset driven primarily by the electric field and on the neutral winds stems from the importance of these terms in the growth rate of the Rayleigh-Taylor instability, which drives the ESF phenomenon Sultan, [1996]. While Gravity waves may seed perturbations that set off an instability, Fritts et al. [2009] demonstrated that F-region eastward neutral winds at sunset play the dominant role in triggering ESF. New neutral wind measurements will further our understanding of ionospheric irregularities and their formation.

The proposed sensor addresses key science goals in the Heliophysics Decadal Survey [NRC, 2013]. The first is to “Determine the dynamics and coupling of Earth’s magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs.” The Decadal Survey underscored the importance of the Magnetosphere-Ionosphere-Thermosphere (MIT) system by stating “Understanding ionosphere-thermosphere interactions is a major area of inquiry, especially during geomagnetic storms.”

In addition to the sensor, a rapid manufacturing technique for the interferometer itself is also explored. The combination of both the sensor and a vertically integrated manufacturing methodology will allow for lower cost and faster production of these sensors, thus enabling not only deployments in arrays but also on buoys and autonomous sea-going vehicles.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- Heliophysics & Space weather
- Ground-based neutral wind sensor
- Core technology can be used in on-orbit interferometric sensors

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- NOAA & US Air Force data buy of thermospheric wind and temperature data
- Sales of piezo tuned etalon

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.03-1272**

SUBTOPIC TITLE: Future Aviation Systems Safety

PROPOSAL TITLE: Spatiotemporal Precursors of Safety Incidents

Small Business Concern

Firm: **Metron, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

We propose to develop, train, and validate machine learning methods to automate the discovery of safety incident precursors so that incidents can be avoided. This supports NASA's In-Time System-Wide Safety Assurance (ISSA) focus area. We will extend recent research by NASA that discovers the times at which precursors occurred for individual flights. Our extension will discover spatiotemporal precursors, i.e., both the times and data feature values that precede the incidents. Our method will find local precursors for individual safety incidents and global precursors specifying general rules of thumb that are patterns across many incidents. Currently, such pattern finding is a manual process. This work will generate new insights into the causes of unstable approaches to inform accident investigators, pilots, ATC, policy makers, and machine learning model developers. This initial Phase I study lays the groundwork for finding precursors

of more complex safety incident types such as anomalies detected by black box models developed by Metron and NASA. Additionally, our precursor models will enable in-time safety incident prediction. Our team includes experts in air traffic, machine learning, and airspace data processing.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- Extends NASA systemwide safety research by discovering precursor data features and thresholds.
- Integration with NASA's In-Time Aviation Safety Management System (IASMS) will discover precursors for NASA-developed anomaly detectors and risk predictors.
- Integration with NASA's Digital Information Platform (DIP) provides predictions of safety incidents to stakeholders and other analytic service providers.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- Wide applicability to explaining time series predictions across problem domains.
- Develop add-on technology to predictive services developed for Metron clients such as DARPA, Navy, Army, and DHS.
- Literature publications will advance the public knowledge.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.01-2323**

SUBTOPIC TITLE: Photovoltaic Power Generation and Conversion

PROPOSAL TITLE: Improving Silicon Solar Cell Efficiency with LUVCON coating

Small Business Concern

Firm: **Regher Solar, LLC**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

Regher Solar proposes this SBIR project to improve the conversion efficiency of ultrathin silicon (UT-Si) solar cell technology by adding the Layer of UV CONverting coating (LUVCON) provided by SSS Optical Technologies, LLC that down-converts UV light to visible, therefore improving efficiency. At present UT-Si cells manufactured by Regher Solar have a 22% Beginning-of-Life (BOL) efficiency, which is exactly in between Copper-Indium-Gallium-Selenide (CIGS) and Epitaxial Lift Off Inverted Metamorphic (ELO-IMM) thin film solar cells that are currently considered for making flexible solar blankets. However, the End-of-Life (EOL) efficiency of UT-Si cells drops minimally when exposed to space radiation making them more attractive for the use in space since radiation damage is mitigated. This was shown in our recent NASA SBIR project. By further improving the efficiency, UT-Si cells can achieve EOL efficiency significantly higher than ELO-IMM cells while being as inexpensive as CIGS cells making them the optimal choice for flexible solar arrays.

The main proposed innovations include: (1) Develop polymer nanocomposite coatings impregnated with the nanoparticles of fluorides doped with rare earth ions to improve the conversion efficiency of the solar cell; (2) Enable radiation the coating be radiation tolerant by optimizing its composition and thickness; (3) Develop a low-cost and manufacturable process of coating to replace cover glass for space solar blankets and panels; and (4) Qualification testing of CICs and mini-blankets with LUVCON coating.

Phase II will demonstrate feasibility of the proposed innovations at the scale of the blanket and conduct comprehensive electron and proton irradiation testing. We will collaborate with blanket manufacturers to package UT-Si solar cells in CICs and blankets and conduct complete qualification to achieve TRL 6.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

UT-Si solar cells with improved efficiency can be integrated into novel flexible solar array deployment systems to meet NASA solar array specific power (250 W/kg) and stowed volume efficiency (50 kW/m^3) goals. UT-Si solar cells have a potential to meet NASA goals for the long-term operation in high radiation environment (1 MeV 6e15 e/cm^2). Together this will make UT-Si solar cell technology an ideal choice for several NASA projects including LISA solar array, Vertical Lunar Solar Arrays and large-scale solar arrays for Solar Electric Propulsion
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The main advantage of improved UT-Si technology is compatibility with high volume manufacturing and low cost. Production of improved UT-Si solar cells can be quickly scaled up to 100 MW/year to meet the demand of growing space industry. The example applications include satellite mega constellations and space based solar power that will need tens of MW of affordable space-stable solar cells.
Duration: **6**

PROPOSAL NUMBER: 22-1- **Z4.05-1921**

SUBTOPIC TITLE: Nondestructive Evaluation (NDE) Sensors, Modeling, and Analysis

PROPOSAL TITLE: High-Throughput and High-Sensitivity Terahertz Scanners for Non-Destructive Evaluation of Non-Conductive Coatings and Thermal Protection Systems in Space Applications

Small Business Concern

Firm: **Lookin, Inc.**
Address: **12016 Washington Place, Apt, 112, Los Angeles, CA 90066**
Phone: **(734) 546-1878**

Principal Investigator:

Name: **Dr. Nezih Yardimci**
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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

To address NASA's need for advanced non-destructive evaluation (NDE) sensors, Lookin, Inc. proposes to develop a transformative diagnostic tool to identify and localize visually inaccessible defects and damages in non-conductive coatings and thermal protection systems with significantly higher throughputs and over significantly larger volumes compared to what can be offered by existing NDE tools. More specifically, we propose to develop a contactless multi-pixel terahertz imaging system capable of capturing three-dimensional terahertz images of samples with a 5×5×20 cm^3 volume and a scan rate of 100 Hz, while providing a signal-to-noise ratio of 65 dB and lateral/depth resolution of 100/10 μm. This terahertz imaging system is controlled by a data analysis algorithm that is capable of creating B- and C-scan images of the sample and

automatically determining the position of the structural defects, such as cracks, voids, and delamination, within the samples.

During the Phase I project, a laboratory prototype of the NDE scanner based of the multi-pixel terahertz imaging system will be developed by using a high-power terahertz source and a high-sensitivity terahertz focal-plane array. The prototype will be used to take terahertz images of non-conductive ceramic structures in laboratory environment to characterize tradeoffs between different system parameters such as scan rate, image depth, spatial/depth resolution etc. The data acquisition and analysis algorithms will be experimentally evaluated.

During the Phase II project, a remote-controllable field prototype of the NDE scanner will be developed and the optimized system components will be packaged in a robust, portable platform suitable for in-situ NDE applications in field settings. The field prototype will be used to evaluate CMCs and other non-conductive composites used in aerospace systems and an advanced application software will be developed for the scanner with an easy-to-use guided interface.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary application of the proposed terahertz scanner is non-destructive inspection of non-conductive ceramic-matrix composites for identification of inaccessible defects and damages on and below the surface with high resolution, precision, and throughput. It can be used in ground inspection facilities as well as in space for in-situ NDE and structural health monitoring of ceramic components of spacecrafts, which are usually used as thermal coatings.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed terahertz scanner is capable of inspecting many non-conductive polymers and composites including glass-fiber reinforced plastic, teflon, polyethylene, etc. Therefore, the same instrument can be used for NDE of many industrial products that heavily use CMCs and other non-conductive polymers, such as those in battery, auto, aerospace, construction, and oil & gas industries.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.02-1793**

SUBTOPIC TITLE: Quiet Performance - Aircraft Propulsion Noise

PROPOSAL TITLE: High Fidelity Noise Prediction for Open Rotors

Small Business Concern

Firm: **Scientific Simulations, LLC**
Address: **1582 Inca Drive, Laramie, WY 82072**
Phone: **(307) 399-0871**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The objective of this proposal is the implementation of a high-fidelity Computational Fluid Dynamics-Computational Aeroacoustics (CFD-CAA) simulation capability for accurate noise prediction of installed contra-rotating rotor (CROR) configurations. The key technology that allows for the success of the project is the use of an acoustic analogy based on surface and volume integrals coupled to a dual-mesh, dual-solver paradigm, where an unstructured mesh near-body solver is coupled to a Cartesian, adaptive Discontinuous Galerkin (DG) off-body solver using an overset domain connectivity algorithm.

The use of unstructured overset meshes affords the necessary flexibility for handling complex moving geometries while at the same time enabling efficient capturing of blade, hub, and other high-Reynolds number wall boundary layers. The use of a high-order accurate method combined with adaptive mesh refinement in off-body regions enables the accurate resolution and convection of vortices and wakes over long distances. Far-field acoustic signatures are obtained using an acoustic-analogy approach based on the Ffowcs Williams-Hawkings (FW-H) equation. Together with the commonly used permeable-surface integration of the FW-H equation, the feasibility of the direct volume integration of the quadrupole term will be demonstrated for moving overset meshes. The quadrupole integration enables accurate characterization of the dominant sources of broadband noise in CROR propulsion systems, such as rotor-wake/rotor interaction and rotor trailing-edge noise. Furthermore, the direct integration of the quadrupole term in the FW-H equation obviates the need to identify a proper permeable integration surface common of other approaches. Hence, our approach results in a noise-propagation methodology that is naturally suited for the prediction of sound generated by the complex moving geometries that are the ultimate interest of this project.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed techniques will provide a novel cost-effective high-fidelity tool for open rotor noise prediction capable of handling complex geometries. This is an important application area for the NASA Aeronautics Mission Directorate, both for fixed wing applications with CROR propulsion and for extensions to rotary wing aircraft. Our surface and volume integration FW-H code will be written in a modular fashion which will be delivered to NASA for inspection and coupling with internal NASA codes.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The immediate customers for CROR noise prediction will be the aerospace propulsion OEMs. However, we anticipate significant opportunities in the rotorcraft industry as well as for propeller and fan driven aircraft. Particularly, in the emerging eVtol industry, noise is a principal driver

towards community acceptance, offering a significant additional commercial market opportunity to be exploited.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H10.01-2452**

SUBTOPIC TITLE: Advanced Propulsion Systems Ground Test Technology

PROPOSAL TITLE: High Temperature, High Speed Pressure Sensors for Advanced Propulsion Systems Ground Test Applications

Small Business Concern

Firm: **Sporian Microsystems, Inc.**
Address: **515 Courtney Way, Suite B, Lafayette, CO 80026**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Rocket propulsion development requires rigorous ground testing to mitigate propulsion system risks inherent to spaceflight. There is a need for advanced ground test technology components and system-level ground test systems that enhance technology development and certification; enhance environment simulation; minimize test program time, cost and risk; and meet existing

environmental and safety regulations. There is a particular interest in ground-test and launch-environment technologies with potential to substantially reduce costs and improve safety/reliability of NASA's test and launch operations.

Sporian Microsystems, Inc. proposes the development and application of ultra-high-temperature, high data rate, “smart” dynamic pressure sensors that are suitable for installation in the combustion chamber wall of advanced propulsion systems, such as liquid rockets, to provide real-time monitoring of combustion stability. This in-situ pressure sensor system will provide combustion stability information during operation, and be suitable for use with advanced controls, resulting in improved safety, reliability, and efficiency for liquid rocket and other advanced engine propulsion operation.

The proposed technology is based on prior/ongoing high-temperature sensor development conducted under NASA, US Air Force, and DOE funding. The long-term objective of the proposed effort is to translate and advance this technology for use in advanced propulsion system ground testing applications. Because of the broad utility and economics of this innovation, both NASA and non-NASA applications are extensive.

Phase I: Work with technical partners and industry stakeholders to define system requirements, evaluate and define hardware/electronics architectures and designs, and proof-of-principle testing/demonstration using benchtop-scale prototype hardware. If successful, Sporian will be well positioned for the Phase II efforts, focused on full system prototyping and field testing/demonstration.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA applications for the current technology include any rocket system program such as Space Launch System with the RS-25 engine systems. With crosscutting advanced monitoring capabilities, the technology has applications in solid and liquid rocket; other advanced propulsion systems; ground test and launch technologies; planetary exploration instrumentation; and any program requiring harsh environment dynamic monitoring; all with potential to substantially reduce the costs and improve safety/reliability of NASA's test and launch operations.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Providing pressure monitoring and performance metrics benefits propulsion markets (military, civilian aerospace, marine, rail, locomotive), ground transportation, energy generation (nuclear, CSP, supercritical CO2, ground turbines), oil and gas, government and academic laboratories. Potential benefits include maximized efficiency, improved safety, and advanced maintenance and PHM capabilities.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.04-2392**

SUBTOPIC TITLE: Sensor and Detector Technologies for Visible, Infrared (IR), Far-IR, and Submillimeter

PROPOSAL TITLE: High Dynamic Range Digital Pixel Readout IC

Small Business Concern

Firm: **Senseeker Engineering, Inc.**
Address: **100 Frederick Lopez Road, Santa Barbara, CA 93117**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

Infrared imaging is key to many NASA missions, whether it be cool astronomy or monitoring the earth. Infrared sensors used in probe and satellite missions need to provide orders of magnitude larger effective well depth, thereby affording longer integration times. Longer integration times provide improved signal-to-noise ratio and/or higher operating temperature, which reduces cooler capacity, resulting in SWaP-C savings. Digital pixel sensors (DPS) can offer vastly improved dynamic range and a welcome disconnect between sensitivity and maximum signal. No longer does the sensitivity have to worsen by the square root of the increase in well capacity, as is the case of conventional analog pixels. Instead, the maximum well capacity can be increased independently on a DPS by increasing the number of bits in each pixel.

