NASA SBIR 2021-I Solicitation

PROPOSAL NUMBER: 21-1- **S1.01-2846**

SUBTOPIC TITLE: Lidar Remote-Sensing Technologies

PROPOSAL TITLE: GRAAL: Geospatial Rastering And Atmospheric Lidar

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 critical science needs for the upcoming decade in Earth Observation, new technologies are required that reduce lidar size, weight, power, and cost while retaining efficiency, reliability, lifetime, and high performance. This is a challenging problem as state-of-the-art space based lidar systems operate at the edge of physical limits. We propose to develop the Earth Compact lidar for Height and altitude Observations (GRAAL). GRAALis an ultra-compact time-of-flight ranging lidar for Earth observation from Low Earth Orbit (LEO), designed to address key observational priorities including ice

sheet thickness, forest canopy thickness, and smoke and cloud cover. GRAAL delivers similar science performance to ICESat-2's ATLAS lidar instrument using. a radically new optoelectronics concept with two critical advances: 1) a greater than 10x reduction in size, weight, power, and cost by using a novel optical architecture; 2) GRAAL's optical path inherently provides a dual-channel capability for multi-sensor configurations such as imaging + lidar or hyperspectral sensing + lidar. With these two advances, GRAAL will be a key enabling technology for the next decade of compact lidar systems tasked with providing high quality data while vastly reducing instrument cost, size, and complexity. We have designed GRAAL as a "stock" lidar system replacing expensive, long-lead custom designs such as ATLAS, which will enable new mission architectures that require cost-effective global coverage and improved responsiveness to dynamic events, for example in constellations of SmallSat-scale satellites.

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

GRAAL has applications in LEO Earth observation for ice sheet and forest canopy thickness, and cloud cover. GRAAL's novel steering capability has applications in entry, descent, and landing to survey a landing site prior to touchdown of a lander, and in hazard avoidance and docking. GRAAL's size is ideal for balloon or airborne application. The proximity of GRAAL to the surface could allow for Raman or differential lidar, expanding close-range capabilities to include chemical analysis.

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

GRAAL has a clear application in a balloon based configuration for monitoring of greenhouse gas emission in oil & gas settings. Here, GRAAL is a key technology to allow companies to respond to new regulations for monitoring emissions at all stages of production.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.02-3103**

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

PROPOSAL TITLE: Fault Tolerant Beam Steering for Cubesats

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5

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

This proposal is an enabling communication technology for small spacecraft beyond LEO. *We propose to adapt real-time coherent combining software for electronically steered arrays recently proven for ground-to-space communications to the computing constraints of small spacecraft.* An electronically steered array antenna system must adjust the phase of multiple received signals so they coherently combine, with errors in the process rapidly degrading the output signal. The chief method of mitigating phase errors is to place the radio antenna elements into a robust, high precision mechanical structure. On a moving platform, another mitigation is also used, precise measurements of movement and/or cessation of all movement during antenna usage. The first is at direct odds with the need for small spacecraft to use lightweight, flexible, and deployable structures. The second is an extreme challenge for orbiting craft, especially those navigating in CisLunar or deep space where relative position knowledge is degraded compared to LEO satellite situations.

Miles Space's coherent combining software continuously adapts to phase differences in radio data streams allowing them to be combined successfully, nearly eliminating grating lobes. Doing so allows flexible, deployable antennas to be used on rotating craft, even those that may have residual antenna vibration due to recent propulsion and attitude control usage. There are corresponding cost and risk reductions in craft mass and machining tolerances with improved tolerance to deployment mechanism issues and on-mission antenna damage.

Through a contract with ATLAS Space Operations, Miles Space demonstrated to the US Air Force its coherent combining software operating on a phased array ground terminal downlinking GEO and LEO satellite signals. The algorithm was used on digitized RF data before the data reached a commercial modem for decoding. As judged by the modem, real-time coherent combining eliminated grating lobes.

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

Dynamic coherent combining breaks constraints of phased array mounting. Arrays can be created from flexible structures, even operating while vibrating, tolerating off-plane rotation while still coherently combining signals, expanding mounting options on a mission.

Scientific missions benefit from placement flexibility, letting the science needs dominate.

CisLunar and deeper missions need high delta-v. Craft mass is lowered by using this algorithm to perform phase shifting on low mass, low volume deployable phased array antennas, raising delta-v.

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

Phased arrays let the commercial market obtain licensing in an ever more crowded orbit and this technology makes phased arrays far more economical and practical.

Military projects will benefit from this technology as well. The dynamic aspect of the software responds quickly to changing signal conditions, tolerating sudden changes due to damage, increasing resiliency and overall advantage.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H9.01-1996**

SUBTOPIC TITLE: Long-Range Optical Telecommunications

PROPOSAL TITLE: Robust Isolation for Vibration Abating (RIVA)

Small Business Concern

Firm: **Shock Tech, 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 main objective of this Phase I project is to fully demonstrate the feasibility of developing Robust Isolation for Vibration Abating (RIVA), suitable for integration in an optical transceiver, to reject high frequency base disturbance by at least 50 dB. The proposed RIVA will have integrated launch locks and latching mechanism with a robust performance. Specifically, RIVA will be applicable to long-range optical telecommunications. RIVA will reduce angular errors from vibration on low mass, high performance, laser beam control assemblies. While this project is focused on space version of RIVA, eventually, our solution will have two additional variants designed for a particular operating condition and platform, i.e., Ground and Air. It will meet qualifications of extreme shock and vibration attenuation during non-operating period and mitigates high frequency vibrations during laser operations while minimizing its weight meet requirements. Our innovative solution offers low size,

weight, and power (SWaP) with improved efficiency, reliability, and robustness as related to its function, high frequency isolation.

RIVA will utilize ShockTech proprietary elastomeric formulas which have been space-qualified and deployed upon NASA spacecraft. In fact, these same elastomeric formulas were used to protect the Seismic Experiment for Interior Structure (SEIS) instrument, used in the InSight mission under NASA's Discovery program, from vibration and loads experienced during its travel from Earth to the Martian surface in 2018.

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

Robust Isolation for Vibration Abating (RIVA) is designed to be suitable for all missions requiring high stability communication pointing and alignment. RIVA is an innovative solution for advancing free-space optical communications by pushing future data volume returns to and from space missions in multiple domains with return data rates >100 Gbps (Lunar to ground), >10 Gbps (Earth-Sun), >1 Gbps/AU2 (deep space), and >1 Gbps (planetary lander to orbiter). Ground-to-space forward data rates >25 Mbps to farthest Mars ranges are targeted.

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

RIVA will be adopted for non-NASA optical communication satellites with the need for high-stability alignment will be necessary. RIVA**'s** flexible design makes it applicable to various communication satellite sizes. We will explore applications to production facilities for sensitive optical devices, sensitive medical devices, and airborne optical sensors onboard reconnaissance aircraft, and drones.
Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.03-2240**

SUBTOPIC TITLE: Technologies for Passive Microwave Remote Sensing

PROPOSAL TITLE: A Board Level Solution for Correlation Radiometers

Small Business Concern

Firm: **Pacific Microchip Corporation**
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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 project aims to develop a board level solution for the NASA's microwave correlation radiometers required for Earth sensing applications. Spaceborne instrumentation requires minimized size, weight and power (SWaP). Present solutions rely on analog signal processing, thus are bulky, power hungry and cannot be reprogrammed. Analog filter parameters tend to be unstable over temperature, power supply voltage, may degrade over time and need tuning.

The proposed approach will process an IF I/Q signal up to 10GHz, derived, for example, in water vapor sounders at 180GHz band. To implement the required function, a previously developed ASIC will be redesigned to improve its analog front-end performance and implement a new DSP function with the increased SEE immunity. Within the DSP block, IF input signals will be channelized into 64 bands and cross-correlated within each band. Several innovations will be introduced to the ASIC and the board level solution to combine improved performance, programmability, minimized SWaP and radiation sensitivity.

The project's Phase I will provide the proof of project's feasibility. Phase II will provide a silicon proven ASIC and the board level solution for correlation radiometers.

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

- Remote sensing instruments for Earth, planet and sun exploration missions

- Radio astronomy

- Position synchronization between satellites in distributed and formation flying missions

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

- Remote sensing instruments developed by the ESA and other space agencies

- Temperature, water vapor, pollutant and other exploration by the EPA and NOAA

- Synthetic aperture radars for military applications and civil aviation

- Military surveillance satellites

- Thermal imaging for security systems

- Navigation satellites

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.04-3292**

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

PROPOSAL TITLE: Multi-stacked Aligned Wafer Bonding for Wide-bandwidth AR treated silicon optics

Small Business Concern

Firm: **Cactus Materials**
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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 objective of this Phase I proposal is to develop multi-stacked wafer bonding techniques for wide-bandwidth anti-reflection (AR) treated silicon optics at terahertz (THz) frequencies. This process can enable high layer-count structures resulting in thick and large needed for the very wide-bandwidth AR treatment. At the end of the Phase I, the goal is to achieve <1% reflectance over a prototype of 4-layers AR structures by stacking with precision alignment and bonding techniques that Cactus Materials, Inc. has developed. Phase II of the project is to develop a complete wide-bandwidth AR treatment for silicon optics applicable for vacuum windows and it can be used in the future for powered optics by integration with a gradient-index lens architecture (GRIN) using wafer bonding, circumventing the challenge of AR-treating a curved surface. Transmission (T) and reflectance (R) on bonded wafers are expected to be 100% and <1% respectively. A precision alignment of <2 micron between wafers will be employed using automated lithographically defined alignment marks. To meet <1% reflectance, the bonding interface needs to be defect free, void free, chemicals and moisture free. In addition, bonding strength needs to be close to silicon bulk strength and withstand any vibration or stress as well as hold up as vacuum windows, so under deflection of 1.5-6 mm (depending on the diameters). For example, vibrational stress of a launch could damage the stacked Si lenses. A detailed testing and modeling will be incorporated to ensure the optics are robust enough

for space platform. If successful, this technology development will be stepping stone towards making a high-performance, larger diameter, and thicker AR treated silicon optics.

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

A wide range of applications include studies of CMB polarization, of galaxy clusters using the Sunyaev-Zeldovich Effect, of galaxy evolution and the Epoch of Reionization using low-resolution spectroscopy and spectral line tomography. Specific spectral bands of interest for astronomy applications e.g. flat optical windows with 4-layer AR structures covering 4:1 bandwidth, specifically 100-400 GHz and 75-300 GHz, 7-layer AR structures covering ≥ 6:1 bandwidth, 80-420 GHz and 30-180 GHz, and a GRIN optic with 4-and 6-layer AR structure

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

The technology can be implemented in a cost-effective way for large optical elements in many applications in the range if FIR, MWIR, and THz. Silicon vacuum windows and gradient index silicon optics with integral AR treatment are two key products. Silicon is significantly cheaper, particularly as size increases compare to other materials e.g. Germanium vacuum windows are 2-3x higher in cost.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.09-2514**

SUBTOPIC TITLE: Vehicle Sensor Systems to Enable Situational Awareness

PROPOSAL TITLE: Real-Time Panoramic Sensing for Enhanced Air Vehicles

Small Business Concern

Firm: **Circle Optics, Inc.**
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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 proposes a Phase 1 project for NASA to explore adapting the Circle Optics technology for low parallax, low distortion, panoramic, multi-camera capture devices that provide real-time 360° imagery, to air vehicle sensing. During Phase 1, Circle Optics would work with NASA, the Air Force (Agility Prime) and others in this developing industry to better understand system specifications, including for SWaP-C, resolution, FOV, and spectral content. Circle Optics would also develop more mature optical designs for the Medusa architecture to optimize it for air vehicle sensing. Finally, Circle Optics would produce a Phase II proposal that describes the development of an actual testable prototype optimized imaging system and its' performance.

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

Circle Optics will enhance situational awareness to enable intelligent vehicle systems that will allow the development of piloted vehicles augmented with autonomous capabilities and autonomous unmanned air vehicles

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

Presently have 150+ customers requesting for beta product of next imaging system, 20 offered letters of interest across over four target markets (entertainment, mapping, industry, defense). Winner of multiple accelerators and imaging competitions. Over $1.9M from Venture Capital, angel investments, and grants.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H4.05-2756**

SUBTOPIC TITLE: Advancements in Water and Air Bladder Assemblies and Technology

PROPOSAL TITLE: Persistently Antimicrobial Polyurethanes for Improved Pressure Garment Bladders

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 is seeking improvements to current spacesuit pressure garment bladders in several key areas, including increased microbial resistance, imparting self-healing capability, and decreasing the friction between the bladder and surrounding materials. To create these improvements, TRI Austin proposes developing a new polyurethane based coating for the Oxford-weave nylon currently used in legacy space suit pressure garment bladders. This new polyurethane will be developed in collaboration with experts at a local university, who have created FDA approved additives to make polyurethanes, as well as other polymers, persistently antimicrobial and resistant to forming biofilms. These new polyurethanes are expected to decrease or even eliminate the need for biocide use in next-gen space suit applications, without causing significant changes to the current production or processing methods. In addition, imparting self-healing properties and minimizing friction with surrounding materials will be investigated as these polyurethanes are formulated. TRI Austin will work with the current producer of pressure garment bladders to ensure the new polyurethane is a drop-in replacement for the legacy material. The new formulation will be iteratively developed until a polyurethane is created which satisfies or exceeds all of NASA's desired requirements.

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

Potential NASA applications include new materials for pressure garment bladders for integration into the Exploration Extravehicular Mobility Unit (xEMU) and used in a variety of space based missions including on the International Space Station (ISS), and in future missions to both the Moon and Mars. Additionally, this material could be used in other applications that require both flexibility and antimicrobial properties.

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

Applications could include use as persistent antimicrobial coatings and films, such as those used for marine diving, water containment, sewage treatment, CBRN protective suits, and creation of antimicrobial surfaces, at the industrial and consumer level. Finally, the new material may find use by the US Department of Defense, in flight suits and coatings for water containment systems.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.01-3039**

SUBTOPIC TITLE: Advanced Air Traffic Management System Concepts

PROPOSAL TITLE: Risk Based Trajectory Service

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):

ATA's proposed innovation is to create an Application Programming Interface (API)-based service that calculates Risk Based Trajectories (RiBT) by integrating multiple geospatial data sources with risk models to provide real-time geospatial risk metrics that are then optimized into risk-optimized trajectories. The RiBT will be used in Unmanned Aerial Systems (UAS) operations by human Remote Pilot in Command (RPIC) and Autonomous vehicles in the Flight Planning and En Route phases of flight.

RiBT enhances trajectory based operations (TBO) for UAS by providing a rigorous safety facet to optimizing trajectories within the National Air Space (NAS) – enhancing "safe, end-to-end TBO", as described in the topic and the FAA NextGen 2025 Trajectory Based Operations goals. The service based design of the proposed RiBT solution supports the service architecture design of UTM and further enables the "integration of independent systems and domains, and increasingly diverse and unconventional operations" by creating common understanding of the relative risk of the airspace.

RiBT supports Thrust 1 of the AMRD Strategic Plan (NASA Aeronautics Research Mission Directorate, Strategic Implementation Plan, 2019 Update) by supporting the safe integration of UAS through consistent risk assessment and application to trajectory. RiBT addresses the research theme of Safety Management and Emergent Risks in Thrust 1 by hosting and delivering multiple prognostic

risk estimates, in real time, to all NAS participants; supporting safety assurance in a NAS with increased traffic volume and diversity of operations.

ATA will provide a fully functional RiBT prototype at a NASA Technology Readiness Level (TRL) of 4 with a testing and performance metrics for validation and verification. The prototype will allow NASA and Commercial evaluators to input planned flight trajectories into the prototype API and receive risk metrics and Risk Based Trajectory segments in return.

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

- Enhanced risk management and risk integration into UAS flight planning for both human controlled and autonomous NASA UAS operations
- Integration and enhancement with complementary Safe2Ditch and high density vertiplex efforts
- Ability to study increased density through better risk management and assess and quantify events against a consistent risk metric to support UTM research and development

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

- Enhanced risk management and integration into UAS flight planning for both human controlled and autonomous UAS operations
- Integrated pre-programmed risk adjusted flight and diversion routes for autonomous UAS vehicles in package delivery and public safety
- Metrics to support improved liability and risk management for insurance purposes
- Integration with commercial USS/UTM provider products

Duration: **5**

PROPOSAL NUMBER: 21-1- **S5.03-3258**

SUBTOPIC TITLE: Accelerating NASA Science and Engineering through the Application of Artificial Intelligence

PROPOSAL TITLE: ML-based Model for Autonomous analysis of Spectral Data.

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):

We propose to develop the foundation of a **Machine Learning (ML) model for autonomous interpretation of spectroscopic data,** and demonstrate in a cloud-based application for interpretation mineralogical data. Our goal is to demonstrate a tool that can process a range of analytical techniques with a high degree of automation and performance that rival that of expert users with conventional analytical software. The automation and ease of use will enable automated analysis of large quantities of data, allow non-experts to extract valuable high-level scientific products from raw data, and empower experts with a new approach to data analysis. The model demonstrated with this effort will provide the base on which methods for automated analysis spectroscopic data can be developed for implementation in autonomous rovers and spacecrafts.

While our proposed approach can be –and will be– extended to more analytical techniques, we are focusing our current development on two methods: X-ray diffraction (XRD), a well-established technique for identification and quantification of crystalline materials, currently deployed on Mars in Curiosity, and Raman spectroscopy, a more recent method that has shown increasing popularity over the last decade and that will be deployed in upcoming Mars missions including Mars 2020. XRD and Raman provide two different case studies on which we will ultimately develop a technique-agnostic analytical tool.

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

Analysis of mineralogical data in planetary exploration using our web-app QAnalyze (X-ray diffraction, Raman spectroscopy, and more). Model for on-board autonomous analysis of a wide range of spectral data from rovers used in planetary exploration or ISRU, or for remote sensing platform fitted with spectroscopic instruments.

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

Provide rapid, accurate, and automated data analysis of XRD patterns and Raman spectra in a Software as a Service model. New applications opportunities in a wide range of industries (oil and mining exploration, pharma, etc) for discovery, quality control and process monitoring.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.02-3303**

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

PROPOSAL TITLE: Using Autonomous Outposts as Data Relays to Support Distributed Spacecraft

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):

Distributed small space vehicles, cooperating in a dynamic environment, are critical for the success of planetary exploration within the next decade. However, the effectiveness of these distributed vehicle swarms will be limited by two factors – the size of the individual vehicles (which will determine onboard data relay capabilities) and their distance from the command centers on Earth. The existence of flexible, rapid, low-cost platforms in the cislunar and translunar environments can increase the resiliency and effectiveness of exploratory mission designs by providing a localized area network capacity for communication, PNT, and data relay back to Earth.

Nanoracks is currently developing a technological capability which will enable such an integrated solution by repurposing launch vehicle upper stages by attaching a modular hardware bus, or Mission Extension Kit (MEK). After primary payload deployment, the MEK takes over control of the upper stage, providing power, pointing, data down/uplink, and maneuver capabilities. The upper stage becomes an Outpost.

Nanoracks proposes undertaking a study to pursue a new path of Outpost concepts of operations: localized data services for distributed space vehicles. This Phase I study will develop a theoretical framework for accomplishing identified and prioritized missions and will demonstrate feasibility for required technological development or integration. The study will provide research results which clearly depict metrics and performance of the technology in comparison to existing solutions. In a

follow-on Phase II, Nanoracks expects to demonstrate a prototype capability onboard a suitable ground testbed, followed by a Phase III flight demonstration of the capability. The ultimate goal of this effort are regular flight missions of an operational Outpost capable of providing services in support of the identified missions

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

This study is designed to address specific Outpost capabilities which can support localized data services for distributed space vehicles to support NASA's exploration goals, to inform the initial development of an Outpost as a robust orbital data relay platform. An Outpost with capabilities can also provide autonomous "carrier" capabilities to vehicles, including refueling, repair, component storage, cargo exchange, and localized PNT/command/data/communication relays.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Nanoracks' MEK is designed to turn Outposts into key platforms for the future orbital ecosystem. Outposts located in LEO/GEO will provide payload hosting services, refueling, repair, and other robotically enabled services, and host OSAM activities. Outposts also can serve as distributed network nodes for communications or PNT. Nanoracks hopes to begin development of such systems within this study.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A2.03-1375**

SUBTOPIC TITLE: Advanced Air Mobility (AAM) Integration

PROPOSAL TITLE: Weather Testbed for Urban Air Mobility

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):

ClimaCell, in collaboration with MIT Lincoln Laboratory, proposes the development of an innovative Urban Air Mobility (UAM) Weather Testbed to provide weather information at a high-resolution to capture fine-scale phenomena impactful to future UAM operations. The testbed will consider the use of currently available sensors, as well as other advanced technology to meet current low-altitude weather information gaps to facilitate safe and efficient UAM operations. Using artificial intelligence and numerical weather prediction approaches, the sparse weather observations will be used to analyze current weather conditions at high-resolution in three-dimensions and produce forecasts with products tailored for the UAM community. In designing this prototype network, input from a variety of UAM stakeholders will be solicited to ensure that the network will meet their anticipated needs, and the interaction will continue as the network is built out for additional feedback. This Phase I work will include a weather information gaps assessment, architecture design for an urban weather testbed for UAM, and identification of suitable municipalities for hosting a build out of a prototype testbed. In a follow-on Phase II effort, the network would be built out in at least one municipality and the high-resolution data would be marketed to additional customers beyond the UAM community to sustain a network in the interim, given that it is expected to be a number of years until a critical mass of UAM customers exists to pay for the network maintenance.

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

NASA is leading the nation's effort to rapidly develop and enable Urban Air Mobility and Advance Air Mobility operations. Complex low-altitude weather adversely affects and poses a hazard to these operations. A reduction in weather and wind uncertainty at high-resolution as provided by this urban weather testbed will help facilitate safe and efficient Urban Air Mobility flights. Additional high-resolution weather information will be useful to unmanned aerial system operators and traditional aviation operators at commercial airports as well.

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

The ultimate operational system resulting from this work will be high-resolution weather data and forecasts produced by a refined network of weather sensing infrastructure to be marketed as an application for Providers of Services for UAM (PSUs). This urban weather information will also be useful to NOAA and the NWS for forecasting, and the many other applications of the weather enterprise.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.05-1390**

SUBTOPIC TITLE: Computational Tools and Methods

PROPOSAL TITLE: Automated and Scalable Mesh Generation for Wall-Modeled Large Eddy Simulation

Small Business Concern

Firm: **Pointwise, Inc.**
Address: **213 South Jennings Avenue, Fort Worth, TX 76104**
Phone: **(817) 377-2807**

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 will provide a robust and automated approach for creating body-conforming meshes suitable for WMLES simulations for arbitrary geometries in a MPI parallel environment. Most current commercial mesh generation software operates on engineering workstations and usually takes advantage of multiple core processors to accelerate the mesh generation process. The proposed effort would work on multi-core workstations and in a distributed parallel environment to take advantage of more processors and much more memory to create large scale meshes for WMLES simulations. The developed framework will also provide a pathway to implement solution-based adaptive mesh refinement during the analysis phase that could operate simultaneously with the CFD analysis tools.

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

NASA has developed numerous simulation tools for WMLES with application in air vehicles (both fixed and rotating wing), space vehicle launch, assent, and entry, parachute deployment, and complex moving-body problems. The proposed technology will be applicable to these program objectives and support existing simulation workflows.

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

Military applications include vehicle aerodynamics and store separation. Civil applications include vehicle aerodynamics, propulsion integration, rotorcraft, medical device, power generation, and complex moving-body problems.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S2.05-1514**

SUBTOPIC TITLE: Technology for the Precision Radial Velocity Measurement Technique

PROPOSAL TITLE: Integrated Photonic Spectrograph

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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Business Official:

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Address: **2501 Earl Rudder Freeway South, TX 77845 - 6023**
Phone: **(979) 764-2219**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

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

Precise radial velocity (PRV) measurements play a critical role in the strategic goal of NASA to find planetary bodies and habitable Earth-like planets. Ground based telescopes currently achieve ~1 m/s single measurement precision. New generation visible PRV systems have demonstrated ~30 cm/s, but in order to reach the sensitivity of 1-10 cm/s, as expressed in the NASA Decadal Survey, advances need to be made in the various components and subsystems of these instruments that lead to space-based systems. Current astrophotonic spectrometers have a limited operational bandwidth of ≤ 200 nm, channel spacing of ≥ 1.5 nm, a limited linewidth of ≥ 0.15 nm. These devices also have large optical loss, relatively large footprints, and require off-chip detection. Lynntech proposes an integrated photonic spectrograph with on-chip photodetection. This device will offer improvements in all the categories above, as well as, on-chip photodetection, multimode input, and spectral filtering.

The Phase I project will target a feasibility demonstration of the proposed integrated spectrograph for multimode input, larger operational bandwidth, and spectral filtering. The Phase II project will develop and demonstrate the full resolution device that can be incorporated with large ground-based telescopes and cube-sats.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Lynntech's integrated photonic spectrograph with on-chip photodetection provides size, weight, and power benefits, as well as, cost savings for the following NASA applications: (1) Large ground-based telescopes, (2) Use in nano-sats and cube-sats, (3) free-space optical telecommunications, and (4) chemical sensing.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The integrated photonic spectrograph with on-chip photodetection can be used in the commercial market in (1) portable sensing applications such as chemical and biological sensing, as well as, spectral characterization of different materials and (2) free-space optical telecommunications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.12-1837**

SUBTOPIC TITLE: Modular and Batch-Producible Small Spacecraft

PROPOSAL TITLE: Software-Defined Power Controller: Enabling Adjustability of Spacecraft Power Systems during AIT and On-Orbit Operations

Small Business Concern

Firm: **Amplified Design Solutions, LLC**
Address: **2 James Circle, Longmont, CO 80501**
Phone: **(303) 523-7842**

Principal Investigator:

Name: **Jerome Hittle**
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Business Official:

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Phone: **(303) 523-7842**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

AmplifiedSpace hypothesizes that the development of a new Software-Defined Power Controller (SDPC) using digital control techniques, commercially available wide-bandgap GaN transistors, and power converter topologies that enable both stepping-up and stepping-down of input voltages, will result in the most efficient, modular, and adjustable power system ever designed for aerospace. During assembly, integration, and test (AIT) the SDPC can quickly interface an assortment of solar arrays, energy storage devices, and payloads into a complete EPS system within minutes, reducing NRE by a factor of 10 or more. Digital control of the load supplies will also provide the ability to change the output voltage, allowing for the Concept of Operations (CONOPS) teams to have the ability to actively interleave power requirements for different loads while in flight – a task that is believed to have never been performed in space.

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

This Software-Defined Power Controller can be used by cubesats ranging from 3U to 12U and is scalable to ESPA class and larger satellites. The technology developed within the control system is also applicable to other control systems in which NASA has expressed interest, including other SBIR solicitations including radiation tolerant point-of-load converters (S3.08), radioisotope thermoelectric generators (RTGs) (S3.02), and large power systems on the surface of the Mars and the Moon (Z1.05) with the Artemis program.

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

The Software-Defined Power Controller can be used in cubesats developed by the Space Force, Air Force, National Science Foundation, and commercial companies. The education sector often has changes in power system requirements from mission to mission where system level modularity is important. The solid state drive industry is also interested in using this tech for capacitive backup systems.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.04-1594**

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

PROPOSAL TITLE: Extended Short Wave Infrared Focal Plane Array for Versatile Imaging Systems

Small Business Concern

Firm: **NOUR, LLC**
Address: **1500 Sheridan Road, Unit 8A, Wilmette, IL 60091**
Phone: **(847) 491-7251**

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):

Several field applications require extended short wavelength infrared (e-SWIR) band capabilities in future systems. It is highly desirable to design a next-generation FPA to overcome the deficiencies of e-SWIR imaging sensors. In recent years, Antimonide-based Type-II superlattices (T2SL) represent the most promising material system capable of delivering more producible, large-format, reduced pixel pitch, e-SWIR focal plane arrays (FPAs) for global observation applications. We propose to develop T2SL-based photodetectors and FPAs for NASA imaging and spectroscopy applications in the spectral band from visible to extended e-SWIR (0.4–2.5μm) with a very low dark current density. Using the highest quality material and a novel bandgap-engineering design and process, we will fabricate high performance photodetectors and FPAs through the e-SWIR region. In Phase I, we are going to continue to advance our previous work on design and structure of NIR and SWIR T2SL photodetectors and then demonstrate a novel e–SWIR uni-traveling carrier bandstructure–engineered photodetector design utilizing an optimum device structure and material(s) to achieve operation at 150K and above. We will simulate essential electrical and optical characteristics for a device that meets the performance requirements for low dark-current ($<1\times10^{-10}$ A/cm^2) and high quantum efficiency (>70%) at 150K. Fabricate and test single element devices as proof of concept for future large format imager suitable for hyperspectral and atmospheric sensing. In this project, Northwestern University will collaborate with Nour, LLC to study and grow strain-balanced $InAs_{1-x}Sb_x$/InAs and InAs/AlSb/GaSb Type-II superlattices with barrier structures for e-SWIR photodetectors. Using these superlattice structures, it is expected to achieve longer minority carrier lifetime and lower dark current densities. This will enable reduced imager cooling and significantly reduce size, weight and power of remote observation platforms.

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

To obtain high sensitivity over the entire 0.4-2.5 μm wavelength band, the usual approach is to use multiple detectors. This approach complicates the size and complexity of the imaging system for earth observation missions. For these missions, a single visible to eSWIR array is of special interest to NASA for global observations to study the world's ecosystems, climate change, atmospheric monitoring and provide critical information on natural disasters such as volcanoes, wildfires and drought.

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

- Commercial applications: geophysics, geology, remote environmental (pollution) monitoring, law enforcement, search and rescue, firefighting and emergency response.
- Department of Defense applications: space-based situational awareness applications, ballistic missile defense, reconnaissance & night vision, and covert night pilotage of sea, land, & air craft.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.06-2529**

SUBTOPIC TITLE: Particles and Fields Sensors and Instrument Enabling Technologies

PROPOSAL TITLE: Variable High Voltage DC with 2 KHz AC Modulator for Faraday Cup Applications

Small Business Concern

Firm: **Busek Company, Inc.**
Address: **11 Tech Circle, Natick, MA 01760**
Phone: **(508) 655-5565**

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):

Advancing the instrumentation to detect elementary particles is critical for future space weather missions. To progress the study of the flow of energy that heats and accelerates solar corona and wind, a next generation Faraday Cup is needed. Extending the range of solar wind speed measurements to 2,500 km/sec or more requires a new, innovative power supply with significant high-voltage DC and AC modulation capabilities.

We propose a variable sine wave power supply capable of delivering up to 40kV DC with a 2kHz AC modulation up to 4kV peak to peak. This venture will leverage Busek's previous experience with delivering radiation hardened PPUs and developing a suite of Plasma Probes with custom electronics to deliver a prototype with a path to a radiation hardened flight system. The proposed architecture is based on a Cockroft Walton Voltage Multiplier to generate a high voltage DC offset and a Resonant Royer Oscillator to produce an AC waveform superimposed on the high voltage DC bias. The proposed architecture offers many advantages that will simplify the path to flight design process. The

multiplier circuit contains simple passives and imposes equal voltage stress on each stage. This eases component selection, reduces BOM costs, and improves compactness. The Resonant Royer Oscillator is a self-resonating circuit used in many high voltage applications that offers user flexibility, simplicity, efficiency and low component count. By implementing high voltage design techniques and testing considerations, this Phase I effort will validate the feasibility of the proposed power supply in a laboratory environment to meet the needs of next generation Faraday Cup.

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

NASA applications include continued and extended research of space weather missions such as characterizing the dynamics of the plasma at the sources of solar wind. This innovation will support the development and use of new particle sensors and instrumentation. In addition, the industry has a large gap in available radiation hardened high voltage supplies. Other NASA missions require advancements in this area. The proposed technology offers to extend that range and introduce a supply that can support various DC offset voltages and applications.

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

Non-NASA applications which utilize high voltage power supplies and probe diagnostic tools for ground based or flight ventures in both academic and commercial fields. There is a critical gap in compact, radiation hardened power supplies that can be applied to other applications such as Electrospray work, Retarding Potential Analyzers, and other missions that require high voltage supplies.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.01-2622**

SUBTOPIC TITLE: Technologies for Large-Scale Numerical Simulation

PROPOSAL TITLE: Virtual MemComputing Machine

Small Business Concern

Firm: **MemComputing, Inc.**
Address: **9909 Huennekens Street, 110, San Diego, CA 92121**
Phone: **(760) 525-1241**

Principal Investigator:

Name: **Mr. John Aiken**
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Phone: **(760) 525-1241**

Business Official:

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Address: **9909 Huennekens Street, 110, 92121 - 2928**

Phone: **(760) 402-6721**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 6
End: 9
Technical Abstract (Limit 2000 characters, approximately 200 words):

MemComputing's technology is disrupting the high-performance commercial computing industry by dramatically reducing the time to find solutions to the most complex optimization problems across all industries today. Using a physics-based approach, MemComputing's novel circuit architecture liberates users from current computational bottlenecks, enabling companies of all sizes to accurately analyze huge amounts of data in minutes or seconds, empowering them to make optimal business decisions quickly.

MemComputing's Software-as-a-Service platform, called the Virtual MemComputing Machine (VMM), is currently being used today by Fortune 500 companies, and is designed to solve the largest and most complex industrial computations associated with optimization, big data analytics, and machine learning. Obtaining optimal solutions in a faster time frame using a fraction of today's required resources not only results in significant cost savings, but also opens the door for greatly improved operational efficiencies.

Studies of the MemComputing platform demonstrate that MemComputing delivers the power expected of Quantum Computers, with its non-Quantum solution. MemComputing boasts 17 peer-reviewed scientific papers, published in prestigious scientific journals, as well as 2 issues patents.

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

NASA relies on supercomputing systems to understand Earth's astrophysical systems and to conduct high-fidelity aerospace engineering analyses. MemComputing targets accelerating the computational workloads of NASA's current and future projects. The economic benefits of achieving optimal solutions to currently intractable problems is tremendous. MemComputing's approach delivers dramatically improved solutions in a fraction of the time while requiring far fewer resources.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

MemComputing's SaaS, the Virtual MemComputing Machine (VMM), is being used by the Fortune 500. It is designed to solve the most complex industrial computations associated with optimization and data analytics. Obtaining optimal solutions in a faster time frame using a fraction of the required resources results in significant cost savings, and opens the door for greatly improved operations.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H3.02-1919**

SUBTOPIC TITLE: Microbial Monitoring for Spacecraft Cabins

PROPOSAL TITLE: Microbial Monitoring of Spacecraft & Habitats Utilizing Advanced Metabolomics Analytical

Methods

Small Business Concern

Firm: **Connecticut Analytical Corporation**
Address: **696 Amity Road, Bethany, CT 06524**
Phone: **(203) 393-9666**

Principal Investigator:

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Business Official:

Name: **Joseph Bango**
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Phone: **(203) 393-9666**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Under the present NASA SBIR solicitation, it has been stated that “future human spacecraft, such as Gateway and Mars vehicles, may be required to be dormant while crew is absent from the vehicle, for periods that could last from 1 to 3 years. Before crews can return, these environments must be verified prior to crew return. These novel methods have the potential to enable remote autonomous microbial monitoring that does not require manual sample collection, preparation, or processing."