As part of a previous NASA SBIR effort, Senseeker Engineering had the opportunity to implement a better DPS using the pipelined Extended Counting approach that improves performance for dual band imaging, reduces power consumption and alleviates signal distribution issues. This DPROIC was successfully designed and fabricated, but has not yet been tested to verify that the operation meets the HDR performance expectations for various NASA applications. Senseeker proposes to execute a new NASA SBIR effort that is focused on testing this advanced DPROIC for high dynamic range infrared imaging. Senseeker's DPROIC will advance the state-of-art relative to readout IC products that are available to NASA today and the digital pixel enabled performance will provide the larger well depth (2.5 Ge-), longer integration times (> 100 ms) and higher operating temperatures that will be required for upcoming NASA missions.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- Earth observing including water vapor, sea ice, land and water temperature, ecosystem dynamics, weather science, land resource mapping

- Solar System and astronomy applications such as imaging cold bodies near bright objects, measuring temperatures and atmospheres of planets

- Applications requiring two color detectors to determine precise irradiances at two different wavelengths radiating from the same area at the same time; this is further enhanced by the ability of the DPROIC's high dynamic range

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- Any infrared application requiring high dynamic range and improved sensitivity

- Ground combat and air combat applications of all types using a wide variety of detector materials and cutoff wavelengths

- Military surveillance compatible with sun-approach warnings

- Missile seekers

- Any application requiring high dynamic range and a lower-cost system

- Homeland security applications

Duration: **4**

PROPOSAL NUMBER: 22-1- **S11.05-2505**

SUBTOPIC TITLE: Suborbital Instruments and Sensor Systems for Earth Science Measurements

PROPOSAL TITLE: Optimized miniature spectrometer for improved trace gas monitoring and satellite validation

Small Business Concern

Firm: **SciGlob Instruments & Services, LLC**
Address: **4656 Tall Maple Court, Ellicott City, MD 21043**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

SciGlob proposes the development of an optimized miniature spectrometer for improved trace gas monitoring and satellite validation.
The new spectrometer will be substantially superior to the ones currently used giving higher signal-to-noise ratio, having less stray light and better temperature stabilization, and also a more repeatable manufacturing and alignment process. This will significantly improve the accuracy for ground-based remote sensing trace gas retrievals.
Out of several design improvements, we consider the following items as the main innovative aspects of the proposed system:

- A round-to-slit fiber concept is applied to increase the system throughput.
- Application of a resistant black paint to the inner walls of the bench to reduce stray light.
- The TEC is integrated into the spectrometer and a micro-dehumidifier is added.
- The optical bench is 3D-printed.
- 3D surface metrology is used to optimize the spectrometer alignment.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary NASA application is that this spectrometer could be used in the NASA-developed Pandora Spectrometer System and hence incorporated in the Pandonia Global Network (PGN). This would improve the satellite calibration and validation (cal/val) activities for existing and upcoming satellite missions from NASA and collaborating agencies (PACE, TEMPO, GEMS, Sentinels).

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

All participants in the PGN (ESA, EPA, national and international institutions) will benefit from this development. This spectrometer could also be of interest to other US government agencies such as the DOE Office of Environmental Management or the Bureau of Ocean Energy Management for general applications ranging from agriculture, biology, chemistry, to general environmental research.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.03-2061**

SUBTOPIC TITLE: Low Emissions/Clean Power - Environmentally Responsible Propulsion

PROPOSAL TITLE: The Common-Path Interferometric Particle Sizer (CPIPS): A new open-path airborne instrument for characterizing small ice and aerosol

Small Business Concern

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Address: **1613 Prospect Park Way, Suite 100, Fort Collins, CO 80525**
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Principal Investigator:

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Phone: **(970) 310-5186**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Contrails represent the single largest impact of aviation emissions on the environment, responsible for over half the estimated radiative forcing. Improved understanding of contrail formation processes and the influence of aero-engine emissions is critical to the development of next-generation aero-engines and fuels able to mitigate the warming effects of contrails. Our project will address gaps in the current state-of-the-art measurement capabilities and enable measurements of small ice crystals and aerosols in the initial phases of contrail formation. This will be accomplished through the development of an open-path airborne instrument, capable of measuring the size, refractive index, and asphericity of particles between 100-900 nm in diameter through the use of self-reference interferometry. This instrument would represent the first major advance in airborne wing-mounted aerosol instrumentation in over 40 years. In Phase I, we propose the development and testing of a simplified breadboard optical system to validate our approach. Various particle types with known size, refractive index and/or shape will be tested

in the prototype to evaluate its performance. In Phase II, additional testing will be carried out, and a final PMS canister design will be developed and built.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This project would be highly beneficial to NASA ARMD's investigation of aircraft engine particle emissions and their interaction with contrails and contrail cirrus clouds. The instrument would also have wide applications within NASA ESD for aerosol characterization studies, validation of remote sensing observations, and verification of model results. The planned instrument would be suitable for deployment on all NASA airborne science platforms including the DC-8, P-3, B-200, WB-57, and Global Hawk.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed instrument would be highly relevant to other entities performing airborne aerosol measurements, including domestic entities such as DOE, NCAR, NOAA, NSF, and University of Wyoming, and international organizations such as NRC (CA), FAAM (UK), SAFIRE (FR), and DLR (DE). Additional development of this technique for ground-based sampling would have applications beyond atmospheric science.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.06-2019**

SUBTOPIC TITLE: In Situ Instruments/Technologies and Plume Sampling Systems for Ocean Worlds Life Detection

PROPOSAL TITLE: An Antibody Microarray for the detection of Life Signatures in Ocean World Samples

Small Business Concern

Firm: **Giner, Inc.**
Address: **89 Rumford Avenue, Newton, MA 02466**
Phone: **(781) 529-0500**

Principal Investigator:

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Business Official:

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Phone: **(781) 529-0507**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

One of NASA's goals is to determine if past or present life exists outside of Earth. Ocean worlds, bodies that contain liquid oceans, contain many of the key ingredients thought to be necessary for life. Ocean worlds such as Jupiter's moon Europa and Saturn's moons Titan and Enceladus, are all ocean worlds that are considered prospects for harboring life. NASA is currently funding efforts to develop technologies capable of detecting molecular signatures of life. Giner proposes to assist in these efforts with the invention of a life detection instrument called the Biosignature Life Chip. This instrument utilizes an antibody microarray with antibodies specific to conserved molecular markers that are widely represented in life on Earth. This approach is compatible with NASA's definition of life, which seeks organisms capable of evolution. Such organisms will likely have similar molecular features including proteins encoded by DNA and cell membranes which encapsulate organelles. Although similar microarray life detection instruments have been proposed, Giner's Biosignature Detection Chip is unique in that it utilizes surface plasmon resonance (SPR) for detection rather than fluorescent detection with labeled secondary antibodies. This allows for a simplified instrument which carriers fewer reagents and buffers and utilizes fewer steps than other similar devices. Giner's Phase I efforts will be directed toward achieving TLR3 by developing an SPR assay capable of selective and specific detection of target antigens. With the completion of Phase I, we will report on the performance of the antibody microarray including sensitivity, specificity, and selectivity for each antibody in the array. Phase II efforts will expand the number of evaluated antibodies and will include the development of a prototype SPR device.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA has several programs that utilize protein or nucleic acid microarrays for commercial applications. Examples include a protein microarray to monitor bioreactor bioproducts, a portable sensor for the measurement of trace toxic metals in water, and the monitoring of microbes in a spacecraft environment. While the microbe monitoring project utilizes mass spectrometry to detect ribosomal RNA, we believe that Giner's Biosignature Detection Chip can be potentially be repurposed to detect bacteria in sterile environments.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Giner's Biosignature Detection Chip is designed to be specific for conserved markers of life. However, a portable SPR sensor instrument can potentially be employed for commercial applications including monitoring of water for contaminants including microbes and toxins, as well as biomedical monitoring of markers of disease.
Duration: **6**

PROPOSAL NUMBER: 22-1- **Z10.05-2755**

SUBTOPIC TITLE: Rotating Detonation Rocket Engines (RDRE)

PROPOSAL TITLE: Optimization of Multiphase Injector Dynamics for Rotating Detonation Rocket Engines

Small Business Concern

Firm: **Spectral Energies, LLC**
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Phone: **(937) 266-9570**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Designing an ultra-high-performance Rotating Detonation Rocket Engine (RDRE) is challenging due to the lack of in-depth understanding of many key mixing and combustion processes. The design of ultra-high-performance RDRE injectors requires improved understanding of how the injector design affects its response and performance under the highly unsteady and impulsive detonation environment. These injectors must be optimized for (i) the ability to improve and control gaseous and liquid injector diodicity, while also minimizing the forward direction injector pressure drop to improve overall system performance, (ii) the ability to optimize the relative injector response and recovery of the fuel and oxidizer to achieve the desired mixture ratio and minimize deflagration losses, and (iii) the ability to control the mixing rate to ensure reliable detonation at the ideal lift-off position. The proposed research effort will develop ultra-high-performance injector solutions that meet these requirements. High performance injectors will be evaluated at multiple fidelity levels with multidisciplinary design optimization combined with Unsteady Reynolds-Averaged Navier Stokes modeling and simulation for design optimization of diode injectors. Concurrently, injector concepts will be designed and experimentally tested and evaluated under cold-flow and hot-fire RDE conditions. The Phase 1 goals are twofold: (1) design, test, and evaluate high diodicity single-element monophase and multi-element multiphase injectors in cold flow and hot-fire RDE experiments, with the CFD design optimization driving some of the injector concepts, and (2) initiating the development of a design methodology that is supported by CFD optimization and experimental validation. These steps will guide the transition and development in the Phase II of (i) multi-element injection behavior and (ii) larger-scale injector concepts to be evaluated initially in a high-pressure oxygen-rich preburner GOx-liquid RP RDRE.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed work seeks to develop ultra-high-performance injector solutions for RDREs. This will include the development of validated accurate rules and tools that can be used for designing ultra-high-performance RDRE injectors, and the knowledge regarding injector design, detonation combustion, and global performance. It will provide NASA an experimental dataset to anchor future modeling and simulations and engine development efforts.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non-NASA applications of the proposed efforts include ultra-high-performance injectors for air-breathing and rocket rotating detonation engines (e.g., DoD, DoE). Commercial applications include air-breathing propulsion, stationary power generation, and fundamental research in a wide range of aerothermal flows.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H3.08-1742**

SUBTOPIC TITLE: Challenges in Carbon Dioxide Removal and Reduction: Carbon Particulate and Thermal Management

PROPOSAL TITLE: Novel Vapor Chambers for Heating and Cooling of Advanced Sorption Systems

Small Business Concern

Firm: **Advanced Cooling Technologies, Inc.**
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Phone: **(717) 205-0628**

Principal Investigator:

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Business Official:

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Phone: **(717) 205-0602**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The current Carbon Dioxide Removal Assembly (CDRA) onboard the International Space Station (ISS) is used to capture and compress CO_2 from the cabin air and then deliver compressed CO_2 to the Sabatier Reactor to make water and methane. The CDRA captures CO_2 using a sorbent material, traditionally zeolite. The zeolite must be maintained at specific temperatures for successful adsorption (20°C) and desorption (200°C) of the CO_2. The CDRA relies on cartridge heaters and solid conductive metal fins to generate and spread heat to the sorbent material. The cooling system connects to the main cooling system on the spacecraft. This thermal management system is employed to maintain the appropriate sorbent (i.e., zeolite) temperature for adsorption and desorption temperatures of the CO_2. The current system has been used for over 30 years, and many problems have arisen during its lifetime including performance vs. resource usage, closed loop operation, zeolite dust causing leaks, and sensors failing due to thermal fatigue. The proposed thermal management system mitigates many of these issues by combining the heating and cooling modes, operating passively, and replacing the solid metal fins with a unique, two-phase heat transfer vapor chamber system. By using vapor chambers instead of solid metal fins, there is minimal temperature gradient along the heat transfer device which will increase the isothermality of the surrounding sorbent material. This allows for faster, and more even, heating and cooling of the sorbent bed, which will ultimately improve the CO_2 adsorption and desorption rates.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This novel vapor chamber thermal management system would be used for the current Carbon Dioxide Removal Assembly (CDRA) on board the International Space Station. It will allow for less power usage, combined heating and cooling mode, high isothermality in the sorbent material, and a more efficient carbon dioxide removal assembly. This concept can also be applied to future metal organic framework assemblies or liquid sorbent systems for carbon dioxide removal.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

This novel vapor chamber design can be applied to other CO_2 capture systems that utilize a temperature sensitive zeolite. This includes direct air capture systems, systems capturing CO_2 from truck exhaust, or systems filtering exhaust from manufacturing facilities. Theoretically, the vapor chamber can be retrofitted to suit the needs of any sized zeolite bed.
Duration: **6**

PROPOSAL NUMBER: 22-1- **Z14.01-1175**

SUBTOPIC TITLE: Lunar Surface Excavation

PROPOSAL TITLE: Low-Reaction Hammer-Chisel Bucket for Icy Regolith Excavation

Small Business Concern

Firm: **Singularity Solutions**
Address: **474 Vaquero Lane, Santa Barbara, CA 93111**
Phone: **(248) 255-6640**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

Excavation of Icy Regolith is a prerequisite for extraterrestrial in-situ resource utilization. We propose a hammer-chisel cutting platform that exists on a backhoe and bucket structure that propagates low reaction forces into its supporting chassis. The chisel will be designed for wear survivability. Analytical models and test data will be used to estimate the durable lifespan, productivity, and energy efficiency of the chisel cutting system. Successful phase 1 feasibility studies will provide the groundwork for prototypes and product demonstration when integrated with commercial backhoe and bucket technology.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The hammer-chisel bucket is a complete solution for excavating hard, cemented, icy lunar regolith. Integrating cutting features onto a backhoe bucket reduces the need for auxiliary machinery to sweep the excavated regolith onto a mobile platform or conveyer making it an efficient use of mass. Three important functions in lunar surface mining will be addressed by our single innovation: Icy regolith breakage, sweeping, and loading.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Chisel cutting provides significant energy savings when compared to terrestrial drilling, blasting, and other traditional mining techniques. The drawback is that it is slow. However, with the acceleration of investments in autonomous technology, slow chisel cutting can very well be the lowest cost option for automated mining of soft to medium strength rock.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z1.05-2466**

SUBTOPIC TITLE: Lunar and Planetary Surface Power Management and Distribution

PROPOSAL TITLE: A Radiation Hardened, Digitally Controlled, Phase-Shifted Full-Bridge Isolated DC-DC Converter

Small Business Concern

Firm: **Alphacore, Inc.**
Address: **304 South Rockford Drive, Tempe, AZ 85281**
Phone: **(480) 494-5618**

Principal Investigator:

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Business Official:

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Phone: **(480) 494-5618**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Alphacore Inc. will develop a low-profile, lightweight, high efficiency, mixed-signal (analog/digital) controlled Isolated DC-DC converter that helps address NASA's demand for Innovative Ways to Transmit Power over Long Distances for Lunar and Mars Missions, including "applications of wide-bandgap electronics in direct current (DC)-to-DC isolating converters with wide-temperature, high-power-density, high-efficiency, power electronics and associated drivers for voltage regulation".