The proposed research leverages off of prior successful NASA and DHS investigations where trace species in the air are attracted to, and captured by, desorbing electrospray droplets. Microorganisms can be captured in this manner, and lysed at will for examination using mass spectrometry for proteomic and metabolic biomarker discovery.

A Phase II in 2008 which included Nobel Laureate Dr. John Fenn, space suit manufacturer Hamilton-Sundstrand, and former Apollo 11 astronaut Buzz Aldrin, teamed with our firm along with Dr. Jim Gaier formerly of NASA Glenn, to create an electrospray air filtration system using only milliwatts of power and zero pressure drop to scrub the air of simulated lunar regolith for use on spacecraft and in lunar habitats. This system was featured in NASA Tech Briefs.

For this new study, we propose to merge the air filtration techniques learned from the earlier study, which revealed that airborne microorganisms could be captured by electrospray, and to direct those

captured trace species into a mass analyzer for identification via metabolomic data.

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

The NASA applications include not only pathogen detection on board a spacecraft or in a habitat, but allow for pathogen removal in addition to any particulates and NASA SMAC gases that may be present. An added potential benefit is the possibility of monitoring crew health via exhaled breath once aboard the spacecraft or while occupying a habitat.

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

Non-NASA applications include potential pathogen air monitoring in a building, hospital air quality monitoring, commercial air filtration, and biosafety air purification applications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z3.03-2201**

SUBTOPIC TITLE: Development of Advanced Joining Technologies, Large-Scale Additive Manufacturing Processes, and Metal Recycling Technologies for On-Orbit Manufacturing

PROPOSAL TITLE: Welding of Thermoplastic Composites Using Smart Susceptor Technology

Small Business Concern

Firm: **Temper, Inc.**
Address: **12333 Luyk Drive Northeast, Cedar Springs, MI 49319**
Phone: **(616) 648-9476**

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 addresses the NASA subtopic Z3.03, Development of Advanced Joining Technologies. Humanity's future in space requires technologies that enable long-duration, long-endurance missions to support human exploration and habitation. Essential to this goal is servicing, assembly, and manufacturing outside of earth's gravity. Upon completion of the proposed work, Temper hopes to provide proof of concept of a fast, low-energy and reliable method for welding thermoplastic composites both on Earth and on-orbit. Designs for robotic end effectors to automate the process will also be developed.

While able to melt, re-solidify and weld like metals, thermoplastic composites have a higher strength-to-weight ratio and better thermostability. However, reliably joining thermoplastic components has proved difficult and costly. The work proposed in this SBIR will fulfil the objectives of performing prototype welding PEEK thermoplastic composites, validation of welded flat panels and tubular joints, identifying design concepts for robotic end effectors, and development of a method for manual repairs.

Temper has developed a Smart Susceptor alloy that controls induction heating to weld thermoplastic composites without the risk of softening, overheating, or deforming the components. This alloy is drawn into wires and fabricated into a weld tape for placement between the materials to be bonded. Utilizing fast and energy-efficient induction heating through alternating magnetic fields, once the Smart Susceptor reaches its Curie temperature, the metal alloy becomes non-magnetic and induction heating stops. Only light pressure (10 psi) is needed to comingle the melted resin and form the weld.

Controlled heating can be set for any length of time and cool-down or tempering profiles can be created to control the microstructure of the thermoplastic resin. This technology can be coupled with additive manufacturing so any type of thermoplastic component can be fabricated and assembled on-orbit.

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

Welding of thermoplastic composites has applicability across several of NASA's planned missions. As Artemis plans for the construction of high value structures such as habitat modules, trusses, and solar arrays, space-based welding supports its mission goals.

In addition to on-orbit manufacturing, repairs can be made to thermoplastics to increase the safety and longevity of equipment currently in space.

This technology can also be utilized pre-launch to manufacture light-weight components for launch system.

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

Smart Susceptor welding technology has commercial applications in the aerospace, defense, wind energy and automotive markets. The technology provides a thermoplastic composite equivalent to spot and seam welding of metals currently used in industry. As lightweighting initiatives and use of thermoplastic composites continue to spread, the applications of this technology will continue to grow.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z1.05-3110**

SUBTOPIC TITLE: Lunar and Planetary Surface Power Management and Distribution

PROPOSAL TITLE: Efficient Laser Power Beaming for Lunar Operations

Small Business Concern

Firm: **LaserMotive Inc. DBA PowerLight Technologies**
Address: **22026 68th Avenue South, Kent, WA 98032**
Phone: **(206) 872-3300**

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 project will develop an efficient laser power beaming system for a variety of Lunar operation scenarios, including crewed bases and autonomous rovers. This Phase 1 effort will explore transmitter, receiver, and system level trade-offs between a multitude of optical, electrical, and thermal subsystem design choices and parameters, based on our previous experience in designing, fabricating, testing and demonstrating long-range, high power wireless laser power beaming systems.

We will determine optimal values for major system design parameters, including transmit and receive aperture sizes, laser wavelength, and more for lunar operating constraints. We will recommend an overall system design that balances optimization between system size, mass, and end-to-end efficiency.

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

The proposed system for wireless optical power distribution will apply to:

- Rovers (e.g., exploration and mining at polar ice caps in perpetually dark craters)
- Remote sensor suites
- Communications gear (with data transfer)
- Remote or distributed habitats and lunar work sites
- In the future, it may be useful for space solar power to beam energy from the sun down to earth

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

Wireless power to remote telecom gear (military , industrial), remote sensors (military, industrial), unmanned vehicles (air, ground, sea, space), consumer devices, and to remote work sites (lighting, equip, tools).
Duration: **6**

PROPOSAL NUMBER: 21-1- **S2.03-3037**

SUBTOPIC TITLE: Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical and Infrared Telescope

PROPOSAL TITLE: Affordable, Maneuvering Cubesat Telescope

Small Business Concern

Firm: **Quadrus Advanced Manufacturing, LLC**
Address: **289 Dunlop Boulevard, Building 300, Huntsville, AL 35824**
Phone: **(256) 679-9189**

Principal Investigator:

Name: **Melissa Forton**
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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):

CubeSats carrying small space telescopes will be the enabling force for the next generation of space research allowing a less expensive route for professional and amateur astronomers to conduct their research. Quadrus Advanced Manufacturing, LLC (QAM) is pleased to offer an innovative approach in the manufacturing of Cassegrain telescope that minimizes the cost and time of manufacture while

enabling the customization of the telescope optics to meet a particular mission's requirements. Additionally, the design integrates a cold gas aerospike propulsion system into the volume around the telescope tube. Our design uses a high strength, machinable, low CTE polyimide plastic, for the majority of the components minimizing the potential for misalignment issues cause by thermal expansion. Our fabrication process has a high potential for drastic cost and time savings.

The Phase I efforts will address the following

- Spin Forming the Primary Parabolic Mirror out of a Low CTE Polyimide Plastic
- Designing the Cold Gas Propulsion System

Testing a Demo Version of the Cassegrain Telescope

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

Our commercialization strategy is to position ourselves as a supplier of inexpensive high quality Cassegrain telescopes for CubeSat applications that provide longer service life through an onboard cold gas propulsion system.

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

The potential non-NASA commercialization opportunities are to make off-the-shelf CubeSat telescope systems that are affordable for academic researchers, graduate students, high schools students, and professional astronomers.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H5.02-2268**

SUBTOPIC TITLE: Hot Structure Technology for Aerospace Vehicles

PROPOSAL TITLE: The Joining of Carbon-Carbon Composites Using Field-Assisted Sintering Technology

Small Business Concern

Firm: **Ballydel Technologies, Inc.**
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Phone: **(610) 304-0606**

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):

Ballydel Technologies will partner with the Penn State University Applied Research Laboratory (PSU-ARL) to develop a novel manufacturing approach for joining two dissimilar ceramic matrix composites (CMCs). Specifically, Ballydel and PSU-ARL will develop a field-assisted sintering technique (FAST) for joining 2D and 3D carbon-carbon composite planes. FAST is a disruptive manufacturing technique that produces sintered solids with near theoretical density, in a *dramatically* shorter period of time (<20 minutes), when compared to traditional sintering methods. The goal of this endeavor is to demonstrate the utility of this technique for the manufacture of a variety of hypersonic components, suitable for defense and aerospace applications.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The development of a FAST process for joining C-C composite structural components will directly address an industry need for an efficient manufacturing process that enables the structural joining of two dissimilar CMCs or two dissimilar C-C composites for high temperature applications. This will subsequently impact a variety of aerospace structures use in space flight, include reusable hot structure components.

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

Primary applications for this technology include C-C composites for reusable hot structures and aerospace vehicles used in space flight missions. Secondary applications include C-C composite architectures for hypersonic applications within Department of Defense.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H3.07-2719**

SUBTOPIC TITLE: Flame-Retardant Textiles for Intravehicular Activities (IVA)

PROPOSAL TITLE: Nanolayer-Coated Flame-Retardant Fabrics for Space Crew Clothing

Small Business Concern

Firm: **Innosense, LLC**
Address: **2531 West 237th Street, Suite 127, Torrance, CA 90505**

Phone: **(310) 530-2011**

Principal Investigator:

Name: **Dr. Maksudul Alam**
E-mail: **maksudul.alam-1@innosensellc.com**
Address: **2531 West 237th Street, Suite 127, CA 90505 - 5245**
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: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA's Environmental Control & Life Support Systems (ECLSS) and Habitation Systems are actively seeking nontoxic, comfortable and durable flame-retardant textiles/fabrics that resist combustion in an atmosphere of 36% oxygen at a pressure of 8.2 psi (56.5 kPa) and are suitable for crew clothing. Currently there is no flame-retardant, nontoxic, comfortable, washable and durable apparel or furnishing fabric for the spacecraft cabin environment planned for lunar and planetary human exploration. To meet this need, InnoSense LLC (ISL) proposes to develop an efficient and durable nanolayer flame-retardant finishing treatment for existing fabrics using our proprietary and patented nontoxic flame-retardant materials and treatment processes. The result will be comfortable, soft to touch, breathable, washable, durable, non-toxic and odorless next-to-the-skin FR fabrics that crewmembers can wear during intravehicular activity in 36% oxygen at a pressure of 8.2 psi. ISL's approach is to introduce permanent, covalently attached nontoxic flame-retardant material to existing fabrics. This will impart excellent FR properties without compromising crew comfort and safety. Phase I results are expected to demonstrate that ISL's flame-retardant treated fabrics outperform the state-of-the art commercially available flame-retardant apparel fabrics. In Phase II, ISL will work with a major NASA apparel fabric provider to test ISL's flame-retardant treated fabric performance under simulated spacecraft cabin atmospheric conditions.

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

ISL's nontoxic and durable FR-treated fabric technology can be used for NASA crew clothing. Other NASA uses are in protective clothing, curtains, drapes, upholstery, bedding, carpets, tents, etc. This technology will also benefit several space programs, particularly the lunar Human Landing System, Orion, Gateway, and Artemis, enabling the astronauts to function in habitats, pressurized rovers, and other space vehicles with enriched oxygen atmospheres and to shorten pre-breathe times prior to extravehicular activities.

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

For commercial applications, ISL's FR-treated fabrics can be used for firefighters, electrical workers, foundry workers, and military personnel. This FR technology will also have applications as treatments for paper (e.g., stocks, bonds, wills, etc.), coatings or fillers for structural and electrical components.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.09-1597**

SUBTOPIC TITLE: Small Spacecraft Transfer Stage Development

PROPOSAL TITLE: Reusable High Delta-V Transfer Stage for Small Spacecraft

Small Business Concern

Firm: **Firefly Research, Inc.**
Address: **1320 Arrow Point Drive, Suite 109, Cedar Park, TX 78613**
Phone: **(512) 277-6959**

Principal Investigator:

Name: **Dr. William Coogan**
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Address: **1320 Arrow Point Dr Suite 109, TX 78613 - 2169**
Phone: **(512) 277-6959**

Business Official:

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Phone: **(512) 277-6959**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Firefly Research, LLC (FFR) is pleased to propose to NASA the development of a Space Utility Vehicle (SUV) to a CDR level of fidelity. This vehicle serves as a solar electric transfer stage, offering enough Delta-V to transfer more than 500 kg of payload from Low Earth Orbit (LEO) to Low Lunar Orbit (LLO) after launch on a small lift launch vehicle. While most technologies needed for such a transfer stage are reasonably mature, the SUV is innovative in how the vehicle architecture breaks

the long-held assumptions of Electric Propulsion (EP) being either slow or expensive. We are able to offer a high-power platform with rapid transit capability at a competitive cost through refueling and reuse of that platform, amortizing platform cost over multiple missions. In this section, we explain the details of this architecture, the roadmap to a commercially viable SUV including developments already underway, and the specific aspects that will benefit from SBIR funding.

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

1) Transfer from LEO to LLO (200 kg payload in near-term at low power, with growth path to 500 kg).

2) Transfer of Commercial Lunar Payload Services (CLPS) lunar lander from GTO to LLO, and further service as a communications relay throughout surface mission.

3) Dedicated mission from small-lift launcher to high Delta-V trajectories like lunar orbit and Earth-Moon Lagrange points.

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

The primary non-NASA market targeted by this platform is the GEO market. While the Northrop Grumman Mission Extension Vehicle (MEV) has already demonstrated the viability of mission extension in GEO, we will provide a similar service with the added advantage of being able to service more satellites in a shorter time span. Also, final-mile service for small satellites launch rideshare to LEO.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H6.22-1743**

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

PROPOSAL TITLE: Neuromorphic Enhanced Cognitive Radio

Small Business Concern

Firm: **Intellisense Systems, Inc.**
Address: **21041 South Western Avenue, Torrance, CA 90501**
Phone: **(310) 320-1827**

Principal Investigator:

Name: **Dr. Wenjian Wang**
E-mail: **proposals@intellisenseinc.com**
Address: **21041 S. Western Ave., CA 90501 - 1727**
Phone: **(310) 320-1827**

Business Official:

Name: **Ms. Selvy Utama**
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Address: **21041 S. Western Ave., CA 90501 - 1727**
Phone: **(310) 320-1827**

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 a new Neuromorphic Enhanced Cognitive Radio (NECR) device based on neuromorphic processing and its efficient implementation on neuromorphic computing hardware. NECR is a low-SWaP cognitive radio that integrates the open source software radio framework with a new neuromorphic processing module to automatically process the incoming radio signal, identify the modulation types and parameters of the signal, and send the identification results to the controller module to properly decode the incoming signal. Due to its efficient implementation on neuromorphic computing hardware, NECR can be easily integrated into SWaP-constrained platforms in spacecraft and robotics to support NASA missions in unknown and uncharacterized space environments, including the Moon and Mars. In Phase I, we will develop the concept of operations (CONOPS) and key algorithms, integrate a Phase I prototype software in a simulated environment to demonstrate its feasibility, and develop a Phase II plan with a path forward. In Phase II, the NECR algorithms will be further matured, implemented on commercial off-the-shelf neuromorphic computing hardware, and then integrated with radio frequency (RF) modules and radiation-hardened packaging into a Phase II working prototype device. The Phase II prototype will be tested to demonstrate its fault and mission tolerances and delivered with documentation and tools to NASA for applications to CubeSat, SmallSat, and rover flight demonstrations.

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

NECR technology will have many NASA applications due to its low-SWaP and low-cost cognitive sensing capability. It can be used to enhance the robustness and reliability of space communication and networking, especially cognitive radio devices. NECR can be directly transitioned to the Human Exploration and Operations Mission Directorate (HEOMD) Space Communications and Navigation (SCaN) Program to address the needs of the Cognitive Communications project.

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

NECR technology's low-SWaP and low-cost cognitive sensing capability will have many non-NASA applications. The NECR technology can be integrated into commercial communication systems to enhance cognitive sensing and communication capability. Automakers can also integrate the NECR technology into automobiles for cognitive sensing and communication.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.01-1749**

SUBTOPIC TITLE: Lidar Remote-Sensing Technologies

PROPOSAL TITLE: Coherent Lidar Transceiver on a Chip

Small Business Concern

Firm: **Beamlet, LLC**
Address: **1420 Oak Street, Apartment G, South Pasadena, CA 91030**
Phone: **(626) 310-4160**

Principal Investigator:

Name: **Ivan Grudinin**
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Address: **1420 Oak St Apt G, CA 91030 - 6327**
Phone: **(626) 310-4160**

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):

Coherent lidar is useful for many applications including navigation, imaging, ranging and Doppler velocimetry during spacecraft landing, proximity operations, hazard avoidance, and docking. A reliable source of coherent modulated optical waveforms is required for simultaneous ranging and velocimetry. Existing sources are bulky since they require large electronic bandwidth, fragile fiber-based lasers and other discrete components, modulators, or long optical delay lines. This makes coherent lidar systems difficult to miniaturize for small platforms such as cubeSats, smallSats, and autonomous aerial and land vehicles.

We propose to develop a low power, mass and size photonic integrated circuit (PIC) that implements a high data rate coherent lidar transceiver operating at the 1550 nm wavelength. The innovation is based on a new method to generate frequency modulated continuous wave (FMCW) laser radiation that relies on optical components present on a PIC only and does not use optical phase locked loops or modulators. This new architecture enables extremely compact and low cost coherent lidar engine for navigation, imaging and object detection.

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

- Automated landing, hazard avoidance and docking.
- Object detection and imaging.
- Position, and navigation in GNSS/GPS denied/degraded environments.
- Terrain relative navigation and odometry for GN&C of lunar and other small vehicles,
- Small body proximity operations, including to augment machine vision techniques in low or variable light conditions and to reduce errors in proximity planning algorithms.

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

In urban environments where usage of UAVs is expected to dramatically raise, the GNSS signals are not always reliable. IMUs and computer vision techniques are not accurate enough for robust localization. Compact navigation Doppler lidar will help reduce drift and improve loop closure in visual SLAM, odometry and exploration of unknown environments.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H12.01-2152**

SUBTOPIC TITLE: Radioprotectors and Mitigators of Space Radiation-Induced Health Risks

PROPOSAL TITLE: Multilamellar vesicle encapsulation of JP4-039 as a radioprotector of space radiation-induced health risks

Small Business Concern

Firm: **ChromoLogic, LLC**
Address: **1225 South Shamrock Avenue, Monrovia, CA 91016**
Phone: **(626) 381-9974**

Principal Investigator:

Name: **Claude Rogers**
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Phone: **(626) 381-9974**

Business Official:

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Address: **1225 South Shamrock Avenue, CA 91016 - 4244**
Phone: **(626) 381-9974**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Currently, NASA uses dietary countermeasures for astronauts to aid in radiation exposure as foods can act as radioprotectors and/or mitigators. Drugs that can be used as radioprotectors and/or mitigators are not currently used because when administered to astronauts at effective concentrations, they are accompanied by side effects such as weakness, fatigue, nausea, and

hypotension. These drugs will remain inadequate until a proper drug delivery technology is developed that can deliver them with appropriate biodistribution, while maintaining safety *in vivo*. As it stands now, there are no drug delivery systems that meet the need for delivering an effective concentration of a radioprotector and mitigator drug for GCR to astronauts.

In order to address this critical need, ChromoLogic LLC (CL) has developed a multilamellar vesicle (MLV) drug delivery platform capable of encapsulating high concentrations of the hydrophobic radioprotector and mitigator drug, JP4-039. The MLV nanoparticles can be administered intravenously where they provide sustained release of the therapeutic. The particles are stable in lyophilized form, allowing the drug to be stored for prolonged periods of time before being reconstituted and injected. This strategy for therapeutic drug delivery, facilitates the use of hydrophobic therapeutics that are otherwise nonviable due to their poor solubility.

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

Radioprotection of astronauts on long-term space missions. Radiation-induced injury is a major health concern for astronauts and available countermeasures do not adequately address the risks. JP4-039 targets the mitochondria and reduces oxidative stress, improving survival in mice exposed to x-ray, neutron, and proton radiation. By encapsulating JP4-039 in a MLV, the JP4-039-MLV reduces the need for frequent administration, allows for longer term storage, and can reduce negative side effects.

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

Radioprotection of DoD personnel. The DoD needs a radiation countermeasure to protect personnel at risk of exposure to radiation.

Mitigation after a RAD-NUC incident. The US Government has a need for a national stockpile of radiation mitigators to respond to a RAD-NUC incident. JP4-039 has been shown to increase survival in vivo when administered 24–48 h after exposure to total body irradiation.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.02-1469**

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

PROPOSAL TITLE: Deep Space Navigation of Distributed Small Spacecraft using Variable Celestial Sources

Small Business Concern

Firm: **Aster Labs, Inc.**
Address: **155 East Owasso Lane, Shoreview, MN 55126**
Phone: **(651) 484-2084**

Principal Investigator:

Name: **Dr. Suneel Sheikh**
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Phone: **(651) 484-2084**

Business Official:

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Phone: **(651) 484-2084**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

This program will develop an innovative Hybrid Navigation (HYNAV) system using multiple energy band observations of variable celestial sources. The concept creates photon measurements across each source observed in unique energy bands where signals are most beneficial, and blends the diverse signals into a single spacecraft position and velocity solution. Previous work by ASTER Labs has demonstrated concept feasibility of X-ray navigation (XNAV) and gamma-ray navigation (GLINT) as stand-alone architectures. The HYNAV instrument unifies the two individual concepts while adding radio observations into an operational prototype hardware instrument and software package. The advantage of the blended approach is it exploits both the periodic nature of the faint, stable radio and X-ray pulsars with the aperiodic, transient nature of bright, chaotic fast radio and gamma-ray bursts. Thus, the operational system would be capable of frequent measurement updates and continuous accurate absolute or relative navigation. The baseline instrument is designed for small spacecraft (< 180 kg) class vehicles, including larger CubeSats, facilitated by emerging detector materials capabilities, with near-all-sky detection configurations, very good energy resolution, lower energy thresholds for high photon counts, and precise onboard photon timing. Benefits include increased deep space autonomy and formation flight for distributed small spacecraft, while decreasing the burden on the DSN. Phase I will evaluate HYNAV feasibility for relevant NASA applications. System requirements will be developed based upon identified and characterized sources assembled into a catalogue. The instrument hardware design will be coupled with blended data processing navigation algorithms that fuse measurements in a single filter. ASTER Labs' XPRESS software and a filter simulation will assess absolute and relative navigation performance under target mission scenarios.

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

This HYNAV system will be directly applicable to NASA's distributed small spacecraft missions. The integrated instrument and software processing will enable self-navigation and coordinated relative navigation between cooperating spacecraft. The instrument can be integrated into proposed operational systems, such as LunaNet communications. Further deep space CubeSat scale exploration missions to planetary or small bodies, asteroids, comets, and planetary rings are enabled by this new technology.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The HYNAV system concept applies directly to commercial constellation systems for self-navigation. It applies equally well to newer commercial ventures to provide rideshare of instruments to explore planets or industrial mining and manufacturing applications to asteroids. Non-NASA applications include military covert space vehicle covert operations, especially with Earth not in view.
Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.07-2536**

SUBTOPIC TITLE: In Situ Instruments/Technologies for Lunar and Planetary Science

PROPOSAL TITLE: In Situ Isotope Analyzer for Lunar and Planetary Science

Small Business Concern

Firm: **Opto-Knowledge Systems, Inc. (OKSI)**
Address: **19805 Hamilton Avenue, Torrance, CA 90502**
Phone: **(310) 756-0520**

Principal Investigator:

Name: **Jason Kriesel**
E-mail: **jason.kriesel@optoknowledge.com**
Address: **19805 Hamilton Avenue, CA 90502 - 1341**
Phone: **(310) 756-0520**

Business Official:

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Address: **19805 Hamilton Avenue, CA 90502 - 1341**
Phone: **(310) 756-0520**

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 new instrumentation based on a concept for trace-gas and isotope analysis that utilizes a priority hollow fiber as a low-volume, compact gas cell. An analyte is drawn into the fiber, which has a reflective inner coating that guides a tunable laser beam to a detector. There is near unity overlap between the laser beam and the gas sample, leading to a highly sensitive system with an ultra-compact size. In Phase I, a breadboard system will be assembled, and proof-of-concept measurements conducted to demonstrate the ability to effectively measure isotope ratios in water. In addition, various concepts appropriate for planetary sampling will be evaluated. Based on the investigations, specific techniques and components will be down selected and risk mitigation strategies developed, culminating with the design of a prototype that will be fully developed and demonstrated in Phase II.

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

The development of the proposed in situ instrument is applicable to NASA's planetary science goals summarized in the Planetary Decadal Survey. Such instruments and technologies will play a crucial role for NASA missions to various celestial bodies. This includes addressing two of NASA's major themes: (1) understanding solar system beginnings and (2) searching for the requirements for life.

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

Sensors resulting from this project will provide an extremely attractive alternative to isotope analyzers. The ability to obtain high-quality isotope data with a small SWaP sensor is appealing for a range of environmental monitoring applications including but not limited to drone-borne sensing and unattended field monitoring.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.10-2628**

SUBTOPIC TITLE: Atomic Quantum Sensor and Clocks

PROPOSAL TITLE: Miniature Iodine-Stabilized Oscillator (MISO)

Small Business Concern

Firm: **Vector Atomic, Inc.**
Address: **1249 Quarry Lane, Suite 100, Pleasanton, CA 94566**
Phone: **(925) 249-5959**

Principal Investigator:

Name: **Dr. Martin Boyd**
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Address: **3733 Randolph Ave, CA 94602 - 1231**
Phone: **(303) 818-0220**

Business Official:

Name: **Dr. Jamil Abo-Shaeer**
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Address: **1249 Quarry Lane, Suite 100, CA 94566 - 8410**
Phone: **(925) 249-5959**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Vector Atomic will prototype and design a Miniature Iodine-Stabilized Oscillator (MISO). MISO's simplified optical clock architecture supports aggressive miniaturization, low-cost manufacturing, and high reliability. The primary focus of Phase I is to prototype the MISO optical reference and feed the

results into the system design. At the conclusion of Phase I, a detailed CAD model will be completed including mechanical drawings and a bill of materials (BOM).

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

Space missions are critically dependent on precise timing and synchronization. Coherent ranging and imaging systems such as the Laser Interferometer Space Antenna (LISA) and the NASA-ISRO Synthetic Aperture Radar Mission (NISAR) are enabled by highly coherent laser and RF oscillators, respectively. Future NASA mission including deep space navigation, space-based gravitational wave detectors, and multi-static radar imaging will require timing precision beyond the capabilities of current hardware

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

LIDAR and RADAR applications can benefit from the long coherence time of the optical local oscillator and the ultralow phase noise provided by the frequency comb. In GPS-denied environments, a highly stable clock can extend missions by maintaining synchronization between distributed systems.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S2.03-2743**

SUBTOPIC TITLE: Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical and Infrared Telescope

PROPOSAL TITLE: Additive Manufactured Very Light Weight Diamond Turned Aspheric Mirror

Small Business Concern

Firm: **Dallas Optical Systems, Inc.**
Address: **1790 Connie Lane, Rockwall, TX 75032**
Phone: **(972) 564-1156**

Principal Investigator:

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Business Official:

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Phone: **(972) 564-1156**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The goal of this Phase I SBIR is to answer a series of important questions and develop solutions and methods for the fabrication of a very low cost, very light weight large aperture Al10SiMg aluminum alloy mirror that were discovered in the previous Phase I NASA SBIR S2.03-9125 and Phase II 80NSSC18C0065 (SBIR 2018-II) efforts. The combination of three manufacturing processes were demonstrated 1. Design of and additively manufactured mirror substrates. 2. Precision robotic welding of hexagonal on-axis and hexagonal off-axis segments to produce a larger mirror. 3. Large capacity diamond turning of large spherical mirrors to visible tolerances on the monolithic welded aluminum mirror substrate. In this Phase I proposal we intend to deliver a one piece hexagonal periphery concave spherical additively manufactured mirror that is 160 percent larger (about 387mm) than the hexagonal mirror segments we made for the Phase I and Phase II SBIR efforts. The mirror will be have a 3 meter radius of curvature with a central hole so that it simulates a parabolic telescope primary. The objective is to develop a manufacturing process capable of producing a round 0.5 meter diameter telescope primary mirror in a Phase II effort utilizing 600mm capacity Velo3D Sapphire XC AM machines Stratasys will have operational by late 2021. The hexagonal periphery mirror with a central hole is proposed to gain information about primary mirror optical telescope mirrors and also address scaling to large segmented primary mirrors.

Components can be produced with features that are impractical or impossible using conventional processes such as machining and molding. Highly light weighted metal mirror substrates are made in small quantities at low cost. Off-axis aspheric mirror substrates are as easily produced as simple spherical surfaces. Aluminum mirror substrates can be directly diamond turned to produce high quality mirror optical components.

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

NASA's mission in space research includes such far-reaching

projects as Deep Space Optical Communication (DSOC),

Large UVOIR (LUVOIR), Balloon Planetary Telescope, NIR/SWIR

Optical Communication, Origins Space Telescope (OST), the Far-IR

Surveyor (FIRS), the Space Infrared Interferometric Telescope (SPIRIT)

and Habitable Exoplanet Imaging Mission (HabEx).

This innovative mirror manufacturing technology is applicable to all

these projects as well as any military or scientific

applications requiring low cost light weight mirror optical components.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Defense applications requiring low cost and high production of visible and infrared quality mirror optical components for satellites and aerospace vehicles. Military and weather satellite optical mirrors and commercial optics such as small satellites for earth observation. Commercial applications requiring light weight stiff optical components such as semiconductor manufacturing equipment.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.02-2877**

SUBTOPIC TITLE: Technologies for Active Microwave Remote Sensing

PROPOSAL TITLE: High-Efficiency S-Band SSPA for Next Generation NASA Remote Sensing SAR/InSAR Platforms

Small Business Concern

Firm: **Recon RF, Inc.**
Address: **10211 Pacific Mesa Boulevard, Suite 408, San Diego, CA 92121**
Phone: **(619) 732-6621**

Principal Investigator:

Name: **Nick Chopra**
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Address: **10211 Pacific Mesa Blvd. Ste 408, CA 92121 - 4327**
Phone: **(619) 732-6621**

Business Official:

Name: **Jeffrey Ritter**
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Address: **10211 Pacific Mesa Blvd. Ste 408, CA 92121 - 4327**
Phone: **(619) 732-1691**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3

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

This proposal will significantly advance Power Added Efficiency (PAE) beyond present-day state-of-the-art SSPAs operating at S-Band in the over 1kW peak output power regime, achieving a TRL 3-4 S-band/ 3.2 GHz solid-state power amplifier (SSPA) module. The greatly enhanced PAE will result in an SSPA with a compact form factor suitable for CubeSat/SmallSat or other NASA remote sensing platforms. The project aims to achieve over 1kW of output power, 50dB of Gain, PAE of no less than 60% and possibly greater than 75% through Recon-RF's advanced power amplifier design techniques based on next-generation waveform design capabilities and practices.

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

The proposed S-Band SSPA module capable of PAE >60% will enhance NASA's remote sensing for SWaP-C conscious applications such as:

- SAR/InSAR Payloads for studying surface topology on Earth and on other planets
- Follow-on Missions to NISAR's InSAR S-Band Geo-Physical Remote Sensing Payload
- VenSAR S-Band SAR payload for Geo-Physical Remote Sensing of Venus

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

Non-NASA commercial and DOD applications stand to benefit from Recon-RF's advancements in S-Band SSPA technology, such as:

- Airport Surveillance Radar
- Surface Ship Radar
- S-Band Satellite Communications
- S-Band Weather Radar
- Rural Broadband Back-Hauls
- Commercial InSAR/SAR for remote sensing of vegetation and geo-physical phenomena

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z10.04-2032**

SUBTOPIC TITLE: Materials, Processes, and Technologies for Advancing In-Space Electric Propulsion Thrusters

PROPOSAL TITLE: High Current Plasma Cathode for Efficient Space Propulsion

Small Business Concern

Firm: **E-beam, Inc.**
Address: **21070 Southwest Tile Flat Road, Beaverton, OR 97007**
Phone: **(503) 628-0703**

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):

A plasma discharge cathode for space propulsion capable of >100 A and employing a novel geometry that moves the bulk of the discharge outside of the hollow emitter insert. This allows the plasma volume to be larger than the cathode tunnel and thus able to deliver the very large currents (100 A or more) without increasing the emitter insert size. By keeping the plasma largely outside of the emitter insert, high performance very small emitters that operate at low temperatures can be used. This means much lower heating power and longer life and higher electron efficiency from these emitters.

We propose two state of the art cathode options:

1. A hollow scandate impregnated cathode capable of delivering 10A/cm^2 at only 810ºC$_b$ and 100 A/cm^2 at only 970ºC$_b$.
2. A hollow osmium-tungsten reservoir cathode capable of 10A/cm^2 at 915ºC$_b$ and 50 A/cm^2 at less than 1000ºC$_b$.

We propose in Phase I to build two testers containing these cathodes and incorporating them into the geometry discussed above. We will test these, pulsed, to at least 100 A xenon discharge. e beam Inc. has more than 30 years of experience developing innovative cathode structures. The device is an important step forward for NASA's quest for a high power (100 kW) thruster to transport heavy payloads on long-range space flights.

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

NASA is planning missions both named and unnamed to asteroids, Mars and other planets. The missions involve very heavy space vehicles and long durations. They will require thrusters in the 100 KW range with discharge and neutralization cathodes >100 A. This proposal offers an alternative to the current approach of scaling existing devices to larger dimensions with the attendant increase in propellent flows and power dissipation along with shortened life and less dimensional stability with high insert temperatures (>1200ºC$_b$).

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

The commercial world needs more bandwidth which means more heavy satellites in geo-synchronous orbits. The long periods of time needed to raise these satellites from LEO is lost revenue. More powerful thrusters will shorten times and enable bigger payloads.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S4.04-2228**

SUBTOPIC TITLE: Extreme Environments Technology

PROPOSAL TITLE: -200 °C Rad-Hard Compact Rugged RF Modulator

Small Business Concern

Firm: **Chronos Technology (Div. of FMI, 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: 4

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

We have proposed to deliver a comprehensive, and conceptually validated feasibility study (in PH 1) for a novel compact ,cold capable (-200 °C), scalable, Rad-hard RF Modulator (CCM) operating to 500MHz. CCM is used as a common subsection of cold capable radios both on the transmitter and receiver side, operates in extreme low temperature rad-hard space environment in excess of 2Mrad-Si and SEL immune. Our intent is to successfully complete the Phase 1 study and deliver a clear design road-map to the implementation and fabrication of the design using SiGe-HBT in PH2. The modulator application starts in the communication systems but extends to navigation modules, its low phase jitter makes it quite suitable for in-situ and agile DSP for robotic systems, sensors in harsh environment and software defined radio (SDR). Furthermore, in addition to being a basic rugged and rad-hard modulator, it is directly adaptable to be used as a stable frequency source for many applications including the local oscillator for critical navigation and also in the signal chain that is typically used in mobile and agile radar. The compact nature of the design stems from our capability to integrate smallest piezoelectric crystals in the same hybrid enclosure as the ASIC. Our present capabilities produce the resonator size down to 2.5 mm so an integrated hybrid CCM will be super compact and its volume to be in the 1cc range. The objective includes scalability and hi-reliability assembly techniques already established in our company. CCM design includes amplifiers, varactor diodes, voltage reference and on-chip inductor. Individual circuit blocks by themselves will be designed on the SiGe-HBT process that will be part of the investigation in PH1 to be implemented in PH2. Adaptability of CCM to be used as a very stable and low phase noise source without the need for any thermal stabilization, enables new paradigm for autonomous robotic navigation.

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

Low power, compact and high radiation tolerance (>2Mrad-si) envisioned for the cold capable modulator intends to be used in wide range of deep space robotics applications including radios (both transmitter and receiver) as well as many examples described in the decadal survey and FARSIDE plans. cold capable and high TID tolerance makes it a preferred choice suitable for missions that need

such performance and reliability. the Individual circuit blocks like SiGe amplifier, varactor diode and voltage reference have existing space applications.

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

In addition to the NASA applications, Due to the specific circuits used in the CCM, CCM and its individual circuit blocks would provide solutions for many space and non-space applications. Usage of high Ft SiGe-HBT leads to RF amplifiers, VCO and components such as varactor diodes temp. sensor and voltage reference offer advantages not typically available in other RF rad hard ASICs .

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z1.06-2276**

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

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

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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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Syrnatec proposes development of radiation hardened Diodes and MOSFETs for high power applications using Ga2O3 technology. Due to increasing power requirements of new systems (such as fast charging technology for electric vehicles), there is a constant need for energy efficient, low noise power conversion electronics compared to the available Silicon based semiconductors. This need opens the avenue for Wide band bap material-based semiconductors, such as GaN, SiC, AlGaN and Ga2O3. Manufacturers have designed various power conversion solutions in the operating voltage range from 600 to 1600V using SiC and GaN; however, there are no products commercially available for operating voltages beyond 1600V, which is why Gallium Oxide Semiconductors offer a promising solution. Ga2O3 falls under UWBGS category, due to the larger bandgap (~4.8 eV) compare to SiC (3.3 eV) and GaN (3.4 eV), and offer better radiation resistance since a higher energy level is required to break their molecular bonds. Ga2O3 semiconductors can operate with several kilovolts and exhibit higher stability and robustness, and therefore is suitable for High voltage, High Power, Medium Power, Low Power applications. Deliverables will be the prototype device design structure and simulation results illustrating resilience to Heavy Ion induced faults (Single Event Effects). Results will be demonstrated with a design of Schottky diode with Metal rings around Schottky Contact to support an operating voltage of 1200 V, current of 40 A, and breakdown voltage of 2000 V while being resilient to 75 MeV-cm2/mg. The scope of work will also include developing a MOSFET design along with simulation results for an operating voltage of 650V, 40A and low R_{DSON} @ $\leq$ 24mOhm. This disruptive technology will allow for the commercialization of game changing high power electronics.

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

-High voltage, High Power Schottky diodes and MOSFETs made using Ga2O3 will be used for Power management and Distribution of Artemis missions.

-High Voltage, low power discretes for drivers of Lasercom terminals, LIDARs. Earth science Lidar, Jovian Moon exploration and Saturn missions. These devices will also find usage in Sensor Power electronics and Switching circuits.

-High voltage, low-Medium power solutions for hi-efficiency DC-DC converters that can be used to operate MPPT tracking systems.

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

-Unmanned ground and aerial vehicles: power and LIDAR system

-Electric vehicle: power conversion and charging station

-Industrial UPS

-Industrial Inverters

-Welding Systems

-Railways Motor Drive electronics and HVAC Control electronics

- Transportation and construction Equipment and Vehicles

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z7.06-2350**

SUBTOPIC TITLE: Entry, Descent, and Landing (EDL) Terrestrial Testing Technologies

PROPOSAL TITLE: Optical Measurements of Particle Size and Trajectory in an Arc Jet

Small Business Concern

Firm: **Innovative Scientific Solutions, Inc.**

Address: **7610 McEwen Road, Dayton, OH 45459**
Phone: **(937) 429-4980**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 6
End: 8
Technical Abstract (Limit 2000 characters, approximately 200 words):

Arc-heated high-enthalpy test facilities at NASA are used for evaluation of reentry vehicle thermal protection system (TPS) materials. The use of newer ablative TPS materials in the high-enthalpy flow result in complex processes such as decomposition of products, surface ablation, and spallation. Optical measurement techniques that can size and track particles in the flow would be of value for validation of facility operation and refinement of numerical models. Unfortunately, optical measurements of particles in an arc jet are challenging due to the strong emission from the test article and reacting flow which can saturate the camera. ISSI proposes employing an optical measurement technique known as Particle Shadow Velocimetry (PSV) that has been used to measure particle size, velocity, and acceleration a solid rocket motor at rates of over 10-kHz. PSV is accomplished by projecting light from an LED through the measurement volume onto a camera which allows the shadows created by the particles to be recorded. The individual particle shadow can be sized or tracked in time to compute particle velocity, acceleration, or trajectory. Utilizing an LED-based PSV system for measurements of the size and trajectory of spallation particles in an arc jet offers several unique advantages. First, the combination of a relatively narrow wavelength LED and a matching narrow-band filter on the imaging system can be used to suppress the broadband emission from the flow. This allows acquisition of distinct particle images, even in the presence of strong emission from the reacting flow. Second, the in-line illumination that is required for PSV measurements allows particles to be imaged very close to surfaces, within 50-mm of the ablating TPS surface. PSV is a high TRL tool that has already been demonstrated for acquiring particle size and trajectory measurements in a high enthalpy flow. This proposal offers a low-risk opportunity to acquire similar data on test articles in an arc jet.

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

NASA programs that utilize scramjets and solid rocket motors would benefit from the proposed low-cost, narrowband PSV system. Specific applications include the spray atomization process in supersonic combustion applications, such as scramjets, and particle dynamics in solid rocket motors.

Characterizing the droplet vaporization process is essential for modeling the combustion process. Large particles in an SRM can ablate the nozzle and modify the thrust profile or the SRM.

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

High-speed PSV is particularly effective in biomedical and hydrodynamic flows such as water tunnels, heart assist pumps, and heart valves which benefit from kHz rate velocity measurements near surfaces. PSI is effective for in-flight droplet sizing in agricultural sprays and has also been used for ice particle measurements in clouds for environmental studies.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A2.02-2358**

SUBTOPIC TITLE: Enabling Aircraft Autonomy

PROPOSAL TITLE: A Certification Means of Compliance Process for Advanced Air Mobility with Increasing Autonomy

Small Business Concern

Firm: **Systems Technology, Inc.**
Address: **13766 Hawthorne Boulevard, Hawthorne, CA 90250**
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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 recent years there has been a proliferation of new vertical takeoff and landing (VTOL) vehicle concepts, many featuring electric propulsion systems and advanced autonomous capabilities, designed for the urban air mobility marketplace as air taxis and personal air vehicles. The Vertical Flight Society is tracking the progress of these vehicle concepts via a web portal that currently identifies over 130 vectored thrust, nearly 60 lift plus cruise configurations, and over 100 wingless multicopters. Many of these vehicles have flown as scaled proof of concepts, while several others are now flying as full-scale prototypes. These vehicles almost exclusively feature fly-by-wire flight control systems including advanced control modes (i.e., response augmentation), increased automation, and autonomous systems of varying levels. Following the Simplified Vehicle Operations (SVO) and progression of the UAM Maturity Levels (UML), technological, infrastructure, and certification advancements are required to ultimately lead to fully autonomous operations. Because of the complexities involved in control system design, autonomous systems, and operating environments, new certification means of compliance methods are needed to ensure safe operations within the national airspace, especially dense urban environments. To address this critical need, a team led by Systems Technology, Inc. (STI) proposes to develop the Simulation-based Automation and Failure Evaluations (SAFE) system, easily exercised via a tablet-based computer, that will provide a means of compliance certification method for autonomous and degraded modes that is safe, repeatable, and discriminating.

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

This proposal addresses ARMD Strategic Thrust 5 In-Time System-Wide Safety Assurance and Thrust 6 Assured Autonomy for Aviation Transformation as SAFE provides a certification process for autonomous systems. SAFE directly supports NASA's RVLT Project and its goal to develop tools that "overcome key barriers to the expanded use of vertical lift configurations in the nation's airspace." SAFE is directly applicable to the National Campaign and its "goal to promote public confidence and accelerate the realization of emerging aviation markets..."

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

The target commercial market for SAFE is the burgeoning urban air mobility market. The estimated market size will be $15.2 billion by 2030. All the emerging vehicles that operate in the US will need to go through a certification process with the FAA thereby defining the market for SAFE, which will be introduced as a tablet-based software system as well as a productized service to support its use

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.04-3096**

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

PROPOSAL TITLE: MULTI-SPECTRAL INFRARED CAMERA COVERING WAVELENGTHS FROM 1 TO 16 MICRONS

Small Business Concern

Firm: **QmagiQ**
Address: **22 Cotton Road, Unit H, Suite 180, Nashua, NH 03063**
Phone: **(603) 821-3092**

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):

QmagiQ proposes to develop and deliver to NASA a multi-spectral infrared camera covering a broad range of wavelengths from 1 micron to 16 microns. A key feature is a broadband high-quantum-efficiency strained layer superlattice focal plane array (SLS FPA) with spectral filters integrated directly on the FPA – a design that allows the camera to be very compact. The spectroscopic information provided by the filters will be useful in detecting and identifying a variety of hot and cold targets at great distances and inferring their chemistry.

In Phase I, we will develop a SLS FPA with 16 micron cutoff wavelength, far past the normal 12 micron cutoff of commercial antimony-based SLS FPAs. In Phase II, we will optimize detector performance and expand array format to 1Kx1K, integrate filters onto the FPA, and package the FPA/filter assembly into a compact camera equipped for remote stand-alone operation.

The camera will be valuable to NASA for space telescopes (where its much higher operating temperature compared to Si BIB detectors offers longer operating life) and for Earth and Planetary Science Decadal Survey priorities like infrared sounding. In addition to detecting, tracking and chemically analyzing fires, a drone equipped with such a multi-spectral camera can also be used to monitor and analyze vegetation, forests, crops, industrial gas leaks, and pollution.

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

1) Space-based astronomy, e.g. future versions of the Spitzer Space Telescope
2) Infrared sounding
3) Detection, tracking and chemical analysis of fires and gas leaks
4) Mapping and analysis of forests and vegetation
5) LANDSAT Thermal InfraRed Sensor (TIRS)
4) Climate Absolute Radiance and Refractivity Observatory (CLARREO)
6) BOReal Ecosystem Atmosphere Study (BOREAS)
7) Other infrared earth observing missions
8) Atmospheric mapping
9) 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: 21-1- **S2.03-1869**

SUBTOPIC TITLE: Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical and Infrared Telescope

PROPOSAL TITLE: RMI Proposal for 2021 Topic S2.03: Near-Infrared LiDAR Spherical Beam Expander Telescope

Small Business Concern

Firm: **Rocky Mountain Instrument Co.**
Address: **106 Laser Drive, Lafayette, CO 80026**
Phone: **(303) 664-5000**

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):

RMI proposes to innovate on previous intermediate aperture off-axis designs used by NASA for flight LiDAR applications by utilizing a Maksutov-Cassegrain inspired beam expander in line with the 20x150mm requirement requested for Phase 1 but focused on it's applicability, scalability, and manufacturability for the Phase II objective of a potential space based 0.5 m system with similar

parameters. RMI will be leveraging it's current work on a system with similar requirements used by NASA that utilizes off-axis aspherical optics. These optics must be produced freeform by CNC systems (diamond turning) and are very labor intensive and aperture restricted in practice. By switching to a spherical design the cost, manufacturability, and physical scale of a system becomes far less restricted. Aberrations are controlled by selective use of refractive surfaces in combination with reflective ones to achieve a low dispersion (but correctible), athermalized, flight hardened, high-power ready optical system with looser alignment tolerances and more precisely manufacturable components.

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

Other groups within NASA are currently contracting with RMI to manufacture similar designs for aircraft based LiDAR applications.

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

A substantial opportunity for use in target marking and directed energy applications may exist outside NASA's use case.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.03-1540**

SUBTOPIC TITLE: Future Aviation Systems Safety

PROPOSAL TITLE: Go-Around Prediction Service

Small Business Concern

Firm: **ATAC**
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Phone: **(408) 736-2822**

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):

Our proposed innovation is a Go-Around Prediction (GAP) service that encapsulates predictive analytics so that stakeholders of NASA's In-time System wide Safety Assurance (ISSA) strategic thrust can readily use it to assess the go-around probability in real time during aircraft arrival operations in the National Airspace System (NAS). Our proposed innovation is directly relevant to subtopic A3.03 Future Aviation System Safety and fills two critical gaps in the state-of-the-art. First, it allows for the continuous monitoring of the arrival domain of the NAS and fuses diverse data sets including airborne trajectory, surface tracking, air traffic automation, and weather data to identify the precursors to a key indicator of risk in the system (i.e., a go-around). Second, it applies innovative machine learning (ML) techniques to build and train a model using historic go-around occurrences in order to predict go-around safety margins in real time. A key outcome in the first decade of ISSA-related research is improved safety through initial real-time detection and alerting of hazards at the domain level and decision support for limited operations. Our proposed innovation directly addresses this outcome by focusing on the near-airport (within 10 miles) domain to identify risks to stakeholders (e.g., air traffic controllers and pilots) in enough time (before a go-around is necessary) for them to employ effective risk mitigations. Through the combination of a real-time data input stream and a ML based predictive model, the software service allows for the continuous computation of the probability of a go-around. Results can be updated and displayed to operators (i.e., air traffic controllers and pilots) as each arrival flight approaches the airport. This additional information will allow operators increased situational awareness during the approach phase of flight leading to earlier mitigation of developing risks and, if needed, more time to safely manage go-arounds.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

(1) GAP advances NASA SWS research by accelerating risk detection to real-time.

(2) GAP integrates with the In-Time Aviation Safety Management System (IASMS) to assess operational safety and identify emerging risks potentially introduced by new DSTs during initial deployment.

(3) Integration with NASA's Digital Information Platform (DIP) provides valuable information on go-arounds to aviation stakeholders.

(4) The predictive analytics service serves as a model for other NASA analytics development.

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

(1) ANSP personnel use the GAP capability to identify risks in airport operations much sooner than currently possible, thereby increasing the safety margin.

(2) Airlines and airports use GAP to provide insight into go-around causes with the intent of reducing their risky and disruptive nature at major airports.

(3) Automated Safety Management System (SMS) reporting for ANSPs, airlines, and airports.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.05-1894**

SUBTOPIC TITLE: Fault Management Technologies

PROPOSAL TITLE: Fault Management Analysis Tool For Model Centric Systems Engineering

Small Business Concern

Firm: **Okean Solutions, Inc.**
Address: **1211 East Denny Way, 32A, Seattle, WA 98122**
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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):

This proposal responds to the need for new technologies to effectively manage and streamline complex FM systems, enable rapid diagnostic model generation and validation, and provide tools to assess FM quality/performance e.g., fault containment regions (FCRs) and false positive/negative (FP/FN) rates. Okean Solutions proposes to improve fault management (FM) system modeling and analysis by integrating their model-based fault management tool/system, called MONSID®, with JPL's Computer Aided Engineering for Systems Architecture (CAESAR) platform. The innovation will create greater visibility into the FM process and lower the barriers to entry for users who are not FM experts. The combined capability will advance the practice of FM to ultimately decrease labor and schedule costs while ensuring FM system robustness and appropriateness. The main application is FM design and software development. This could also be used in I&T and operations phases to update onboard FM models and in support of recovery operations.

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

A MONSID adaptor for CAESAR can support FM development in current and future programs, providing rapid model development and improving HW/SW trade accuracy and efficiency for fault containment, and FM performance analyses. It is applicable to a broad range of NASA missions that leverage model-based systems engineering tools. Such missions include CubeSats (Lunar Flashlight, SunRISE), Trident, Mars Sample Return, and others from near-Earth to interplanetary, risk-adverse, and experimental.

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

MONSID and CAESAR are both model-based and application agnostic. The combination of these tools makes it applicable to a wide variety of DoD, ESA, JAXA and commercial programs. This innovation can be adapted to other modeling environments to streamline and accelerate FM design and development practices. Industries including aerospace, automotive, and chemical can all benefit from this technology.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.02-2295**

SUBTOPIC TITLE: Increasing Autonomy in the National Airspace System (NAS)

PROPOSAL TITLE: FLITE Core Human/Autonomy Interaction

Small Business Concern

Firm: **Atlantic Drone Pros, LLC**
Address: **2605 Whispering Oaks Terrace, Midlothian, VA 23112**
Phone: **(804) 479-0046**

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):

In this NASA Phase I SBIR, Atlantic Drone Pros, LLC (ADP), with Daniel H. Wagner Associates, Inc. (DHWA), as a subcontractor, will investigate appropriate combinations of human intelligence (HI) and artificial intelligence (AI) in improving flight planning and real-time decision making in the future (2030 and beyond) National Airspace System (NAS). Leveraging ADP's 37 years of manned flight experience, including 5 years of flying and instructing on small unmanned aerial systems (sUAS) and 2 years of flying MQ-9s in tactical airspace, as well as DHWA's decades of experience with advanced algorithms and AI, and building on our team's recent award of a Phase I STTR for Agility Prime to design and demonstrate combined HI/AI capabilities for unmanned aerial systems (UAS) in the FLITE Core Cloud System (FCCS) (which will enable control of multiple UAS by a single pilot, while monitoring and mitigating any potential risks even should a UAS go into a lost link condition, all while sharing telemetry with other USSs and ATM), the ADP team will help NASA, FAA, and other aviation stakeholders answer key questions regarding the effective application of AI to piloted, remotely-piloted, and eventually autonomous aviation. Additionally, the ADP team will design a ground control station (GCS) that is built for HI/AI collaboration. This investigation will result in the design of a set of Phase II prototype components to be integrated with FCCS and existing/emerging UTM systems, and eventually NextGen air traffic management (ATM). Benefits to NASA, FAA, and other aviation stakeholders include a better understanding of the appropriate combinations and interactions of HI and AI, leading to safer and more efficient piloted, remotely piloted, and autonomous flight in the NAS

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

Human operators utilizing AI and an AI-ready GCS to control 10+ aircraft safely through this technology will introduce new capabilities for air traffic management and airspace operations (e.g., TBO). Additionally, our approach will introduce new methods of utilizing artificial intelligence, data science methods and machine learning.

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

Our target markets for this software are AAM/UTM, package delivery firms, food delivery firms, public safety agencies, U.S. Government agencies, military in addition to UAS manufacturers. The platform is being designed for having a pilot ultimately control 10+ aircraft safely and for the AI to be in a position to handle all flight scenarios including emergencies fully autonomous.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z2.02-2936**

SUBTOPIC TITLE: High-Performance Space Computing Technology

PROPOSAL TITLE: RadRISC: A Secure, Resilient RISC-V Processor Infrastructure for Space Operations

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):

To address the needs of image processing and other data parallel scientific applications TCL proposes RadRISC a scalable architecture composed of simple cores based on the RISC-V ISA with a Single Instruction Multiple Data (SIMD) architecture similar in organization to modern GPU processors. The preliminary overall system architecture includes an array of RISC-V cores connected via a RapidIO fault tolerant switch which also enables connections to a fault tolerant external memory for program data and an independent fault tolerant memory for checkpointing. The RapidIO switch in RadRISC also provides a connection to the hardware root of trust and any connected I/O devices or peripherals. An emphasis will be placed on keeping the cores relatively simple as this will enable more effective fault tolerance. The introduction of architectural complexity is an invitation to increase the potential failure points in a given processor design.

While RadRISC will have many robust reliability features it will not sacrifice performance. The targeted signal and image processing workloads will be highly data-parallel which drives a simple, in-order pipeline architecture for RadRISC in lieu of a complex out-of-order design to enable maximum performance-per-watt. Per-cycle performance will be further enhanced through the addition of a SIMD unit to take advantage of the data parallelism. Previous resilient processor architectures have focused on strictly protecting user code. However, the RadRISC hardware and software stack will protect code executed in machine mode, supervisor mode and user mode. This is enabled by the combination of the aforementioned hardware techniques as well as a series of compiler-driven software techniques. This compiler-centric approach allows us to subsequently compile all the software components required to operate the system. This system and software architecture can be modeled using Sandia National Laboratories' Structural Simulation Toolkit (SST).

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

In addition to the prescribed in flight system architectures, the proposed approach is applicable to a number of other NASA-associated markets. Our proposed approach can also be applied to other mission critical systems. This includes robotic control systems for flight operations and landing vehicle operations. Further, with a sufficient degree of compute density, these devices can be extended to create autonomous robotic vehicles and to traditional autonomous satellite or deep space probe devices.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

There are several non-NASA market that include the ability to adapt the IP to commercial space applications, the application of the technology to miniature satellites, the application of the technology

to traditional aeronautics and the application of the technology to autonomous vehicle platforms. We may also apply this for national security environments associated with DoE NNSA applications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.06-3081**

SUBTOPIC TITLE: Space Weather Research-to-Operations/Operations-to-Research (R2O/O2R) Technology Development

PROPOSAL TITLE: Advanced Climatology Innovations for Space Radiation Environments

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

The Space Ionizing Radiation Environment and Effects Advanced Climatology (SIRE2-AC) tool will enhance the capabilities of space climatology, system design, and system performance evaluation. The SIRE2 toolkit will be modified to interface with the new iPATH tool, using the current conditions around the Sun to propagate the radiation environment to the Earth over the next few days. The radiation environment can then be propagated into the Earth's geomagnetic field and an electronic part using the models available in SIRE2.

The SIRE2-AC proposal is submitted to the Space Weather Research-to-Operations/Operations-to-Research (R2O/O2R) Technology Development subtopic and will provide an innovative tool to the space weather forecasting. The new capability for SIRE2 will provide enhanced **forecasts of the energetic particle conditions** encounter by spacecraft within Earth's magnetosphere. SIRE2 can calculate the environment inside the Earth's magnetosphere using the built-in geomagnetic cutoff models. Arbitrary trajectories can be read into SIRE2, allowing for environment calculations anywhere in the Earth's magnetosphere, including **Lunar space environments**.

The proposed Phase I effort will result in a demonstration of the SIRE2 toolkit that is able to use iPATH databases of the solar radiation component. This Phase I effort will also develop a synthesized SPE environment from the iPATH model for a selected significant SPE event. One such candidate events would be the August 1972 event.

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

When the goals of the Phase I effort are completed, NASA will have access to a tool that can provide enhanced forecasts for any mission to space. The demonstrative version of SIRE2 will be to use the iPATH output for the current conditions of the Sun. The current NASA programs, projects or missions that could benefit from this effort are the Artemis Mission, International Space Station, Space Launch System, Multi-Purpose Crew Vehicles, and any satellite or instrument inside the Earth's magnetosphere (JASON-3, SMAP, etc.).

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

Companies like SpaceX and Blue Origin can utilize this Phase I/II work support future space adventure plans. SIRE2 could provide these companies with state-of-the-art models to support their space missions. The Phase I/II effort could be used to support SpaceX's missions to the International Space Station. There are also numerous DoD and DoE programs that could benefit from enhanced forecasting.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H8.01-1850**

SUBTOPIC TITLE: Low Earth Orbit (LEO) Platform Utilization to Foster Commercial Development of Space

PROPOSAL TITLE: Polymer Composites with Exceptional Atomic Oxygen Resistance for Low Earth Orbit Applications

Small Business Concern

Firm: **Material Answers, LLC**
Address: **66 Buckskin Drive, Weston, MA 02493**
Phone: **(617) 378-1976**

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 work will develop lightweight multifunctional composites based on novel continuous fiber reinforced fluorinated polybenzoxazine (FPBZ) resin with an ultra-high nanofiller concentration nanocomposite coating. The composites are designed to provide exceptional atomic oxygen erosion resistance as well as thermal stability and structural performance. Atomic oxygen erosion resistance will be provided primarily through the application of a nacre-memetic coating comprised of layered silicate. This approach provides a path towards addressing the need for a lightweight alternative to aluminum in low earth orbit (LEO) applications such as satellites and orbiting spacecraft. FPBZ's can be processed using liquid resin molding techniques such as lay-up, compression molding, and autoclaving. Thus, polymers and composites developed during this project are expected to provide a unique combination of properties and processing characteristics to meet the needs of NASA and the rapidly expanding commercial space market. Ground-based testing and modeling tasks will be utilized during Phase I to provide a preliminary assessment of atomic oxygen resistance; ultimately leading to testing aboard the International Space Station (ISS) during Phase II using the MISSE-FF (Materials International Space Station Experiment – Flight Facility).

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

The proposed work addresses the need for a lightweight alternative to aluminum in low earth orbit (LEO) applications such as satellites and orbiting spacecraft. A key market driver is the need for lighter weight materials that can replace metal components to reduce launch costs. Applications include components requiring a lightweight atomic oxygen-resistant material to replace aluminum while increasing volume efficiency and/or reducing mass, for example, structural components and non-structural components exposed to the LEO environment.

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

Opportunities for new structural materials in spacecraft, such as CubeSats, are steadily increasing and are driven by the demand for materials with improved volumetric efficiency and lower mass compared to conventional materials such as aluminum. Targeted applications include primary structural components (e.g. frames and chassis) and secondary structural components (e.g. panels and covers).

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.06-2874**

SUBTOPIC TITLE: Vertical Lift Technology and Urban Air Mobility

PROPOSAL TITLE: Onboard Prognostics and Health Management for UAM using Machine Learning Techniques

Small Business Concern

Firm: **Empirical Systems Aerospace, Inc.**
Address: **3580 Sueldo Street, San Luis Obispo, CA 93401**
Phone: **(805) 275-1053**

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):

During this Phase I effort ESAero will research and develop a prognostics and health management system (PHM) designed for electric motor inverters. The final PHM system will consist of a microcomputer or FPGA loaded with a fault detection algorithm connected to the sensors in an inverter. This stage will focus on refining the algorithm. Past ESAero PHM used deep autoencoder, but convolutional autoencoder, a recurrent neural network (RNN), long short-term memory (LSTM) units, and gated recurrent units (GRUs) will be investigated as alternatives and improvements. ESAero will add additional software functions of fault classification and remaining useful life. K-Nearest Neighbor (KNN), support vector machines (SVMs), and random decision forests are candidates for fault classification methods. For remaining useful life, ESAero will explore several physic model based and data-driven approaches. This effort will utilize ESAero's large depository of X57 test data taking during prototype and acceptance testing. PHM will "operate" on the data and detect and predict faults recorded in the X57 tests. This will demonstrate PHM's capability, performance, requirements, and reduce risks before entering hardware design. Planning ahead, ESAero will investigate the certification and regulations that will be applicable to PHM. ESAero will develop a risk mitigation plan to overcome regulatory barriers. The product of this research will lead to the development of PHM requirements for UAM inverters. In addition, ESAero will begin prototype component selection which will verify currently available hardware can meet these requirements.

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

This effort will add understanding of health and remaining useful life (RUL) of inverters for electric UAM. The results of this effort will benefit NASA's Advanced Air Mobility (AAM) National Campaign, NASA X57 Maxwell, and other NASA electric efforts. Determining reliability, RUL, and how to maintenance electrical components of electric systems has burdened regulators. Electric systems have no visual detection of ware. A system that can manage the health and predict RUL will provide actionable data to technicians and regulators.

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

PHM for inverters will provide health and remaining useful life (RUL) to electric components that previously would only be hours operated or operation to failure. PHM planned in this effort could be a small integrable board or a software addon to an inverter with enough computational power. This inverter PHM could later be incorporated in a aircraft level PHM health manage system.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H10.02-1504**

SUBTOPIC TITLE: Autonomous Operations Technologies for Ground and Launch Systems

PROPOSAL TITLE: Automated System for Managing Assets, Resources, and Tasks

Small Business Concern

Firm: **TRACLabs, Inc.**
Address: **100 North East Loop 410, Suite 520, San Antonio, TX 78216**
Phone: **(281) 461-7886**

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):

Safely and efficiently launching payloads and vehicles into space requires a carefully orchestrated coordination between critical assets, expensive resources, and highly trained personnel performing complicated and safety-critical tasks. Managing this coordination is complicated by the use of disparate and unconnected tools such as paper checklists, Excel spreadsheets, siloed databases, and voice communication. While automated systems such as robots and smart sensors can help, the goal of this proposal is to automate processes and not the individual tasks themselves. The Automated System for Managing Assets, Resources, and Tasks (A-SMART) system will focus on identifying inefficiencies in ground operations due to use of paper procedures, unconnected data, and disconnected workers. A-SMART will also focus on increasing efficiencies of ground operations by collecting data about assets, resources, and personnel utilization in a common database that can be mined by business intelligence tools to identify dwell times, bottlenecks, and unsafe operations. At the heart of A-SMART is an automated, electronic procedure platform called PRIDE that can coordinate personnel with assets and resources while performing ground operations tasks. PRIDE is already being used by the 45th Space Wing at Cape Canaveral for range safety operations. A-SMART will employ advanced AI and machine learning algorithms to track asset and resource utilization while incorporating Internet of Things (IoT) and smart sensor data processing to pull analyzed data into procedures automatically. The A-SMART system can automate many of the complicated processes associated with ground operations and automatically generate the data needed for signing off on launch decisions. The benefits to NASA of A-SMART will be safer and more efficient ground operations as the tempo of launches increases.

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

This research will have immediate application to ground automation at NASA KSC. PRIDE is already being used at several NASA centers and this research will increase its capabilities. NASA AFRC is using PRIDE for ground tests on the Air Volt test stand. PRIDE has been selected for use in ground operations for the VIPER robotic mission to the moon with operations at NASA ARC. Human spaceflight operations at NASA JCS are another NASA application.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The electronic procedure platform proposed in this project is being used by major oil field services companies, chemical manufacturers, commercial space companies, and the 45th Space Wing at Cape Canaveral. Each of these existing customers is a potential customer for this research. We will license the software developed under this project separately as an add-on to the existing product.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z13.03-2204**

SUBTOPIC TITLE: Lunar Dust Mitigation Technology for Spacesuits

PROPOSAL TITLE: xEMU Lunar Dust Protection Devices

Small Business Concern

Firm: **Innovative Aerospace, LLC**
Address: **8 Woodland Ridge, Southwick, MA 01077**
Phone: **(413) 426-8121**

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):

The Primary Life Support System (PLSS), within the xEMU, helps to provide a safe environment for astronauts during lunar exploration. NASA identified seven PLSS venting items that they consider as at risk of operational degradation due to the presence of lunar dust. The intent is to protect these items from the dust that is very invasive, electrostatically and magnetically charged and tends to stick to surfaces due to its static-electricity charges.
To meet this need, Lunar Dust Protection Devices will be designed to stop dust from reaching sealing surfaces or hydrophilic membranes within safety critical PLSS components. Self-sealing silicone covers will be developed to protect valves and quick disconnects until activated by crew force or venting gas pressure, while protective screens will be used to protect the membranes, which flow water vapor intermittently. The protection devices will be treated with anti-static elements to reduce lunar dust adherence and use forces, available during EVA or IVA, to encourage gathered dust to fall from them. The forces include lunar gravity, vibration generated by PLSS rotating equipment, crew impact loads while walking/working, overboard gas flow from PLSS components and crew member interaction. Magnetic brushes can take advantage of the dusts magnetic property, during post-EVA, to remove any remaining dust from the devices.
The Lunar Dust Protection Devices will consume very little weight and volume and no power. Each protection device will be developed addressing specific xEMU item geometry, flow rates, flow direction, fluid properties and related human factors. Functioning prototypes will be constructed using accepted manned flight material and design practices and be tested for analytical correlation. Once proven, these design concepts can be readily adapted to other Artemis dust mitigation needs, offering NASA a common set of solutions that may be deployed throughout lunar exploration systems.

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

Many countries are interested in lunar exploration, including the USA, EU, Russia and China. Commercial manned exploration is further enhanced by interest of up to three companies competing to build the Lunar Lander. Presented passive, dust protection devices mitigate safety risks and may solve many different challenges when developing commercial exploration systems. Creating a family of Dust Protection Devices may lead to State-of-The-Art solutions applicable to a wide range of applications.

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

Dust presents challenges to many industries on Earth including coal handling, cement fabrication, metal fabrication, mining, chemical processing, woodworking, pharmaceutical, recycling and agricultural industries. The included covers may be readily applied to protect considerable equipment within these industries since the core “elements” employed to develop them are also present on Earth.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z2.01-2526**

SUBTOPIC TITLE: Spacecraft Thermal Management

PROPOSAL TITLE: Passively Actuated Ultra-Low Mass Radiator for Lunar Surface

Small Business Concern

Firm: **Novus Energy Technologies, Inc.**
Address: **7548 Silver View Lane, Raleigh, NC 27613**
Phone: **(919) 619-8153**

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 lunar surface thermal technologies to enable human-class landers operating in the challenging lunar environment where surface temperatures range from 100 (or less) to 400 K. Novus proposes an innovative solution for modular, passively actuated, ultra-low-mass radiators, offering near-constant temperature control, high fault tolerance against micrometeoroids and deep

mass/volume reduction. The radiator system specific mass target is 1.5 kg/m^2 (20% that of deployed systems (7.6 kg/m^2)). A modularized architecture of many parallel thermosiphons each containing an ingenious integrated spring mechanism allow the system to passively maintain a designed pressure/temperature. The proposed work builds off past accomplishments at Novus prototyping ultra-low mass flexible space radiators and heat rejection systems for aerospace clients including a radioisotope thermoelectric generator (RTG) for NASA's Next Gen RTG program.