The developed converter will have a reduced component count, enabling reduced failure modes, lower PCB area and it includes over voltage protection, fault tolerance, load monitoring, and allows control and status monitoring by a remote power system controller. This solution includes all controller circuitry and drivers integrated in a single CMOS ASIC chip, as well as the GaN-based DC-DC converter's power stage.

Alphacore's converter will utilize CMOS based drivers and controllers for the GaN power stage. The driver and controller would be based on X-FAB's latest XT018 process, a 0.18 µm modular high-voltage SOI technology. It combines the benefit of conventional SOI wafers with Deep Trench Isolation (DTI), those of a state-of-the-art six metal layers 0.18 µm process, and localized partial SOI for unique high-voltage super-junction (SJ) power transistors. Unlike traditional high-voltage LDMOS devices from conventional bulk or SOI CMOS processes, the unique high-voltage SJ DMOS power transistors with VDS breakdown voltage of 100V, 140V and 200V offered in XT018 have reduced conduction loss (RDS) with the same silicon area, such that lower FOM (RDS·Qgd) is available for higher efficiency applications. The planar high-voltage SJ DMOS transistor also has significantly better radiation tolerance for both TID effects and SEE. In addition, the low-voltage CMOS devices (which we will use for the controller design) in this process are extremely radiation tolerant.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Our DC-DC converter solution will contribute greatly to NASA's Watts on the Moon Surface Challenge and other space applications, e.g., Artemis program; Lunar Gateway. This solution allows more technological functions to fit within less volume, operational in the ranges: 153 to 123 °C for lunar applications and -125 to 80 °C for Mars bases. Alphacore's solution will be radiation-hardened and integrated to provide a single-package solution. This converter prototype will undergo the best known relevant environmental testing.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Defense and commercial space applications also benefit from this solution. The proposed converter has potential commercial applications in the space electronics market sector due to its high radiation hardness, high input voltage, high efficiency, high output current and compact size. The rise in demand for industrial robots is expected to also be a significant driver to the commercial market.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z8.09-2858**

SUBTOPIC TITLE: Small Spacecraft Transfer Stage Development

PROPOSAL TITLE: Multimode Chemical-Electric Propulsion Transfer Stage for Flexible Cislunar Operations

Small Business Concern

Firm: **Froberg Aerospace, LLC**
Address: **8143 Kemper Court, Wilmington, NC 28411**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

The **innovation** is a multimode chemical-electric propulsion equipped transfer stage for venture class small launch vehicles that is flexible and adaptable to meet a wide range of NASA lunar mission needs and requirements. This innovation is enabled by a novel space propulsion system that combines chemical and electric propulsion with shared propellant between the modes (multimode propulsion, MMP). Through previous efforts, we have developed technologies that enable this type of system. This includes development of our electrosprayable 'green' monopropellants FAM-110A and FAM-122A, demonstration of chemical and electric thrusters using these monopropellants, and development of a propellant feed system capable of supplying the three order of magnitude difference in flow rates required for operation in either mode. This project will demonstrate a 22 N chemical monopropellant thruster using our FAM-122A monopropellant, designed for inclusion as the main engine in a transfer stage capable of injecting a 25 kg small satellite payload into a TLI orbit from a small venture class launch vehicle using only chemical propulsion. The transfer stage systems, however, will also accomodate our feed system and electrospray thrusters, initially used for purposes of minor course correction, pointing, and disposal maneuvers. As electrospray technology matures, upgraded thrusters can be swapped into the vehicle to enable missions to Mars, Venus, and near Earth asteroids. This project will also perform small scale hazard classification tests, data from which will be used to assign a DOT 1.3 interim classification by the conclusion of the project in addition to investigation and development of production scale up plans.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

A transfer stage with the proposed multimode propulsion system is capable of performing near term missions to the moon using near term ready technology advances, but has the capacity to

grow in capability with further developments in electrospray technology. Further improvements to electrospray technology will enable the same transfer stage to accomplish missions to Mars, Venus, and unique near-Earth destinations along with the flexibility to achieve these missions without significant alteration to the propulsion hardware.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

A multimode propulsion transfer stage can also function as a last-mile delivery service or on-orbit servicer for commercial and DoD applications, with the resiliency offered by the use of a shared propellant. An assembly line of the same transfer stage hardware could be created that meets the needs of a wide variety of customer missions where only the propellant allocation is altered.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.04-2589**

SUBTOPIC TITLE: Sensor and Detector Technologies for Visible, Infrared (IR), Far-IR, and Submillimeter

PROPOSAL TITLE: DEPOSITION OF MULTIPLE INFRARED SPECTRAL FILTERS DIRECTLY ON FOCAL PLANE ARRAY

Small Business Concern

Firm: **QmagiQ**
Address: **22 Cotton Road, Unit H, Suite 180, Nashua, NH 03063**
Phone: **(603) 821-3092**

Principal Investigator:

Name: **Mani Sundaram**
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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA instruments like the Thermal Infrared Sensor (TIRS) on LANDSAT-8 and -9 feature multiple infrared focal plane arrays (FPAs) integrated with several spectral filters to provide satellite-based push-broom multi-spectral imaging of planet Earth. A key drawback is the use of discrete filters that need special hardware for stabilization (to survive a rocket launch) and precision alignment to within microns of the FPAs, adding weight to an assembly that has to be cooled by a large cryocooler for cryogenic operation. A more elegant solution is to deposit thin-film filters directly on a single large-format FPA, lightening the package, making it more reliable optically, and drastically improving the size, weight, reliability, and mission life of the cryocooler.

In Phase I, we propose to develop and demonstrate such a solution, a key challenge being to achieve the demanding passband requirements of such filters. In Phase II, we will develop and deliver a camera featuring a large-format FPA with multiple spectral filters deposited on it that will provide NASA with greater ground resolution in a smaller and lighter package than current multi-spectral sensors in use.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

1) LANDSAT Thermal InfraRed Sensor (TIRS)
2) Infrared sounding
3) Detection, tracking and chemical analysis of fires and gas leaks
4) Mapping and analysis of forests and vegetation
5) Space-based astronomy, e.g. future versions of the Spitzer Space Telescope
6) Climate Absolute Radiance and Refractivity Observatory (CLARREO)
7) BOReal Ecosystem Atmosphere Study (BOREAS)
8) Other infrared earth observing missions
9) Atmospheric mapping
10) Pollution chemistry

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

1) Gas leak detection and identification for the petrochemical, gas, and mining industries
2) Crop health monitoring and analysis
3) Missile detection for countermeasures systems
4) Thermography
5) Product inspection for pharmaceutical and agricultural industries
6) Security and surveillance

Duration: **6**

PROPOSAL NUMBER: 22-1- **H5.05-2588**

SUBTOPIC TITLE: Inflatable Softgoods for Next Generation Habitation Systems

PROPOSAL TITLE: Accelerated Creep Test Methodologies for Space Habitat Softgood Structural Materials

Small Business Concern

Firm: **Texas Research Institute Austin, Inc.**
Address: **9063 Bee Caves Road, Austin, TX 78733**
Phone: **(512) 263-2101**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

Space habitat inflatable structures require complex material configurations and manufacturing processes. There is a need to develop a standardized accelerated creep test methodology with analysis capability to compute the master creep curves for high strength aramid webbing/cord. Texas Research Institute Austin, Inc. (TRI Austin) in Phase I proposes to refine our in-house developed Step-Isothermal Method (SIM) and Accelerated Life Testing hardware and analysis capability on Kevlar fiber reinforced composites, leveraging the extensive research and development effort of NASA Langley and Ames Research centers. During Phase I we will develop an accelerated creep test methodology to compute baseline master creep curves for selected high strength aramid webbing/cord or other NASA directed structural materials. In Phase II, we will extend the accelerated creep test methodology and analysis capability to compute master creep curves for NASA-specified high strength aramid webbing and/or cord to include larger scale coupon testing. TRI currently offers conventional Creep/Stress Rupture and Stepped Isothermal (SIM) to support the geosynthetic/geotextile industries. TRI Austin is partnering with ILC Dover who is currently developing prototype space habitats for NASA. ILC Dover will supply materials and bring years of experience in selection, optimization, and evaluation of structural materials for current state of the art space habitats to this effort.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary NASA application is inflatable softgoods for next generation habitation systems. This research development effort will document creep test methodology and analysis capability to compute master creep curves for NASA specified high strength aramid webbing/cord and generating relevant lifetime material use data. The developed testing methodologies could be

included in qualification testing and certification plan for human-rated inflatable space structures, advancing the state-of-the-art in this technology area.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

It is anticipated that with a variety of corporations including Bigelow Aerospace LLC, ILC Dover, Maxar Technologies, Inc., The Boeing Co., Northrop Grumman Corp., and Blue Origin, among others, entering the area of space travel, that demand for evaluating the creep behavior of inflatable structures will increase in coming years as competition for, and quantity of, manned space travel increases.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.06-1369**

SUBTOPIC TITLE: Vertical Lift Technology for Urban Air Mobility -Electric Motor Fault Mitigation Technology

PROPOSAL TITLE: Single Fluid Tuned Winding Induction Motors

Small Business Concern

Firm: **CGC Ultramarin Ltd.**
Address: **8848 Stonehenge Drive, Pickerington, OH 43147**
Phone: **(614) 260-1406**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

This proposal focusses on the development of two high power density and high reliability asynchronous lift motors for Electric Vertical Takeoff and Landing (eVTOL) being relevant to the NASA Revolutionary Vertical Lift Technology (RVLT) Project. These motors are proposed in response to NASA's A1.06 Vertical Lift Technology for Urban Air Mobility -Electric Motor Fault Mitigation Technology request of advanced technologies supporting electric/hybrid-electric propulsion for the advance air mobility, specifically, to the area of Single Fluid Motor with High Power Density and High Reliability.

The key issues in the Phase I/Phase II program are the redesigning - scale down of the present highly successful Ohio State University megawatt class induction motor to, (1) optimize overall design (poles, topology, size, etc.) from 1 MW class to a 200 kW class UAM eVTOL motor as well as, (2) to operate with single fluid bearings and (3) synergistically integrate the lubrication with cooling in order to operate a single fluid and to achieve maximum power density and reliability.

During this program, two full-size motors (shaft equivalent performances) with different coolants and cooling lubrication methods will be fabricated in order to allow a complete shaft-to-shaft testing program and an apple-to-apple comparative analyze of the two cooling/lubrication solutions. The first motor will use deionized water for both cooling and lubrication while the second motor will use a proprietary single fluid & semi-evaporative cooling and lubrication method.

At the end of Phase I, the electromagnetic circuits and the cooling/semi-evaporative cooling will be fully modeled and simulated, while all fundamental bearings aspects (tribological, dimensional, life estimation etc) will be addressed. A full design concept will be developed for both motors in order to assess/estimate the technologies, materials, fabrications and costs related to Phase II.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Assuming the goals of the proposed R/R&D are achieved, the innovations may be directly and immediately applied to the other area (the first area) of the A1.06 solicitations: Electric Machine/Motor Fault Detection and Fault Mitigation. In the meantime, such solution may be applied to: Megawatt electric propulsion systems in the A1.04 Electrified Aircraft Propulsion subtopic.

In addition to eVTOL, UAMs and electric passenger aircraft, NASA can benefit for many other lightweight applications as smaller land-based motors and generators.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The results of this work can lead to various applications related to high power density rotating machines. The weight saving feature is an important avenue for the electrification of various domains whit focus on transportation with immediate applications for aircraft turbo-generators, aero-propulsion motors, marine propulsion and portable emergency power systems.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A2.04-2410**

SUBTOPIC TITLE: AERONAUTICAL INFORMATION SYSTEM SECURITY (AISS): Aircraft Systems

PROPOSAL TITLE: ONRIDE: an Onboard Noninvasive IntRusIon DEtection system

Small Business Concern

Firm: **University Technical Services, Inc.**
Address: **6411 Ivy Lane, Suite 108, Greenbelt, MD 20770**
Phone: **(301) 345-3797**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

The integration and digital connection of National Airspace System (NAS) with Unmanned Aircraft Systems (UAS) and Advanced Air Mobility (AAM) provides more pathways for hackers to attack the aircrafts. To address this critical challenge, University Technical Services, Inc. (UTS) proposes to develop an onboard noninvasive intrusion detection system (ONRIDE). The key innovation in this work is the development of traffic-flow analysis techniques and machine learning-based anomaly detection algorithms to achieve efficient and effective cyber threat detection, analysis and mitigation. The proposed technology, if successful, will achieve a breakthrough in the computational efficiency for onboard and noninvasive cybersecurity assessment and risk analysis of aircrafts as well as the space segments in the NAS. ONRIDE can monitor and analyze aviation data bus traffic in real time and detect if there is a threat.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed technology addresses a critical need in NASA's strategic goals to advance the state-of-the-art in the autonomous flight operations and onboard cyber/system security. Within NASA, the Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) (UAS-

NAS) Project, the Advanced Air Mobility (AAM) project, and the System-Wide Safety (SWS) project will be directly benefit from ONRIDE.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Has uses for satellite communications, network on-the-move, swarm drone/robotic networks, and UAVs. The proposed technology can be directly applied to the Urban Air Mobility (UAM) systems.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z7.04-1934**

SUBTOPIC TITLE: Landing Systems Technologies

PROPOSAL TITLE: Wall Shear Measurement Technology for Plume Surface Interactions

Small Business Concern

Firm: **Ahmic Aerospace**
Address: **400 Sugar Campc Circle, Suite 302, Dayton, OH 45409**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 6

Technical Abstract (Limit 2000 characters, approximately 200 words):

Future exploration of the Moon, or Mars, will require the development of landing vehicles, whose primary task is to decelerate its cargo and safely touch down on the surface. However, this is not a trivial task for these types of environments. As the jet/plume from the rocket engine, used to decelerate the vehicle, encounters the surface, the low atmospheric pressure, low gravity, and cohesive soil properties result in large dust clouds and even crater formation. These phenomena are called plume surface interactions (PSI). Incremental progress is being made to study PSI through a series of proposed test campaigns being conducted at multiple NASA Research Centers and utilizing large vacuum chamber facilities, such as the MSFC TS300 or LARC 60' Sphere, and tested under relevant conditions. One critical instrumentation need that NASA has identified for these tests is direct surface (wall) shear stress measurements. In the Lunar environment, surface shear stress is the primary driving force by which surface erosion occurs. To overcome this technology gap, Ahmic Aerospace and our assembled team propose to adapt our state-of-the-art wall shear measurement technology to target surface erosion environments occurring in plume surface interactions. In Phase I, Ahmic will conduct a series of incremental steps along two parallel paths to meet this end goal. The first path will simplify the PSI problem and consider a series of static-surface erosion tests utilizing existing wall shear sensors and known erosion geometries, thus circumventing the immediate need for an active erosion sensor. These tests will serve to compare direct and indirect wall shear measurement approaches in a jet impingement environment and examine the influence of surface erosion geometry on wall shear. The second path will consist of a feasibility study to develop a wall shear measurement methodology for active surface erosion environments and examine the steps necessary to achieve this goal.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed wall shear diagnostic techniques present a direct solution for NASA's PSI ground testing needs. As part of the recent project focused on advancing modeling and simulation capabilities, PSI validation data is being acquired in a campaign known as the Physics Focused Ground Test (PFGT). Much of this initial work is being carried out in NASA's Marshall Space Flight Center (MSFC) in the Test Stand 300. This test campaign would directly benefit from Ahmic's proposed instrumentation and methodology.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The Air Force and SpaceX represent non-NASA markets for the proposed diagnostic techniques. These entities are currently investigating the technical feasibility of using rockets for point-to-point transport of high-value cargoes to remote landing sites. To do this safely will require knowledge of PSI, viscous erosion physics, and how the granular particles will be ejected from the surface.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A2.04-2874**

SUBTOPIC TITLE: AERONAUTICAL INFORMATION SYSTEM SECURITY (AISS): Aircraft Systems

PROPOSAL TITLE: Avionics Intrusion Detection and Attack Identification

Small Business Concern

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

Aircraft and avionics systems have become increasingly sophisticated, connected, and technologically advanced. The intricacies associated with advanced technology, however, introduce complexity that makes it difficult to discern vulnerabilities that may exist due to underlying functionality, interconnections, associated subsystems and weaknesses in hardware/software. Such weaknesses may be exploited by threat actors using a variety of tactics, techniques, and procedures to deliver effects against aircraft and avionics systems. Although the safe and effective operation of aircraft are dependent on proper functionality of aircraft communications and avionics systems, there is not an effective means for the detection of cybersecurity threats that may impact safety of flight and operations.