Novus is a component/subsystem level US-manufacturer with an experienced R&D team pursuing transformative thermal management and thermoelectric heat pump/heat engine products. This technology will serve space and terrestrial consumer markets. Our technology portfolio offers an exciting class of terrestrial products that bring thermal control immediately close to the body e.g. wearable active thermal systems and portable refrigeration products. The inflatable radiator heat rejection system offers aerospace thermal performance, in a small, flexible form factor, low-mass and silent operation. Our synergistic go-to-market strategy in the terrestrial consumer market will accelerate penetration in the space market by ramping up manufacturing, increasing technical industry knowledge and generating reliability data.

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

- thermal systems on planetary bodies with enough gravity to run thermosiphons such as the Moon and Mars
- mass-constrained heat rejection systems that benefit from a reduction in radiator mass of >90% compared to legacy systems
- crewed missions with large thermal systems (vehicles, landers, bases) and a centralized heat rejection loop that benefits from high fault tolerance and passive thermal control during cold nights
- uncrewed robotic missions that benefit from passive thermal control during cold nights which need a high turn-down ratio

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

Terrestrial heat pumps are becoming miniaturized and portable, which means that the heat exchangers need to be lighter and flexible. Novus has near-term opportunities in the emerging market of distributed consumer thermal management products for refrigeration, HVAC, portable cooling devices, thermal transport in wearable electronics, clothing, camping gear, furniture, and bedding.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z10.03-1310**

SUBTOPIC TITLE: Space Nuclear Propulsion

PROPOSAL TITLE: Distributed High-Temperature Fiber-Optic Temperature Sensing System for Nuclear Thermal Propulsion

Small Business Concern

Firm: **Intelligent Fiber Optic Systems Corporation**
Address: **4425 Fortran Drive, San Jose, CA 95134**

Phone: **(408) 565-9004**

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 meet NASA's NTP objectives for spaceflight missions, IFOS proposes ***Reactor*Sense***™ as a rugged, miniaturized, multi-function, and multiplexable high-temperature sapphire optical fibers (SOF)-based Distributed Temperature Sensing (DTS) system. The system will be designed for the extreme operating environments with Phase I design for 1,800°C and Phase II design for ~ 2,800°C. The use of Raman sensing also enables growth provisions to add spectroscopic measurements of species. Reactor*Sense™ has a miniaturized photonic integrated interrogator that will be placed remotely in cooler regions (< 200°C). The Reactor*Sense™ photonic, ultra-high-speed signal processing uses IFOS' massively-parallel Photonic Spectral Processing (PSP) in Photonic Integrated Circuit (PIC) architecture, eliminating conventional speed bottlenecks and providing breakthrough system miniaturization for spaceflight missions.

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

Rocket*Sense™ will enable accelerated NTP development to support NASA's human exploration missions, including reduced time to Mars. The Rocket*Sense™ technology will also be applicable to NASA's propulsion and flight research programs, offering enhanced awareness of key parameters often out of reliable reach of conventional sensors due to the harsh environments involved.

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

The IFOS technology will benefit both military and commercial engine applications by providing the sensing scalability required to keep pace with next-generation propulsion systems. It is also applicable to DOE's power generation/management, renewable energy, and fossil fuel programs.

Duration: **6**

PROPOSAL 21-1- **Z10.03-2783**

NUMBER:

SUBTOPIC TITLE: Space Nuclear Propulsion

PROPOSAL TITLE: Ultrahigh-Temperature Material Property Testing Above 2000C in Vacuum and Hot Hydrogen

Small Business Concern

Firm: **Ultra Safe Nuclear Corporation-Technologies**
Address: **2356 West Commodore Way, Unit 120, Seattle, WA 98199**
Phone: **(858) 342-4837**

Principal Investigator:

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Business Official:

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Phone: **(858) 342-4837**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3

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

USNC-Tech proposes the design of a scalable ultrahigh-temperature material property testing and performance evaluation facility specialized for space nuclear reactor core and fuel components. This testing facility will be capable of material evaluation under vacuum, hydrogen, nitrogen, and argon atmospheres at temperatures up to 2700 °C. Both contact and non-contact measurement methods for testing data collection are included as part of the design of this system, and are within the scope of this proposal. The combination of ultrahigh-temperature testing, hydrogen atmospheric conditions, and contact/non-contact data collection is a very challenging set of requirements to simultaneously achieve. Two existing facilities can perform hot hydrogen testing (CFEET and NTREES) but neither has the capability to perform in-situ material characterization. The proposed solution will be the only known system that simultaneously combines ultrahigh-temperature testing, hydrogen atmosphere, and material property data collection at temperature.

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

LEU-NTP and NTP flight demonstrator projects are developing NTP technologies for use in deep space exploration missions. Additionally, the U.S. Department of Defense is beginning a project to

develop NTP technologies for military applications. Among the nuclear fuel technologies currently being developed in those projects, carbide fuels are uniquely capable for operation at the highest operational temperatures and compete in a class of their own for capabilities of operation above 1,000s Isp.

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

USNC-Tech is actively engaged with multiple companies that are seeking to develop space nuclear technology for the emerging in-space economy. Additionally, hydrogen production is key to USNC-Tech's parent company, USNC. USNC has entered into agreements to develop hydrogen production technologies with major industry partners and the capabilities developed in this SBIR are highly relevant.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.02-1628**

SUBTOPIC TITLE: Dynamic Power Conversion

PROPOSAL TITLE: Microfabrication of Stirling Heat Engine Regenerators

Small Business Concern

Firm: **Polaronyx, Inc.**
Address: **2526 Qume Drive, Suites 17 and 18, San Jose, CA 95131**
Phone: **(408) 573-0930**

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):

This NASA SBIR Phase I proposal presents an unprecedented laser nano additive manufacturing system for making Stirling heat engine regenerators, by using a pulsed fiber laser and nano-technology. It is the enabling technology for manufacturing fine structures with micron precision. With our successful history in AM and SM processing, this proposal has a great potential to succeed. A proof of concept demonstration will be carried out and samples will be delivered at the end of Phase 1.Prototypes in compliant with the Stirling heat engine system requirement will be delivered at the end of Phase II.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

In addition to NASA's heat engine components manufacturing, the proposed pulsed laser AM 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 deployments.

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

3D printing uses various technologies for building the products for all kinds of applications from foods, toys to rockets and cars. The global market for 3D Printing is projected to reach US$44 billion by the year 2025, driven by the advent of newer technologies, approaches, and applications.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z13.01-1629**

SUBTOPIC TITLE: Active and Passive Dust Mitigation Surfaces

PROPOSAL TITLE: Passive Nano-and Micro-Textured Dust-Mitigation Surfaces in Space-Grade Materials Made with a Highly-Scalable Fabrication Process

Small Business Concern

Firm: **Smart Material Solutions, Inc.**
Address: **984 Trinity Road, Raleigh, NC 27607**
Phone: **(919) 521-4440**

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):

In this SBIR Phase 1 project, Smart Material Solutions, Inc. will fabricate passive dust mitigating surfaces using micro- and nano-texturing. The texturing will be created by SMS's novel and highly scalable "Nanocoining" technique, which uses mechanical indenting to rapidly replicate micro- and nano-patterns onto a metal surface, such as a seamless cylindrical drum mold for roll-to-roll nanoimprint lithography.

The project involves a partnership with Professor Chih-Hao Chang at the University of Texas, Austin, an expert in the wetting and adhesion properties of nanotextured surfaces. Professor Chang's experience will guide the design of surfaces to resist adhesion of lunar dust simulants. Designed surfaces with a range of topographies will be created on a 6" diameter metal mold and replicated into space-grade polymers such as FEP, Teflon, and Kapton using thermal and UV-assisted embossing. The fabricated textured surfaces will then be chemically treated and tested with lunar dust simulant at UT Austin.

The proposed work will further develop a nano-patterning technique that is more than 500 times faster than electron beam lithography and can be used for multiple surface modification or optical applications with value in industry, at NASA, and beyond.

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

- Passive dust mitigation surfaces
- Superhydrophobic surfaces
- Drag reduction surfaces
- Anti-reflective surfaces for improved solar panel efficiency
- Metamaterials for sensing and energy harvesting

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

- Micro optics for augmented and virtual reality
- Light extraction films for LED/OLED displays and lighting
- Tuned spectral absorbers for camouflage
- Anti-microbial surfaces

Duration: **6**

PROPOSAL NUMBER: 21-1- **S2.04-2951**

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

PROPOSAL TITLE: Foundational Thin Film Coating Technology for Advanced Geometry X-Ray Mirrors

Small Business Concern

Firm: **Summit Information Solutions, Inc.**
Address: **3957 Westerre Parkway, Suite 120, Richmond, VA 23233**
Phone: **(804) 201-4399**

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):

Thin film coatings are used on X-Ray mirrors to provide high reflectivity surfaces, to increase the detector blaze angle, and even to increase the detection energy bandwidth of X-Rays through the use of bilayer stacks of high Z and low Z materials. With the age of the current NASA X-Ray detector work horses, Swift and Chandra, there are numerous missions in various stages of development so that wide field of view detection will not be lost. Each of these missions use slightly different mirror configurations to accomplish the tasks. Unfortunately, the mirror or focusing optics structures have become more complex as new capabilities are required by the scientific community. These complex mirror geometries and channel plate optics have posed a challenge for traditional coating technologies. Summit Information Solutions, Inc. proposes the use of a mature coating technique that offers conformal coatings with tight film thickness control and no need for line of sight during deposition. Although there has been some exploring of use of this technique in a University setting for this challenge, Summit will be able to leverage our experience using the deposition technique to successfully coat challenging materials on large three dimensionally complex objects for both the government and the private sector. Summit proposes two traditional X-Ray coatings to show feasibility, a W/Si bilayer and a Ni coating.

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

The immediate NASA applications for this topic include the Gamow explorer, Lynx, and STORM. In addition, the technology developed here would see use on ESA's ATHENA. Moving forward NASA would have access to a foundational manufacturing capability that would be able to coat high reflectivity coatings on arbitrarily complex X-Ray optics.

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

As stated under NASA applications, this technology would also benefit NASA's partners, such as ESA, in development of X-Ray detector systems. The silicon pore optics and micro channel plate

coating methods developed would also see use by the DoD on subwavelength, nonlinear optics sensor development.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z7.01-1832**

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

PROPOSAL TITLE: Rapidly Tuned Random Access Laser Source

Small Business Concern

Firm: **Freedom Photonics, LLC**
Address: **41 Aero Camino, Santa Barbara, CA 93117**
Phone: **(805) 967-4900**

Principal Investigator:

Name: **Mr. Donald Kebort**
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Business Official:

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Address: **41 Aero Camino, CA 93117 - 3104**
Phone: **(805) 967-4900**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 6
End: 7
Technical Abstract (Limit 2000 characters, approximately 200 words):

Semiconductor-based widely tunable lasers are attractive in that they are capable of wavelength switching on short timescales (<10ns); however, in order to switch at those speeds and remain stable, sophisticated control electronics and strategies are required. The traditional approach to achieving switching speeds on the order of 100ns is to use an FPGA that interfaces to multiple digital to analog converters via a high-speed interface, resulting in a relatively large footprint and high power consumption (10s of watts not including the laser itself). In our proposed approach, we suggest using our proprietary semiconductor devices that provide on-chip thermal compensation to remove the sensitivities to changing injection current, in conjunction with high-speed, low power consumption

direct digital synthesis waveform generation integrated circuits. This will result in a small footprint (approximately 2.7" x 3.4" x 0.54") module that consumes less than 10W total (including laser and thermoelectric cooler). This solution will enable volume and power constrained applications to adopt the capabilities that widely tunable laser source modules have to offer. These applications include lidar (employing wavelength sensitive beam steering elements and/or FMCW), atmospheric gas sensing (methane, etc.), and fiber sensing.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed innovation directly supports multiple NASA interests including lidar, atmospheric gas sensing, and fiber sensing.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed innovation directly supports multiple market interests including lidar, atmospheric gas sensing, and fiber sensing, and metrology.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S2.01-1942**

SUBTOPIC TITLE: Proximity Glare Suppression for Astronomical Direct Detection of Exoplanets

PROPOSAL TITLE: Manufacturing and Tooling Optimization for Mirror Quality Assurance of High-Actuator-Count Deformable Mirrors

Small Business Concern

Firm: **Microscale, Inc.**
Address: **800 West Cummings Park, Suite 3350, Woburn, MA 01801**
Phone: **(781) 995-2245**

Principal Investigator:

Name: **Xingtao Wu**
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Business Official:

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Phone: **(339) 927-1996**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

This SBIR Phase I project aims to continue the manufacturing optimization of the mirror quality for both of our PZT stack actuator DMs and our next-generation single-crystal PMN-PT stack actuator DMs. With verified DM performance in terms of key performance parameters such as stroke, leakage current, speed, influence function as well as the validity of the superposition law in the DM control, the innovation further strives to scaling up the manufacturing process and tooling capability to ultimately improve the mirror quality of large-actuator-count DMs in order to make them worthy of being considered for future NASA's flagship missions. The innovation leverages on our experience in developing stack actuator DMs as well as ASIC-based driver electronics, enabling the next-generation DM systems (with compact and high-resolution driver electronics) that are also featured with: reduced number of wires from thousands to several tens, reduction of the power dissipation by two (2) orders of magnitude, shrinking of the form factor (weight/size) of the DM driver electronics by up to two (2) orders of magnitude, and reducing the DM cost by about 5 times. With both DM and the driver ASIC scalable to 96x96, 128x128 or larger format, the innovation holds promise of filling the NASA Technology Gap on DM and associating driver electronics connectors/cables as listed in the recently released Exoplanet Exploration Program Technology Plan Appendix.

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

With both DM and the driver ASIC scalable to 96x96, 128x128 or larger format, the innovation holds promise of filling the NASA Technology Gap (Gap ID: CG-3) on DM and associating driver electronics connectors/cables of the recently released Exoplanet Exploration Program Technology Plan Appendix 2018, and will be able to serve future exo-Earth flagship missions such as HabEx, Exo-C probe, and LUVOIR by providing higher actuator count DM-ASIC systems with less cables, low mass, volume and power. .

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

Commercial markets for these systems include retinal imagers, supernormal human vision systems, and amateur telescopes. The research is also expected to lead to a family of compact, low-cost, high performance spatial light modulators for direct retinal display, head mount display, and large-screen projection display applications (digital cinema).
Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.01-1009**

SUBTOPIC TITLE: Lidar Remote-Sensing Technologies

PROPOSAL TITLE: Compact Integrated Midwave Infrared Spectrometer

Small Business Concern

Firm: **Mirios, Inc.**
Address: **835 East Canon Perdido Street, #104, Santa Barbara, CA 93103**
Phone: **(805) 364-2987**

Principal Investigator:

Name: **Alexander Spott**
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Phone: **(805) 364-2987**

Business Official:

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Phone: **(805) 364-2987**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

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

Mirios proposes to construct a miniaturized (~2.5 cm^3), high resolution, mid-wave infrared spectrometer, fully integrated on silicon. Our technology requires no moving parts or free-space optics and enables a >50x reduction in size and weight compared to conventional mid-infrared spectrometers. This spectrometer will be ideal for implementation in size, weight, and power (SWaP) constrained LIDAR systems, such as for use on unmanned aerial vehicles, spacecraft, landers, and satellites.

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

- LIDAR receiver instrumentation deployed on platforms requiring very low size, weight, and power (SWaP): unmanned aerial vehicles, satellites/cubesats, landers, and spacecraft
- Remote or in-situ chemical analysis and gas sensing of atmospheric and surface constituents on Earth, comets, and other planetary bodies.
- In-situ spectroscopy of radiative heating emission for entry, descent, and landing (EDL) sensor suites

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

Scientific:

- Chemical bond spectroscopy for scientific laboratory and field use

Commercial:

- Environmental analysis
- Industrial monitoring, including vehicle and factor emissions analysis
- Water, food, and soil analysis
- Gas sensing

Military:

- Remote sensing of trace chemicals

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z10.03-1350**

SUBTOPIC TITLE: Space Nuclear Propulsion

PROPOSAL TITLE: Ultrahigh-Temperature Property Testing of Nuclear Propulsion Materials

Small Business Concern

Firm: **Advanced Ceramics Manufacturing**
Address: **7800 South Nogales Highway, Tucson, AZ 85756**
Phone: **(520) 547-0850**

Principal Investigator:

Name: **Zachary Wing**
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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):

While chemical propulsions systems are necessary for launch into space, other propulsion systems are far more efficient for space travel. Nuclear Thermal Propulsion (NTP) and Nuclear Electric Propulsion (NEP) technologies are of interest for future programs that require high ΔV (interplanetary, deep space, etc.). Nuclear propulsion will allow for shorter travel times and fewer launches when human missions to Mars begin.

Current fuels being considered for NTP/NEP are based on cermet and carbide construction. Cermet fuel uses UO_2 bonded with a refractory metal (e.g. Mo, W, Ta). Refractory carbides are also being considered (primarily ZrC) mixed with UC. These fuels can reach temperatures well above 2000°C.

Under these conditions and mission durations, it is critical to understand the mechanical behavior and their stability of the bonding agents used in the fuel. Conducting physical characterization >2000°C is non-trivial since few materials can operate in this regime. To reduce the risks of using NTP/NEP systems, NASA needs to characterize the candidate materials at operational temperatures.

Advanced Ceramics Manufacturing has significant experience in processing Ultra High Temperature Materials (refractory metal nitrides, carbides, and borides) and developing novel ultra high temperature mechanical test systems.

ACM's proposed technology utilizes small, custom test geometries that are tested using non-contact forces. This enables characterization of modulus, strength, fatigue, and creep at 2700°C.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Nuclear propulsion development

Hypersonic leading edges

Hypersonic propulsion

Rocket propulsion

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

Hypersonic leading edges

Hypersonic propulsion

Rocket propulsion

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.11-1815**

SUBTOPIC TITLE: In Situ Instruments/Technologies and Plume Sampling Systems for Ocean Worlds Life Detection

PROPOSAL TITLE: A Compact, Integrated, Modular, Multi-Technology, Optical Sensor (CIMMOS) for In-Situ Characterization of Ocean Worlds

Small Business Concern

Firm: **Brimrose Technology Corporation**
Address: **19 Loveton Circle, P.O. Box 616, Sparks, MD 21152**
Phone: **(410) 472-2600**

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 goal of enabling comprehensive standoff sensing of chemical bonds, we propose to develop a compact, integrated, modular, multi-technology, optical sensor (CIMMOS) with high spectroscopic information content for in situ reconnaissance and characterization of ocean world surface/subsurface materials that is also applicable for interrogation prior to sample return. CIMMOS is a novel concept that incorporates a suite of five advanced optical spectroscopy technologies to give a comprehensive 3D analysis of target atomic and molecular composition variation of as function of location and depth in centimeter scale. CIMMOS is innovative in being the first standoff in situ optical sensing facility capable of probing the broad vibrational response of molecules by acquiring Raman, IR and mid-IR LIBS spectroscopic signatures of condensed phase inorganic and organic samples. Combined with multi-elemental analysis of UVN LIBS emission, this novel system has the potential to offer a rapid, complete, and robust chemical characterization of surface targets. While the 3D composition mapping capability of CIMMOS make it an ideal in situ probe for ocean world missions, the modular design implementation of CIMMOS permits subsystem assemblies tailored to the application with cost-efficiency, resulting in a versatile instrument that can be optimized for size, power, and science objective requirements of a broad variety of Ocean World missions such as icy moons of Jupiter and Saturn. With its versatility, we envision CIMMOS being deployed on landers of ocean worlds. The fore-optics will be designed to be fully reflective to support the modularity principle in our design. In our Phase-I effort, we will evaluate CIMMOS system design parameters for various modular configurations. In a future Phase-II effort, we intend to develop a breadboard system based on our existing NIR/SWIR system, optimized for lunar science, to minimize development cost.

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

Deployed on an ocean world exploration lander, CIMMOS can rapidly characterize minerals, salts, and organics deposited on the surface, as well as have the ability to resolve depth profiles ≥ 1 cm beneath the surface to understand diagenetic alteration. In addition, CIMMOS is fully compatible with a lander or rover drill to probe at the bottom of a drilled hole and study the deposits buried ≥10 cm below the surface.

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

In addition to NASA applications, the proposed instrument can be used for
1. Explosives, chemical and biological agent detection,
2. Water and soil pollution and contamination monitoring,
3. Quasi-nondestructive detection/evaluation in manufacturing industry
4. Composition analysis and counterfeit detection in pharmaceutical products.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A2.03-2374**

SUBTOPIC TITLE: Advanced Air Mobility (AAM) Integration

PROPOSAL TITLE: Urban Weather Sensing Infrastructure Testbed

Small Business Concern

Firm: **TruWeather Solutions**
Address: **235 Harrison Street, Ste 64, Syracuse, NY 13202**
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Principal Investigator:

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Business Official:

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Phone: **(609) 367-6459**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

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

Advanced Air Mobility (AAM) operations and airspace management depend on accurate weather data for safe, sustainable, affordable and accessible services. Accurate urban weather data requires a robust, autonomous and reliable sensing and data processing system capable of detecting and communicating weather hazards in near-real time.

TruWeather Solutions (TWS) is addressing wind challenges that impact small Unmanned Aerial Systems (UAS) and Urban Air Mobility (UAM) airframes. TWS seeks to underpin an aviation metropolitan based weather sensing and prototype testbed architecture resulting in a Wind Hazard Impact Location Service (WHILS) to better characterize wind impacts for operators and airspace managers. WHILS will integrate into our In-Time System-Wide Safety Assurance (ISSA) platform, TruFlite V360. WHILS will inform when and where it is safe to fly, and which corridors and vertiports will provide the safest route(s) of transit and locations for terminal operations. This project will focus on low-altitude, urban environments to accelerate deployment of a robust urban wind sensing platform scalable to any urban area in the world.

We will develop our urban wind hazard framework with the goal of a proof-of-concept demonstration in Phase 2 that will highlight wind and wind shear “hotspots” of all types. We will quantify the potential impact of sensor fusion and the collected data on wind predictions using simulated observations. We will assess the influence of this service on selecting optimal routes using our route optimization capability RouteCast.

Our vision is to enhance TruFlite V360 with a low altitude urban weather model capable of detecting and predicting urban wind “hot spots” and hazards to avoid. This initial model will accelerate commercialization of an important data set to keep airframes and people safe as we test, demonstrate, and deploy initial UAS operations in urban environments in order to reach 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: 21-1- **A1.04-2744**

SUBTOPIC TITLE: Electrified Aircraft Propulsion

PROPOSAL TITLE: Additively Manufactured, Structurally-Integrated, Passive Two-Phase Heat Sink for Electrified Aircraft Propulsion Systems

Small Business Concern

Firm: **ThermAvant Technologies, LLC**
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Principal Investigator:

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Business Official:

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Phone: **(573) 397-6912**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

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

In an effort provide significant improvements in aircraft fuel/energy economy and emissions, turbo-, hybrid, and fully electric aircraft are being developed to utilize high-efficiency electric propulsion systems (EAPs). To enable these systems, thermal management systems (TMS) are needed which can be scaled to the power ranges required while providing the efficiency and power density that makes these technologies compelling. ThermAvant Technologies, LLC proposes a novel TMS based on the company's flagship technology: structurally embedded oscillating heat pipes (OHPs). The OHP is a passive two-phase heat transfer device that relies on concentrated heat loads to passively drive a working fluid through a high-density array of microchannels, which are ideal for embedding within thin structures such as a structural skin. Without the need for the wick structures of their conventional predecessor heat pipes, OHPs are especially well suited for integration into materials within which it is difficult to construct traditional heat pipes. In addition to the absence of a wick structure, the OHP's unique I-beam architecture (formed by the walls between the microchannels) enables the structure to be multifunctional and serve as a structural member with integrated passive thermal management. Furthermore, through the use of additive manufacturing technology, these devices can be deeply integrated within the structure of EAP systems.
These high-conductance, embedded devices will provide significant improvements to power density by both decreasing thermal impedance and reducing mass, and provide additional design freedom for the layout of heat generating components within the EAP system while still providing improved thermal performance. To provide further performance optimization under both transient and steady-state conditions, energy storage devices will be evaluated to independently optimize the conductive and capacitive properties of the heat sink.

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

NASA's Electrified Aircraft Propulsion project resides within the Aeronautics Research Mission Directorate Strategic Thrust 4: Transition to Low-Carbon Propulsion. In particular, within Thrust 4, this technology has direct application to the X-57 program, as well as to the Revolutionary Vertical Lift

Technology project. Beyond these applications, this technology also has application to the cooling concepts for hybrid electric aircraft that are being investigated through the HEATheR program.

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

ThermAvant is aware of a number of applications that could potentially use such additively manufactured, thermal devices, e.g. commercial manned/unmanned aerial vehicles, and various commercial space applications. ThermAvant believes there are a multi-million-dollar annual revenue opportunities within each of these industries if the multifunctional prototypes are able to successfully be produced.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.01-3300**

SUBTOPIC TITLE: Advanced Air Traffic Management System Concepts

PROPOSAL TITLE: AirWAZE Expanding Flight Operator Autonomy in National Airspace System (NAS) Decision Making

Small Business Concern

Firm: **CGH Technologies, Inc.**
Address: **600 Maryland Avenue, Southwest Suite 800W, Washington, DC 20024**
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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):

In much the same way crowd-sourcing improved safety and efficiency of surface vehicular travel (www.waze.com), we propose the AirWAZE concept will provide similar benefits for aerospace. As envisioned, AirWAZE is a cloud-based, interactive, icon-driven, web application/display of NAS events, weather constraints, route impacts and operational anomalies where NAS stakeholders – pilots, controllers, dispatchers, safety and security personnel, crowd-share information to observe, create, or react to events occurring in the NAS to improve safety and efficiency and enhance gate-to-gate Trajectory Based Operations (TBO). This innovation provides real-time and near real-time data to all approved, connected stakeholders in a user-friendly, readily consumable format. AirWAZE data will be passively and actively collected, and designed for viewing on most smart phones, tablets, laptops and desktops. Most common browser versions will be supported and as the application will be cloud based, there is no need for software downloads.

Our aviation industry has a long and productive track record with tools and concepts of Collaborative Decision Making (CDM). AirWAZE moves this process further forward, capitalizing on available technology and with crowd-sourced inputs exponentially broadens common situational awareness for improved CDM results. Through simple inputs and with easily understood icons, the community can rapidly alert to safety events (icing, turbulence, wind shear), and inefficiencies (holding, vectors, departure delays) thereby having useful, actionable information for flight and fleet planning decisions. This concept includes a “NAS Chat” feature to accommodate amplifying event information providing a running record to allow self-briefing at any time for improved situational awareness. In the long-term artificial intelligence/machine learning (AI/ML) will help improve predicting and generating alerts on ANSP restrictions and inputs can be autoformatted for rapid NOTAMs.

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

Our research supports NASA’s focus area for Advanced ATM System Concepts, providing novel and innovative concepts addressing known ATM challenges in efficiency, capacity and throughput. It enables the identification and immediate sharing of NAS constraints to affected stakeholders, improving situational awareness and data-informed decision making. It supports the integration of new operators, vehicles and missions including UAS/UAM, Commercial Space Transportation, Super and Hypersonic flight very high-altitude Balloon and Military operations.

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

This concept has direct application to non-NASA Agencies including Department of Defense, Department of Agriculture, Department of Homeland Security and others having an aviation/aviation security presence. This interactive platform has great benefit to the VFR community, particularly the State of Alaska. We see broad application for efficiency and safety in air traffic operations internationally.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H5.01-2752**

SUBTOPIC TITLE: Lunar Surface Solar Array Structures

PROPOSAL TITLE: Sunflake Solar Array and Ultra Compact Tripod Tower (UCTT)

Small Business Concern

Firm: **Gendell Associates DBA Folditure**
Address: **1031 Bloomfield Street, Hoboken, NJ 07030**
Phone: **(201) 656-4498**

Principal Investigator:

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Business Official:

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Phone: **(718) 908-5877**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Combining our proprietary Pyramid Hinge, with other novel mechanical and geometric solutions, we propose a disruptively compact, robust structure for Lunar Solar Power Generation – The Sunflake Solar Array and Ultra Compact Tripod Tower (UCTT).

The solicitation request is for a structural and mechanical innovation, with a deliverable of an elevated Lunar Solar Array system, that is compact, lightweight, robust, retractable, and redeployable. This project is very well aligned with our area of expertise, as we have successfully developed and patented folding mechanisms and structures that meet all of the above requirements.

The Sunflake Solar Array and UCTT fold together, to stow in an estimated volume of 0.32 m^3 which compares favorably to the stated requirement of 0.5m^3.

The novel design combines the strength, compactness, and durability of the Pyramid Hinge, with super lightweight HC core panels, and other SOA materials, pivots, and simple motor and pulley operation. With this proposed technology, we expect to achieve an extremely compact foldable structure with a solar array that spans 35 square meters, raised up to 10 meters off the ground, and is extremely robust and reliable.

The Sunflake rotates and tilts for optimal sun tracking, while the UCTT provides a stable vertical structure. And apart from size/weight performance, they will bring to the field completely reliable deployment and retractability.

Both technologies are scalable, and modular.

In Phase 1 we propose to fully develop a working mechanical design for the structure, while applying the best available technologies. The design will be proven through a detailed 3D model, calculations, and physical models of specific details. This work will be the foundation for prototyping in Phase 2.

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

The Array could be used on any form of Human Lander, or future Lunar Outpost, Orbit Stations.

Sunflake is designed for multiple actuations, but can be modified for Satellite use with single actuation.

Any current or future missions that require lightweight portable high efficiency PV energy could be of interest.

The Array and Base can be used on other Planetary Missions. As the design is inherently stable, it can easily be scaled up for deployment when stronger gravity is present. It can be adjusted for use at different sun angles.

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

The UCTT could be used as:

- reliable lightweight Tactical Mast, for fast deployment.

- quick to deploy portable tower- from Radio communication, to supporting a portable wind turbine.

A modified array, could:

- become a portable shelter system with solar roof

- be used for pop up PV power generation

- be programmed to track sun angles

Potential for DoD, other government agencies or commercial use.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z1.07-1116**

SUBTOPIC TITLE: Dynamic Energy Conversion for Space Nuclear Power and Propulsion

PROPOSAL TITLE: Radiator Free Engine

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: 2
End: 4

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

The Radiator Free Engine (RFE) is a new technology enabling very high power to mass ratio nuclear electric propulsion. In the RFE, cold water propellant or hydrogen used as the heat rejection dump for a dynamic cycle heated by a nuclear reactor, enabling Carnot efficiencies as high as 0.79 for water or 0.99 for hydrogen. Some of the propellant that is boiled or sublimated off is then sent to an electric propulsion system, which ejects it from the spacecraft at high velocities to produce thrust. Potential RFE conversion systems include Brayton, Rankine, and Stirling cycles. The RFE can be operated in either steady state or in pulsed modes, with the later enabling very high thrust/mass ratios. Potential alternative RFE propellants include nitrogen, methane, CO_2, and ammonia stored in either liquid or frozen phases. Because its thermal to electric conversion efficiency is about a factor of 3 higher than conventional NEP systems, and it does not require radiators for heat rejection, the RFE can achieve power to mass ratios an order of magnitude higher than conventional multi megawatt power systems. Other advantages of the RFE include its ability to use cheap, dense propellants that are plentiful or producible in space. In the proposed program, the potential performance of the RFE will be analyzed, design options compared, technical concerns addressed, and the concept validated by means of computer analysis and laboratory tests.

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

The Radiator Free Engine (RFE) enables very high power to mass ratio NEP and solar thermal electric propulsion. RFE systems could be used to transport payloads from LEO to the Deep Space Gateway. RFE systems could use water as propellant, enabling the Artemis Moonbase to support both cis-lunar and interplanetary transportation. RFEs could enable fast trips between Earth and Mars. RFE reactor systems could also be used to supply power on surface of the Moon, Mars, and Titan. RFE lunar surface vehicles could go into shadowed craters to mine ice.

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

Solar thermal RFE space transfer vehicles could support LEO to GEO transfer of commercial satellites, and cis-lunar transportation. RFE propulsion would be extremely attractive for asteroid development, since water ice is present on many asteroids. RFE technology could also be used to support high efficiency power generation on Earth.
Duration: **6**

PROPOSAL NUMBER: 21-1- **H6.04-1205**

SUBTOPIC TITLE: Model-Based Systems Engineering for Distributed Development

PROPOSAL TITLE: Exchange Model for Harmonizing Model-Based System Engineering (MBSE) Products and Tools

Small Business Concern

Firm: **Mosaic ATM, Inc.**
Address: **540 Fort Evans Road Northeast, Suite 300, Leesburg, VA 20176**
Phone: **(800) 405-8576**

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):

Key elements of NASA's Digital Transformation initiative strategy calls for "digitally transforming NASA's data use, collaboration, model-based work, administrative processes, application of artificial intelligence, and workforce and culture" and this SBIR proposal is specifically addressing the model-based work area. Mosaic proposes to develop a Digital Engineering Information Exchange Model

(DEIXM) based on open-source standards including SysML, UML and ISO's STEP – standards for the exchange of product model data – group of standards along with a DEIXM Model Viewer (DMV) that provides a centralized location to view digital model artifacts in a common format. Ultimately, the DMV along with the DEIXM will demonstrate the integration of digital models developed in different MBSE tools that maintains model integrity with minimal need to manually edit the digital models. The idea of creating a standards-based approach to sharing digital model data between organizations was presented by the Department of Defense in a 2018 briefing for the 21st Annual National Defense Industrial Association Systems and Mission Engineering Conference. The briefing called for the creation of a DEIXM that would facilitate the exchange of textual, graphical, tabular, and other digital model artifacts along with an "integrated digital viewer." Implementing a DEIXM is envisioned to reduce the amount of effort required to integrate digital models between the government and contractors, as well as between contractors. The DEIXM created in this effort will focus on establishing a standard that supports NASA missions. It will leverage previous efforts to use MBSE to support space mission design from the NASA MBSE Pathfinder work done across NASA, as well as lessons learned from the DEIXM Working Group established by the OMG.

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

- Any new NASA project that is required to use an MBSE design approach to meet the goals of NASA's Digital Transformation initiative.
- Existing NASA projects in the early design phase that are not currently using an MBSE design approach.
- Established NASA systems that are undergoing an enhancement design that could use MBSE to support evaluation of design alternatives.