QED Secure Solutions proposes a solution consisting of capabilities to support detection, identification and reporting of cyber-based attacks against avionics components. The dedicated capabilities include both stand-alone and distributed detection tools. Stand-alone components consist of embedded applications capable of profiling avionics systems at the operating system/firmware level and detecting changes to the established baseline, as an avionics system host-based attack identification capability. Distributed components consist of sensors and a centralized analysis engine that monitors critical avionics data buses for intrusion detection. The centralized analysis engine collects data captured by sensors and consolidates the data for synthesis, target identification, tactics development, attribution, and later data sharing with other platforms. In addition to detecting indicators of compromise, the analysis engine also collates collected data into standardized formats for off-board analysis.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Expected benefits and applications for NASA:

- Ability to readily deploy host-based and distributed attack identification and host-based intrusion detection for air-vehicle based systems.
- Monitoring of critical systems to detect cyber-based attacks in real-time to mitigate safety of flight and operations concerns.
- Integration with In-Time Aviation Safety Management System.
- Leverage QED advanced experts in the area of avionics cybersecurity.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Expected applications extending beyond NASA:

- Ability to apply solution to commercial fleet of aircraft
- Transition of technology to Department of Defense
- Integration with existing solutions for safeguarding National AirSpace System
- Leverage QED association in this avionics security space for coordination of findings with Department of Homeland Security and National Labs

Duration: **6**

PROPOSAL NUMBER: 22-1- **S12.01-1957**

SUBTOPIC TITLE: Exoplanet Detection and Characterization Technologies

PROPOSAL TITLE: Integrated Fourier Transform Spectrometer

Small Business Concern

Firm: **Obsidian Sensors**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

A MEMS enabled photonic integrated circuit is proposed, to implement a high resolution Fourier Transform Spectrometer. The targeted NASA application is EPRV (extreme precision radial velocity), a technique used to measure the masses of temperate planets orbiting sun-like stars that calls for a spectrometer with R~100,000 in the visible to NIR spectrum (400-900nm). A single chip measuring occupying less than 170 square millimeters of area can implement this function, minimizing the need for complex control systems that are required for stabilizing larger bulk realizations. In a FTS, two replicas of an input lightwave signal are subjected to independently controlled time delays and recombined to produce a so-called interferogram. By forming the interferogram over a suitably wide range of time delays, an autocorrelation representation of the signal is formed which can then be digitally Fourier Transform to yield the desired spectrum. The iFTS uses a novel set of coarse and fine time delay adjustments with a digital architecture wherein MEMS actuation provides 17 bits of time delay control. In this phase 1 effort, the complete system will be analyzed to produce reachable system performance specifications for a later Phase 2 consideration. Moreover, an early effort involving the deposition and characterization of key layer materials for optical waveguide construction will be performed, using Obsidian Sensors' proprietary Integrated MEMS on Glass manufacturing process. The goal will be to explore the possibility of adding an optical waveguide module to produce a low cost photonic integrated circuit fabrication technique that includes MEMS and thin film transistors. PDK (process design kit) from commercial photonic waveguide foundries will also be considered with recommendations compiled for which direction to follow for a later Phase 2 implementation.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

EPRV instruments that are being contemplated for ground based telescopes is the immediate outlet for the iFTS technology. The market for such scientific instruments with performance goals that far outstrip any defense or commercial application is not large but significant for a small company like Obsidian Sensors. Because we are targeting a production technology that promises to be lower cost per unit area of device, higher volume applications stand to benefit from a successful iFTS development.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The successful demonstration of iFTS for the EPRV application can directly impact much larger volume applications across the medical and even consumer markets where less challenging spectroscopy performed in real time in the molecular fingerprint regions of the infrared can be used for diagnosis and analysis. COVID-19 is a very recent and important application example.
Duration: **6**

PROPOSAL NUMBER: 22-1- **Z1.08-2067**

SUBTOPIC TITLE: Space-Rated Fuel Cell Technologies

PROPOSAL TITLE: Water Management System for Reversible PEM Cells Applications

Small Business Concern

Firm: **Precision Combustion, Inc.**
Address: **410 Sackett Point Road, North Haven, CT 06473**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Precision Combustion, Inc. (PCI) proposes a combined next generation regenerable desiccant and an effective water recovery system (based on a restively heated desiccant support) for water management in Reversible Proton Exchange Membrane (PEM) Cells.

For increased space exploration payloads, PEM cell designs that efficiently operate at high pressure with pure oxygen and hydrogen are being developed. Crucial to the efficient operation of these next generation cells is water management of the supply gasses (hydrogen and oxygen) under operating conditions. The desiccants must supply fuel and oxidizer with a dew point of up to - 40^{o}C at pressures over 35 psi and temperatures between 4 and 85^{o}C. Under these conditions traditional desiccants and membranes will not be able to achieve the dew point.

We propose to synthesize and test several nanomaterials that have very high capacity (up to 60-70%) for retaining moisture and coat them on our proprietary support for enhanced sorption and desorption properties. The materials are non-toxic and compatible with PEM gases.

The support can be rapidly and restively heated for desiccant regeneration with minimized power consumption. The system will be adapted to the topic requirements and tested with humid oxygen and hydrogen in Phase 1 of the project. A microgravity condenser will separate water post desiccant regeneration. The condenser will be sized for over 99 % water recovery based on Phase 1 data. Successful implementation of PCI's strategy will increase flexibility of equipment including for extended use while reducing total equipment volume and material inventory required for efficient PEM cell operation.

PCI brings extensive experience in the development of sorbents and coatings on high-surface-area mesh supports, including development of multiple high fidelity regenerable air cleanup prototypes for NASA, DoD, and other private space companies.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The main NASA application is water management of supply gasses (H2 and O2) for reversible PEM fuel cells. Novel reversible fuel cell architectures are needed for long term missions and planetary exploration for energy management. The reversible cell technology generates O2 and H2 through electrolysis. These gasses are humid and need to be dried to very low dew points prior to storage.
Other potential NASA applications include any life-support system related water recovery process such as recovery from cabin air or sanitation systems.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Potential non-NASA applications include dehumidification for closed environments such as stored vehicles or storage units and also for water recovery from air in desert environments where water scarcity brings the need for recovery of humidity from air.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H3.08-2836**

SUBTOPIC TITLE: Challenges in Carbon Dioxide Removal and Reduction: Carbon Particulate and Thermal Management

PROPOSAL TITLE: Continuous Wire Embedded 3D Printing for Sorbent Regeneration

Small Business Concern

Firm: **Mainstream Engineering Corporation**
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Phone: **(321) 631-3550**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA is seeking an advanced heater to replace the current heaters used in the carbon dioxide removal assemblies. The current SOTA spacecraft sorption system utilizes commercial off-the-shelf (COTS) resistive heaters coupled with conductive fins. These current heaters were not manufactured for use on spacecraft, and as such, are sub-optimal, particularly for planned deep space missions. These deep space missions will be power limited and therefore require a more efficient method of sorbent regeneration. To address this need, Mainstream proposes a method of embedding a heating element directly into the sorbent structure. This method will drastically reduce thermal contact resistance, reducing regeneration cycle time and total power input. In Phase I, Mainstream will formulate a zeolite paste capable of being 3D printed into a self-supporting structure, develop the process of embedding the heating elements into the structures, and demonstrate the fabrication of a zeolite structure with embedded heating elements. These tasks will lead to the ultimate goal of printing fully functional replacement sorbent beds with embedded heating elements for existing and planned spacecraft during the Phase II.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This proposal aims to improve on SOTA via structured packing of the sorption bed using AM to embed heating elements. For NASA, the ability to 3D print adsorbent and catalysts beds that include embedded heating/cooling elements will make an immediate impact in a variety of applications. The reduction in cost and SWAP provided by the upgraded systems will allow for further systems to be incorporated so that waste gas no longer needs to be vented overboard and chemical looping can be utilized.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Packed beds with embedded heating elements will offer large efficiency gains over traditionally packed beds as structures can be fully optimized for heat and mass transfer. Applications in extremely critical and high value markets including catalytic convertors, chemical and toxic

industrial scrubbers, pharmaceutical production, fuel cells, and breathing apparatuses could see large improvements.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H5.05-2584**

SUBTOPIC TITLE: Inflatable Softgoods for Next Generation Habitation Systems

PROPOSAL TITLE: Frequency Selective Surfaces for Passive, Unpowered, Wireless, and Non-Contacting Softgood Structural Health Monitoring

Small Business Concern

Firm: **Texas Research Institute Austin, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

A key enabling technology for the future of crewed habitation systems is developing inflatable softgood materials and structures to provide larger habitat volumes with a lower structural

mass. NASA requires technologies to mature inflatable softgoods via integration of sensing capabilities for structural health monitoring (SHM) for deployment of these devices as part of future space habitation systems. Texas Research Institute (TRI) Austin and The Missouri University of Science and Technology (MST) propose the development of frequency selective surface (FSS)-based structural health monitoring capabilities for inflatable softgood material systems to monitor the structural performance of these materials in situ. This technology provides the ability to measure load/strain on softgood components, detect damage, and potentially predict further degradation/potential failures via a non-contacting, passive, and unpowered system. TRI and MST will couple this technology to a commercial-off-the-shelf vector network analyzer to allow NASA to acquire, process, and make use of this data in real time as an important risk mitigation mechanism for potential structural failure modes. In Phase I, TRI and MST will demonstrate the validity of this system via proof of concept and preliminary testing on representative inflatable softgood structures in the creep strain range of interest (0.1-0.5% strain, or 1,000-5,000 microstrain). This technology can be incorporated into softgood structures as either a “stand alone” add on (built on a substrate and implanted/adhered into the layer of interest in the structure), or as a “built in” piece of the inflatable (such as by using conductive textiles), as the FSS can be illuminated and the response designed specifically to transmit through a dielectric material, or a series of dielectric materials.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

FSS-type sensors can be applied to current/future pressurized vehicles, including launch vehicles to sense strain changes for warnings from impacts or potential leaks, providing additional safety for both flight and ground crews. FSS sensors can be embedded in habitat structures for the ISS and Lunar/interplanetary exploration. These low mass, wireless, unpowered, passive, and non-contacting sensors are easily incorporated into metallic or inflatable habitat structures without increasing mass, power requirements, cost, or EM environment.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The U.S. faces a backlog of infrastructure inspections. FSS sensors can provide long-term monitoring for deformations in structures, such as bridges and dams, and can be applied to structures in areas subject to natural disasters (hurricanes and earthquakes). As the aerospace industry adopts more composites, FSSs can be incorporated into aerospace structures such as fuselages or wing skins.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z4.05-2122**

SUBTOPIC TITLE: Nondestructive Evaluation (NDE) Sensors, Modeling, and Analysis

PROPOSAL TITLE: Laser Ultrasonic Testing for Defect Correction during In-Space Additive Manufacturing

Small Business Concern

Firm: **Intelligent Optical Systems, Inc.**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

Technical Abstract (Limit 2000 characters, approximately 200 words):

Additive manufacturing (AM) has unrivaled capability for rapid, low-cost production of parts directly from a CAD file, but is limited by microstructural defects, which could significantly degrade the structural integrity of the product. Parts for NASA safety-critical applications require 100% inspection to certify uncompromised mechanical performance. There is thus a key opportunity for in-line, in-situ, identification and correction of defects during the AM build to produce finished parts that are already fully qualified, and eliminate the need for scrapping finished defective parts.

Laser ultrasonic testing (LUT) is the only currently viable method for in-line defect detection during the AM build. The IOS LUT receiver's automatic compensation for optical distortion enables it to work on rough as-built surface finishes. Its noncontact nature allows it to operate on hot, moving, vibrating surfaces, while quickly moving along the surface of complex geometries. This gives close access to defects for sensitive detection, so that corrective measures can be taken, often during the following build layer, before they are covered over by further deposition. LUT thus has great potential to make AM parts more reliable and cost-efficient.

Our previous work has addressed the application of LUT to detect defects in parts during AM conducted on Earth. This proposed project extends that work to AM in space, in reduced gravity.

In Phase I we will produce interrupted-build samples with simulated defects on an AM machine designed for use in space, run LUT scans on them, and further develop algorithms and software to enhance defect detection and identification from the scans. We will also make preliminary assessments to show the feasibility of integrating LUT into this AM machine, of greatly reducing LUT system size, weight, power, and cost (SWaP-C), and of in-line correction of detected defects during a build. In Phase II we will develop and test a prototype in-line inspection system.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

An in-line LUT inspection system will enable the production of fully qualified AM parts on the surfaces of the Moon and Mars, to support sustainable exploration there, as well as on the International Space Station.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

An LUT system miniaturized for in-space use will also find utility in industrial applications where space and power are limited, or where greater portability is desirable. Equipment cost is also expected to be greatly reduced for such a system. The introduction of in-line, real-time laser ultrasonic testing for AM supports Executive Order 13329, "Encouraging Innovation in Manufacturing."