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

- Any large-scale development project sponsored by government organizations such as the DoD, FAA, and DOE that want to pursue an MBSE design approach.
- Non-government system integrators such as Boeing, Raytheon, and Lockheed Martin that are responsible for integrating design artifacts from subcontractors to support a project

Duration: **6**

PROPOSAL NUMBER: 21-1- **S4.03-1278**

SUBTOPIC TITLE: Spacecraft Technology for Sample Return Missions

PROPOSAL TITLE: Thermal Management System for Comet Sample Return

Small Business Concern

Firm: **Advanced Cooling Technologies, Inc.**
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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):

Advanced Cooling Technologies, Inc. (ACT) proposes to develop a thermal control system for a sample return capsule utilizing evaporation of a consumable working fluid that is vented to the environment. The preliminary vision of the proposed concept (and system) architecture is approximately based on the Orbiting Sample Capsule integrated with the Earth Entry Vehicle for Mars Sample Return (MSR). The proposed concept consists of several annular/concentrical (not necessarily spherical and continuous) chambers (layers) surrounding the sample chamber as follows: a Vapor Chamber containing the working fluid in saturated state, which is vented to provide evaporative cooling at the wick-sample chamber interface, a bladder or bellows based Flexible Liquid Reservoir for liquid storage, displacement and delivery to the vapor chamber, a Compressed Gas Chamber that continuously provides the pressure required to passively drive the liquid into the vapor chamber and a Heat Guarding Chamber that allows the vented vapor to flow towards the ultimate exit and further collect and remove any incoming environmental heat leaks. In addition, the system will include liquid delivery headers, temperature and pressure sensors and solenoid and check valves.

The proposed concept/system has the following advantages: lightweight, passive, low energy consumption (mostly for sensors and valve actuation), simple, low cost, scalable, allows set point change remotely and it can generate precooling on demand. It is applicable to sample-return (SR) missions that require landing on large bodies (e.g., Luna, MSR), as well as particulate-class SR missions (e.g., Genesis, Hayabusa) or touch-and-go missions to relatively small asteroids or comets (e.g., OSIRIS-Rex, Hayabusa2).

During the Phase I program, ACT will develop a sub-scale consumable-based thermal control system prototype and demonstrate its capability through mathematical modeling and experimental measurements.

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

The proposed consumable-based thermal control system represents a low mass, passive and effective thermal solution that will enable a Sample Return Mission to preserve the sample in pristine form through all the phases of the mission. The proposed thermal control system can be applied to missions like MSR or other envisioned missions to dwarf planets (e.g., Vesta, Ceres), planet moons (e.g., Phobos, Europa) or comets.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The consumable-based thermal control technology can be used for the thermal management systems that typically rely on PCMs for mid-duration temperature control, such as undersea vehicles, aircraft systems, medical devices and high energy weapons. ACT is working with primes on such systems as well as identified its potential application to flight vehicles, Blood Delivery, and Helmet Cooling.
Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.05-1401**

SUBTOPIC TITLE: Terrestrial Balloons and Planetary Aerial Vehicles

PROPOSAL TITLE: A Compact Drone-Based Instrument Sonde for Venus Balloon Missions

Small Business Concern

Firm: **Creare, 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 currently developing concepts for controlled variable-altitude balloons for study of the Venusian atmosphere at altitudes ranging from 52 to 62 km. A balloon mission could closely study the chemical composition of trace compounds in the upper atmosphere and resolve ongoing scientific debate regarding the presence of specific gases having biological origins on Earth. The moderate Earth-like pressures and temperatures at such high altitudes on Venus allow for long-term operation of scientific equipment, unlike the very the high surface temperature and pressure which severely limit survivability of exploration vehicles. Prior lander missions to Venus survived just over two hours on the surface before overheating, while high-altitude balloons have operated for days (limited by battery capacity). Future balloon-based missions could far exceed previous mission durations, but balloons have an inherently limited lifetime due to loss of lift. Balloon platforms also have limited altitude operating range and do not penetrate the lower atmosphere. To address these balloon system limitations, Creare proposes the Venus Sonde, a drone-based ballast sonde with a mass of 5 to 10 kg capable of flying multiple missions and returning to the balloon prior to a final one-way flight to the surface. During the initial high-altitude flights, the Venus Sonde launches from the balloon platform

under fixed-wing flight to profile the atmosphere in the vicinity of the balloon up to 70 km in altitude and then returns to land on the platform under vertical flight. The final flight occurs when needed to reduce the ballast weight of the system, thereby increasing net lift. The drone sonde includes thermal management systems needed to survive surface conditions for several hours to conduct image surveys and then transmit data from the surface.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary intended application for Creare's Venus Sonde is to support NASA and its planetary exploration missions. The design resulting from this effort could be adapted to planetary exploration missions to other planetary bodies with an atmosphere. This design can also be adapted for terrestrial applications to help achieve NASA's Earth observation objectives.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The applications for Creare's Venus Sonde are broad and far reaching for terrestrial applications. These could include routine commercial services such as drone delivery services, atmospheric profiling, and monitoring and surveillance activities for agriculture and utility companies. Each application would likely entail application-specific requirements and customization of the system.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.10-1483**

SUBTOPIC TITLE: Wireless Communication for Avionics and Sensors for Space Applications

PROPOSAL TITLE: Wireless Passive Wideband DC to 5MHz Sensors

Small Business Concern

Firm: **Nanosonic, 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 objective of this NASA SBIR program is to develop wireless passive sensors for a variety of measurement applications. Wireless passive sensors are important because they will eliminate the volume, weight and time-consuming hand installation of bulky and heavy wire bundles that interconnect large numbers of sensors to centralized data analysis systems, and instead allow sensor networks to be interconnected wirelessly. The sensors consist of an additively manufactured matched dipole meanderline antenna, commercial radio frequency identification chips, and a representative strain and acoustic sensor NanoSonic has developed for demonstration purposes. The antennas will be designed using computational electromagnetic software codes and the designs turned into 1-bit bitmap files that will be used to drive a Dimatix Materials Printer. NanoSonic will use conductive inks it has developed through prior programs to print the antennas on DuPont polyimide Kapton substrates and achieve printed thin film conductivities near that of bulk copper. The circuitry of the chips and resistive sensor elements will be modeled in LTSpice and integrated with the balanced antenna. RF measurement hardware will be used to measure the insertion loss and S-parameters of the antennas. Wireless sensor demonstrations would be performed first inside NanoSonic's indoor RF anechoic chamber and then in a mechanical testing lab on samples under strain in an Instron load frame. Additional wireless passive sensors will be demonstrated on representative metal, composite and deployable membrane and fabric materials. NanoSonic will work with the RF group in the Hume Center at Virginia Tech and with MoonPrint Solutions. Staff at NanoSonic, the Hume Center and MoonPrint Solutions have backgrounds in sensor development, RF antenna design and measurements, additive manufacturing processes, and deployable space materials and structures through academic, industrial and product manufacturing programs.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Sensors are important to terrestrial and space systems - they report on thermal, mechanical, chemical and biological conditions so astronauts or control systems can react to values. They eliminate the volume, weight and installation of heavy wire bundles that interconnect large numbers of sensors to data systems. Also, each sensor element operates without the need of supplied electrical power. This reduces the overall system power budget so lowers the need for power generation and storage.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Applications for developed technology include non-wired sensors for the nondestructive evaluation of materials and structures, use in industrial manufacturing systems and civil infrastructure. Developed additive manufacturing materials and techniques are applicable in the bottom-up rapid production of consumer goods with controlled material properties at lower cost and improved function.
Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.04-2238**

SUBTOPIC TITLE: Nontraditional Airspace Operations

PROPOSAL TITLE: Emergent-to-Legacy Automated Voice Comms for Airspace Safety

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 7

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

UAV usage has proliferated in the US national airspace, and there is a requirement for UAVs to be able to alert proximal traffic about their presence and intent. We propose the development of a miniature VHF radio annunciator that broadcasts simple position, status and intent messages using standard air traffic terminology. These messages can be readily heard by local air traffic and controllers using current (legacy) VHF airband communication radios, thus enhancing the overall safety of the system. Also, a ground-based annunciator is proposed, which can be used to meet ground-node requirements of the FAA's RemoteID rules for FAA Recognized Identification Areas (FRIAs). In Phase I, we will develop and demonstrate these devices, further refining proof-of-concept hardware built and tested in 2020. In Phase II, the design will be refined and prototyped, and comprehensive flight testing will be undertaken.

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

NASA conducts tests of UAV technology which involve routine flights of UAVs. The proposed automated airband radio (AAR) can be used to enhance the safety of such operations.

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

The automated airband radio can be used for all sizes of UAVs, emerging urban air mobility vehicles, and civil and military aircraft. It can be used to reduce overall pilot workload, and serve as a backup during emergencies where the pilot may be incapacitated.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S4.04-2330**

SUBTOPIC TITLE: Extreme Environments Technology

PROPOSAL TITLE: High Temperature SiC Modular Power Conversion Platform

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):

In the Phase I effort of this this work, we will commence the development of a power conversion modular platform for very high temperature (500C) and high-level radiation environments. We will design, simulate and fabricate key components of this configurable platform. We will also prototype a specific implementation of this power conversion platform as an example application for near term space missions. The platform is based on the nascent wide bandgap semiconductor Silicon Carbide that can operate at temperatures far greater than the capabilities of silicon-based electronics. Silicon is typically rated to 220C maximum, whereas CoolCAD has fabricated MOS SiC transistors and circuits that operate above 500C, which will be utilized in this new modular platform. To realize this power conversion platform, we will design and fabricate SiC Power Transistor converter topologies, consisting of half-bridges and full bridges, as well as control electronics, into easy-to-use modular components. Multiple high temperature SiC power switching transistors (LDMOSFETs) will be integrated onto a single chip to form an easy-to-use power block. SiC high temperature CMOS control electronics that regulate the output DC distribution bus voltage while being able to supply the load current demand, will be integrated into a control component. These two modules will be relatively easy to couple together to form a complete modular power platform. Finally, in a subsequent effort, we plan to integrate the control and power electronics onto a single die that can operate at high temperature. Of course, under certain circumstances, power levels will not allow for integration into the space of a single die. Under these circumstances, the various power converter modules will be connected on a high temperature printed circuit board (PCB). The modularity and integration of SiC components will significantly streamline NASA's power converter development efforts for future space missions.

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

Harsh environment SiC power converters have wide applications in (a) spacecraft power management, (b) DC distribution systems in Venus/Mercury/Mars exploration, (c) motor drives, inverters and power supply derivatives in the Space Station, satellite power systems, and (d) motor drives in 'more electric' technology applied to aircraft generators and reusable launch vehicles. SiC technology find unique applications in harsh environment CMOS-based control, driver integrated circuits and sensors, where regular Si technology cannot operate.

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

Applications of high temperature (500C) harsh environment SiC power electronics include, (a) automotive engine control, (b) power management systems in ground/naval/air vehicles (c) electrical actuator and motors drives in jet engines, (d) compressors in geothermal energy, (e) deep-well drilling telemetry modules and electric actuation in gas turbines, (f) smart high-temperature sensors.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.09-2356**

SUBTOPIC TITLE: Vehicle Sensor Systems to Enable Situational Awareness

PROPOSAL TITLE: Long-Range Thermal 3D Perception in Low Contrast Environments

Small Business Concern

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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 proposed technology intends to improve the future air vehicles' situational awareness by providing a novel 3D perception capability targeting the critical for the AAM applications gap between currently available short-range automotive LiDAR and long-range radars with the limited transversal and temporal resolution, especially for the obstacle-rich urban environment. It will provide high-contrast day/night and all-weather image data, independent of GPS that allows robust depth sensing at hundreds-to-thousands of meters range and high vehicle speed. This robustness of depth perception contributes to the overall safety of NAS operations.

We propose a multi-sensor long-wave infrared (LWIR) 3D technology that mitigates the limitations of the compact uncooled thermal sensors: low contrast, low resolution, and high thermal inertia. The novel sensor configuration, calibration methods, and image processing algorithms
yields composite system performance by far exceeding that of the individual COTS thermal imagers' performance. Using the LWIR sensors with noise-equivalent temperature difference (NETD)=40 mK, this technology will demonstrate system-equivalent NETD of 10 mK in the intrascene mode and 1 mK for the low-contrast environmental features, by order of magnitude exceeding the performance of cryogenic photon detectors in the traditional binocular configuration.

This proposal's research objective is to build the LWIR/EO multi-sensor prototype and demonstrate the dramatic improvement of the microbolometer-based LWIR detectors sensitivity, especially for the 3D measurements and motion blur mitigation. The results of this research will enable passive thermal 3D perception systems for a broad spectrum of environmental conditions. It will pave the way to using large arrays of low SWaP-C microbolometer devices advanced by consumer thermal imaging products.

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

The resulting low SWap-C thermal depth sensing system will enable situational awareness for Autonomous Air Vehicles for the Advanced Air Mobility project. It will provide highly accurate 3D information regarding the surrounding environment, including low-contrast static and moving objects, at far distances, such as 1000 meters, and in degraded visual conditions (in the dark, fog, or blizzard), in GPS-denied areas. Passive depth sensing in low contrast environments can be useful for Space Technology Mission Directorate planetary explorations.

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

We target the advanced driver-assistance systems (ADAS) and autonomous vehicle market. LWIR 3D provides a longer range than LIDARs and prevents fatalities by detecting high contrast live organisms in any weather conditions.
It also provides a passive depth-sensing method for stealth operations in military applications, such as navigation for military vehicles and head-mounted thermal 3D.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.06-2422**

SUBTOPIC TITLE: Thermal Control Systems

PROPOSAL TITLE: Passive Variable Heat Rejection Freeze-Tolerant Direct Condensation Heat Exchanger/Radiator

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 ever-increasing processing power of spacecraft and satellites puts a tremendous demand on the thermal control subsystem (TCS) to acquire, transport, and reject large amounts of heat. Consequently, the radiator surface needed to reject the anticipated highest amount of heat become large. The TCS gets very cold in the nominal or part-load operations in the cold spacecraft attitudes. Temperature control of the on-board payloads is essential for the optimal performance and long lifetime of the equipment. Electrical power is often expended to maintain the payloads above the temperature limit, conceivably overwhelming the power subsystem. The radiator temperatures may drop below the freezing point of the working fluid in the worst-case survival mode. The existing “direct condensation” radiator technology does not allow the fluid to freeze, precluding the best available refrigerant – Ammonia – to be used for room-temperature applications. The proposed *Passive Variable Heat Rejection Freeze-Tolerant Direct Condensation Deployable Radiator* offers an innovative method of (i) autoregulating the heat rejection just enough to condense the vapor load back to saturated liquid, (ii) allowing the heat transport loop to operate while the radiator fluid is frozen, and (iii) gracefully thawing out the radiator and return the loop to normal operation

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

NASA have developed thermal technologies to meet the ever-increasing thermal requirements of space thermal control systems (TCS). The current state-of-the-art heat acquisition/transport/rejection system has reached the upper limit of its capacity. New more capable technologies have been developed in the acquisition and transport of heat but the rejection aspect still remains unchanged. In particular, the fluid in the radiator is not allowed to freeze. The proposed radiator concept will resolve the issue to increase the system capacity.

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

The commercial satellite market has been increasing at a very fast rate from the demands of telecommunications and entertainment industries. The heat dissipation rises. The thermal technologies must be utilized in the most efficient way to maximize the heat transport capacity. The proposed radiator concept allows the thermal subsystems to provide optimal conditions for the onboard payloads

Duration: **6**

PROPOSAL NUMBER: 21-1- **H3.05-2091**

SUBTOPIC TITLE: Additive Manufacturing for Adsorbent Bed Fabrication

PROPOSAL TITLE: Additive Manufacturing of Structured Sorbents for CO2 and H2O Removal

Small Business Concern

Firm: **TDA Research, Inc.**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

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

NASA aims to use 3D-printed sorbent beds as drop-in replacements for the packed sorbent beds that are currently used in the Carbon Dioxide Removal Assembly (CDRA) on the

International Space Station (ISS). This change will have the benefits of providing equivalent system mass reduction due to better thermal and fluid management and mass transfer properties.

In this SBIR project TDA Research, in collaboration with Missouri University of Science & Technology (MUST), proposes to develop optimized 3D printed sorbent structures with SOA zeolite (5A and 13X) and silica adsorbents that have been previously shown to be effective in removing CO_2 and humidity respectively from spacecraft cabin air. In our approach we will optimize the 3D sorbent structures for cyclic operation i.e., as part of the additive manufacturing (AM) of the 3D printed sorbent structures we will incorporate integrated heating elements, which will allow us to directly apply heat to the sorbent and also use additives such as graphite as part of the binder mix to improve the heat transfer in the 3D sorbent structures. Finally, we will develop ways to scale-up the size of the sorbent monoliths that can be 3D printed so we can produce sorbent structures that can be used as drop-in replacements for packed sorbent beds such as those found in the Carbon Dioxide Removal Assembly (CDRA) on the International Space Station (ISS).
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA aims to use the 3D-printed sorbent beds as drop-in replacements for packed sorbent beds that are currently used in the Carbon Dioxide Removal Assembly (CDRA) on the International Space Station (ISS). It has the benefits of providing equivalent system mass reductions due to better thermal and fluid management and mass transfer properties.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

3D sorbent printing methods and techniques developed here will directly be applicable to other non-NASA applications, such as for use as a catalytic filter for indoor air quality management. The techniques can be easily adopted for other sorbent families such as metal organic frameworks and high silica zeolites.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z1.05-2519**

SUBTOPIC TITLE: Lunar and Planetary Surface Power Management and Distribution

PROPOSAL TITLE: Prototyping 12.5KW Hall Thruster Discharge Power Supply Paralleling 2.25KW Rated Discharge Modules

Small Business Concern

Firm: **Colorado Power Electronics, Inc.**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The proposed research is the follow up activity for our 2019 80NSSC19C0390 SBIR award. We performed an analytical work that helped us to properly select a way to parallel our existing 2250W Discharge modules developed for CPE HiVHAc PPU contract. The analysis that was done in 80NSSC19C0390 SBIR convinced us that our existing modules can operate in parallel, controlled from the master module. Analysis shows that any discharge module in the system can be configured as a master or as a slave to allow redundancy. Any module that operates as a slave can be dynamically turned ON or OFF to optimize system efficiency. The analytical package for CPE HiVHAc PPU 2250W Discharge module and the electrical test data for the module are readily available now. The module is implemented using flight grade components. NASA GRC is going to perform its Thermal/Vac test of that module (4500W HiVHAc PPU) in 2021. Above statements convince us that CPE 2250W Discharge module could be used as a very good building block for any Hall Thruster PPU that requires Anode power output scalable from 4.5KW (2 modules, refer front page of the proposal) to at least 13KW (6 modules) . The proposed solution provides continuously regulated output in the voltage range between 200V and 700V (13KW power range is 300V to 700V) in the wide input voltage range of 95V to 140V or 150V. We would like to test a full scale Anode supply solution in Phase I of this SBIR and make 13KW Brass Board available to NASA GRC for integration test with high power thrusters. The biggest benefit of this solution that we are going to use is our HiVHAc PPU 2250W discharge modules ASIS. This may help to reduce analytical work for the future high power applications. Design work as well could be reused.

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

The NASA application that can immediately benefit from this discharge supply solution is HERMeS thruster since we have compatible voltage output. We will be able to drive H6 or H9 thrusters (JPL) using this discharge supply as well with limited to 700V output voltage range.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Our scalable solution could be offered to use with any commercial HET, scalable from 4500W to 13 KW by adding or removing modules. Two modules solution will be tested with HiVHAc and SPT140 thrusters. Our 4500W PPU can also derive XR5 (Aerojet).
Duration: **6**

PROPOSAL NUMBER: 21-1- **A2.02-2555**

SUBTOPIC TITLE: Enabling Aircraft Autonomy

PROPOSAL TITLE: Enabling Aircraft Autonomy

Small Business Concern

Firm: **Nokomis, Inc.**
Address: **310 5th Street, Charleroi, PA 15022**
Phone: **(412) 650-6236**

Principal Investigator:

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Business Official:

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Address: **310 5th Street, PA 15022 - 1517**
Phone: **(724) 483-3946**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

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

Any transient high stress events can affect the ongoing health and safety of the system and require a system which can unobtrusively monitor the electronic health of the critical systems in real-time to prevent system failure or unsafe conditions. Nokomis' approach to identify functionality and health diagnostic data relies on identifying changes in unintended RF emissions and characterizing them using a hybrid of spectral quantification metrics and machine learning algorithms. Nokomis proposes to create a system which can autonomously monitor system and subsystem health to identify possible critical failures or unsafe states and monitor electronics with no a priori knowledge to detect meaningful variations from emissions baseline indicative of critical states. This will allow for more efficient and direct reaction to critical states and allow for countermeasures to protect the system prior to system failure. The autonomous nature of the system addresses trends towards unsafe states without relying on operator response.

Most electronic devices have precipitous changes in emissions when under a stress state indicative of system degradation which can rapidly lead to system faults. When the frequency spectrum data is processed via algorithms to quantify these changes, the signal extracted by analysis algorithms clearly differentiates between safe and stressed system states. In this effort, Nokomis will develop a methodology to allow for the fault monitoring of electronics without a priori knowledge of the emissions of a standard condition. The proposed effort will autonomously discriminate these critical system faults from changes in emissions related to background changes, normal changes in operation, or expected normal wear.

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

The primary application of this technology is use by unmanned vehicles to provide a safety system to identify any threats to vehicle performance and mission. Safety and reliability of electronic subsystems and equipment is crucial to the success of a space mission, as failure of a single component can lead to a catastrophic failure or cripple mission. The real-time threat analysis system

will enhance vehicle safety without the need for an operator to either identify issues or initiate measures to compensate for unsafe operating states.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Nokomis has identified a significant need in the commercial market for autonomous vehicle, especially drone, safety. As the drone market is rapidly expanding, the detection of safety faults and avoiding critical failures will be an important factor in the wider implementation of UAS in commercial applications such as law enforcement, surveying, precision agriculture, and commercial delivery.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z4.04-2969**

SUBTOPIC TITLE: Real-Time Defect Detection, Identification, and Correction in Wire-Feed and Fused-Filament Additive Manufacturing

PROPOSAL TITLE: Enhanced Process Control of Electron Beam Additive Manufacturing

Small Business Concern

Firm: **Sciaky, 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):

Sciaky has been witness to a number of process deviations that have resulted in component defects. One such “defect” is related to metal vapor condensate contamination. One of the benefits of the EBAM process is its efficient use of power as well as the high purity vacuum environment. These process characteristics allow EBAM to provide fast deposition speeds that in many cases lead the industry. One side effect of this high deposition rate with the vacuum is that the raw material is often vaporized at a high rate as well and this metal vapor condenses back into solid form on surfaces local to the process. Over time the condensate build up can become substantial and occurrences have been observed where the condensate gets dislodged and can fall into the melt pool. Sciaky has learned that in the case of EBAM deposition targeting Ti-6Al-4V, the condensate is made up of predominantly aluminum. This issue is a well-documented concern when processing alloys with elements having various vapor pressures in a high vacuum environment. If the condensate becomes entrapped within the molten pool, the local area no longer achieves the target chemistry or metallurgical properties. There has been at least one instance where the condensate provided a crack initiation site that resulted catastrophic failure of a preform in response to residual stress buildup.

Our phase 1 approach will target the real-time identification of metal condensate events, document the location of detected events and provide the basis for corrective action avoiding the scrapping of a part. This proof of concept shall provide the basis for a series of other identified defects to be addressed via a machine learning approach that may include material contaminants, process interruptions, gross lack of fusion type defects, large porosity and potentially others as the approaches get refined.

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

With the additional capability of in situ monitoring and real-time defect detection and identification being coupled with Sciaky's closed-loop control, EBAM can provide solutions for countless NASA applications. These applications include but are not limited too: aerospace (lightweight components, often titanium), onsite fabrication, and on-demand production of customized unique components with minimal postprocessing.

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

With the vast majority of Sciaky's customer base being affiliated with Aerospace, Space, & Defense, the potential applications are very similar to potential NASA applications. Sciaky's EBAM technology is capable of depositing any autogenously weldable alloy available in wire-feedstock, including refractory materials often used for high temperature/speed applications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.04-2891**

SUBTOPIC TITLE: Electrified Aircraft Propulsion

PROPOSAL TITLE: Structural Supercapacitors for Energy Storage in Airframe Components

Small Business Concern

Firm: **Structured Ions, LLC**
Address: **10479 South 86th East Avenue, Tulsa, OK 74133**
Phone: **(918) 706-9618**

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):

In this Phase I SBIR proposal, Structured Ions, LLC, will develop and demonstrate a structural supercapacitor that synergistically provides both structural load-bearing capabilities and electrical energy storage and distribution capabilities. The proposed structural supercapacitor is based on carbon-fiber--epoxy composite laminates suitably modified to provide the required multifunctionality of electrical energy storage in load-bearing aerospace structures. These multifunctional structural supercapacitors provide increased operational parameters in electrical propulsion aircraft without introducing parasitic weight by using batteries. Thereby, Structured Ions, LLC, provides a key enabling technology for commercial development and deployment of both unmanned and manned aircraft powered by electrical propulsion.

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

NASA applications included manned and unmanned aerial systems powered by electrical propulsion. This includes cargo and passenger transport electric airplanes, and UAVs for payload delivery, surveillance, data gathering, and weather monitoring applications

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

Non-NASA applications include power storage for portable electronics, automotive panels for electric vehicles, UAVs for payload delivery and recreation, UAVs for law enforcement, DoD, and other security applications, and electric aircraft for urban air transport.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.04-1405**

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

PROPOSAL TITLE: F-band Solid-State Power Amplifier (106-114 GHz)

Small Business Concern

Firm: **Quinstar Technology, Inc.**
Address: **24085 Garnier Street, Torrance, CA 90505**
Phone: **(310) 320-1111**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 5

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

QuinStar Technology proposes to develop an efficient, GaN based solid-state power amplifier (SSPA), operating over the 106 to 114 GHz with 4-W output power and power-added efficiency (PAE) > 25%, for the Scanning Microwave Limb Sounder on the Global Atmospheric Composition Mission and the SOFIA (Stratospheric Observatory for Infrared Astronomy) airborne observatory. The proposed amplifier will drive the LO multiplier chain for mixers in the submillimeter-wave detector. QuinStar plans to meet the power and efficiency goals of this program by employing a combination of state-of-the-art (SOA) GaN device technology, innovative circuit design techniques and power combining techniques. We plan to design the MMIC amplifier in a quasi-switching mode with high-Q matching networks implemented on chip. Second, for improved efficiencies, we are proposing to limit the MMIC power level to about 1 watt and use high-efficiency waveguide circuit combining techniques to achieve higher power levels. For this, we propose to use a high-efficiency, 4-way H-tee combiner. Computer simulations show that this approach is capable of realizing combining efficiencies of greater than 95%. QuinStar is the leader in power combining techniques at millimeter-wave frequencies. We have developed both radial and E/H-plane waveguide combiners with SOA power levels and efficiencies in the past decade.

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

NASA Earth Science missions require submillimeter-wave remote sensing instruments to monitor air quality, climate variability and change, ozone layer stability, weather, and the global hydrological cycle. Due to its shorter wavelength, submillimeter-wave sensors can provide enhanced resolution over lower frequency sensors. A key enabler for this technology is an F-band (106-114 GHz) solid-state

power amplifier (SSPA) capable of providing 4-W output power and power-added-efficiency as high as 25% such as the one described in this proposal.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Applications of the W/F-band high-efficiency amplifier technology abound at agencies ranging from helicopter landing and obstacle detection/avoidance radars to cloud radar, UAV, and DoD's V/W-band (Hotspots) communications systems. Space-based applications include broadband RF cross-links communications constellations and long duration reconnaissance UAV missions in airborne.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z3.03-2606**

SUBTOPIC TITLE: Development of Advanced Joining Technologies, Large-Scale Additive Manufacturing Processes, and Metal Recycling Technologies for On-Orbit Manufacturing

PROPOSAL TITLE: Large structure repair via UAM

Small Business Concern

Firm: **TGV Rockets, Inc.**
Address: **2519 Benning Road Northeast, Washington, DC 20002**
Phone: **(301) 913-0071**

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):

Identification and Significance of Innovation: The goal of this program is to demonstrate the use of Ultrasonic Additive Manufacturing (UAM) for the repair of a damaged structure or to build a new structure. UAM allows for 3D printing metals in space with very low energy, relatively low pressure, low temperatures, and the flexibility to print a myriad of different metals and metal combinations. The ultimately envisioned end-product is a UAM ultrasonic weld head that incorporates metal material feed through while on a robotic arm. This will provide off earth repairs at 97% of original material properties.

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

NASA researchers have an interest for in-space welding capability that is autonomous, and which enables on-orbit servicing, assembly, and manufacturing. This is needed for longer space missions such as a lunar base and missions to Mars which cannot rely on Earth for easy replenishment.

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

Fabrisonic already has interest from a number of customers for a mobile ultrasonic repair system. There are a wide range of potential uses for all kinds of metals that degrade (e.g., corrode) in the field but which cannot get hot or be taken out of service. UAM has traction within the DoD-USMC for expeditionary repair and

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.03-2216**

SUBTOPIC TITLE: Future Aviation Systems Safety

PROPOSAL TITLE: System Wide Analysis Network for In-Time Safety Monitoring

Small Business Concern

Firm: **Robust Analytics**
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Phone: **(410) 980-3667**

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):

Our innovation offers NASA and the aviation community a robust, extensible data processing and analysis infrastructure that supports near-real-time (NRT) monitoring of safety metrics and predictive analytics. The **System Wide Analysis Network for Safety (SWANS)** will provide continuous measurement of risk precursors and events in terminal areas around the NAS. With updates every five minutes, SWANS will provide insight into safety margin trends and identify increases in risk events at specific locations. These changes may indicate changes in airspace risk status, and identify possible procedural or other deficiencies. Our innovation provides a data processing, distribution, and display infrastructure for adding other data sources and algorithms to measure and predict risk. SWANS can also accommodate Urban Air Mobility (UAM) and other non-traditional operations and their interactions with traditional flight operations.

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

The SWANS concept supports several NASA System Wide Safety (SWS) Project milestones: domain-specific safety monitoring and alerting tools; integrated predictive technologies with domain-level applications; and adaptive in-time safety threat management. SWANS delivers terminal area safety monitoring alerting and with planned development will enable predictive technologies in the terminal domain.

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

SWANS has commercial aviation benefits by giving operators an important, easy to deploy monitoring and analysis tool to identify operational risks. A SWANS capability in non-traditional airspace is also needed by industry, as the FAA has indicated that it does not intend to provide the constant airspace management and safety monitoring provided in traditional airspace.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H12.03-2293**

SUBTOPIC TITLE: Portable Spatial Disorientation Simulator - Trainer

PROPOSAL TITLE: 3WAVeS – Three-Axis Wearable Adaptive Vestibular Stimulator

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: 2
End: 4

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

The vestibular system is the primary biological method by which humans retain balance, spatial orientation, and both fine and gross motor skill coordination. One cause of vestibular alteration is a change to the gravity environment; this is particularly relevant to astronaut populations, who uniquely experience these gravity transitions in the temporal vicinity of atmospheric re-entry. As various issues with astronaut task performance were discovered to be due to vestibular alterations, significant research at NASA has focused on continued study of vestibular alteration, with specific focus on recreating these alterations via Galvanic Vestibular Stimulation (GVS).

In response to this need, Luna Innovations and partners propose the Three-Channel Wearable Adaptive Vestibular Stimulator, or 3WAVes. Development of 3WAVeS is enabled by Luna's low-power embedded physiological electronics expertise, integration of an existing three-channel GVS stimulation paradigm, and real-world input from SMEs. 3WAVeS is designed as a completely wireless, non-invasive head-worn device that contains all electronics and hardware to perform accurate three-dimensional, head-coupled GVS.

Multiple layers of built-in hardware and software safety cutoffs ensure that overcurrent is never applied to the user during stimulation. Kinematic stimulation coupling is provided by an internal inertial measurement unit (IMU), and a simplified user interface allows an operator to monitor and adjust stimulation parameters such as axial sensitivity and velocity coupling, as well as observing, recording, and exporting of stimulation data. Bidirectional communication between the user interface and the device is afforded by secure wireless communications protocol. The headset's compact, wireless, and self-contained form factor allows it to be used in a wide range of training environments. Additionally, a rechargeable battery permits un-recharged runtimes of 8+ hours.

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

The 3WAVeS System fits squarely into NASA's need for a portable, head-coupled disorientation trainer. 3WAVeS will be specifically designed for use in the Human Research Program's Sensorimotor Standards Project, but it could find significant use in other areas of Human Health Countermeasures, in the larger Human Research Program, or even within other branches of the Human Exploration and Operations Mission Directorate.

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

Vestibular disorientation is a major cause of aviation accidents in both military and civilian populations. Incorporation of disorientation-inducing 3WAVeS technology into initial and recurrent

safety training would allow both military and civilian pilots to become familiarized with a wide range of disorienting vestibular sensations in a completely safe environment.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z12.01-2467**

SUBTOPIC TITLE: Extraction of Oxygen and Water from Lunar Regolith

PROPOSAL TITLE: Sintering End Effector for Regolith

Small Business Concern

Firm: **Blueshift, 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):

NASA is requesting technologies for a sintering end-effector. Blueshift d/b/a Outward Technologies proposes to develop an end effector system for selective sintering of lunar regolith with sunlight that can interface with different types of solar concentrators. This Sintering End Effector for Regolith (SEER) will implement an innovative design that enables indefinite exposure to sintering temperatures and utilizes Outward's patent pending concentrated solar thermal control technology for delivering and maintaining temperatures within 1% of the set point. Benefits of the proposed innovation include precise temperature control for consistent sintering, resistance to damage from high temperature

exposure for prolonged use, 95% transmission efficiency across the spectrum of sunlight, up to 5x concentration enhancement, and a system that is lightweight and easily deployed. The Phase I effort will focus on the design, fabrication, and testing of the SEER system for sintering lunar regolith over long periods of time. Three key features will be developed and demonstrated: precision temperature control around the sintering temperature of regolith (1,100° C to within 1% of target), prolonged use at sintering temperatures (30 minutes non-stop in Phase I), and maximizing efficiency through testing various prototype design variables. Phase I will conclude with a demonstration of sintering a 2D shape into a bed on Lunar regolith simulant JSC-1A.