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z14.01-2623**

SUBTOPIC TITLE: Lunar Surface Excavation

PROPOSAL TITLE: RocketM for Lunar ISRU

Small Business Concern

Firm: **Masten Space Systems, Inc.**
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Phone: **(888) 488-8455**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

The objective of Phase I is to mature RocketM prototype hardware designs through two iterations of excavation tests which will demonstrate the effectiveness of the systems icy regolith excavation capability. Ice will be harvested from depths beyond 1m and transported out of the mining dome to simulate transfer to the processing portion of the system. Repeated firings of the rocket engine to excavate, break up, and transport the regolith will be performed to demonstrate the low maintenance capabilities and the ability to transport regolith with minimal melting of the ice. The current system design is based on tested heritage systems such as Masten's 100 lbf rocket, PSI tests, Aqua Factorem, PlanetVac, and Lunar Outpost rovers.

The RocketM system surpasses the required technical objectives, with the ability to extract 270,000 kg of refined ice in 225 of operation during a calendar year at a rate of 100+ kg/hr. All non-ice particles are sorted and returned to the surface so only ice is included in the delivery to the extraction plant. It can operate in PSR's, scale steep slopes and harvest its own energy through ice mining, electrolysis, and fuel cells. It generates its own rocket propellants through electrolysis as well.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Rocket Mining provides direct benefit to NASA objectives and significant mission infusion potential. The capability to efficiently mine lunar resources for water will help enable NASA's sustained presence on the moon and in deep space, Gateway, and Mars. The water and volatiles mined may be usable as consumables for life support systems and astronaut use. Enough water will be available so that it may be used for radiation shielding at Gateway.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non-NASA customers for lunar water or propellant include ULA, which has committed to purchase water either on the lunar surface or in LEO. Additional customers would include SpaceX, which has public plans to go to Mars. With the 200-300% cost savings provided by acquiring water and propellant in earth orbit compared to launching multiple refueling missions.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.04-2296**

SUBTOPIC TITLE: Nontraditional Airspace Operations and Aerial Wildfire Response

PROPOSAL TITLE: Organic Airspace Monitoring System for Aerial Wildfire Response Operations

Small Business Concern

Firm: **KALSCOTT Engineering, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 7

Technical Abstract (Limit 2000 characters, approximately 200 words):

KalScott Engineering is developing miniature electronic position reporting systems for unmanned air vehicles. These conform to FAA's the RemoteID and ADS-B standards, while also being interoperable with IoT standards. Using the ADS-B standard, vehicles or personnel carrying these devices can be "seen" by ADS-B equipped aircraft. The position can also be reported via the RemoteID standard using wifi and bluetooth, and LTE, and received on other airborne or ground vehicles or ground nodes. In this SBIR project, we propose to develop and demonstrate the technology to support wildfire management operations, where manned and unmanned ground and aerial vehicles and personnel are involved in a highly dynamic and challenging environment. In Phase I, we will refine the technical requirements in conjunction with NASA and first responder personnel, make the necessary adaptations to our hardware, and rapidly demo a proof-of-concept solution. In Phase II, the hardware and software solution will be refined, along with the network elements. Our firm already has commitments from a third party investor already for cost matching for Phase II-E, CCRPP and any post-SBIR commercialization (letter included).

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Potential use in NASA initiatives for wildfire management missions: this system can be rapidly developed for testing in NASA initiatives for wildfire management missions. The devices can be demo'ed at a proof-of-concept level in Phase I, followed by field testing in Phase II. The devices can also be used for real-time vehicle tracking for flight tests involving UAVs, which NASA conducts routinely, both at NASA installations, and elsewhere. These devices can also be used for the emerging eVTOL (UAM) air taxi industry.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

We are working with DoD and FAA to demo these devices for UAV operations in government and civilian airspaces. We are working with a regional energy utility to demo these in energy infrastructure inspections in 2022 under on-going NASA SBIR Phase II-E. The data from these devices is interoperable with emerging IoT networks, enabling coordination between manned and unmanned ground and air vehicles.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.07-2707**

SUBTOPIC TITLE: Cryogenic Systems for Sensors and Detectors

PROPOSAL TITLE: Cryogenic Oscillating Heat Pipes

Small Business Concern

Firm: **ThermAvant Technologies, LLC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

In response to NASA SBIR Topic S16.07, ThermAvant Technologies, LLC proposes to develop high conductance cryogenic oscillating heat pipes for space applications. Working fluids will be investigated at temperatures between 77 K and 230 K. The oscillating heat pipes will be developed in a range of geometries to demonstrate high effective thermal conductivities in complex 3D geometries and small form factors, and demonstrate ambient storage conditions. Specifically, ThermAvant aims to develop oscillating heat pipes that can handle heat fluxes up to and above 5 W/cm^2 with power levels up to 100 W over distances of up to 1 m.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The high conductance cryogenic oscillating heat pipes have many applications where rigid connections must be made, such as the Wide Field Infrared Survey Telescope (WFIRST), Plankton, Aerosol, Cloud, ocean Ecosystem (PACE), L'Ralph Instrument on the Lucy space probe and Surface Water Ocean Topography (SWOT), Spectro-Photometer for the History of the Universe, Epoch of Reionization, and Ices Explorer (SPHEREx), the Lunar Flashlight, and Thermal InfraRed Sensor (TIRS-2).

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The high conductance cryogenic heat spreader has many commercial applications including superconducting systems, cryocooler heat transfer devices, quantum computing, maglev systems, MRI machines.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z13.04-2399**

SUBTOPIC TITLE: Lunar Dust Filtration and Monitoring

PROPOSAL TITLE: A Particulate Air Quality Monitor for Manned Lunar Explorations

Small Business Concern

Firm: **Aerosol Dynamics, Inc.**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

As NASA embarks on a new era of manned lunar missions, it needs a means to reliably monitor the mass of suspended airborne particulate matter in its inhabited environments. Apollo missions revealed surprising levels of dust in the near-surface lunar environment. This dust is implicated in fouling of joints and seals on equipment. It is also believed to be an inhalation hazard. As NASA takes precautions to prevent the transport of this lunar dust into its inhabited environments, both on the orbiter and lunar habitats, it needs a means to assess whether those controls are effective. This method must be sufficiently accurate to guide NASA crews and operations, and reliable for long-term deployment.

This Phase I project explores the use of ensemble optical methods, including both angular scattering dependencies and light intensity fluctuations, to assess suspended particulate mass in the identified size fractions below 10μm and below 2.5μm. Additionally, it will incorporate a space-proven ultrafine particle monitor to distinguish the presence of particles below 100 nm in size which are characteristic of smokes. The ensemble scattering approach uses an optically defined sampling volume, eliminating the need for small focusing nozzles that can become clogged, thereby increasing the robustness of the instrument.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This project targets NASA's stated need to monitor the mass of suspended airborne particulate matter aboard the Artemis lunar habitat and spaceship environments. Envisioned is a compact, low-power instrument that could be deployed in multiple locations within these environments. The aim is a robust monitor that indicates whether the control measures are effective in excluding lunar dust from these environments.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Robust monitoring of airborne particulate matter is needed in many environments, from assessing ambient air quality, to measurements in industrial fabrication and warehousing facilities. Future extension of the underlying concepts of the ensemble scattering detector of this project are readily extended to Earth-based applications, and could fill the important need for air quality monitoring.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H10.02-1385**

SUBTOPIC TITLE: Autonomous Operations Technologies for Ground and Launch Systems

PROPOSAL TITLE: Generative Adversarial Networks for Detecting Erroneous Results

Small Business Concern

Firm: **TRACLabs, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

As part of the broader ARTEMIS effort, NASA's Human Exploration and Operations Mission Directorate (HEOMD) is targeting an increase in the use of robot and automated systems to enable the unattended setup, operation, and maintenance of ground systems and systems on the surfaces of other planets and moons. There is a critical need for technology to realize this target, specifically technologies to enable autonomous inspection, maintenance, and repair (IM&R).

Under previously funded NASA efforts TRACLabs has developed CRAFTSMAN, a supervisory robot control framework. However, this approach still requires supervisory/operator interaction to perform verification of task outcomes and inspection. This potentially limits the ability to widely deploy such a supervisory system due to the level of required operator attention and interaction. Techniques to automate such tasks are needed to reduce operator burden. Additionally, the lack of robust error detection becomes increasingly critical in remote tasks on the lunar surface and in dangerous ground-based tasks such as those involving propellant transfer. To address this shortcoming and to increase the autonomous capabilities of TRACLabs' robot control suite for use in HEOMD domains TRACLabs proposes the Generative Adversarial Networks for Detecting Erroneous Results (GANDER) system to leverage Generative Adversarial Networks to perform online error detection in ground operations tasks. The resulting system will increase the inspection and task outcome verification capabilities of these systems, thus increasing the autonomous behavior of deployed robot systems on Earth and on other planets and moons.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

In addition to benefiting NASA's Human Exploration and Operations Mission Directorate (HEOMD) operations at KSC, enabling autonomous inspection, maintenance and repair functionality will be of increasing importance in the upcoming Artemis missions. It is expected that the tools developed under the proposed effort will have direct application for lunar surface operations to increase the level of autonomy of systems such as the Lunar Surface Manipulation System by providing autonomous verification tools.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Tools for autonomous inspection, maintenance, and repair have a large number of potential applications, from sub-sea robots to factory systems. Additionally, tools that enable verification of execution and task outcomes will become increasingly important as robot systems increase their level of autonomous operations. The proposed GANDER system addresses these needs.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z10.05-2909**

SUBTOPIC TITLE: Rotating Detonation Rocket Engines (RDRE)

PROPOSAL TITLE: Rotating Detonation Engine Novel Injector Design

Small Business Concern

Firm: **Masten Space Systems, Inc.**
Address: **1570 Sabovich Street, Mojave, CA 93501**
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Principal Investigator:

Name: **David Masten**
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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The proposed innovations are as follows:
1. Rotating detonation engine (RDE) injector using Masten's patent-pending permeable additive manufacturing (PermiAM) method, which provides improved propellant distribution and cooling in the engine relative to traditional injector methods.
2. Liquid-liquid injector using liquid oxygen (LOX)/Methane.
3. The ability to manufacture single parts with varying material properties will enable cost savings in areas where, in the past, multiple components required manufacturing and assembly with a high touch time. Masten has demonstrated a cost reduction of 60% in past injector builds.

Success of this SBIR project will be indicated by the construction and testing of two PermiAM RDE injectors. The three phases of this project are: design, manufacture, and testing. This SBIR will provide valuable information for several existing questions relating to RDE research. How to design a flight like liquid/liquid detonation engine, and how to design an injector capable of handling the extreme temperature and pressure environments.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

RDE's have the inherent advantage of being theoretically more efficient than standard combustion engines. This is due to the detonation engine utilizing a Humphrey cycle over a Brayton cycle. A Humphrey cycle is a constant volume cycle, where a Brayton cycle is constant pressure.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

In a perfect system and RDE has the potential to be about 15% more efficient than that of a constant pressure device. The ability to utilize this kind of increase would be invaluable in commercial application, where fuel consumption can be a major driver in cost.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H4.07-1817**

SUBTOPIC TITLE: Low Volume, Power and Mass CO2 and Humidity Control for xEMU

PROPOSAL TITLE: High Capacity RCA Sorbents for Increased Cycle Times

Small Business Concern

Firm: **Reaction Systems, LLC**
Address: **17301 West Colfax Avenue, #160, Golden, CO 80401**
Phone: **(303) 216-2950**

Principal Investigator:

Name: **Dr. David Wickham**
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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA is interested in improving the method to control CO_2 and water in the Exploration Extravehicular Mobility Unit (xEMU) to meet the ambitious objectives of the Artemis program, which includes human presence on the surface of the Moon and Mars. These levels must be controlled to established values of 2.2 mm Hg at a metabolic rate of 2.44 g/min. Historically, the Metox has been used to remove CO_2 from the suit. The sorbent in the Metox has a finite capacity during an EVA and must be regenerated after the mission is complete. The capacity limits mission times, which can only be increased by making the Metox larger. The technology that is planned to replace the Metox is the RCA which utilizes two beds that are alternately used to remove CO_2 and H_2O and then regenerated by exposure to space vacuum. The RCA has been under development for over 10 years and has utilized an amine-based sorbent (SA9T). Although SA9T has good reversible CO_2 uptakes, higher capacities are desired to maintain low CO_2 levels and reduce O_2 losses. In addition, this sorbent emits low levels of ammonia which must be removed from the suit using a separate technology.

In this SBIR Phase I project, Reaction Systems will develop new sorbents that will outperform SA9T and at the same time exhibit reduced ammonia emissions. Reaction Systems' strategy to accomplish this goal consists of two important components. The first component consists of identifying sorbents that have high probability to perform better than the SA9T. Reaction Systems has demonstrated expertise in the development of advanced sorbents for CO_2 control in both EVA and cabin applications and will also employ a consultant who is an expert in gas surface interactions and in the synthesis and characterization of organic compounds. The second component of our strategy is the application of a rapid screening method that will provide accurate and relevant performance data so compounds with the highest potential can be quickly identified.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This technology could be used for CO_2 control in a space craft cabin or on the surface of the Moon or Mars (Artemis goals). The CDRA, used on the ISS for CO_2 control, uses pressure and temperature swing adsorption cycle to remove CO_2. The CO_2 is removed with a mol sieve that is heated to 400°F during regeneration. The cycling causes the sorbent to break down into dust,

which clogs filters or ends up in the cabin air. A sorbent that does not require a temperature increase for regeneration would reduce power consumption and eliminate dust.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

This could also be used for control of CO_2 emissions from power plants. The concentration of CO_2 in the atmosphere has increased from 280 ppm to over 400 ppm over the last 50 years primarily due to CO_2 emissions from fossil fuel combustion. An effective method to remove CO_2 could be used to remove CO_2 from the effluent and compress it into a concentrated liquid for sequestration, storage, or use.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A1.04-2551**

SUBTOPIC TITLE: Electrified Aircraft Propulsion

PROPOSAL TITLE: Tail propulsor generator for NASA SUSAN sub-scale flight demonstrator

Small Business Concern

Firm: **Hinetics, LLC**
Address: **1804 Vale Street, Champaign, IL 61822**
Phone: **(217) 239-1628**

Principal Investigator:

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Business Official:

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Address: **60 Hazelwood Drive, IL 61820 - 7460**
Phone: **(217) 717-1991**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 2
Technical Abstract (Limit 2000 characters, approximately 200 words):

Hinetics is proposing a detailed study to evaluate the integration of a lightweight, high efficiency 150 kW generator-drive subsystem within the SUSAN concept aircraft. Subsystem and system level integration strategies required to maintain the stability and reliability across all operating conditions of the propulsion system and maximize the system level performance will be identified and verified with computer simulations. This will set the stage for hardware development for a sub-scale SUSAN demonstration within a potential Phase-II program, helping to increase the TRL of critical technologies for future low carbon aircraft.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Subsonic Single Aft Engine (SUSAN) Electrofan would be the major targeted application for this motor design and system integration study. It will also be applicable to any of the drivetrain testing and qualification programs of NASA in a similar power scale with a few varying details such as cooling availability and drivetrain.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

While this study is targeted at the generator coupled to aft engine, it is directly applicable to a distributed propulsor or the propulsor in any turbo-electric, hybrid-electric or fully electric concept. In addition, the drivetrain developers can potentially use this study to test the sub-systems and to validate the performance and reliability of electric aircraft drivetrains.

Duration: **3**

PROPOSAL NUMBER: 22-1- **S16.06-2114**

SUBTOPIC TITLE: Command, Data Handling, and Electronics

PROPOSAL TITLE: Hoku: Radiation-Tolerant Analog and Mixed-Signal Circuits with Autonomous Element Level Adjustability

Small Business Concern

Firm: **Nalu Scientific, LLC**
Address: **2800 Woodlawn Drive, Suite 240, Honolulu, HI 96822**
Phone: **(808) 343-9204**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 2
Technical Abstract (Limit 2000 characters, approximately 200 words):

We propose to develop the "Hoku ASIC", a mixed-signal integrated circuit designed using a new method we call Element Level Adjustability (ELA). Most radiation robust mixed-signal integrated circuits utilize specific CMOS technologies and substrate strapping layout techniques to achieve high degrees of radiation robustness. In a mixed-signal IC, each of the transistors in the circuit play a specific role. The IC becomes dysfunctional after radiation exposure when the characteristics of one or more of the transistors changes and the affected transistors are no longer able to perform their intended role in the circuit at the intended level of performance. As a result, the circuit fails one or more specs. With autonomous ELA, each transistor may be isolated and tested during a calibration routine. If the transistor fails a designated test, its size (effective W/L) or bias condition can be modified until it is able to perform its intended role. By performing these calibrations during calibration periods and self-correcting the circuit as it is exposed to radiation, the resulting circuit can potentially function with a higher dose of radiation than otherwise possible without ELA.

Architecture, choice of technology, and transistor layout structure are elements that have been studied and compared for radiation robustness. We are developing a new general approach that may be suitable for improving the radiation hardness using a number of architectures, can be applied to any CMOS technology, and can be better suited to conventional layout techniques due to the higher density achievable as compared with ELT transistors. In the solicitation, analog-to-digital converters (ADCs), digital-to-analog converters (DACs), charge-sensitive amplifiers, and readout integrated circuits for photomultipliers are identified as demonstration vehicles. In this proposal, we gear our description to ADCs but the concepts may be applied to other analog circuit blocks called out in the solicitation.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Our new method of ELA will be able to be applied to any analog or mixed-signal IC resulting in improved radiation hardness for a wide variety of applications required in space vehicles and their payloads. Our approach exploits the ease with which basic microprocessors can be implemented on ICs providing control, and the high transistor density allowed in even non-leading edge CMOS technologies.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Our new method of ELA will be able to be applied to any analog or mixed-signal IC resulting in improved radiation hardness for the large number of applications and environments where radiation-tolerant and/or radiation-resistant analog or mixed-signal ICs are required. Our approach develops design principles which can be exploited in even non-leading edge CMOS technologies.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.04-1715**

SUBTOPIC TITLE: Nontraditional Airspace Operations and Aerial Wildfire Response

PROPOSAL TITLE: Resilient Network Planning and Disruption Management for Urban Air Mobility Operations

Small Business Concern

Firm: **ATAC**
Address: **2770 De La Cruz Boulevard, Santa Clara, CA 95050**
Phone: **(408) 736-2822**

Principal Investigator:

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Business Official:

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Phone: **(408) 736-2822**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Optimizing the day-of-operations UAM network planning/dispatching and responding efficiently to network disruptions are crucial, make-or-break capabilities without which UAM operator business will not be viable. Today's methods used by airlines and car ridesharing companies will not work for UAM because UAM operations have significant differences and unique features (minimizing deadhead flights, staging aircraft offsite due to Vertiport space constraints, unique disruption events, etc.). The proposed SBIR develops the Resilient UAM Network Optimizer (RUNO), which the UAM day-of-operations planning problem as an Integer Program (IP), applies innovative constraint and objective function models to emulate unique characteristics of UAM operations, and uses a NASA-developed, open-source fast IP solver to provide optimized solutions in realistic times matching the UAM operator's planning cycles. Since the SBIR addresses an *airspace* network planning for *nontraditional* UAM operations, it is highly relevant to Subtopic A3.04's "Nontraditional Airspace Operations".

Phase I breaks the day-of-operations planning/dispatch problem into three inter-related sub-problems: Strategic Scheduling (weekly or monthly calculation of long-term schedules), Tactical Planning (real-time planning in response to incoming trip requests), and Disruption Management (event-driven network recovery planning). For each problem, we develop innovative customizations of the proposed IP and solve them to provide a comprehensive network planning and disruption management solution.

Phase II operationalizes RUNO by integrating it with cloud-computing platforms such as NASA Digital Information Platform and ATAC SkyView Data Services. UAM operators can access RUNO as a digital service over NASA or ATAC cloud platforms to obtain benefits including increased profitability, enhanced On-Time performance, reduced operating costs, and efficient responses to network disruptions.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- Integration of RUNO with ATM-X DIP platform provides a high-value digital services to UAM operators
- RUNO UAM network management SDSP to support AAM National Campaign live tests and ATM-X UAM Traffic Management lab simulations
- Integration with NASA AutoResolver to provide full end-to-end UAM network optimization
- Integration of RUNO with NASA's VAMOS! will provide a complete UAM flight assessment capability which can be run as a simulation tool to assess UAM network design parameters

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- Day-of-operations planning/dispatch/disruption management service for UAM operators, large UAS network operators (e.g., package delivery), and smaller/regional traditional airlines
- Network-impact-sensitive excess Vertiport delay alerting tool
- Operational impact prediction app for Providers of Service for UAM (PSUs), Vertiports, and UAM maintenance personnel

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z10.01-2528**

SUBTOPIC TITLE: Cryogenic Fluid Management

PROPOSAL TITLE: Efficient High-Pressure-Ratio Compressor for Xenon On-Orbit Refueling

Small Business Concern

Firm: **Flight Works, Inc.**
Address: **17905 Sky Park Circle, Suite F, Irvine, CA 92614**
Phone: **(949) 387-9552**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Flight Works is proposing to expand its on-orbit propellant management and refueling product line and add Xenon to its current chemical propellant transfer capabilities with the development of an efficient high-pressure-ratio Xenon compressor. Current capabilities include refrigerants, hypergols, “green” monopropellants, and cryogens like LOX and methane.

The proposed concept is based on an efficient transfer of the propellant, staying as close as possible to isothermal conditions and integrating heat exchangers between compressor stages in order to minimize power consumption, the work done on the fluid, and associated excess

heat. The result is a compact, lightweight, efficient compressor specifically designed for on-orbit use and optimized for Xenon compression from 300 to over 3,000 psia at flow rates optimized for the future Gateway station and existing geosynchronous spacecraft. The compressor relies on positive displacement and is driven by a brushless electric motor. The objective of the program is to develop, manufacture, assemble and test a proof-of-concept unit under Phase II and transition to a flight unit for operational use under follow-on Phase III or commercial funding.

The compressor can also be used for other gases such as helium, oxygen or methane.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The compressor is designed for the NASA Lunar Orbital Platform-Gateway and can be used on any spacecraft using Xenon or other fluids such as GHe, GOX, methane, etc. Because it is highly scalable and designed to move inert gasses, refrigeration and thermal management tasks are likely candidates. These include electronics or optics cooling, and recompression systems. Scavenging gasses for processing in habitats or sampling missions, or even deflating structures for relocation or re-entry, are other potential applications.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non-NASA applications include Xenon (and other propellant) on-orbit refueling of DoD and commercial spacecraft. The scalability and versatility of the system in compressing other inert gases makes it an attractive candidate for numerous fluid systems.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S15.01-2544**

SUBTOPIC TITLE: Plant Research Capabilities in Space

PROPOSAL TITLE: PHILM (Plant Habitat Ionic Liquid Membrane) for CO2 Control

Small Business Concern

Firm: **Space Lab Technologies, LLC**
Address: **5455 Spine Road, Suite ME, Boulder, CO 80301**
Phone: **(720) 745-9321**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

Accurate control of the plant environment in space growth chambers is pivotal for space plant biology research. The PHILM (Plant Habitat Ionic Liquid Membrane) for CO_2 control uses a supported ionic liquid membrane (SILM) to selectively separate CO_2 from cabin air and then dose the gas into closed plant chambers to maintain constant CO_2 concentrations. Utilizing respired cabin CO_2 for plant growth has the advantages of 1) eliminating the continuous resupply mass for compressed cylinders and scrubbing cartridges and 2) reducing the load on the cabin CO_2 removal system when larger scale crop production systems are integrated into the spacecraft. Membranes are attractive for spacecraft use because they require less power, fewer components, and less infrastructure volume than alternative methods, with no consumable mass, noise, or safety hazards. In support of NASA's priorities for space plant biology and space habitation system development, PHILM™ provides precise and timely CO_2 control for plant growth chambers that is reliable, safe, compact, and energy efficient. PHILM™ can operate in microgravity and reduced gravity, advancing space plant biology research and space agriculture capabilities in space stations, transit vehicles, and surface habitats. PHILM™ is also readily transferrable to terrestrial botanical research and agriculture (plant growth chambers, greenhouses, and indoor farms). With PHILM™, indoor farmers can enrich greenhouse CO_2 for increased crop yield, by *sequestering* carbon from the atmosphere, a safer and more sustainable alternative. This Phase I project will establish feasibility and demonstrate proof of concept for supported ionic liquid membranes to maintain target CO_2 concentrations in spacecraft plant growth chambers utilizing cabin air. The team will analyze a baseline system architecture, develop a breadboard prototype, and conduct experiments to validate performance predictions over expected operating conditions.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

PHILM™ provides precise CO_2 control for plant growth chambers in microgravity and reduced gravity applications advancing space plant biology research and space agriculture capabilities in space stations, transit vehicles, and surface habitats. PHILM can also readily integrate with spacecraft air revitalization systems to reliably and efficiently control cabin CO_2 levels. PHILM™ has potential for infusion into the SMD Division of Biological and Physical Sciences and HEOMD Advanced Exploration Systems program.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

PHILM™ is readily transferrable to terrestrial botanical research and agriculture (plant growth chambers, greenhouses, and indoor farms). With PHILM™, indoor farmers can enrich greenhouse CO_2 for increased crop yield, by *sequestering* carbon from the atmosphere, providing a distinct competitive advantage over facilities with compressed gas tanks or fuel burning CO_2 generators.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z8.13-2481**

SUBTOPIC TITLE: Space Debris Prevention for Small Spacecraft

PROPOSAL TITLE: Structurally Embedded Electrospray Thruster for Orbital Debris Reduction Through Enhanced Small Satellite Maneuverability

Small Business Concern

Firm: **Integrated Defense Applications, LLC dba IDA Technology**
Address: **1171 Larry Mahan Drive , El Paso, TX 79925**
Phone: **(915) 504-6529**

Principal Investigator:

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Business Official:

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Phone: **(915) 504-6525**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

Perform a feasibility study on the use of embedded electrospray thruster (EET) technology as a small-satellite orbital debris reduction tool. The study includes direct measurements of performance of an EET prototype, with results used in astrodynamics simulations investigating the application to end-of-life (EOL) de-orbit or disposal and collision avoidance. The outcome of this work is a summary of the size, weight, power, and cost (SWaP-C) penalty for using the EET technology as an orbital debris reduction tool for mission in all Earth orbits, ranging from LEO through to GEO.

Objectives:

1. Directly measure performance of a prototype EET
2. Determine SWAP penalties for application to EOL de-orbit / disposal
3. Estimate advanced warning time required to implement collision avoidance maneuvers
4. Predict embedded electrospray thruster technology impact using hypothetical mission scenarios
5. Report on SWaP-C penalty for implementing EETs as an orbital debris reduction tool

Findings from Objectives 1-4 will be reported in a single Phase I Final Report detailing SWaP-C penalty and orbital debris reduction potential of the EET technology. The report will demonstrate that the EET thruster component has achieved TRL 5 and will propose follow-on development for a Phase II SBIR study to raise the TRL level of the complete EET system, including power processing unit (PPU) to TRL 6.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

An embedded electrospray thruster propulsion system implemented as a low Size, Weight, Power, and Cost (SWaP-C) technology that enables end-of-life satellite disposal and collision avoidance maneuvers for small satellites to reduce the amount of orbital debris build-up in critical orbits over time. An array of electrospray thrusters embedded into existing satellite structural elements gives 6 DOF (degree of freedom) maneuvering capabilities to small satellites while maximizing the available payload volume.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Small satellite missions are increasing in complexity. An embedded electrospray thruster will enable longer, more intricate missions by providing active maneuverability while also increasing the available payload volume inside a small satellite allowing for larger, more complex scientific payloads.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z14.02-2669**

SUBTOPIC TITLE: Extraterrestrial Surface Construction

PROPOSAL TITLE: Additive Manufacturing of Hydrogen-rich Polymer-Regolith Composites for Radiation-Shielding Habitat Materials

Small Business Concern

Firm: **International Scientific Technologies, Inc.**
Address: **P.O. Box 757, Dublin, VA 24084**
Phone: **(540) 633-1424**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA has identified a need in Subtopic Z14.02 for extraterrestrial (*i.e.* Lunar or Martian) surface construction using *in situ* resources, such as regolith, in order to lower the cost to fabricate habitats on future space exploration. Consumable materials that must be brought from Earth also will need to be minimized. International Scientific Technologies, Inc., in conjunction with Virginia Tech, proposes the Additive Manufacturing of regolith combined with hydrogen-rich polymers to develop radiation-shielding structural materials for habitats. The program Technical Objectives include evaluation of hydrogen-rich polymer-regolith compositions for use in radiation-shielding habitat materials, Additive Manufacturing of hydrogen-rich polymer-regolith materials and structures for habitat construction, and measurement and test of the hydrogen-rich polymer-regolith composites for construction on Lunar or Mars surfaces. The innovation is the development of polymer-regolith composites and their efficient Additive Manufacturing for structural materials to protect humans on extraterrestrial missions. The anticipated result is the Additive Manufacturing structures of composite materials that combines *in situ* resource utilization (ISRU), *i.e.* regolith, with a minimal amount of hydrogen-rich polymeric binder that is effective in slowing and fragmenting the incoming particles found in galactic cosmic radiation (GCR). Additives, such as boron, could be included to enhance absorption of neutrons generated by interactions of GCR and solar particle event (SPE) particles with the shielding materials. The anticipated result is Additive Manufacturing composites that have multifunctional properties of radiation shielding against galactic cosmic radiation, neutrons and electromagnetic radiation, and structural integrity to permit use in habitats.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA directorates that can use the proposed Additive Manufacturing composite technology are Space Technology Mission Directorate (STMD), Human Exploration and Operations Mission Directorate (HEOMD), and Science Mission Directorate (SMD). The multifunctional habitat composite materials addresses the NASA Strategic Plan to extend human presence deeper into space, including to the moon and Mars, for long-term exploration and utilization, and to develop and transfer technologies for exploration capabilities.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Additive Manufacturing of composite materials will find application in developing radiation-shielding structural materials for extraterrestrial habitats. DoD and DHS will find applications that include protection of soldiers, first responders and emergency medical personnel against radiation resulting from dirty bombs as well as from hazards from accidental release of radiological materials.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.08-2718**

SUBTOPIC TITLE: Atomic Quantum Sensor and Clocks

PROPOSAL TITLE: High-sensitivity isotopically-purified all-electrical chip-scale atomic magnetometers

Small Business Concern

Firm: **QuantCAD, LLC**
Address: **1165 Oakes Drive, Iowa City, IA 52245**
Phone: **(319) 594-2507**

Principal Investigator:

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Business Official:

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Phone: **(319) 594-2507**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

All-electrical chip-scale atomic magnetometers based on spin-coherent transport effects through atomistic defects in semiconductors will have orders of magnitude improved sensitivity if the semiconductor hosts are isotopically purifiedand related device parameters optimized. Current all-electrical chip-scale atomic magnetometers have room-temperature sensitivities ~400 nT/root-Hz, and the proposed innovation we estimate conservatively to provide room-temperature sensitivities of 400 pT/root-Hz with possibilities as low as 100 pT/root-Hz. These are comparable to those achievable with NV-diamond chip-scale atomic magnetometers, but without the requirement for microwave fields or optical elements. These small-scale magnetometers would avoid the need to self-calibrate, compared to fluxgate magnetometers, and avoid challenges related to diffusion of gas through a glass cell and radiation damage of fiberoptics. They would thus be very well suited for nanosats or picosats as their size, power, and complexity restrictions are most severe.