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

The primary application within NASA's technology roadmap for the SEER technology is TA7.1.4 for regolith sintering as well as TA7.1.3 for efficient heat and energy transfer from a solar concentrator for various thermal applications. As a system developed for solar additive manufacturing and construction, the SEER can be incorporated into several future unmanned NASA missions to near earth asteroids, the lunar surface, Martian moons, Mars orbit, and the Martian surface.

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

The SEER technology will be most useful anywhere that electrical infrastructure is not established and sufficient sunlight is available. The technology is ideal for enhancing Outward's solar additive manufacturing system under development and would be attractive to underserved communities in the US, in developing countries around the world, and in the burgeoning commercial space industry.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H9.01-3281**

SUBTOPIC TITLE: Long-Range Optical Telecommunications

PROPOSAL TITLE: Radiation-tolerant C-band Detectors for Free Space Optical Communications

Small Business Concern

Firm: **Amethyst 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: 2
End: 3

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

InGaAs photodiodes are widely available and are the standard detectors for optical telecommunication systems operating at 1300nm and 1550nm wavelengths. They are high performance detectors in ground-based applications, however InGaAs detectors are not suitable for space-based applications because their dark current performance significantly deteriorates during exposure to ionizing radiation. Literature reports indicate that over a several year space mission, InGaAs detectors' dark current can increase by a factor of 10 – 25 x, which increases power consumption and produces excess noise. An alternative to InGaAs is the semiconductor material GaSb. The two materials have similar bandgap energies leading to similar nominal performance characteristics, however GaSb has more favorably located fundamental defect energies than InGaAs, which will produce superior radiation tolerance through reduced defect-related dark current generation in the presence of space-based radiation.

This program will develop GaSb detectors with nominal performance equal to conventional InGaAs telecom detectors, but with greatly improved radiation hardness. The key innovation in this proposal is to assess radiation tolerance by considering defect-related energy levels in the detectors' semiconductor materials. The main defect level in InGaAs is at an energy of 0.46 eV above the valence band. This is near the middle of the bandgap, which from a dark current perspective is the worst possible scenario. In contrast, the main defect level in GaSb is at an energy of 0.26 eV above the valence band, which is sufficiently far away from midgap to enable significant reduction in defect-related dark current generation. This can be seen from the well-known equation for Shockley-Read-Hall generation, which shows that the electron-hole generation rate, and thus also the radiation-induced dark current, of InGaAs defects are more than 40 x times greater than those of GaSb defects.

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

The radiation-tolerant NIR detector technology developed in this program is broadly applicable to any mission or application requiring the ability to detect 1550nm photons in the presence of ionizing radiation. Examples of planned activities that would benefit from such free-space optical communications technology include the Laser Communication Relay Demonstration (LCRD), the Illuma -T Project, the EM-2 Optical to Orion (O2O) demonstration, and the DSOC Project technology demonstration hosted by the Psyche Mission spacecraft.

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

Amethyst predicts the technology will be disruptive in the NIR/SWIR imaging markets, where binary GaSb optical absorber material offers unparalleled pixel uniformity within a focal plane array. The practical outcomes are significant performance enhancements and relaxed manufacturing requirements which will result in a low-cost NIR/SWIR imaging technology with wide applicability.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H9.01-1372**

SUBTOPIC TITLE: Long-Range Optical Telecommunications

PROPOSAL TITLE: Optical Communication Array Transceiver

Small Business Concern

Firm: **Relative Dynamics, Inc.**
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Phone: **(410) 978-8210**

Principal Investigator:

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Business Official:

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Phone: **(301) 335-0491**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Relative Dynamics Inc. will develop an Optical Communication Array Transceiver (OCAT) with capabilities required in **NASA Subtopic H9.01: Long-Range Optical Communication.** Telescope arrays have advantages of lesser cost, improved diffraction-limited performance, slighter gravitational effects, scalability, ease of maintenance, and redundancy in operations. In addition, the use of multiple apertures adds additional benefits such as the ability to mitigate atmospheric fading with spatial diversity, to use small aperture size to reduce or eliminate AO complexity, to increment ground station collection area over time, to reduce cost, to remove a single point of failure, and to enable support for simultaneous communications links by federating the array to multiple targets. Our technical objective is to analyze and develop a monostatic duplex (transmit and receive) coherent transceiver array with new commercial coherent integrated photonics modems and mass production composite-structure telescope array elements. The innovations in OCAT are for both spaceflight and ground systems and the array concepts can selectivity be applied to coherent and direct detection systems.

Our innovative Koester's prism precision wave-front and angular sensor enables closed-loop control of (1) transmitter collimation (receiver focus) and (2) fine-pointing. The prism sensor samples the edge of the beam.

Carbon fiber composites have high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion. Continuous-carbon-fiber rivals

beryllium in the key parameters of specific stiffness, and both transient and steady state thermal stability due to its much lower coefficient of thermal expansion (CTE). Our high-strength-to-weight ratio continuous carbon fiber structures will be manufactured by a world-leader composites manufacturer that is leveraging a multi-million dollar 5-year DARPA-sponsored automated manufacturing project.

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

Scalable versions of the innovations in the Optical Communication Array Transceiver (OCAT) will enable future data volume returns to and from space missions in multiple domains with return data rate (up to 100 Gbps) and distance (up to planetary) trade-offs. The innovations in OCAT are for both spaceflight and ground systems and will also enable navigation services (ranging, Doppler, and pointing knowledge) for NASA missions. Optical ground terminals are much smaller than RF ground terminals for a given data rate and data volume capability.

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

SpaceX, Google, Facebook, Amazon, Airbus and other large companies are pursuing High Altitude Platforms and very large (thousands) LEO satellite constellations for global internet deployment. This is a key commercial market for low-cost high-data-rate optical communication terminals. The monthly data for video is expected to increase to 38.1 million TB by 2021 from 4.4 million TB in 2016.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S2.03-1664**

SUBTOPIC TITLE: Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical and Infrared Telescope

PROPOSAL TITLE: Thermal Expansion Mapper

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. Vyacheslav Lebedev**
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Address: **1891 North Gaffey Street, Suite 224, CA 90731 - 1270**
Phone: **(310) 935-2206**

Business Official:

Name: **Mr. Alex Kolessov**
E-mail: **kolessov@hedgefogresearch.com**

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Phone: **(310) 935-2206**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

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

The proposed innovation is aimed at the Focus Area 10 Advanced Telescope Technologies, subtopic S2.03 Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical and Infrared Telescope (Scope Title: Fabrication, Test, and Control of Advanced Optical Systems). Hedgefog Research Inc. (HFR) proposes to develop a new Thermal Expansion Mapper (TEM) providing rapid, nondestructive characterization of the coefficient of thermal expansion (CTE) homogeneity in 4-m-class Zerodur and 2-m-class ULE mirror substrates. TEM sensor, employing almost exclusively COTS sub-components, is capable of measuring CTE at multiple locations to sub-ppb/K uncertainty with spatial sampling on a 100×100 grid. In principle, TEM technology has the potential to far exceed the requirement of this solicitation by reaching sub-mm^2 spatial resolution and 10 ppt/K uncertainty of CTE (ppt: part per trillion). This new characterization capability will allow selection of mirror substrates before they undergo costly manufacturing process to turn into lightweight space mirrors for NASA's telescopes.

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

NASA applications for TEM are mainly focused on fundamental physics research, characterization of large and small optics and, possibly, aerospace components. In essence, TEM provides a simple and ultrasensitive approach to mapping the CTE of various components, small and large in size, by employing a novel sensing scheme while leveraging mature commercial technologies. As the result, HFR's approach promises a low-cost, versatile solution not just to NASA but all branches of the Government and numerous Government contractors.

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

Commercial applications of the proposed technology include optics characterization, materials for aerospace, automotive, semiconductor industry (EUV lithography) and, possibly, medical instrumentation industry. All these applications require mapping of the inhomogeneity of CTE. Additionally, TEM technology will find uses in micro-optics.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.04-1861**

SUBTOPIC TITLE: Integrated Science Mission Modeling

PROPOSAL TITLE: Observation Planning in Spaceline

Small Business Concern

Firm: **Ascending Node Technologies, LLC**
Address: **2548 East 4th Street, Tucson, AZ 85716**
Phone: **(520) 314-5595**

Principal Investigator:

Name: **John Kidd Jr.**
E-mail: **john@ascendingnode.tech**
Address: **2548 East 4th Street, AZ 85716 - 4416**
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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):

Observation planning for any NASA mission is essential for demonstrating a spacecraft's ability to achieve goals, whether the target is Earth or any other astronomical body. As demands have grown, so has the fidelity, complexity, and precision of spacecraft observations. In addition, modern spacecraft communications bandwidth allows for the transmission of more data than ever. These increased capabilities have placed extra demands on spacecraft science observations. Although creating observation plans is usually relegated to the flight operations period of a mission, teams can benefit by considering these observation designs during early stages of mission planning as well. Collaboration between science teams and operations teams requires a complex web of cumbersome technology for sharing and integrating observation plans and their resulting data. This significant complexity hinders the ability of responsible parties to make informed, sensible, and rapid decisions. Spaceline solves this problem with an application that every party involved can access. Additionally, Spaceline's flexible access allows users of both browser-based GUI or WebAPI to work with Spaceline directly or link Spaceline to their own tools, maintaining a known provenance for every kernel.

We propose to extend the core functionality of Spaceline from supporting only pre-compiled observation plans to allowing users to create observation plans directly within Spaceline. The expanded capability will require an additional user interface. Users will define a collection of components including points, vectors, and coordinate frames that define the explicit attitude targets of an observation plan.

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

Our proposed addition of observation planning 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: 21-1- **Z7.06-1879**

SUBTOPIC TITLE: Entry, Descent, and Landing (EDL) Terrestrial Testing Technologies

PROPOSAL TITLE: Laser Absorption Imaging diagnostic system for arc jet facilities

Small Business Concern

Firm: **Opto-Knowledge Systems, Inc. (OKSI)**
Address: **19805 Hamilton Avenue, Torrance, CA 90502**
Phone: **(310) 756-0520**

Principal Investigator:

Name: **Jason Kriesel**
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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 the development of a Laser Absorption Imaging (LAI) diagnostic system, with a design that is specifically optimized for NASA arc jet facilities. We will exploit advances in high-speed infrared cameras and rapidly tunable lasers to image a range of species in the mid-wave infrared spectral range. The spectral / spatial / temporal data will provide needed empirical information. In Phase I, a breadboard system will be assembled, and proof of concept measurements conducted to demonstrate temporally and spatially resolved gas property measurements. Based on the investigations, specific techniques and components will be down selected and risk mitigation

strategies developed, culminating with the design of a multi-species prototype that will be fully developed and demonstrated in Phase II.

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

The gas imaging sensor will be developed to support testing at NASA Arc Jet Facilities(AJF). AJF support Entry and Descent/Entry, Descent and Landing missions, e.g. crewed Moon or Mars missions, high mass Mars landers, Venus and gas/ice giant probes. These missions require testing and qualification of Thermal Protection Systems(TPS). Only AJF provide ground-based simulation of flight entry conditions and are critical to the TPS development. The Space Technology Mission Directorate's Entry Systems Modeling Project will benefit from this effort.

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

Sensors from this project will provide an extremely attractive alternative to existing gas diagnostics for a wide range of commercial applications. The ability to obtain high-speed, spatially resolved species concentrations and temperature information will be used to develop products for rocket engines / burner performance diagnostics, and fence-line monitoring of industrial facilities pollutants.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.05-2505**

SUBTOPIC TITLE: Fault Management Technologies

PROPOSAL TITLE: Robust Simulator for Fault Management in Systems-of-systems of Multiple Nodes

Small Business Concern

Firm: **Ridgetop Group, Inc.**
Address: **3580 West Ina Road, Tucson, AZ 85741**
Phone: **(520) 742-3300**

Principal Investigator:

Name: **James Hofmeister**
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Business Official:

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Phone: **(520) 742-3300**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Ridgetop Group shall investigate and prove the feasibility of designing, developing, and proving a Robust Simulator for Fault Management (FM) in Systems-of-Systems having Multiple Nodes; (1) each system representing one or more line-replaceable units (LRU); (2) each LRU comprising one or more data nodes; (3) each data node producing a characteristic waveform related to a classified fault based on physics-of-failure (PoF); (4) signature data extracted with or without digital signal processing such as data fusion, domain transforms, and progress from a state of 100% health to a state representing 0% health or functional failure as defined by no longer operating within specifications; (5) onset of degradation at each node beginning at any time by specification; (6) period of time from onset of degradation to functional failure by specification or random selection; (7) each failure level having a specifiable level of effect on system criticality and specifiable levels of alerts and actionable specifications; and (8) each node being processed to produce prognostic information such as estimates of remaining useful life, prognostic horizon, and state-of-health.

The proposed simulation tool shall incorporate advanced techniques and methods in the specification, generation, and processing of faults from onset of degradation to functional failure, estimating prognostic information, distribution of failures, and effect on mission criticality. Examples of those techniques and methods include the following: (1) artificial intelligence, case-based reasoning, knowledge-based models, and machine learning; (2) models based on PoF analyses; (3) use of well-known distributions such as Gaussian, Poisson, and Weibull to select when faults begin and end; (4) time-of-event setting by specification and/or random selection; (5) selection and level-setting for alerts; (6) alert actions; and (7) extendible and flexible architecture in the design and implementation of the simulator.

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

The proposed FM simulator has applicability to all NASA systems for which FM applies: Vehicles= land, air, sea, space. Any complex system having data nodes monitored for signal changes indicative of damage leading to increasing levels of degradation and eventual failure.

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

The proposed FM simulator has applicability to all NASA systems for which FM applies: Vehicles= land, air, sea, space; structures; manufacturing plants; electrical power; space. Any complex system having data nodes monitored for signal changes indicative of damage leading to increasing levels of degradation and eventual failure.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H10.01-2913**

SUBTOPIC TITLE: Advanced Propulsion Systems Ground Test Technology

PROPOSAL TITLE: Processing of Refractory Metals for Extreme Temperature Testing

Small Business Concern

Firm: **Transition45 Technologies, Inc.**
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Phone: **(714) 283-2118**

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):

Traditional manufacturing of refractory metal products by machining mill products results in considerable material waste and long lead times while placing limitations on their microstructures and properties. The high cost of these materials and the difficulty in processing them from start to finish further restricts their use. Forging of near-net shape parts can potentially reduce material waste, shorten cycle times, and improve properties, which would open up many additional applications in current markets. Refractory metals can be hot forged but traditional forging of W requires temperatures up to 3000°F. These temperatures, however, limit tool life, require protective atmospheres to prevent severe oxidation, and result in relatively poor properties. This SBIR Phase I work will demonstrate a novel manufacturing process to form refractory metals and alloys at much lower temperatures that presently possible. A lower temperature process will ultimately be safer and less expensive, since less energy is needed and cheaper tool materials can be used and will last longer. Significant reduction in part costs will also be possible given that less starting material is needed and the amount of machining necessary will be greatly decreased given that the near-net shaping capability. The proposed technology will also allow for better microstructural control and therefore more robust properties, thus may enable this class of materials to begin to reach its full promise for extreme temperature use.

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

This program should result in higher performance, more affordable refractory metal/alloy parts for use in very high temperature hot zone structures and components such as advanced ground propulsion testing, reactor fuel elements, hot gas path nozzles, and thrusters for spacecraft. Other NASA applications include hot structures and heat shields (i.e., thermal protection system) for reusable launch vehicles and/or aircraft engines

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

Better, more affordable manufacture of refractory metals/alloys for use as: 1) very high temperature (hot zone) structures/parts for spacecraft/rocket propulsion, gas turbines, power generation (nuclear, fossil), and chemical process/industrial furnace equipment; 2) armaments and munitions; and 3) tooling for semiconductors, sputtering targets (e.g., flat panel displays), and medical imaging.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.12-2995**

SUBTOPIC TITLE: Remote Sensing Instrument Technologies for Heliophysics

PROPOSAL TITLE: Multichannel Thermosphere Ionosphere Photometer Scanner (MTIPS)

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

As a community, we are at a Tipping Point, where the needs and capabilities of different players have become aligned as follows: the development of small satellites, miniaturized instruments, and electronics is aligned with NASA mission needs, together with computational and algorithmic capabilities to handle large amounts of ionospheric/thermospheric data to produce a mission-applicable product. In this Phase I SBIR proposal for Topic S1.12: Remote Sensing Instrument

Technologies for Heliophysics, we describe our research plan to design a CubeSat-compatible instrument for imaging the ionosphere and thermosphere in ultraviolet light. The purpose of this imaging is to derive several key ionospheric environmental parameters (including electron density and ionospheric irregularities) and thermospheric composition (column O/N_2). Images of the irregularities or “bubbles” are more useful than a single line measurement (or 1-D cut) through the same bubble feature because an image permits the geographic extent of the irregularity and its motion to be deduced. The proposed instrument, called Multichannel Thermosphere and Ionosphere Photometer Scanner (MTIPS), will allow us to image the ionospheric and column O/N2 densities to gain valuable insights into the solar and magnetospheric forcing of our space environment. The MTIPS design will be flexible in its ability to accomplish the mission science objectives over a range of expected NASA-sponsored LEO CubeSat launch opportunities. The proposed research will establish the feasibility of CubeSats for UV remote sensing and develop a conceptual design of the MTIP payload.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

NASA has an interest in the accurate characterization of the ionosphere-thermosphere system for many applications, ranging from spacecraft charging to communications. We expect that the data from MTIPS instruments will provide complementary data to the NASA GOLD and ICON missions. Future NASA missions would also benefit from the development of the MTIP payload, the miniaturization of the imager in this project would be able to be transitioned for future NASA CubeSat and SmallSat missions.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The small size, weight, and power of the proposed MTIPS instrument mean that it could easily fly on CubeSats. MTIPS will obtain useful data from almost any Low Earth Orbit (LEO) mission, ranging from three-axis stabilized to spinning. This versatility makes it attractive to a number of different agencies, including the US Air Force, US Navy, and NSF.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.01-1748**

SUBTOPIC TITLE: Technologies for Large-Scale Numerical Simulation

PROPOSAL TITLE: Low Cost, Low Power, Low Latency 1602 nm 100 Gbps NRZ Laser–EAM for a 7.2 Tbps Transmitter.

Small Business Concern

Firm: **Photon Sciences, Inc.**
Address: **4520 Savino Drive, Plano, TX 75093**
Phone: **(214) 207-9427**

Principal Investigator:

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Business Official:

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Phone: **(214) 207-9427**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

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

Exascale computing for Large-Scale Numerical Simulation requires a new technology for optical communication. VCSEL based transmitters run out of bandwidth at 56 Gbps PAM4, and the latency of PAM4 is incompatible with exascale computing. Other available technologies are expensive, have high power consumption, are far from proven or they require PAM4 and temperature control. Our proposed concept integrates an Electro-Absorption Modulator (EAM) with a laser capable of >> 100 Gbps/channel NRZ which can be arrayed to > 1.2 Tbps for a 12 element array and using Course Wavelength Division Multiplexing (CWDM) with 6 wavelengths can reach > 7 Tbps. Using NRZ instead of a more complex format (e.g. PAM4) reduces latency dramatically. The proposed device can operate over a wide temperature range, at least 20C to 100C and potentially over the full military range (-55C to 125C) without temperature control. The characteristic which distinguish our device from traditional Laser-EAM solutions is the extremely short, high absorption, low capacitance EAM which allows significantly higher data rates, lower power and operation over large temperature ranges so TE coolers are not needed. The SE Laser-EAM has a 50% (0.3 pJ/bit vs 0.6 pJ/bit) reduction in power per bit compared to VCSEL solutions. The proposed low cost device can be manufactured by the billions. The SE Laser-EAM array can be flip-chip mounted onto silicon. This unique device has ten times the reach of VCSELs, more than sufficient for any data center or exascale computer. Further, our proposed device has the inherent capability for 300 Gbps NRZ (600 Gbps PAM4) when packaging and IC driver technologies are available.

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

As the HPSC needs of NASA grow with exascale computing latency, bandwidth, power consumption and footprint ultimately limit the computing performance. The proposed transmitter with the novel SE Laser-EAM solves the latency problem as well as the bandwidth, footprint, and power consumption problems of optical communications in Exascale computing. This is vital to the success of NASA's mission to accelerate delivery of a capable exascale computing system delivering approximately 100× the performance of current systems.

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

Data centers and HPSC in the US continue moving to single mode fiber data links, and the requirement for low cost, high speed optical transceivers is driving a multibillion dollar component market. The direct sales of our laser/EAM based transmitter would go to optical transceiver integrators such as Menara Networks, Advanced Optical Interconnects (AOI), II-VI, Broadcom and Lumentum.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.08-1823**

SUBTOPIC TITLE: Aeronautics Ground Test and Measurement Technologies

PROPOSAL TITLE: Surface Mount On-blade Optical Telemetry System (SMOOTS)

Small Business Concern

Firm: **Continuum Dynamics, Inc.**
Address: **34 Lexington Avenue, Ewing, NJ 08618**
Phone: **(609) 538-0444**

Principal Investigator:

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Business Official:

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Phone: **(609) 538-0444**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

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

Engineering development and certification testing of new Advanced Air Mobility (AAM) concepts will require measurement of rotor and propeller properties to validate predicted loads and assure operational safety of these systems. These AAM configurations employ multiple distributed rotors and propellers, driven by electric motors, presenting a measurement challenge if they are to be simultaneously monitored during a test program. While wireless RF telemetry provides a potential solution to this problem, issues with multipath and signal interference still limit the application of this technology to a few data channels. This effort will expand upon a customized optical telemetry system developed in support of extracting rotor-mounted sensors that provides synchronized burst transmission of data between optical transducers that come into alignment at least once every revolution of the rotor or propeller blade. Design modifications are suggested to make the unit, previously developed for helicopter main rotor use, applicable for installation on AAM vehicles with their smaller diameter rotors that rotate at higher rates. The units promise to make instrumentation for wind tunnel or flight test on these multi-rotor aircraft easier, with significantly reduced size, weight and power requirements over existing conventional techniques.

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

NASA applications would directly benefit from having access to a wider spectrum of available test data from rotating components, supporting both wind tunnel and flight test programs and furthering research on AAM aircraft as well as conventional rotorcraft. Installed optical telemetry hardware would avoid RF interference that plagues extensive use of RF wireless instrumentation systems.

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

Small form factor instrumentation with optical links to non-rotating surfaces could support a health and usage monitoring system, providing real-time rotating frame stresses, displacements, and other indicators of applied loading conditions. DoD applications could include wind tunnel and flight qualification testing, as well as support various research programs in aeromechanics modeling.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.12-2472**

SUBTOPIC TITLE: Modular and Batch-Producible Small Spacecraft

PROPOSAL TITLE: Modular and Batch-Producible Small Spacecraft

Small Business Concern

Firm: **Vistacent, LLC**
Address: **111 Veterans Memorial Boulevard, Suite 1600, Metairie, LA 70005**
Phone: **(504) 405-3386**

Principal Investigator:

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Business Official:

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Phone: **(504) 831-1900**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Vistacent, LLC, proposes to develop modular open systems architectures for SmallSats/CubeSats. SmallSats/CubeSats are quicker/cheaper to develop than their larger predecessors. The primary bottleneck has been a lack of standards in the type of subsystems being offered in form, fit, and function. Standardization would go a long way to improve the mission success and reduce development time and cost of a CubeSat. Payload developers spend >50% of their time/resources on

creating a satellite bus system instead of on development of the sensor/device, the data from which is the primary rationale for the mission. Attempts have been made to create standardized systems, interfaces, and even materials for SmallSats/CubeSats. However, there has not been a universal acceptance for these “yet to be finalized” standards. The perception exists that those involved in trying to establish certain requirements are focused on specific CubeSat architectures that are in their immediate portfolio. For this proposal, Vistacent is defining “standardization” of the modular units as the basic CubeSat structure to allow structural and electrical standard connectivity between modules. Vistacent proposes to 3D print modular “building blocks” for a complete architecture. This “standardization” will also allow COTS components to be “plugged-in” or “hot-swapped” to the modules. With the addition of rails or tabs, a CubeSat will be able to adapt to any current dispenser. NASA wishes to have a fabrication method to facilitate mass/batch production of CubeSats. The current market of SmallSat/CubeSat system components will be reviewed/assessed to determine system compatibilities. These components will be grouped together into building block functional groups. Modification of our existing 3D printing software will allow innovative solutions such as embedding electrical circuitry for each module in the module walls. This will allow effortless integration of COTS items with standardized CubeSat modules.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

From first-hand experience three recent NASA CubeSats could have been developed for a fraction of their $30+ million budgets, if modular building blocks were available. NASA will benefit from Vistacent’s approach by mass producing modular CubeSat blocks using 3D printing, significantly lowering development cost and time for NASA CubeSat missions. The resultant reduction in cost and schedule will enable NASA to leverage more launch opportunities and put more mission-critical payloads in orbit.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Vistacent recognizes the effectiveness of the proposed modular approach for mass production. The military is becoming a strong user of CubeSats with the ability to fly large constellations. Our approach will be very adaptable and scalable to such military needs. Leveraging 19.8% growth expected in the future, Vistacent will facilitate payloads for the private sector and educational institutions.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z13.01-2510**

SUBTOPIC TITLE: Active and Passive Dust Mitigation Surfaces

PROPOSAL TITLE: Modal Optimized Vibration dust Eliminator (MOVE)

Small Business Concern

Firm: **Paragon Space Development Corporation**
Address: **3481 East Michigan Street, Tucson, AZ 85714**
Phone: **(520) 903-1000**

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):

Paragon proposes an active dust mitigation system for thermal radiators that uses vibrational excitation at targeted modal frequencies to mitigate dust adhesion with the assistance of passive dust mitigation coatings.

NASA is advancing multiple space exploration missions to planetary bodies with the near term goal of returning to the Moon and lunar dust is of particular concern. The lunar surface is, and has been, bombarded with a range of micrometeorites that create a relatively fine dust powder on the surface that is easily agitated, has sharp structural edges, and is charged by photons and solar winds. This combination allows for and even generates fine, charged clouds of dust that coat and obscure structures on the lunar surface. This includes the necessary structures for thermal regulation, thermal radiators.

Thermal radiator systems are commonly cantilevered panel structures designed to extend beyond a main structure to increase the surface area utilized for the absorbance or emittance of thermal radiative energy. Dust buildup on thermal regulators can greatly decrease thermal performance by simultaneously increasing solar absorptivity by darkening the surface and decreasing effective emissivity by adding a low-conduction layer on top of the surface. To help with dust mitigation on structures like thermal radiators, Paragon proposes a Modal Optimized Vibration dust Eliminator (MOVE) as a low cost solution to NASA's desire for dust mitigation on the lunar surface.

The proposed innovation is a two-part lunar dust mitigation solution which utilizes autonomous, active vibration at modal frequencies coupled with an anti-static coating to minimize the performance reduction caused by lunar dust accumulation on radiative surfaces and panels. The vibration system component is used to loosen and move lunar dust particles off of radiative surfaces to improve thermal radiator performance.

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

Direct NASA applications of dust mitigation techniques on radiators include human-piloted and autonomous rovers, Lunar decent and ascent vehicles, and surface-installed static equipment. Radiators are highly tailorable for different applications, which yields its use to nearly every application requiring the rejection of heat from electronics or power sources.

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

The challenges for NASA and commercial missions related to accumulation of dust on radiator surfaces are similar. Accepted and successful applications for NASA missions would be directly transferable to commercial lunar missions. Potentially, there will be more commercial applications due to diversity in mission objective and the nature of market competition.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H6.23-2564**

SUBTOPIC TITLE: Spacecraft Autonomous Agent Cognitive Architectures for Human Exploration

PROPOSAL TITLE: ADAPtive agenT Architecture

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):

We are proposing a cognitive agent architecture that leverages Interactive Machine Learning, which will allow ground controllers and crewmembers the ability to train and retrain their cognitive agents during a mission based on new/novel mission data. Interactive Machine Learning (IML) is a human-centered paradigm in which end-users, e.g. crewmembers and ground-based Subject Matter Experts, iteratively build and refine the ML model through iterative cycles of input and review. Model refinement is driven by user input that may come in many forms, such as onboard data and communications, crew preferences, modified mission parameters along with a description of features and selection of high-level model parameters. IML is distinct from classical machine learning in that human intelligence is applied through iterative teaching and model refinement in a relatively tight loop. With this approach, our goal is to develop an architecture that provides end-users with the ability to interactively explore and adapt the training space with the goal of guiding the adaptation of the cognitive agent toward an intended behavior. This approach will allow crewmembers the ability to control how the cognitive agent learns and adapts during a long duration exploration mission, assuring that its

performance improves and does not degrade over time. This work will present crewmembers and SME centered approach to applying IML methods to the design of a system that learns and adapts based on crewmembers inputs to the system. By leveraging IML we are able to address one of the primary challenges associated with the use of cognitive agents during a long-duration mission, the inability to adapt and learn from observation, instruction and interaction as missions proceed.

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

We expect the IML approach to developing training models for multi-agent assignment along with the ability for end-users to retrain the system will be of interest to a number of groups within NASA, e.g., Gateway habitat. Of course, future Mars expeditions could certainly make use of our cognitive agent, as those are the types of scenarios we've used in our development. In particular, our agent will be of interest at JSC to the EVA Exploration Office, the EVA Strategic Planning and Architecture group, and the Exploration Mission Planning Office.

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

The proposed cognitive architecture will benefit a number of TRACLabs commercial customers. For example, Baker Hughes has already expressed interest in licensing some of the new capabilities being developed in previous cognitive agent efforts, particularly the ontology and anomaly management aspects. We expect the ability for end-users to direct the adaptation of the system will be of interest.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z13.01-1244**

SUBTOPIC TITLE: Active and Passive Dust Mitigation Surfaces

PROPOSAL TITLE: Dust Tolerant Mechanisms Alpha Particle Emitter Coating System (APECS)

Small Business Concern

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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):

Lunar dust contamination poses one of the most difficult challenges to long-term lunar colonization. The dust is highly charged and highly insulating in a low gravity, vacuum environment that makes terrestrial dust mitigation methods inoperable. Passive coatings that can mitigate lunar dust have been based on friction reduction and do not address the electrostatic charges associated with the lunar environment. To remove static charge from the dust particles, the Alpha Particle Emitter Coating System proposes to apply a thin coating of Americium-241 to the surfaces of interested. Am-241 is a long-lived alpha emitter (432-year half-life) used for ionization in smoke detectors. This coating will supply positively charged alpha particles that can neutralize negative charges on the surfaces of the dust particles that attach to the surface. Furthermore, the coating would provide ionization to air used to blow dust off of surfaces in the lunar environment. These coatings would provide the long-lasting protection from lunar dust accumulation needed for repeat landings and habitation.

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

The APECS has the potential to create passive dust mitigation surfaces that can enable long-term operations on the lunar surface. As such, it stands to play a crucial role in the current Artemis mission to the moon, as well as for future missions to Mars and beyond. For terrestrial applications, the APECS could improve mixing and efficiency for pharmaceutical powder handling equipment. Currently, the electrostatic charge built up on the surface of pharmaceutical powders impedes homogenous mixing, resulting in uneven efficacy and performance.

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

Although static charge neutralization systems exist for pharmaceutical powders, none are passive in nature, requiring dedicated, high-voltage systems for operation. APECS could be applied directly to the mixing equipment surfaces to remove the need for auxiliary static charge neutralizing equipment, simplifying operations and reducing operational costs.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S2.04-3214**

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

PROPOSAL TITLE: A New Platform of Tunable Multispectral EUV Coatings

Small Business Concern

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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 a new platform of highly reflective tunable, multispectral, normal incidence, Extreme Ultraviolet (EUV) reflective coatings with a wavelength range 10-40 nm. The proposed innovation enables next generation EUV telescopic designs with higher magnification, high cadence, larger field of view and better imaging resolution using smaller EUV wavelengths. As humans extend their reach into space, understanding the nature of solar activity and the interconnected Earth-Sun system, as well as high resolution mapping of distant planets such as Pluto, and other potentially new exoplanets are needed to provide knowledge and predictive capabilities essential to the future use and exploration of space. New telescopes such THEIA or ATLAST or upgrades to the Heliophysics Hi-C imager will benefit from this technology allows more flexible telescopic design, lower cost, solar durable coatings with longer lifetimes and reduced cooling requirements and thermal and technical payloads. A single coating will be designed to have a reflective electromagnetic resonance for between 1-3 EUV wavelengths, with a peak wavelength that is tunable in the lower range of EUV wavelength regime, and individually observable by filtered detectors. Unlike traditional coating approaches, which have a single resonance for a given wavelength by exchanging the interplay of bilayer materials in a Bragg multilayer architecture for a limited set of wavelengths, we propose to use a single foundational material as the platform for all coatings, and controlling the design of the coatings to ultimately achieve highly reflective electromagnetic resonances at multiple different wavelengths tunable within the 10-40 nm regime to achieve multispectral imaging.

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

Astrileux coatings can enable advanced functionality and flexibility to normal incidence next generation telescopes used in space such as Richey-Chretien Telescopes, and all Cassegrain refracting and reflecting telescopes. Specific applications include the upgrades to the Heliophysics Hi-C imager, ATLAST or THEIA telescopes (if EUV coatings are deployed) and potentially Next Generation EUV High-Resolution Spectroscopic Telescope (for Solar-C) and on the NuSTAR optics replacements for grazing incidence coatings using synthetic materials.

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

Primary Non NASA Applications exist in carbon based coatings for EUV light sources, high harmonic generation sources and coatings for biological imaging the water wavelengths. Potential also exists

for next generation EUV Lithography for High NA Anamorphic magnification coatings and with wider angular range, next generation lithography tools using light of 6.7 nm and EUV Mask Blanks

Duration: **6**

PROPOSAL NUMBER: 21-1- **H5.01-2876**

SUBTOPIC TITLE: Lunar Surface Solar Array Structures

PROPOSAL TITLE: R-ROMA VSAT Pedestal

Small Business Concern

Firm: **Opterus Research and Development, 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):

Opterus proposes a trade study between two Solar Array Pedestal Tripod (Pedestal) designs, which are base architectures for the Opterus R-ROMA array for a lunar surface mission. The trade study will further develop the designs to determine which has the best performance, manufacturability, and operations.

The first design utilizes Opterus' high strain composite Trussed Collapsible Tubular Mast (T-CTM) booms and Recirculating Deployer system. The T-CTM boom is a High Strain Composite structure

with a large diameter lenticular cross section and co-cured truss features. Testing has been done to ensure the boom meets load requirements and matches finite element model predictions. The T-CTM is designed to withstand high compression and bending loads while maintaining the ability to flatten and stow compactly by spooling tightly inside the Deployer. The Deployer is a compact mechanical system that contains the motor that actuates extension and retraction. It is currently being developed to withstand lunar dust build up for multiple operational cycles. Both the T-CTM and its deployer are easily scalable for larger systems. This Pedestal design utilizes three T-CTM legs terminating to a foot.