Microscopic modeling of the spin-dependent dynamics in SiC-based all-electrical devices will confirm the extreme sensitivity to magnetic fields in isotopically purified SiC. Device simulations of the macroscopic electrical device surrounding this spin-dynamical active region will determine optimal band alignment, electric field distribution, and carrier density profiles. We will design the optimal sensitivity of the magnetometer based on tradeoffs for isotopic purity, regularity of thickness of dielectric and defect occurrence. A Phase II plan will be constructed, identifying the issues related to device growth and fabrication, testing approaches for the near-zero-field magnetoresistance, and integration into magnetometers. Plans will be developed to mitigate issues and partners confirmed for the Phase II project.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

These small-scale magnetometers have features that depend on fundamentals of quantum spin dynamics, and so are very stable. They avoid the need for spacecraft rolls, unlike fluxgate magnetometers, and avoid challenges related to diffusion of gas through a glass cell and radiation damage to fiberoptics. They are exceptionally small and do not require high-frequency microwave elements or optical components. They would thus be very well suited for nanosats or picosats as their size, power, and complexity restrictions are most severe.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Magnetometers have extensive applications or potential applications in aerospace, health, and noninvasive materials monitoring. Examples include GPS-denied navigation, magnetocardiography, underground/underwater anomalies, planetary probing and solar weather monitoring, and high-resolution crack detection.
Duration: **6**

PROPOSAL NUMBER: 22-1- **S13.04-2465**

SUBTOPIC TITLE: Contamination Control and Planetary Protection

PROPOSAL TITLE: Mesh-Free Contamination Transport Modeling using CAD Geometries

Small Business Concern

Firm: **Particle in Cell Consulting LLC**
Address: **30700 Russell Ranch Road Suite 300, Westlake Village, CA 91362**
Phone: **(661) 202-9812**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters, approximately 200 words):

We propose to develop a simulation code capable of performing contamination transport analyses using complex geometries with moving components without needing a surface mesh of the utilized geometry. Meshing is a time consuming process that can easily account for over 50% of the total effort involved in completing the analysis. It requires modifying the CAD model to delete small parts such as drill holes to avoid an excessively fine mesh which increases simulation run time while at the same time reducing the quality of results due to an increased numerical noise arising from fewer particles striking the small triangles. The code will utilize the existing open source CAD library OpenCASCADE to directly operate on STEP files. The CAD library will be used to load the geometry and to replace the line-triangle intersection checks used for testing surface impact in particle tracing codes with a line-CAD check. This approach retains the analytical description of the surface geometry preventing feature loss due to tessellation. It also simplifies introducing dynamic behavior since the CAD components can be transformed or translated through parametric equations. Objective of the Phase I effort is to complete the feasibility study by developing a standalone code that can simulate motion of particles around a CAD-defined geometry. We also investigate schemes for storing surface data using options such as point clouds or face splitting. Timing of this direct method will be compared to the legacy approach based on a triangular surface mesh. We also investigate approaches for utilizing surface charge to compute the spatial variation of electric fields to simulate charged particle transport which may arise when analyzing lunar regolith or electrostatic return. This study will naturally lead to a Phase II effort during which the developed algorithms will be further developed into an end-user contamination analysis code.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The mesh-free CAD based approach lets NASA contamination control engineers analyze redistribution of molecular, particulate, or biological contaminants in complex dynamic systems such instrument signal pathways, sample return enclosure seals, or drills without needing to perform the time consuming meshing that also leads to a loss of detail and divergence from models used by the mechanical team. It will simplify modeling of contamination transport during spacecraft deployment, during servicing operations, or during landing and re-entry.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The NASA CC applications extend to the wide aerospace industry, as contractors tend to follow the same set of requirements. The algorithms developed under this proposal can be further used to develop commercial simulation codes for electrostatic analyzers, radiative heat transfer, plasma physics, or orbital debris / micrometeoroid risk assessment.
Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.04-2587**

SUBTOPIC TITLE: Unpiloted Aerial Platforms and Technologies for NASA Science Missions

PROPOSAL TITLE: Skydweller for NASA Science Missions

Small Business Concern

Firm: **Skydweller US Inc**
Address: **1601 Northwest Expressway, Suite 1600, Oklahoma City, OK 73118**
Phone: **(405) 596-4325**

Principal Investigator:

Name: **John Dixon**
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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

The NASA Science Mission Directorate has a critical need for a high-altitude long-endurance platform to support extended duration NASA Earth Science missions studying the environment.

Potential solutions include satellites, high altitude balloons, and manned observation aircraft. These solutions all have limitations related to persistence, resolution, flexibility, and control. To overcome these limitations and deliver the robust capability the NASA Science Mission Directorate requires, Skydweller US Inc. proposes development of a solar-powered Unmanned Aircraft System (UAS) that combines the persistence of a geostationary satellite with the operational flexibility and powerful sensing capabilities of a large surveillance aircraft.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

As a persistent flight platform, the proposed Skydweller high-altitude pseudo satellite (HAPS) would enable a multitude of NASA science, communication, and testing missions.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Interest in HAPS for commercial applications such as telecommunications and governmental applications such as remote sensing and surveillance are receiving increasing interest, and the proposed Skydweller HAPS could meeting this emerging market need.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.05-1989**

SUBTOPIC TITLE: Thermal Control Systems

PROPOSAL TITLE: Novel Coating Concepts for Lunar Regolith Dust Mitigation for Thermal Radiators and Extreme Environments

Small Business Concern

Firm: **Applied Material Systems Engineering, Inc. (AMSENG)**
Address: **2309 Pennsbury Court, Schaumburg, IL 60194-3884**
Phone: **(312) 498-9673**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

This proposal is to fulfill the technology gap and provide affordable options for durable, stable thermal control material systems (TCMS) based coatings that can be dust shedding in charging environments and can furthermore can survive and operate in extreme environments. The recent efforts at AMSENG for the TCMS for the Lunar Applications indicated that the Charge Dissipating TCMS based on the secondary emission engineering are the promising concepts. It concluded that the coatings have very low dust sticking ability to the lunar simulant dust. The suggested phase I proposal is for extending this work towards affordable coatings for the extreme environments. The involved nano engineered material technologies at AMSENG are: Nano Engineered filled PDMS, the Carborane Siloxane Monomer based cross linkers and primers; along with the Pigments: PBT™, the Doped Zn:βLiAGO™ and the IR&D based Rad Hard Cementatious Inorganic Sols to be cured above RT to <100°C. Thus, the proposed efforts can address the feasibility evaluation of the advanced dust shedding TCMS coatings for the Lunar Extreme Environments. Thus, the proposed feasibility evaluation efforts can address the Novel Affordable dust shedding TCMS coatings products for the Lunar Extreme Environments through:

- Process Ultra low outgassing space stable filled PDMS with Carborane-Siloxane based cross linkers and Primers, nano engineered filled Elastomers with PBT™, BNNM™ and Doped Zn:βLiAGO™
- Process Selected Pigments with New Rad Hard Cementatious Sol concepts and define Processing window for each concept composition
- Provide the feasibility data for the Dust Shedding TCMS coatings concepts for Thermal Control for harsh extreme environments
- Evaluation and selection of low cost coating processing options, with feasibility proof through GEO simulation, and Dust Simulation
- Recommend Qualification and Validation efforts for the Reliable Material Systems and processing options for Extreme Environment Lunar Mission hardware

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA Science Mission Directorate (SMD) missions can greatly benefit from this dust mitigation thermal coating technology: all lunar-relating project - Power and Thermal Bus Sub Systems, and all projects involved with robotic science rovers and landers in Extreme Environments i n Affordable manner.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The Technology Developed can be useful for:

- Survivable Thermal Control Material Systems, Films & Adhesives that are hardened for the upper atmospheric man made or natural Nuclear Event
- Solar Storms and GEO, MEO & LEO survivable Products that can employ electron on demand strategies in products like: Hardened Thin Film Products, Wiring harnesses, Balloons

Duration: **6**

PROPOSAL NUMBER: 22-1- **S14.01-1861**

SUBTOPIC TITLE: Space Weather Research-to-Operations/Operations-to-Research (R2O/O2R) Technology Development

PROPOSAL TITLE: Dragster: An Ensemble Assimilative Model for Satellite Drag

Small Business Concern

Firm: **Atmospheric & Space Technology Research Associates, LLC**
Address: **282 Century Place, Suite 1000, Louisville, CO 80027**
Phone: **(303) 993-8993**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 7
Technical Abstract (Limit 2000 characters, approximately 200 words):

Under the National Space Weather Strategy and Action Plan and the Promoting Research and Observations of Space Weather to Improve the Forecasting of Tomorrow Act, NASA's role is to provide increased understanding of the fundamental physics of the Sun-Earth system through a variety of space-based observations and modeling, including development of new research and technologies to advances operational and commercial space weather science and technology. This response to SBIR Topic **S14.01 Space Weather R2O/O2R Technology Development** addresses one of four areas identified for priority development: ***Space weather forecasting technologies, techniques and applications.*** Specifically, exploring transition of tools, models, data and knowledge from research to operational environments–including preparation and

validation of an existing science model that may be suitable for transition to operational use.
The main innovation of the new model is the ability to provide uncertainty estimates in addition to the computation of satellite drag. Satellites are affected by the variability in density and motion of the near-Earth space environment. Drastic changes in the thermosphere's neutral density, due to geomagnetic storms or other phenomena, result in perturbations of LEO satellite motions through drag on satellite surfaces that can lead to difficulties locating important satellites, temporarily losing track of satellites, and errors in predicting collisions in space. To meet increasing needs of upper atmospheric and space weather conjunction analysis and debris tracking requires improved satellite-drag nowcasts and forecasts in the 150-2000 km altitude region. Orion Space Solutions' aerodynamic drag-forecast tool, "Dragster," addresses those needs with well-validated, full-physics atmospheric models and ensemble data assimilation techniques.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA's current operational satellite drag needs are the responsibility of CARA, which provides NASA asset protection and mission support in collaboration with the US Space Force 18 SPCS. Dragster benefits NASA via CARA by outperforming the current operational model, and reducing risk. The Project would benefit NASA's CCMC for research purposes, and CCMC will help with metrics analysis.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The $400B space economy will be $1T by 2032. The Kessler Effect could result in the closure of a $1T industry. Dragster errors are smaller, and error bars are realistic, therefore spacecraft can fly closer together because the threat of collisions is reduced. Potential customers include government agencies, commercial satellite operators, satellite service industry, insurance companies.
Duration: **6**

PROPOSAL NUMBER: 22-1- **S11.05-2140**

SUBTOPIC TITLE: Suborbital Instruments and Sensor Systems for Earth Science Measurements

PROPOSAL TITLE: Compact autonomous solar radiometer for atmospheric trace gas sounding

Small Business Concern

Firm: **Mesa Photonics, LLC**
Address: **1550 Pacheco Street, Santa Fe, NM 87505**
Phone: **(505) 216-5015**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

We propose developing mid-infrared, laser heterodyne radiometers for long term automated field measurements of multiple atmospheric trace gases including – but not limited to – formaldehyde (H2CO), ozone (O3), nitrogen dioxide (NO2), and methane (CH4). Profile precisions will be better than or equal to 5% and fiber optics will help reduce stray light to $\leq 10^{-4}$.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed technology meets NASA's need for small, turn-key spectrometer-based Sun photometer sensors capable of detecting NO2, CH2O, and O3, at <5% uncertainty. These sensors must be capable of long-term measurements to support NASA ground networks. Improved

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

N_2O and NH_3 plume measurements and source identification within large agricultural areas such as the US Corn Belt.

Duration: **6**

PROPOSAL NUMBER: 22-1- **A3.04-2854**

SUBTOPIC TITLE: Nontraditional Airspace Operations and Aerial Wildfire Response

PROPOSAL TITLE: Portable Traffic Management Tool for Wildfire Operations

Small Business Concern

Firm: **Improving Aviation, LLC**
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Phone: **(386) 307-5436**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5

Technical Abstract (Limit 2000 characters, approximately 200 words):

An underlying difference between wildfire management operations versus other segments of non-traditional traffic management is the critical need for coordination between manned and unmanned vehicles in an area with limited availability of datalink communications. To successfully integrate UAS for wildfire operations, traffic management limitations among not only manned and unmanned vehicles, but also air and ground actors, need to be overcome. During today's operations, emergency responders are overwhelmed with data from different sources and platforms. UAS operations need to be integrated without increasing the workload of emergency responders or sacrificing the safety of operations. Effectively communicating and providing a common situational awareness on a single platform is key for the successful integration of new technologies in the firefighting field. Improving Aviation is proposing to develop a portable wildfire management tool that combines two critical aspects of wildfire suppression efforts: a common situational awareness map for multi-modal vehicle operations (including crewed and uncrewed aerial vehicles, ground vehicles, and pedestrians) and a real-time weather transmission standard to exchange atmospheric information required for real-time models of wildfire spread. The proposed platform is based on Embry-Riddle Aeronautical University (ERAU) open-source software, MoVE, a publicly available multi-vehicle testing framework that incorporates multi-modal vehicle motion and provides a common situational awareness picture where connected vehicles share telemetry data, including position and atmospheric information. The MoVE platform will be enhanced to serve as a wildfire management operations platform providing a self-powered, self-contained portable station with telemetry information exchanges from multiple ground and air vehicles equipped with varying data links.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed solution aims to advance the development of the Traffic Management-eXploration (XTM) project and System Scalable Traffic Management for Emergency Response Operations (STEReO) system by providing a tool and framework to enable the integration of UAS in emergency management operations, leveraging principles from the UAS Traffic Management (UTM) system. The research performed in this effort will enable effective, low-latency communications and a common situational awareness picture.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The target commercial market is the wildfire suppression industry as well as public and agencies responsible for emergency response. These agencies can use the proposed tool to obtain a common operational picture, ensuring the safety and efficiency of wildfire management operations and achieving an interoperable real-time communication system that can share data across multiple involved actors.