The second proposed Pedestal design uses a simple 4 bar linkage. Each leg will be individually motorized for deploy and stow operations, with each leg fully extending to hard stops. Pinned joints will be tolerant to dust. The legs will stow by folding up and around the array while the feet package tightly under the system.

Both systems have similar CONOPs in that an autonomous rover transports the system to the site of operation, the rover arm or crane holds the stowed system in place and level above the surface, the legs deploy into position, and the rover arm or crane transfers the load to the Pedestal and releases the system. The systems are designed to operate autonomously on uneven terrain up to 15 degrees

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

NASA's Artemis I-III missions will require several high-power solar arrays for sustainable surface power on the Moon. Sustainable power is critical for powering landers, ISRU equipment, Lunar bases and rovers. All technology required for the Artemis missions will also be needed for further Mars expeditions. Additionally, SEP is critical for the Moon-Mars campaign for orbiters, tugs and deep space propulsion. These mission needs also align well with NASA's need for solar power technologies for the next decadal planetary science missions.

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

Following NASA's advancements for creating a sustainable lunar environment it is anticipated that the newly created Space Force will expand the DoD's presence on the Lunar Surface. Although, the Space Force presence is anticipated to be solely autonomous robotic systems and will not sustain huma presence, a sustainable and scalable source for solar power will still be necessary.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.01-2364**

SUBTOPIC TITLE: Lidar Remote-Sensing Technologies

PROPOSAL TITLE: Multi-Channel Long-Range Wind LIDAR

Small Business Concern

Firm: **Systems & Processes Engineering Corporation**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Advanced systems for wind sampling and measurement are a prime area for technical innovation. Applications range from atmospheric and climate modeling to aerospace vehicle design. Systems with higher temporal resolution and fidelity offer the ability to record increasingly transient atmospheric phenomena, leading to improved feedback for atmospheric modeling and for real-time adaptive systems for flight dynamics and wind power generation systems.

Systems & Processes Engineering Corporation (SPEC) proposes a Multi-Channel Long-Range Wind LIDAR system toward increasing the scan rate, and therefore the temporal resolution, of advanced Wind LIDAR systems. The proposed system scales up from an already-developed single-channel fiber optic based, eye-safe wind LIDAR, initially designed for UAV systems and brought to breadboard level through Army and NASA programs. The single-channel transceiver consists of a narrow band laser seed, acousto-optic modulator for frequency shift and pulse forming, a three-stage erbium-doped fiber amplifier, and a coherent receiver, all operating at an eye-safe wavelength of 1550 nm. The system electronics and computational stack are in PCIe/104 format, allowing miniaturized light-weight packaging suitable for small UAV applications and the entire range of commercial and military aircraft. This LIDAR allows air current Doppler detection beyond 3 km. The Wind Measurement LIDAR was originally designed to detect energy sources such as vertical uplifts, wind direction, wind gradients and transient gusts for optimal path determination for energy conservation in UAVs. By further developing the capabilities of this wind LIDAR system, specifically by increasing the channel count up to a targeted 32 channels, the overall system scan rate can be increased proportionately thereby improving the temporal resolution by up to 32x. Lockheed Martin Space and Rotary & Mission Systems divisions have provided a letter of support for this LIDAR program.

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

This multi-channel long-range Wind LIDAR will have far reaching impact for all NASA low altitude applications for UAVs and all aircraft for clear air turbulence and wind shear detection. Wind speed detection can also be used to optimize high altitude aircraft loitering to enhance mission duration. The small size, weight and power allow widespread platform applications. The unit can also be used to discriminate and track targets for obstacle/collision avoidance.

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

Improved atmospheric modeling data is useful to improve existing and future military and commercial aircraft design, aiding weather forecasting and scientists studying climate change, and find low turbulence flight paths or improve in-flight aeronautical stabilization. Lockheed Martin business divisions are supporting our roadmap and have provided a Letter of Support for this proposal.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.02-2205**

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

PROPOSAL TITLE: Swarm Array Coherent Combining (SACC)

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):

Over the last several years, the satellite landscape has seen the vast immergence of smaller and smaller satellites. These new satellite designs offer many benefits not only for science but also for reduced mission costs and increased mission robustness for exploration of our planet and beyond. Further, the notion of a 'swarm' of smallsats is being considered as a novel and useful way to do science and/or support the attendant communications. Swarm concepts—multiple satellites flying in formation near one another in similar orbits—are of growing interest, as a solution to the challenge of simultaneous measurement. However, communications for smallsats, and even more significantly swarms of smallsats, are challenged as a result of both the size limitations restricting available power for communications links, and the complexities of coordinating and collecting data from multiple spacecraft. JPL has explored the concept of an Earth receiver coherently combining the received deep space smallsat signals which each individually are too small to process. For the concept to succeed, each member of the swarm must phase its signal very accurately relative to all

other swarm signals. This proposal not only seeks to address the deep space application but also expands to include swarm scenarios with higher dynamics – thereby involving signals that are much harder to coherently combine. Our Swarm Array Coherent Combining (SACC) scenarios span the complete space of possible orbiting swarms and their links to include lunar and other planetary orbiting swarm. Anticipated results of the effort include a recommended SACC architecture, modeling and simulation of the architecture that demonstrates viability of the concept, and prototype design for Phase II demonstration.

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

Within the scientific community, there is growing interest in smallsat swarm operations for simultaneous measurement and observation, and NASA efforts are being applied to enabling swarm operations concepts as demonstrated by the NASA Ames support tool being developed to address control of satellite swarm. The swarm array coherent combining concept proposed here, will address not only deep space, but higher dynamic LEO swarms, as well as lunar missions which are anticipated to increase dramatically in this decade under the Artemis Program.

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

The commercial space sector has grown rapidly, with a majority of spacecraft launched being commercial, and many new businesses being developed around data and applications that rely on space-based observations. Commercial companies in the remote sensing sector for example, often fly constellations of small satellites to meet data collection and could benefit directly from this capability.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z1.06-2388**

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

PROPOSAL TITLE: Radiation-Tolerant High-Voltage, High-Power Electronics WBG Drain Engineered Transistor

Small Business Concern

Firm: **IceMOS Technology Corporation**
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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 project, we propose a 1200 Volt Silicon super-junction power transistor with a Silicon-

Carbide engineered drain to take advantage of the low on resistance performance from Wide Band Gap

(WBG) materials. By further merging high volume Micro-Electro-Mechanical Systems (MEMS)

manufacturing techniques to enable structures robust to harsh space radiation environments a new class of

vertical-power transistors are created. The merger of **S**JMOS structures-**M**EMS manufacturing techniques-

WBG material creates **SMW** concepts enabling devices that in this case have the potential to sustain 1200V

blocking with no heavy-ion-induced permanent destructive effects upon exposure to high energy radiation of

87 Mev-cm^2/mg while delivering Rdson of 90milliohms at ID max = 40A. IceMOS will partner with the

School of Earth and Space Exploration at ASU to develop and demonstrate a novel **SMW**

Silicon-Carbide Drain Engineered rad-hard super-junction Transistor.

Phase I of the project will include design modeling, device simulation and analysis of SJMOS structures

embedded in hetro-junction Si/Si C material to create a Silicon-Carbide WBG drain. This **SMW** concept

device will be designed to block 1200V with low on-resistance. Additionally, several radiation hardening

techniques applied to the Silicon super-junction structure and Si/Si C hetro-junction substrate to enhance

SEE and TID performance will be investigated. A 1200V SJMOS baseline device will be fabricated and

characterized for radiation effects.

In **Phase II** with the physical mechanisms limiting heavy-ion-induced permanent destructive effects upon

exposure to high energy radiation of 87 Mev-cm^2/mg now understood from phase I and addressed, a

device designed to be capable of 1200V blocking and high current handling (40A) will be fabricated. and

prototypes tested to demonstrate potential Rdson of 90 milliohms for improved power system efficiency.

Targeted radiation hardness performance is SEE = 87 Mev-cm2/mg and TID = 300 Krads for this device.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

High voltage power distribution on spacecraft allows designers to eliminate power conversion components, which would significantly reduce spacecraft volume and weight. Such power distribution systems require enabling innovative products for increasing operational lifetime, radiation tolerance, and reliability in the extreme space environment, the proposed **SMW** Transistor is novel device that will lead to smaller, lighter weight and more efficient power supplies for space systems.

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

Power electronic systems must be efficient, compact, and less costly to meet society's increasing demand in energy conservation. The key technology that delivers the performance required by spacecraft power systems is **SMW** Transistor. Commercial applications for these SMW devices include LED Lighting, AC/DC power stages in Data Centers Servers for Cloud Computing and Fast Battery Charging for EV.
Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.05-2469**

SUBTOPIC TITLE: Terrestrial Balloons and Planetary Aerial Vehicles

PROPOSAL TITLE: Plasma-based Wind Speed Sensor

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):

A trajectory control system (TCS) for high-altitude scientific ballooning has been a long-term goal of NASA's Balloon Program Office (BPO). One milestone in the critical path of TCS development is the ability to measure the speed of the winds seen by the gondola during a balloon mission. In addition, NASA has identified wind-speed measurements from a balloon explorer under the TX10.1.2 of the 2020 NASA Technology Taxonomy (see References below). Currently, the BPO has no method of measuring relative winds (wind speed relative to the gondola) in situ above ~15 km in altitude for terrestrial applications. The proposed innovation is a weakly ionized plasma based sensor concept that can measure three components of relative wind speed and meet or exceed the specifications outlined in the project scope document. The sensor concept leverages work Innoveering has been performing over the past 4 years under other SBIR efforts funded by the DoD and DoE on implementing glow micro electrical discharge plasmas as transduction mechanisms for aerodynamic property measurement targeting harsh environment applications.

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

The proposed relative wind sensor solution will provide a unique measurement capability for high altitude balloon operation. A trajectory control system (TCS) for high-altitude scientific ballooning has been a long-term goal of NASA's Balloon Program Office (BPO). One milestone in the critical path of TCS development is the ability to measure the speed of the winds seen by the gondola during a balloon mission.

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

Adaption of the sensor technology to small aerial platforms to provide data for weather prediction is another potentially good opportunity with government and commercial implications. On the commercial side, there is increased investment in predicting local weather trends as more and more end users find timely and accurate weather guidance important for their business.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.03-2620**

SUBTOPIC TITLE: Technologies for Passive Microwave Remote Sensing

PROPOSAL TITLE: Low-loss deployable reflector antenna at frequencies up to 200 GHz for small satellites

Small Business Concern

Firm: **Boulder Environmental Sciences and Technology**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

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

We propose to develop a deployable antenna technology for radiometers and active sensor with 0.5 meter aperture operating up to 200 GHz. Such reflector antenna will lower the cost of microwave instruments and allow to meet future constellation repopulation and frequent revisit needs. This technology will enable deployment of radiometers and active sensors, such as radars and scatterometers with practical aperture sizes, larger than 0.5 m on small satellites. The parabolic reflector antennas for these sensors are necessary to provide reasonable spatial resolution. They are also a very significant cost drivers for such sensor since their size drives the overall sensor size, mass, and power consumption.

Operating frequency range up to 200 GHz covers a number of important water vapor, oxygen absorption lines, and atmospheric windows. Data from the active and passive microwave sensors operating in this part of spectrum provide invaluable information for operational weather observations, but also for scientific research of global water and energy cycle, climate monitoring and other applications.

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

Multiband passive microwave sensors provide a unique capability for Earth observation and have done so for over 4 decades. Their strength is measuring water in all its forms in all-weather, day-night conditions. They can provide measurements related to water and energy cycles, climate variability and change, and weather and atmospheric dynamics.

Reducing launch size of the reflector antenna enables NASA to deploy these microwave sensors more economically.

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

Small satellite revolution enabled many commercial applications that were difficult or impossible just a decade ago. There isn't one commercial passive or active microwave sensor on orbit yet. It is likely because of the apertures required for such sensors. Our technology can significantly reduce the cost of microwave sensors and allow economical deployment of such sensors in constellations.

Duration: **6**

PROPOSAL NUMBER:	21-1- **Z8.10-3108**
SUBTOPIC TITLE:	Wireless Communication for Avionics and Sensors for Space Applications
PROPOSAL TITLE:	Multi-Materials Additive-Manufacturing for Platform-Integrated Avionics

Small Business Concern

Firm: **Nanovox, LLC**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

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

Robust multi-material direct print additive-manufacturing and custom nanocomposite materials will be demonstrated for the fabrication of conformal and structurally-integrated wireless RF sensors, antennas, feeds, and transmission lines made directly into functional structural elements. The multi-functional devices will be shown to enable new avionic architectures and capabilities that expand mission performance while decreasing the size, weight, and power consumption (SWaP) and cost of the resulting spacecraft. After developing mission-oriented performance specifications and operational requirements, design trade studies will be conducted using existing design and optimization tools. Structurally integrated sensors and antennas will be shown to have performance at or above that of conventional antennas. Proof of concept additive manufactured multi-functional devices will be fabricated and characterized.

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

Mass and volume reduction are the main drivers for wireless avionics due to the weight of traditional wired infrastructure. Cables are at least 10% of most aircraft's mass. Wireless sensors can be deployed where wires are impossible; external mounted sensors can be used for mobile applications such as bio-monitors for astronauts or live specimens; equipment monitoring, added avionic redundancy, easy integration of smart sensors, and non-invasive monitoring of spacecraft payloads and systems while waiting for launch.

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

Applications include wireless communications in telecommunications, defense, and healthcare. There is growth in antennas for base station transmission, smartphones, and satellites due to new wireless standards such as 5G cellular. Other key industries include consumer electronics, autonomous automobile navigation, and vehicle-to-vehicle communications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.06-1633**

SUBTOPIC TITLE: Thermal Control Systems

PROPOSAL TITLE: High Density Cooling and Efficient Thermoelectric Heat Pumps

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Robotic science rovers operating on the Lunar surface over diurnal cycles face extreme temperature environments beyond operating limits, even with shielded and articulated radiator assemblies. In general, a heat pump provides the common extensibility for thermal control over the lunar diurnal. Active cooling systems or heat pumps such as mechanical cryocoolers and thermoelectric coolers are commonly used on spacecraft for small heat loads while vapor compression systems have been flown and, more recently, reverse turbo Brayton-cycle coolers are being developed for high load, high temperature heat lift. However, technology gaps exist for mid-range heat pumps that are suitable for small science rovers where internal heat dissipation may range from 20 Watts to 100 Watts. To address this limitation, Nanohomics Inc., in consultation with Dr. Bed Poudel at Penn State University, proposes to design a high cooling density and efficient V-shunt thermoelectric cooling (TEC) system (heat pumps) suitable for small science rovers. The V-shunt TEC will employ recently invented BiTe-based thermoelectric materials at Penn State University which have the best figure-of-merit (ZT) at the temperature of interest (< 100 °C) to meet the required 20 – 100 Watts of heat load and coefficient of performance (COP). Furthermore, the increase in effective TE fill factor would enhance the overall cooling power and efficiency as required for the lunar science rovers. The proposed TEC cooling system will be fabricated based on the Nanohmics' recently developed modular and conformal TE technology and addresses the cooling need of small science rovers at lunar surface below 50 °C by lifting 20 – 100 Watts (at the rate of 230 W/m2) of heat to environmental sink temperature of around 75 °C, i.e., $\Delta T > 25$ °C.

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

The proposed work will enhance the cooling power and efficiency of thermoelectric convertor (TEC) at the temperature of interest. These V-shunt TECs can be used in many NASA missions, which require localized cooling to remove heat or to achieve low temperature to replace currently available complicated multistage TECs. 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):

The efficient TEC systems would provide a means to meet next generation smart cooling systems which can reduce the CO2 and greenhouse gases emission compared to the competitive cooling systems. These mass-marketable TECs can replace most of commercial TECs and compression-based system in other applications such as automotive, defense and biomedical cooling applications of $1bn market.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.08-2638**

SUBTOPIC TITLE: Command, Data Handling, and Electronics

PROPOSAL TITLE: A Radiation Hardened, Digitally Controlled Single-Inductor Multiple-Output (SIMO) Buck Regulator

Small Business Concern

Firm: **Alphacore, Inc.**

Address: **304 South Rockford Drive, Tempe, AZ 85281**
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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):

Alphacore will design, fabricate and test a buck DC-DC converter that can directly convert voltages from 5V – 12V down to 900mV, while supporting at least 10A of current to the load. Our goal is 20A load current, a requirement for some of the most powerful FPGAs. The output voltage will be settable between 900mW and 3.3V. In this Phase I program, we will design a digitally controlled, high-efficiency, radiation hard, hybrid GaN/CMOS integrated single module SIMO DC-DC converter to meet these specifications. 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. The hybrid module will have a very small form factor, namely 20mm x 20mm x 6mm.

Alphacore's SIMO POL 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 with the same silicon area, such that lower FOM is available for higher efficiency applications. The planar high-voltage SJ DMOS transistor also has significantly better radiation tolerance for both total ionizing dose effects and single event effects.

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

Multi-output POL converters such as Alphacore's solution allows compact, cost-effective spacecrafts, such as nanosatellites, to deliver capabilities that traditionally require larger satellites. It can also be applied to support future heliophysics missions like AWE launching in 2022, PUNCH and TRACERS, both launching in 2023, and IMAP launching in 2024. Future outer planets instruments that may benefit include the Galaxy Evolution Probe, PICO, POEMMA.

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

Non-NASA applications for Alphacore's solution include planned constellations of nanosatellites or CubeSats for hypersonic missile defense and the United States Space Force, commercial spaceflight companies like SpaceX and Blue Origin, and satellite-based weather, data and global intelligence companies like Planet Labs and Capella Space.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z12.01-1986**

SUBTOPIC TITLE: Extraction of Oxygen and Water from Lunar Regolith

PROPOSAL TITLE: Lunar Water Extraction Techniques and Systems (Lunar WETS)

Small Business Concern

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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):

We propose Phase 1 of Lunar WETS, a comprehensive research and development effort to characterize and mature a pair of lunar water harvesting technologies that include in-situ heating methods based on stationary or mobile domes used with subsurface microwave heating and a

method in which icy regolith is placed into vessels for heating and extraction. We propose to map their performance to a wide range of possible concentrations and distributions of water resources so that as the uncertainties in these factors are reduced by exploration and prospecting, the best possible water harvesting technology can be quickly infused into NASA missions. In our Phase 1 work we will demonstrate 6 kW microwave heating of frozen icy regolith simulants using a dome on top of a simulated regolith substrate (following on our NIAC Phase II experiments) and in a custom built vessel which can be loaded with simulated regolith, both in cryogenic vacuum conditions to simulate the lunar environment, i.e., temperatures between 40 and 100 K and 10-9 torr vacuum.

The current state of lunar water extraction and collection technology includes a gamut of concepts in the TRL 1-3 range based on systems for which there has been conceptual formulation and, for some, initial proof-of-concept experiments. PI Sercel at TransAstra is the inventor of the patent pending Radiant Gas Dynamic (RGD) method of lunar ice mining that is currently under development in the accelerated 1 year Lunar Polar Mining Outpost (LPMO) NIAC Phase 2 grant activity which is synergistic but not overlapping this proposed work. Co-I van Susante has lead research efforts at MTU into excavation of planetary surfaces and ongoing work into vessel-based reactors and is also a Co-I on TransAstra's related NIAC effort. The NIAC work has been completed to TRL 2 at the time of this proposal submittal and has produce hardware designed for use in the same facility at MTU as proposed for Lunar WETS.

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

The impact of this work on the Artemis program will be large because it will allow the program to plan for material, logistical, and operational support of water extraction techniques and will fundamentally shape the entire program. The work we propose is timely because it will lead the way to elevate the TRL of these technologies to level 4 in preparation for the next stage of development, leading to sustainable lunar missions starting in 2028 with water and establish a propellant supply at a fraction of the cost of Earth supplied propellant

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

Any commercial firm that wishes to exploit lunar resources or establish a commercial presence (tourism or resource extraction) will benefit from this evaluation of extraction techniques. TransAstra is currently working with Blue Origin, who has already agreed to purchase lunar water to create propellant made possible by using TransAstrs's patented Sun Flower™ power systems.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z10.01-3013**

SUBTOPIC TITLE: Cryogenic Fluid Management

PROPOSAL TITLE: Integrated Cryogenic Propellant Liquefaction System (I-CPLS)

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: 2
End: 3

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

Mainstream proposes a lunar-based Integrated Cryogenic Propellant Liquefaction System (I-CPLS) that: 1) has a mass of less than 200 kg, 2) power requirement less than 15 kW, and 3) and produces liquifies oxygen (O_2) (3.3 kg/h) and hydrogen (H_2) (0.4 kg/h). The key enabling components of the I-CPLS are 1) an integrated cycle that liquifies O_2 and H_2 using a single cooling stream and 2) an ultra-lightweight carbon fiber/titanium composite compressor housing. The proposed system consists of a hermetically-sealed magnetically coupled five-stage H_2 turbo compressor with a single-stage turbine. The integrated design uses H_2 as the working fluid, eliminating the need to transport additional fluid to the lunar surface. The warm-end recycle H_2 stream provides the additional refrigeration capacity required for O_2 liquefaction without adding any additional O_2 equipment (compression and expansion).

In Phase I, detailed system and component models will be developed and used to optimize the system weight and power. The final system has a mass of less than 200 kg and power requirement less than 15 kW. To accomplish this, we will refine the cycle model including component design equations, optimize the system using the stage pressure ratios, recuperator draw temperatures, and component designs. A proof-of-concept turbo compressor composite housing will be fabricated and demonstrated to provide the required mechanical integrity at cryogenic temperatures.

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

The proposed research is targeted at improvement in the cryogenic propellant liquefaction state of the art, in particular system weight reduction. This fills a need for ultra-lightweight and low power liquefaction system designs for lunar and Martian vehicle refueling systems.

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

As superconducting technologies advance and begin to be implemented this technology may fill a need for highly mobile liquefaction systems may be required for emergency response, military, and remote applications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H9.07-2088**

SUBTOPIC TITLE: Cognitive Communication

PROPOSAL TITLE: Delay/Disruption Tolerant Reinforcement Learning and Aurora Based Communication System

Small Business Concern

Firm: **Stottler Henke Associates, 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):

Stottler Henke proposes **DREAMS**, the **Delay/disruption tolerant REinforcement learning and Aurora based coMmunication System**, to address NASA's need for distributed autonomous adaptive network communications technology, including planning and scheduling. DREAMS-equipped devices will sense and receive data and utilize the latest advances in Reinforcement Learning to discover optimal link parameters (e.g., frequency, modulation scheme) to improve various metrics (focusing on maximizing throughput and minimizing BER). The best links are combined to form potential communications paths from a start node to an end node. When feasible, these paths are aggregated by a nearby scheduling node which consolidates the network state and then allocates communications through the network. The proposed work builds on a series of our relevant research efforts (including several NASA-funded efforts) involving resource planning and scheduling, machine learning, low-SWaP algorithms, and distributed algorithms. We have already built a graphical satellite communications simulator which uses NASA's WorldWind to display satellites and shifting communications links. In addition, we have already integrated our core planning and scheduling

algorithm into NASA's **core Flight System**. For these reasons, we propose aggressive Phase I objectives culminating in a Phase I Prototype of TRL 4.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Distributed autonomous network communication optimization will become increasingly important as our activity and ambitions in space increase. Optimizing network communications by hand is becoming increasingly challenging; there is a clear need for machine-to-machine fully autonomous network optimization. Stottler Henke's proposed technology can uniquely fulfill this gap, leveraging past successes with intelligent scheduling, machine learning, and distributed algorithms.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

A clear transition opportunity is communications for military operations to coordinate mobile and stationary assets in real time in potentially denied environments. Improving situational awareness by increasing data flow in adversarial environments will significantly improve mission outcomes. Commercial networks with intermittent/variable links (including commercial space networks) could benefit.
Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.01-1537**

SUBTOPIC TITLE: Advanced Air Traffic Management System Concepts

PROPOSAL TITLE: NAS Metering Impact Prediction and Collaborative Scheduling System

Small Business Concern

Firm: **ATAC**
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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 proposed SBIR applies innovative air traffic data processing, machine learning (ML), and time-based scheduling emulation methods to develop a NAS Metering Impact Prediction and Collaborative Scheduling (NMIPACS) Service. NMIPACS is highly relevant to Subtopic A3.01 because it addresses a key ATM challenge related to improving efficiency for the near-future (2025-2030) NAS. A FAA-NASA-Industry SWIFT working group identified the lack of an early TBFM delay impact prediction capability as a top priority because it prevents the FAA and flight operators from collaboratively negotiating TBFM program parameters. This results in avoidable and inequitably distributed TBFM delays. To solve this problem NMIPACS develops the following innovative microservices (and the associated digital assets): (1) A ***TBFM SWIM Data Interpreter*** to parse the existing TBFM scheduling configuration, parameters, and scheduling times; (2) An ML-based ***Prediction Engine*** for predicting Estimated Times of Arrival (ETAs) at TBFM scheduling points (a key digital asset); (3) A ***TBFM Scheduling Emulation*** that applies the TBFM scheduling steps to the scheduling data, and computes an accurate estimate of the TBFM Scheduled Times of Arrival (STAs) and the per-flight delay impact of those STAs (another digital asset). We make the TBFM Scheduling Emulation flexible so that it can compute STAs for multiple user-specified TBFM parameter choices. This enables NMIPACS to operate in a real-time what-if analysis mode so that the FAA and airlines can use it to collaboratively evaluate strategies for managing TBFM delays or distributing them more equitably among flights. In Phase II, we expand NMIPACS to address multiple other applications that address TFMS-TBFM interaction issues, among other things. Thus, NMIPACS enables multiple advances to the way TBO is executed in today's operations and enables TBFM to advance from an open loop system to a higher performance one that includes the airlines in a closed loop.

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

(1) NMIPACS provides high-value small-scope digital services to support NASA ATM-X Digital Information Platform sub-project

(2) NMIPACS proof-of-concept demonstration helps DIP project demonstrate measurable benefit of digital services via collaborative testing

(3) ATM-X Collaborative Traffic Management sub-project can leverage NMIPACS service to provide a time-based scheduling service model in its simulations of Upper Class E airspace operations as well as for other new entrants

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

(1) Collaborative what-if analysis tool for FAA and airlines to mitigate TBFM delay impacts

(2) Excess TBFM delay alerting tool for airlines and airports

(3) FAA ARTCC ATC Workload Prediction Service

(4) Combined TFMS-TBFM-TFDM TBO impact prediction service for the FAA ATCSCC and airlines

(5) Airspace De-Confliction and Reservation Service for Upper Class E vehicle climbs/descents

Duration: **6**

NUMBER:

SUBTOPIC TITLE: Accelerating NASA Science and Engineering through the Application of Artificial Intelligence

PROPOSAL TITLE: Abstraction and Model Simplification to Identify Interesting Data (RAMS)

Small Business Concern

Firm: **ATC-NY, Inc.**
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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):

Remote sensing platforms are often able to transfer only a small portion of all collected data to end-users, requiring significant manual effort to select the most relevant information for analysis. To address this challenge, the ATC-NY team will develop Response Abstraction and Model Simplification (RAMS), a decision-support tool that assists scientists and automates remote and deep-space data collection for known events. RAMS operates efficiently on remote sensing platforms by quantizing samples of telemetry data to enable highly parallel processing of Quantized Neural Network (QNN) operations. RAMS also applies transfer learning and active learning techniques to train effective event detection models that reproduce human data-selection processes using a limited number of examples. Using RAMS, scientists supporting the Magnetospheric Multiscale (MMS) mission identify several examples of target signals for magnetic reconnection events near the Earth's magnetopause and magnetotail, which RAMS uses to automatically select such events in future data.

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

RAMS can be applied to improve data collection, as well as automate and enhance event detection in NASA missions involving remote sensing with limited data access. Applications of RAMS include Earth-observing, atmospheric, and magnetospheric survey missions, such as MMS, WIND, THEMIS, Cluster II, STEREO, and the Europa Lander.

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

RAMS has application in commercial and government Geographic Information Systems (GIS). Long-running surveillance operations, including law enforcement, energy and utility monitoring, as well as security systems, can employ RAMS to reduce manual effort and quickly identify time-critical events at the point of occurrence to improve incident response time.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.05-3218**

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

PROPOSAL TITLE: Metamorphic Substrate and Fabrication Process for Solar-Blind UV Imaging Arrays

Small Business Concern

Firm: **Sivananthan Laboratories, 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):

Imaging in the ultraviolet (UV) is important for heliophysics, astrophysics, exoplanet survey and solar system exploration missions. Many of the currently used UV detectors are sensitive to longer wavelength (i.e. visible) light pollution, and so instruments employ filters to block wavelengths longer than those of interest; however, these filters also attenuate the UV radiation, reducing the external quantum efficiency (EQE) of the instrument. Visible wavelengths of light have energies less than the bandgaps of InGaN and AlGaN, and so are not absorbed by them, thus UV detectors based on (In,Al)GaN are insensitive to visible light (i.e. solar blind) and do not require any filters, which increases their EQE.

A significant problem preventing AlGaN and InGaN-based UV imaging devices from realizing their true potential is the presence of dislocation defects that result from growing active layers of (In,Al)GaN on lattice-mismatched substrates. The availability of a low-dislocation, lattice-matched virtual substrate would present significant benefits to the availability and performance of (In,Al)GaN UV imaging devices. Other semiconductor technologies make use of lattice-matched virtual substrates that are created by depositing thick buffer layers on a suitable, although lattice-mismatched substrate. This approach fails for (In,Al)GaN because the predominant dislocation types are sessile under biaxial stress and do not glide to interact and reduce their concentration. We propose that nanometer-scale patterning of the substrate (e.g. AlN, GaN, SiC, Si or sapphire) can induce dislocations to glide and reduce in concentration within the buffer layer. The resulting virtual substrate would have a dislocation density low enough to support the fabrication of high-performance (In,Al)GaN transistors and photonic devices.

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

Solar-blind UV imaging is important for heliophysics and astrophysics, as the Lyman series is used to observe hydrogen in stellar coronas and around dark phenomena, as planned to be used in LUVOIR. Exoplanet surveys, such as HabEx, search for atomic and molecular oxygen emission lines in the UV. (In,Al)GaN can be fabricated as linear-mode or Geiger-mode avalanche photodiodes (APD), enabling solar-blind single-photon detection of UV radiation from atmospheric fluorescence caused by cosmic rays, which is important to Physics of the Cosmos.

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

Solar-blind UV detectors aid in the early detection of ballistic missiles. A low-dislocation virtual substrate will improve the performance of AlGaN/GaN high-electron mobility transistors, providing advantages for a applications in RF amplification and power control and conversion. The virtual substrate will also provide benefits for ultraviolet light emitting diodes and diode lasers.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z13.02-1132**

SUBTOPIC TITLE: Dust-Tolerant Mechanisms

PROPOSAL TITLE: Dust Tolerant Joint for In-Space Assembly

Small Business Concern

Firm: **Cornerstone Research Group, Inc.**
Address: **510 Earl Boulevard, Miamisburg, OH 45342**
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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):

Cornerstone Research Group (CRG) proposes the development of a dust tolerant joint to facilitate reliable payload reconfiguration and automated in-space construction in regolith inundated environments. CRG will demonstrate a lightweight, mechanically robust joint capable of securing structures while exposed to regolith particles of similar size to what are known in various space environments such as the lunar surface. This state-of-the-art dust tolerable joint leverages CRG's shape memory polymer (SMP) reversible joining system, which facilitates self-alignment, low dexterity operation, capture and lock features, electrical isolation, and connectivity feedback if desired. Additionally, CRG's dust tolerant reversible joint provides NASA with a scalable, modular joining capability that can be used with autonomous assembly systems. Leveraging CRG's prior development work on shape memory polymer fastening systems and mechanical design expertise, the proposed R&D herein will provide NASA with a multifunctional dust tolerable reversible joint with technology readiness level (TRL) of 4 at the conclusion of the Phase I effort.

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

- In-Space structural assembly and construction
- Moon to Mars Campaign
- Commercial Lunar Payload Services (CLPS)
- Rotary, linear, and static joints
- Manned and unmanned space vehicles
- Payload attachment and removal
- Satellites, solar arrays, and deployable structures

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

- DoD and commercial satellite construction, expansion, refurbishment and In-Space test ranges (i.e. orbital outpost)
- Deployable solar arrays, antennas, and variable vibration damping structures
- Reusable launch vehicles and payload delivery systems
- Space transportation vehicles
- Remote terrestrial shelter construction

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z13.02-1328**

SUBTOPIC TITLE: Dust-Tolerant Mechanisms

PROPOSAL TITLE: Surface micro-texturing of advanced bearing materials for lunar dust mitigation

Small Business Concern

Firm: **ATSP Innovations**
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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):

This proposal addresses subtopic Z13.02 Dust Tolerant Mechanisms and specifically the listed interest in long life dust-tolerant
bearings, protective materials, and tribological surfaces. NASA is interested in long-term operation in the Moon, Mars and other space
bodies such as asteroids, and comets. The Artemis program will land the first woman and next man on the Moon by 2024, followed by
manned missions to Mars. The Moon is covered by large amounts of dust particles, called regolith, which could cause serious problems
for tribological components on the Moon, which makes dust as the number one concern in returning to the Moon. In addition to dust
issues, the temperature has a large variation between day and night, from cryogenic temperatures of -147°C to upwards of 100°C.
Therefore, the effect of temperature should also be taken into account in combination with abrasive

dust. The reliable operation of
moving parts and tribological components (e.g., bearings, gears, sealings, etc.) in the Moon environment is a key for successful
accomplishment of future NASA missions. Therefore, selection and design of new lubrication and protection are imperative for each
application. Tribological experiments are therefore necessary to simulate relevant environments so as to mitigate mission risk. This
proposal offers unique solutions for these extreme conditions: ATSP coating sliding against ATSP coatings have shown low coefficients
of friction and “zero wear” from -196°C to 300°C. This excellent tribological performance leads us to introduce ATSP-based coatings for
the abrasive conditions and wide thermal demands of the Moon. We will investigate the tribological performance of ATSP-based
composites under conditions in combination with temperature effect and abrasive dust. The tribo-pairs will be micro-textured/flat
polymer pins sliding on steel, and textured/flat polymers pin on polymer coating, thereby allowing selection of an optimized tribo-pair.