Duration: **6**

PROPOSAL NUMBER: 22-1- **Z12.01-2885**

SUBTOPIC TITLE: Extraction of Oxygen, Metal, and Water from Lunar Regolith

PROPOSAL TITLE: High purity oxygen separation from a pyrolysis gas mixture by rapid solid oxide ion transport

Small Business Concern

Firm: **A-Terra LLC**
Address: **5305 River Road North Suite B, Keizer, OR 97303**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

With the Artemis program, NASA plans to land the first woman and next man on the Moon by 2024, using innovative technologies to explore more of the lunar surface than ever before. The need for oxygen extraction from lunar regolith has been identified by STMD (Space Technology Mission Directorate). As knowledge about lunar water recourses is limited, alternative pathways to extract oxygen are requested, recognizing the need to make progress on the technology required to extract oxygen from dry lunar regolith. The entire lunar surface is covered with regolith, which can be 4 – 15 m deep depending on locations. As a whole, it holds more than 40 wt.% oxygen (O) as solid oxides with SiO_2 being the largest (up to 53 wt.% SiO_2). Successful oxygen extraction from lunar regolith resources would benefit for life support and propulsion needs.

Oxygen extraction from lunar regolith by **vacuum pyrolysis** has been demonstrated and considered to be one of the ideal options because no reagents and reductants are required, thus needing minimal consumables. Despite its large oxygen production potential, it is reported that vacuum pyrolysis needs to overcome several technical hurdles to be commercialized. The following four **key technical challenges** are identified that have been impeding technology readiness level (TRL) advancement of the vacuum pyrolysis approaches. This project provides a supporting technology for vacuum pyrolysis, by utilizing a solid-oxide oxygen ion transport approach, which intends to address the technical challenges identified above, to contribute to advancing the current TRL of the vacuum pyrolysis technology. Oxygen separation using a solid oxide electrolyte for vacuum pyrolysis has never been reported in the literature and U.S. patents.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed technology that extracts high purity oxygen from a complex volatile mixture during vacuum pyrolysis is applicable to NASA's lunar exploration needs (**Artemis Program**).

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed technology that extracts high purity oxygen from a complex volatile mixture during vacuum pyrolysis and it also effectively produces high purity metals such as silicon as byproduct to be used by metallurgical industries.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.04-2763**

SUBTOPIC TITLE: Unpiloted Aerial Platforms and Technologies for NASA Science Missions

PROPOSAL TITLE: All Weather UAS for Long Term Unattended Environmental Observations

Small Business Concern

Firm: **Black Swift Technologies, LLC**
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Phone: **(720) 638-9656**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

The challenge here is to expand the envelope of unpiloted aerial platforms to allow operations in some of the most difficult environments on Earth. Flights in environments such as volcanic plumes, wildfires, and severe storms can gather critical data to validate existing models that are used to provide information that can affect human safety. The accuracy of these models has direct implications to the uncertainty of warnings and limitations for volcanic ash hazards, pollution alerts, severe storms, and wildfire smoke hazards. Improved data collection and model validation are two powerful ways to improve the accuracy of the models and the important safety systems they support. Ground systems, crewed aircraft, and balloons supply this in situ data but are not without limitations. Satellites are also used but suffer from various limitations such as infrequent coverage, cloud masking, and limits in resolution.

BST proposes the S3 UAS, an uncrewed aircraft that leans heavily on legacy BST UAS and represents a revolutionary change in the capabilities of small UAS for Earth observing. The innovation can be grouped into two main areas; a redesign of the S2-VTOL airframe for all weather operations and developing technologies for long duration unattended missions consisting of many flights over days to months. The S2 has conducted many difficult deployments, but the proposed work will extend the capabilities to a much larger mission set. The redesign for severe weather will be extensive and include a new aerodynamic design and modifications for precipitation and icing. The long duration capability represents a dramatic shift in how UAS data gathering for Earth science is conducted. Essentially, the aircraft will be capable of autonomous landing and recharge of it's batteries through solar panels integrated into the wings. The idea here is that the S3 does not have to return to base after each flight, but can be left out to conduct missions of timescales of days to months.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA applications will focus on existing areas BST flies UAS for NASA missions and then expand to new areas with the unique capabilities of the S3. Current areas include volcano monitoring and satellite calibration. BST uses the S2 and S2-VTOL for volcano monitoring and the S3 will expand the capabilities in this area greatly. BST has also worked on satellite calibration for the MALIBU project. The capabilities of the S3 will enable much larger areas for this type of work and the potential to demonstrate the weeks to months mission concepts.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The primary non-NASA application is the monitoring of pipelines for methane leaks, which is a very potent greenhouse gas. A system like the S3 that can inspect hundreds of miles of pipeline per day without the cost of a human operator could vastly expand the ability to monitor and find methane leaks. BST is already partnered with a sensor company to provide this service with the S3.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S16.04-1968**

SUBTOPIC TITLE: Unpiloted Aerial Platforms and Technologies for NASA Science Missions

PROPOSAL TITLE: MDO, Rapid Prototyping, and Experimental Validation of HALE Aircraft Propulsion and Avionics Systems

Small Business Concern

Firm: **Electra Aero Inc**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Electra, in conjunction with MIT and Harvard, has over the last two years been developing a stratospheric airborne climate observatory system (SACOS) based on solar-powered HALE UAVs for a variety of stratospheric climate science missions such as in situ measurements of atmospheric chemistry, radar surveys of ice sheets, and storm monitoring. Electra is in the process of building a demonstrator solar UAV designed for an ice sheet radar survey mission. This vehicle was designed using a novel approach to vehicle optimization pioneered by the SACOS team and is intended to demonstrate the operational feasibility and aerostructural design concepts needed to conduct useful science missions. In this proposal, we intend to leverage this program and the expertise developed in building this aircraft to design a vehicle that meets NASA stakeholder requirements. Phase I (described in detail in the remainder of this proposal) will consist of stakeholder engagement, trade space exploration, and vehicle conceptual design activities to determine the vehicle capabilities of most value and identify areas of substantial overlap with current SACOS stakeholders. Additionally, ground testing will be conducted of critical propulsion system components (batteries, solar panels, and motors) to validate the objective vehicle sizing and performance capabilities. Phase II will consist of stratospheric test flights of Electra's current demonstrator aircraft with representative science payloads to prove out key flight control and system technologies at high altitude. Phase III will then consist of the development and delivery of the full capability objective vehicle to NASA.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Airborne Science Program

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

- High Latitude Ice Observations
    - Antarctic Ice Shelf Cllapse Forecasting
    - Greenland Glacier Flw Prediction
- Direct Stratospheric Sampling
    - Sampling f Stratospheric Aerosols
    - In-situ Measurement f Storm Driven Stratospheric Chemistry
- Drought, Wildfire, and Flood Monitoring
    - Castal Flood Monitoring
    - Drught and Wildfire Prediction
- Oceanic Surface and Cyclone Monitoring.

Duration: **6**

PROPOSAL NUMBER: 22-1- **S17.02-2603**

SUBTOPIC TITLE: Integrated Science Mission Modeling

PROPOSAL TITLE: Enabling Integrated Spacecraft Simulation and the Evolution of JPL's Concurrent Engineering Environment

Small Business Concern

Firm: **Sedaro Technologies, LLC**
Address: **4601 Fairfax Drive Suite 1040, Arlington, VA 22203**

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

The NASA Jet Propulsion Laboratory (JPL) Innovation Foundry “works with internal and external JPL partners to bring their space mission ideas, from the initial concept, all the way to a complete proposal package, targeting an opportunity for flight.” Over the last 25 years and with the institutional knowledge gained through their extensive experience - the Innovation Foundry has developed extremely capable and highly customized modeling and analysis software infrastructure.

The Innovation Foundry has been doing “digital engineering” for many years and well before that term became prevalent. In these facilities, the pace required to conceptualize, model, simulate, and analyze complex space systems for early-stage work has led to the development of custom tools analogous to those that are now being deployed across entire organizations to support full-lifecycle digital engineering. This leads to challenging decisions regarding whether to transition to broader and newer tools or to stay with heritage tools for which there may be a viable commercial or open-source alternative. A flexible, scalable interfacing mechanism between existing internal infrastructure and new digital engineering technologies is required to enable the combination of these capabilities and graceful evolution of JPL’s concurrent engineering environment.

The Open Model-Based Engineering Environment (OpenMBEE) is an open-source collaborative engineering system. Integration of the existing JPL concurrent engineering infrastructure with OpenMBEE will efficiently support this gradual evolution of the JPL concurrent engineering environment that is consistent with the state-of-the-art and positioned to keep up through community contributions. This integration will also enable connections to the Sedaro Satellite platform for unified spacecraft simulation - enabling more mature concepts through integrated, high-fidelity simulation and analysis.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The interfaces developed through this effort will enable the JPL concurrent engineering environment to efficiently leverage new and emerging digital engineering software technologies. This will improve their ability to deliver mature concepts that are less likely to change and cause cost and schedule overruns later in the project. In addition, this incorporation of OpenMBEE and Sedaro Satellite in the earliest stages of the project lifecycle will "seed" the digital thread with model information and simulation assets and ease phase transitions.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Modifications to Sedaro Satellite to support JPL missions will benefit other commercial and government customers developing innovative missions. In addition, the implementation of Sedaro Satellite at a leading organization like JPL will deliver value to commercial organizations using the platform by creating a uniquely high-fidelity mechanism for communication of their COTS capabilities with JPL.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H5.01-2788**

SUBTOPIC TITLE: Lunar Surface 50 kW-Class Solar Array Structures

PROPOSAL TITLE: Advanced material and structural design of a lightweight stiff mounting system for a 50kW-class photovoltaic array

Small Business Concern

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

This project proposes to develop a relocatable lightweight ~50kW-class solar array mounting structure where ultra-lightweight structural members will be used with increased stiffness for power generation at the lunar South Pole. Multiple pieces of PV blankets with the width of 4 m are mounted on the ultra-lightweight structure and provide a total area of 216 m^2 and power output of ~60KW with the III-V PV cells at an efficiency of ~30% at the standard test condition (STC). During the installation, a stable base will first be set up with a double tripod, which will support the vertical axis with a motor for solar tracking. A foldable frame will be erected with an inflatable envelope as well as an actuator in the horizontal direction to reduce the dimension of the base and provide support to the solar blankets. Then horizontal beams are unfolded, and solar blankets will be raised and hung on the beams. Each blanket is attached to a smart mounting fixture to provide in-plane rigidity, so that the load will be transferred to the base through multiple loading paths for the stability and rigidity of the large PV array. This smart mounting system enables novel packaging, deployment, retraction, and modularity concepts and can be scaled up for higher PV capacity at the lunar South Pole. The innovations in materials discovery and structural design can be brought back to the earth for temporary solar array for shading and energy supply to remote communities, or power supplies to rescue sites after extreme weather events. The model and algorithm for virtual experiments will advance the state of the art of the material and structural design and analysis.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

A lightweight, vertically deployed, retractable 50-kW-class (~60-kW) solar array is proposed for surface photovoltaic energy harvesting near the lunar South Pole, which can meet diverse needs including lunar bases, dedicated power landers, and rovers. This robust, lightweight, re-deployable solar array is applicable to different solar modules as well. The success of this project will lead to new technology for the next generation of solar arrays for the NASA Artemis Program.

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The highly efficient lightweight thin film cell is ideal for unmanned aerial vehicles; the vertical structure can be used for energy harvesting and shading for residential and commercial buildings; the smart mounting fixture can be used for building integrated photovoltaic systems; the ultra-lightweight composite can be used for vehicles, naval vessels, aircrafts, and building structures.

Duration: **6**

PROPOSAL NUMBER: 22-1- **H4.07-2376**

SUBTOPIC TITLE: Low Volume, Power and Mass CO2 and Humidity Control for xEMU

PROPOSAL TITLE: Nanoporous Materials to Provide CO2 and Humidity Control for the xEMU with Minimal

Power Requirements and Low Volume and Mass

Small Business Concern

Firm: **XploSafe, LLC**
Address: **712 Eastgate Street, Stillwater, OK 74074**
Phone: **(918) 813-2955**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

In this Phase I SBIR, XploSafe proposes to develop and confirm the technical feasibility of the use of beads, pellets made from pure and surface functionalized nanoporous silica as a vacuum regenerable sorbent within the Exploration Extravehicular Mobility Unit (xEMU) for carbon dioxide (CO_2) and humidity control. The proposed self-cleaning technology shall not require heat based regeneration, reduce power draw, volume envelope, and mass while maintaining the current CO_2 and humidity removal capacity in the desired operating conditions. Higher sorption capacities for carbon dioxide and moisture and more rapid sorption rates that could lead to reduced weight and size requirements while providing a longer service life. In this investigation, the sorption rate and capacity for spacesuit CO_2 and humidity will be determined. The ability for these contaminants to be removed from the sorbent by exposure to a moderate vacuum at ambient temperature will be demonstrated. Once the uptake capacities and rates are known for the OSU-6 sorbent and the logistics for vacuum regeneration of the sorbent have been determined, it will be possible to create a concept design for the prototype vacuum regenerable element that could be integrated into the xEMU. This design will be used in Phase II to produce and test prototypes.

Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Successful development of the proposed technology will advance the state of the art in CO2 and humidity removal via a pressure swing adsorption system. As a part of the Exploration Portable Life Support System (xPLSS) and the Exploration Extra-vehicular Mobility Unit (xEMU) units, the platform technology will advance the viability of NASA's crewed deep space exploration objectives

Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Success in developing more effective and efficient filtration media could provide a significant enhancement in the protection of public health and the environment. This new filter media will serve a wide variety of markets as high efficiency carbon dioxide, VOCs and moisture control in HVAC systems. Applications range from clean rooms, labs, pharmaceutical manufacturing etc.

Duration: **6**

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