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

1. ATSP-based tribological products have wide temperature range (-196 to 300°C) with low wear and friction and have applicability for
mechanical devices used in future missions to Titan, the Moon, and Mars.
2. Best-performing tribo-pairs will be identified for Lunar dusty conditions as a durable high bearing tribo-pair – impacting design of
deployables, pumps, bearings, and seals.

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

ATSP-based tribological products applicable for Aerospace, Automotive, Space Exploration, and Energy. The tribo-pair concept
developed in Phase I offers world-leading reduction in friction and wear across a broad range of temperatures in abrasive conditions.
ATSP has entered evaluation cycles with firms such as: Dover Precision Components, Valco Instruments, ExxonMobil, GGB Bearings,
Daicel, etc.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.08-2483**

SUBTOPIC TITLE: Aeronautics Ground Test and Measurement Technologies

PROPOSAL TITLE: Non-Intrusive Fiber-Optic Boundary Layer Profile Measurement System

Small Business Concern

Firm: **Prime Photonics, LC**
Address: **1116 South Main Street, Blacksburg, VA 24060**
Phone: **(540) 961-2200**

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):

Prime Photonics has been working with Virginia Tech (VT) since 2017 to develop a filtered Rayleigh scattering system for multi-property flow measurement (MPFM; velocity vector, temperature, and density). We validated the MPFM system at Virginia Tech on a JT15D gas turbine engine inlet and recently performed validation testing at the Air Force Compressor Aero Research Laboratory (CARL). Thus far, our efforts have focused on the characterization of complex high-swirl bulk flows, and the MPFM system has not been specifically tuned or utilized for boundary layer characterization.

In Phase I, Prime and VT will implement the methods described in this proposal to demonstrate the capability of a new derivative of the MPFM system, our fiber-optic boundary layer profile (FOBLP) measurement system, to measure boundary layer velocity profiles without seeded particles. Analytical design followed by an experimental proof-of-concept measurement in a VT wind tunnel will be completed and key capability metrics will be characterized. Finally, a conceptual design for the proposed system will be completed for a NASA selected facility.

In Phase II, the conceptual FOBLP system design will be progressed through a critical design stage and fabricated, installed, and validated at a NASA facility. Further data acquisition and post-processing software improvements will also be made to improve usability and increase data analysis speed.

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

The first product planned for the FOBLP technology will be a Test & Evaluation (T&E) system for wind tunnel model applications. It will be marketed to wind tunnel operators, engine OEMs, airframers, NASA facilities, DoD personnel, and universities.

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

Other applications beyond boundary layer profiling on flightcraft and in wind tunnels are likely. Due to the very compact size of the fiber-based approach, and the ability to measure velocity, density, and temperature, applications could include interrogating difficult regions of interest in medical diagnostics, internal combustion engine diagnostics, and thermal systems.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A2.01-1659**

SUBTOPIC TITLE: Flight Test and Measurement Technologies

PROPOSAL TITLE: MEMSonic Boom: Sensing and Acquisition for Sonic Boom Flight Research

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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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

The Interdisciplinary Consulting Corporation (IC2) proposes to develop a low-cost, low-frequency (infrasound) microphone and a highly-distributed wireless sensing and acquisition system for the measurement of sonic booms. The microphone and acquisition system are applicable in far-field acoustic measurements such as those encountered during supersonic over-ground tests. This proposed technology is in response to NASA SBIR 2021 Phase I solicitation subtopic *A2.01: Flight Test and Measurement* for the improvement of *"Test techniques…that capture data in various spectra, for conducting quantitative in-flight boundary … near and far-field sonic boom determination, and atmospheric modeling as well as measurements of global surface pressure and shock wave propagation."*

By minimizing the technological, logistical, and cost-prohibitive issues surrounding the deployment of spatially distributed acoustic arrays, the proposed distributed wireless acoustic sensing and acquisition system expands NASA's technology portfolio with test equipment that allows for faster, higher-accuracy testing at a lower cost. The measurement capabilities of the proposed hardware will

allow for an array with a broadened capture area of sonic boom impact on the ground, enhanced resolution and accuracy of sonic boom direction of arrival estimations, volumetric capture of sonic boom propagation, and high-fidelity sonic boom signature capture at every measurement location. These improvements will enable arrays with substantial expansion of the instrumented volume for sonic boom measurements compared to current and previous arrays. The primary target application for the system is overland sonic boom testing with a specific focus on low boom development testing. Other general flyover applications where two- or three-dimensional capture of the propagating sound from an aircraft is desired, could also be supported by this system's capabilities.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The realization of this system not only benefits the testing of next-generation low-boom supersonic aircraft [1], but also adds to the capabilities of the NASA Armstrong Flight Test Research Center and the Edwards Flight Test Range Complex. Due to its ease of deployment, the system is also viable for other supersonic testing corridors at which NASA tests. Other general flyover applications where two- or three-dimensional capture of the propagating sound from an aircraft is desired, could also be supported by this system's capabilities.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Some key potential customers that perform flight testing with noise concerns are: The Boeing Corporation, and the Lockheed Martin Corporation. In addition to these larger entities, supersonic aircraft developers, such as; Boom, Aerion, and Spike Aerospace will be of great interest upon product release.
Duration: **6**

PROPOSAL NUMBER: 21-1- **A2.03-1888**

SUBTOPIC TITLE: Advanced Air Mobility (AAM) Integration

PROPOSAL TITLE: AAM Community Integration Platform

Small Business Concern

Firm: **Crown Consulting, Inc.**
Address: **1400 Key Boulevard, Suite 1100, Arlington, VA 22209**
Phone: **(703) 650-0663**

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):

AAM encompasses a wide variety of use cases, including medical transport, emergency response, law enforcement, passenger service, and cargo transport. Cities world-wide are mobilizing to attract AAM service providers with an expectation of economic and humanitarian benefits. However, these benefits accrue only if the AAM network supports viable business cases while meeting operational, regulatory, environmental, and community concerns. We propose to develop a platform to support AAM community integration studies, emphasizing business cases, intermodal connectivity, community and environmental concerns, and safety. This will require fusion of data and analysis tools such as: economic, demographic, terrain, weather, airspace, and vehicle performance.

We propose to build a framework for creating and evaluating plans to transition AAM from concept to implementation. We will partner with two leading firms to develop this toolset: one specializing in financial, economic, infrastructure, and demographic information to support business case analysis and investment requirements, and one specializing in environmental analysis to support noise and other environmental studies. Leveraging our expertise in airspace design and modeling, we will produce a toolset capable of creating and evaluating AAM implementation designs. The platform will be extensible through standard interfaces to incorporate other factors.

Our proposal responds to Topic A2.03, AAM Integration – specifically by establishing "…a set of tools that could be utilized by local community stakeholders to support the planning, public acceptance, and analysis of various design options to incorporate AAM into the local or regional transportation system," by providing urban regions with a capability to develop a preliminary design for AAM according to local objectives and constraints. This proposal amplifies the impact of ARMD's AAM Mission by providing a mechanism to highlight the value of NASA-developed technology.

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

This capability can help guide NASA research opportunities. Analysis enabled by this tool would highlight the challenges and benefits of AAM implementation plans, helping focus R&D and increase the impact of NASA's contributions. Potential NASA users include:

- AAM Mission Integration Office: system studies, communications, advocacy
- ATM-X, AAM, and RVLT projects: ID high payoff research needs
- Systems analysis groups at ARC and LaRC: studies of use cases and technology
- ARMD's Portfolio Analysis and Management Office: policy, portfolio analysis

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

This capability can support city, state, and local governments interested in implementing AAM to develop robust designs that promote public and economic benefits and successful businesses. Local and state governments can realize a coherent, interoperable business and regulatory environment. AAM operators and infrastructure investors will be able to optimize services and manage risk.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H3.07-2484**

SUBTOPIC TITLE: Flame-Retardant Textiles for Intravehicular Activities (IVA)

PROPOSAL TITLE: Flame Retardant Textile Treatments for Crew Clothing

Small Business Concern

Firm: **Giner, Inc.**
Address: **89 Rumford Avenue, Newton, MA 02466**
Phone: **(781) 529-0500**

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):

NASA has identified the need to develop new technologies that will result in a next-to-skin fabric with improved flame retardancy in the unique, oxygen enriched atmosphere of intravehicular activities. The novel material will require flame resistance (FR), comfort, durability, and be non-toxic to the wearer. It is imperative that these enhancements survive the rigors of the astronauts' use. It is also desirable that the manufacturing process be scalable so as to minimize cost at high volumes. Giner, Inc will develop a novel, non-toxic fabric treatment method to impart FR properties with fiber-level precision on synthetic and natural fiber blends. The proposed coatings fabricated with a versatile, high-throughput multilayer spray processing method will improve flame resistance in a saturated oxygen environment without impacting base material properties such durability, toxicity and comfort. The innovation of the proposed method is the combination of a novel flame-resistant coating formula with a high-precision, scalable spray coating technique that can apply FR coatings with fiber-level precision to a variety of fabric substrates including Rayon, Nylon/Cotton blends, and 100% cotton. The coated textiles will have improved FR in the oxygen rich environment while maintaining durability and comfort. FR and base material properties will be evaluated internally and by 3rd party

independent testers using standard ASTM methods as well as modified protocols for testing in an oxygen rich environment.

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

State of the art FR fabrics do not provide the required flame resistance in an oxygen rich atmosphere. Giner's proposed FR textile technology will provide durable flame resistance for comfort fabrics in ambient and oxygen rich air at a low cost. This will improve the safety of the crews for intravehicular activities. Giner's technology can be used for next to skin fabrics, sheets, upholstery, uniforms, and crew clothing.

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

FR fabrics are used for the protection of firemen and first responders, soldiers, and workers in industrial settings such as petroleum refineries. They are also used to cover seats and other components on commercial and military aircraft. Giner's FR textile will provide safety and quality of life improvements in any working or living environment at risk of fire hazards.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.06-1893**

SUBTOPIC TITLE: Space Weather Research-to-Operations/Operations-to-Research (R2O/O2R) Technology Development

PROPOSAL TITLE: OSU Provided, SET Produced RAdiation Detector (OPSRAD)

Small Business Concern

Firm: **Space Environment Technologies, LLC**
Address: **1676 Palisades Drive, Pacific Palisades, CA 90272**
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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 *OSU Provided, SET Produced Radiation Detector* (OPSRAD) will demonstrate an innovative, low-cost, low size/weight/power, mass producible, multi-application, active radiation sensor useful for monitoring the real-time radiation environment from the atmosphere, through low Earth orbit, and into deep space. The standardized datatype will be ideal for operational systems and will be the next generation workhorse for providing total ionizing dose (TID) and energy deposition spectra. The latter is the LET of ionizing charged particles, including energetic protons, muons, electrons and positrons, as well as gamma-ray photons. The system will be sensitive to neutrons by creating neutron-induced energetic secondary protons produced in a high-density polyethylene (HDPE) layer by neutron–proton reactions. OPSRAD Phase I will provide a prototype: i) detector to demonstrate our approach of measuring energy deposition and TID; ii) system to demonstrate modularity in microprocessor, data storage, and communications features; and iii) design strategy to integrate these capabilities into a single module for operational use. The objectives of this proposal are aligned with NASA technologies, including the Moon to Mars initiative. This proposal supports NASA's Moon to Mars mission by identifying and filling critical gaps in improving scientific discoveries related to the poorly sampled radiation environment in time, space, and energy ranges. It provides a pathway for an order of magnitude reduction in cost; iii) halving the size, weight and power compared to existing state-of-the-art; iv) doubling the speed for operational implementation; and v) retaining a comparable ability for continuous temporal and spatial monitoring. This instrument can help send humans safely to the Moon and OPSRAD would be a perfect instrument for use in the Gateway Habitation and Logistics Outpost (HALO) as well as in a lunar surface outpost or at remote site locations.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

OPSRAD supports Space Weather Research-to-Operations/Operations-to-Research (R2O/O2R) Technology Development by providing real-time, operational, low-cost radiation exposure data. NASA desires to specify and/or forecast the energetic particle and plasma conditions encountered by spacecraft in low Earth orbit, within the magnetosphere, and enroute to as well as at the Moon. OPSRAD will provide those measurements servicing these interests and generate products that support tools for identifying spacecraft anomalies and human tissue exposure.

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

OPSRAD can be use in commercial suborbital and orbital space systems vehicles, as well as in commercial aviation. All these require radiation exposure information to satisfy system performance and due diligence requirements. SET is already providing some commercial services to these industries and OPSRAD will improve quality and reduce costs for end users.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.04-3327**

SUBTOPIC TITLE: Nontraditional Airspace Operations

PROPOSAL TITLE: Microscale Weather Based Unmanned Aircraft Systems Traffic Management Optimization System

Small Business Concern

Firm: **Aeris, 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):

In this NASA Phase I SBIR effort, Aeris proposes to develop and demonstrate an Unmanned Aircraft Systems Traffic Management (UTM) capability that can enable route planning and scheduling of Urban Air Mobility (UAM)/Advanced Air Mobility (AAM) vehicles in scenarios with dynamically changing weather and operational conditions. Our solution involves the integration of two enabling technologies: 1) highly resolved and accurate microscale weather information from a “building-resolving” atmospheric model that can provide near surface winds and turbulence at meter-scale resolutions. 2) graph analytics data analysis methodologies designed to fuse the microscale weather data, aircraft operational parameters, UTM characteristics and operational constraints.

The proposed system uses a large eddy simulation (LES) model to translate standard environmental data into highly resolved micro-scale wind/turbulence information that can account for terrain, land-use characteristics, and buildings. LES microscale weather data will then be combined with aircraft performance parameters to calculate UAM/AAM aircraft specific parameters for all of the scheduled UAM/AAM vehicles over all of the possible routes and flight plans. Graph analytics will then be utilized on this dataset to estimate the best combination of routes and corresponding departure and flight schedules for both the in-flight and departing UAM/AAM aircraft. This graph analysis calculation will also incorporate flight duration and/or path length, aircraft separation safety requirements, and aircraft arrival delay relative to the planned arrival time. The UAM/AAM UTM flight scheduling and route guidance products produced by this system will act to condition the UTM airspace to ensure safe aircraft separation, merging and sequencing of aircraft along the flight routes, metered arrivals at destination aerodromes, and efficiency through the identification of the shortest flights routes through the UTM system.

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 make Urban Air Mobility (UAM) / and Advanced Air Mobility (AAM) flight

schedule and route guidance products that will undoubtedly be required to ensure safe an efficient Unmanned Aircraft Systems Traffic Management (UTM) operations.

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

The notional UTM architecture concept currently envisioned by the FAA is public-private information system between the FAA and a federated set of participants. A key element within this UTM system will be precision UAM/AAM flight scheduling and route guidance information products. If successful, the technology proposed here will provide key data products to this UTM system.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S4.03-3134**

SUBTOPIC TITLE: Spacecraft Technology for Sample Return Missions

PROPOSAL TITLE: Transparent, lightweight aluminum-polymer composites for increased-value sample-return missions

Small Business Concern

Firm: **Amphionic, LLC**
Address: **875 North Lima Center Road, Dexter, MI 48130**
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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 Phase I project will develop lightweight, high-strength aluminum-based structural components derived from a facile manufacturing process. In previous work, large volumetric fractions of Au, Ag, and Cu nanoparticles (NPs) were incorporated into a porous aramid nanofiber (ANF) matrix to realize films that have high electrical conductivity, yet maintain superior mechanical strength, properties that are usually hard to achieve simultaneously. Furthermore, the composite films demonstrate excellent flexibility, which is superior to other related classes of reported flexible conductors including carbon based nanomaterials (CNTs and graphene) and other metallic materials. The unique network structure enables high electrical conductivity and robust mechanical behavior of the metal-ANF films. Most pertinently for mass-restrictive applications, we previously demonstrated that copper-ANF composites had ~90 % less mass density than solid copper, but with electrical properties (conductivity, ampacity) that were at least 33 % of the bulk value. During Phase I, we will extend the material system to aluminum structural components that are relevant to sample-return missions that require mass-efficient materials. We will first find the lower limits of achievable mass that still provides acceptable conductivity, ampacity, and strength in both cylindrical and polygonal cross-sectional solids. We will then characterize the conductive and insulating properties of self-insulated solids, in which the ANF can be functionalized with various levels of conductivity. We can control the optical properties of the Al-ANF composite by modifying the surface plasmon resonance of the aluminum NPs, knowledge that will be used to make solids of various optical properties. Finally, we will design manufacturing tools to scale-up the production of the solids.

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

The high-strength, reduced mass conductor material modality is multi-use and cross-cutting for a broad range of NASA mission applications, whether that includes hybrid electric aeronautical craft or spacecraft. For space applications, the innovation can be used for sample-return spacecraft bodies, planetary surface power, large-scale spacecraft prime power, small-scale robotic probe power, and small-sat power. For aeronautical applications, the low-mass wiring can efficiently distribute power to aircraft propulsors with minimal mass overhead.

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

Lightweight metals can substantially impact the terrestrial electric vehicle and power-transmission markets. Energy storage systems must be flexible, robust, lightweight, and exhibit superior electrochemical activity. Furthermore, robust, flexible conductors are needed to meet the rapidly growing demand in smart sensors, roll-up displays, and other applications with unconventional form factors.
Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.01-3216**

SUBTOPIC TITLE: Aerodynamic and Structural Efficiency - Integration of Flight Control with Aircraft Multidisciplinary Design Optimization

PROPOSAL TITLE: Incorporating control design for distributed electric propulsion in MDO

Small Business Concern

Firm: **Intelligent Automation, Inc.**
Address: **15400 Calhoun Drive, Suite 190, Rockville, MD 20855**
Phone: **(301) 294-5221**

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 is spearheading the efforts on Urban Air Mobility (UAM) and providing impetus to the industry to follow with concepts for the same. Several manufacturers, as well as, NASA, have come up with concepts for UAM aircraft; mostly using Distributed Electric Propulsion (DEP). However, the multidisciplinary interactions involved and the ability to utilize the distributed propulsors for improved control are not fully understood. In particular there is a need to incorporate control surface and controller design in the design framework and account for aeroservoelastic interactions. To achieve this, we are developing the ADEPt, a design optimization architecture that includes multidisciplinary analyses for integrated airframe-DEP design. This technology, if successful, can push the state of the art in UAM aircraft concept design and DEP enabled aircraft in general.

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

The AAM project at NASA (and UTM as well) will directly benefit from this research, in terms of availing the true benefits of DEP-enabled aircraft. The design tool will help understand and leverage the multidisciplinary interactions involved and will directly benefit programs such as AAVP, AATT, TTT and RVLT, which are looking for advanced aircraft designs, particularly electrified distributed propulsion concepts.

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

Several aircraft manufacturers have responded to the UAM Grand Challenge and are actively pursuing designs for DEP aircraft for UAM. Hence, both commercial and civil contractors will benefit from ADEPt that can help them refine their designs or come up with new ones. We have also secured the support of Lockheed Martin, who is highly interested in this technology

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z1.07-3267**

SUBTOPIC TITLE: Dynamic Energy Conversion for Space Nuclear Power and Propulsion

PROPOSAL TITLE: Cycle Optimization for Mass of Advanced Heat Exchangers Used in Nuclear Space Propulsion

Small Business Concern

Firm: **Brayton Energy**
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Phone: **(603) 601-0450**

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):

Trade studies to recommend a novel, nuclear-fueled, recuperated, Closed Brayton Cycle (CBC) power system optimized for use in space are proposed. A CBC with nuclear heat source will need to incorporate at least three critical heat exchangers:

1. Primary Heat Exchanger (PHX): transfers thermal power from the nuclear source, or secondary loop, to the engine's working fluid at turbine inlet temperature
2. Recuperator: exchanges heat from turbine exhaust to PHX inlet to improve cycle efficiency
3. Radiator (or Pre-cooler): rejects heat from the cycle upstream of compressor inlet

This program will include the preliminary design of the above components to arrive at defensible system-level mass estimates. The optimization of these critical heat exchanger components must be done collectively and in tandem with cycle and engine design efforts to appropriately capture the competing effects controlling total system mass. While architecture selection will favor production-ready heat exchanger concepts based on decades of related research, manufacture, and testing, the end result is predicted to be a novel blend of demonstrated fundamentals combined in new ways to achieve long, reliable life at extreme operating temperature and pressure with minimal mass. The special end use case of this system will likely require some deviation from established heat exchanger

design methods, in which case preliminary design, analysis, fabrication, and lab demonstration of key innovations will be accelerated to fall within Phase I of the program.

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

A robust thermal-to-electric power convertor directly supports long duration manned missions, such as exploration of Mars. Power conversion unit may also serve as stationary power bridge during critical power infrastructure buildout for lunar or planetary bases.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Supports power generation needs for the burgeoning private space travel sector. Additionally, this effort will support ongoing commercial nuclear gas turbine projects for terrestrial power generation progressing toward reduced system cost, mass, and complexity. Advancement of high pressure, temperature, & effectiveness heat exchangers has application in emerging non-fossil power generation.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.04-2681**

SUBTOPIC TITLE: Nontraditional Airspace Operations

PROPOSAL TITLE: Patterns-of-Life Geofencing supporting Advanced Aerial Mobility (AAM)

Small Business Concern

Firm: **The Innovation Laboratory, 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):

To accelerate AAM maturity and address the needs of the mature state for UAM, this SBIR effort addresses the need for a capability to: (1) assess from historical data the traffic patterns and needs of GA traffic, and (2) assess, in real-time, the patterns-of-life for GA activity at low altitudes in urban environments, so as to geofence those regions and protect both GA and UAM traffic from anomalous events. The Innovation Laboratory proposes to develop an enabling technology that assists geofencing between GA and UAM vehicles, for instance, eVTOLs in urban environments. With this innovation, the patterns-of-life data for GA traffic can become an asset for UAM airspace operational planners and USS providers monitoring UAM airspace constraints.

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

We address NASA's needs in both the AOSP and ARMD Strategic Thrusts 1 (Safe, Efficient Growth in Global Operations) and 6 (Assured Autonomy for Aviation Transformation). The technology adapts UTM geofencing concept elements for application to UAM, including:

- Geofencing designs that enable dense and/or increasingly complex UAM operations, with a goal to safely and efficiently integrate with existing operations and mission types
- Integration of emergent users with legacy users, in particular, GA users.

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

Our product will have utility to inform of low altitude operations geofencing boundaries that benefit state and local facilities operating GA airports, heliports for commercial, local law enforcement, and medical emergency operations. Our innovation targets commercial entities that want to participate in the UAM vertiports or fly UTM services (e.g., drone package delivery services).

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.04-3268**

SUBTOPIC TITLE: Nontraditional Airspace Operations

PROPOSAL TITLE: UAM Demand Capacity Modeling through Ensemble Learning (UDC-ModEL)

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):

UAM operations are estimated in the hundreds to thousands of flights every day in each of their metropolitan market regions. Further, most of these flights are expected to employ electric propulsion vertical takeoff/landing aircraft (eVTOL). While eVTOLs offer many advantages over conventional gasoline fueled aircraft, huge strides are needed in battery or energy storage technologies to enable long duration flights. The immediate implication for this is that airborne eVTOLs may not have large reserves of energy to implement congestion mitigation procedures such as hold patterns. Further, current technology requires many hours to recharge the batteries on these aircraft, which implies that the UAM operators require accurate predictions of available airspace capacity to schedule their operations and manage their fleet's energy resources. Given this situation, there is a need for accurate estimation of available capacity and how the prevalent demand can be balanced to take full advantage of this capacity, also known as demand capacity balancing (DCB). From another perspective, accurate DCB estimation offers the opportunity to evaluate which technological and operational enhancements best serve the prevalent and anticipated demand. The concept of DCB has been implemented within the commercial aviation world at some of the busiest airports across the world. However, those DCB approaches do not readily translate for the UAM paradigm. To address these needs and gaps, IAI proposes UAM Demand Capacity Modeling through Ensemble Learning (UDC-ModEL) to accurately and rapidly model DCB at UAM vertiports. As the name suggests, our technology leverages the latest advances in machine learning and artificial intelligence to erect a rapid estimation capability that is agnostic to the UAM market's location or the eVTOL fleet mix used by a UAM operator. UDC-ModEL will be a valuable decision support tool for UAM operators and the proposed Providers of Services for UAM (PSUs).

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

The ATM-X project, the UAM Sub-project, the AAM National Campaign, RVLT program and IASP program will directly benefit from UDC-ModEL. With UDC-ModEL, it will be possible to not only evaluate the performance of existing airspace conditions at a vertiport but also in comparing candidate enhancements to operating procedures and technologies under consideration by vertiports, PSUs and UAM operators. Also, UDC-ModEL will be valuable for design and development of eVTOL and other concepts to provide improved airspace capacity and throughput.

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

Aircraft manufacturers, PSUs and vertiport operators are customers for UDC-ModEL. Since UAM will serve both people and cargo movements, it is important to understand the subtleties of these two broad categories when operating the aircraft and the vertiports. UDC-ModEL will provide an agile platform to conduct what-if studies to quickly evaluate candidate options for the aforementioned customers.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.04-1166**

SUBTOPIC TITLE: Nontraditional Airspace Operations

PROPOSAL TITLE: Public Safety and Contingency Management: Collaborative Services for Urban and Advanced Aerial Mobility

Small Business Concern

Firm: **Unmanned Experts, Inc.**
Address: **720 South Colorado Boulevard, Penthouse North, Denver, CO 80246**
Phone: **(315) 677-3015**

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):

The National Academies' blueprint for advancing air mobility found that public safety (PS) applications provide opportunities to build experience, refine technology and establish acceptance of AAM technology. Information-sharing gaps currently hinder scalability for a broad range of interagency PS responses, from frequent local incidents to less common widespread disasters. Echoing UAM/AAM scalability limitations imposed by the need for human operators to safely manage air traffic, we begin developing a rapid-response UML2 emergency protocol by analyzing PS command and control (C2) information flows and developing scalable services based on UTM's architecture to support information exchange between PS-C2 and air traffic management (ATM). Increasing automation and reducing operators' load for contingency management (CM) supports the ATM-X vision of digitally

integrated airspace operations. Integrating PS-C2 and ATM systems information flows should reduce scheduling and separation uncertainty for PS-related CM.

The scalable services also support development of a PS AAM concept of operations (CONOPS) enabled by and for UML4 operational density and complexity. Transportation and logistics are critical for widespread disaster response. Building on NASA's Scalable Traffic Management for Emergency Response Operations (STEReO) project and our collaborative services, we will explore how UML4 and the AAM airspace pillars can be rapidly reconfigured to support logistical operations for disasters. STEReO envisions a new emergency response ecosystem using NASA's UTM for PS MUMT, and other NASA tech for scalability and operational resiliency in airspace coordination during dynamic disaster events. By extending STEReO's CONOPS and using our services, rapidly reconfigurable AAM can support UML4 disaster logistical operations such as mass evacuation or casualty transport, the re-supply of commodity essentials, and critical infrastructure restoration.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Collaborative UAM/AAM services offer a new approach to ARMD & AOSP priorities associated with ATM-X Includes: Vision 2045: providing public safety perspective & input into community-supported CONOPS for 2045; UAM UML-4: developing concepts and technologies that will use the National Challenges to build toward UML4; and Traditional Ops: to enable new public safety services for improved efficient and safe operation, and to demonstrate services in an operational environment. This work additionally supports NASA ARMD's STEReO CONOPS development.

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

Collaborative UAM/AAM services will be embraced by Federal, state, tribal and local public safety agencies, and it also has applicability for homeland security operational and S&T, and homeland defense operational and S&T agencies. Private sector interest includes support for, and use as Supplemental Data Service Provider, a Provider of Services for UAM and System-Wide Information Management.
Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.04-1904**

SUBTOPIC TITLE: Electrified Aircraft Propulsion

PROPOSAL TITLE: Next Generation Inverter Technologies

Small Business Concern

Firm: **Polarix Corporation**
Address: **7960 Silverton Avenue, Suite 119, San Diego, CA 92126**
Phone: **(202) 812-0088**

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):

A new inverter / converter concept is proposed which combines the next generation of semiconductor switching technology with two sided microchannel cooling and a new folded planar topology is proposed. It results in the combined improvement of all the three key performance parameters: specific power ,efficiency and reliability. Furthermore its distributed architecture facilitates integration with various distributed loads such as linear and rotary electromechanical systems.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The applications which will benefit the most from this development are those where specific weight, efficiency and reliability are key. They include aviation propulsion in both the hub and the rim motors for integrated motor fan systems; flight control actuators; linear systems such as cargo movers; high specific motors for inertial wheel for satellite, winches for both aero systems and tethers; low speed robotics; distributed systems for de-icing.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The major thrust in commercial all-electric aviation critically depends on propulsion system with high specific power efficiency and reliability. This inverter development will provide a major enhancement to electric propulsion such as the Polarix turn-less ACTS motor whose key attribute is its High specific power, efficiency and reliability.
Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.07-2210**

SUBTOPIC TITLE: Electric Power Generation Via Thermionic Conversion for Hypersonic Applications

PROPOSAL TITLE: Thermionic energy conversion for hypersonics

Small Business Concern

Firm: **Spark Thermionics**
Address: **1540 62nd Street, Suite B, Emeryville, CA 94608**
Phone: **(360) 389-6882**

Principal Investigator:

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Business Official:

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Phone: **(360) 389-6882**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Spark Thermionics proposes to develop a design for thermionic devices that integrate directly into hypersonic vehicles. Thermionic energy conversion has the potential to leapfrog competing technologies but has largely been neglected for decades. Today, we have demonstrated best-in-class thermionic performance using novel materials and manufacturing techniques, as well as fully encapsulated prototypes meeting solicitation targets, including power density (1-10 W/cm^2). Using these devices as a baseline, we propose to develop a new design that is compatible with harvesting heat directly from high temperature surfaces in the vehicle, relying on existing thermal pathways within the vehicle to simultaneously generate electricity while thereby displacing and reducing the vehicle thermal load. These devices can increase the Mach number in any vehicle and we believe will be enabling for long-duration and reusable hypersonic vehicles. If successful, our solution will add virtually no extra weight or volume vs the existing skin / liner, becoming the “APU” for all next-generation long-duration hypersonic vehicles.

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

Development of hypersonic capabilities is “the highest technical priority” according to Dr. Michael Griffin, DoD Under Secretary for Research and Engineering. However, for reusable and long-duration hypersonic vehicles, no good way to power the vehicle currently exists: a standard APU is not compatible with the lack of moving parts in typical hypersonic propulsion systems. For reusable and long-duration vehicles, of strong interest to NASA, we propose thermionics can become the "APU," generating power from existing high-T waste heat streams.

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

The applications outside of NASA are numerous for Spark's uniquely high power density technology. We have identified multiple commercial markets that value the small size and low weight of our generators, and we have received strong validation of scalable, compact generators from the Army, including SBIRs as well as being named finalists in xTechSearch 2.0 and AFC Innovation Combine.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H3.02-2794**

SUBTOPIC TITLE: Microbial Monitoring for Spacecraft Cabins

PROPOSAL TITLE: Flow-through Luminescence Analyzer for Real-time Evaluation (FLARE)

Small Business Concern

Firm: **Leiden Measurement Technology, LLC**
Address: **1230 Mountain View Alviso Road, Suite A, Sunnyvale, CA 94089**
Phone: **(408) 351-6720**

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):

FLARE is a real-time, in-line, flow-through fluorescence spectrometer that operates using four excitation wavelengths ranging from the DUV (~250nm) through the visible to excite fluorescence in microbial proteins, metabolites (e.g., NAD(P)H, siderophores), and pigments. The use of multiple excitation wavelengths allows for the detection of many different molecular species (including background contaminants) which would otherwise not all be accessible and/or as distinguishable with a single excitation wavelength.

FLARE draws heritage from another flow-through fluorescence instrument developed by LMT which uses a single excitation wavelength (265nm) and six emission bands to detect microbial protein fluorescence. This predecessor has been deployed and tested aboard the VALKYRIE cryobot at the Matanuska Glacier (AK) where it monitored, in real time, microbial cells in the generated melt water at concentrations below 50 cells/mL with good precision. By expanding the number of excitation wavelengths and significantly increasing the number of detection channels to 16 or even 32, FLARE will be able to excite a much larger number of compounds and be better equipped to spectroscopically distinguish between them. This will allow FLARE to detect cells (e.g., via proteins) and, by measuring the fluorescence from tell-tale fluorophores such as NAD(P)H (which only

fluoresces in a reduced state) and siderophores (e.g., pyoverdin), inform as to the metabolic activity or possible pathogenicity of the microbes.

Since FLARE is a continuously-monitoring flow-through system, it can detect larger eukaryotic cells such as protists and fungi at very low levels (<< 1 cell/mL). Their relatively large biomass will cause very large distinguishable spikes in the data. Based on performance of its predecessor, we expect that FLARE will be able to meet the monitoring requirements of NASA's microbiological limits of detection for potable water sources.

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

FLARE would be ideal to deploy aboard the ISS or other crewed vehicle where it could continuously monitor the potable water for microbial contamination. Future missions would include those to and on the Moon and, later, Mars. Additionally, FLARE could be used aboard a long-duration science exploration mission to an Ocean World where it could be used as a triage instrument to trigger sample acquisition and analysis by a limited-run high-performance instruments.

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

FLARE could be used for industrial water monitoring. For example, FLARE could be deployed at sites of mining operations and oil/gas exploration where industrial holding pond water must be monitored for aromatic compounds before being released into the environment. Additionally, FLARE can monitor drinking water quality for aromatic compounds and microbes at treatment centers and bottling plants.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H6.22-2890**

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

PROPOSAL TITLE: 3D Integrated Memristor Chip for Neuromorphic Processing

Small Business Concern

Firm: **Prixarc, LLC**
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Phone: **(937) 782-8206**

Principal Investigator:

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Phone: **(937) 782-8206**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Technical Abstract:

This SBIR project proposes an integrated, multi-functional and reprogrammable memristor array having a multilayered crossbar architecture to emulate biological synapses in a small scale. Passive memristor crossbar array will be integrated with necessary peripheral circuitry for control of resistance states of memristors for imitating synaptic weights of neural networks. The input-output signals will be modulated using appropriate field programmable gate array (FPGA) control. Our proposed work demonstrates a less costly FPGA controlled integrated neuromorphic processor chip design scheme using oxide based memristors and peripheral circuitry from traditional CMOS technology. The proposed 3D memristor architecture could provide a unique cross-bar array technology with reconfigurable memristors, with the resistance states of memristors controlled using an FPGA. The FPGA based system would allow for precise programming of the memristors for the training, and the available computing and memory resources for inferencing. The innovation is in the design and fabrication of oxide thin film based memristors for each layer, with some of the memristors exhibiting large off/on resistance ratios, some used for switching, and some with low off/on resistance ratio with large number of intermediate resistance states (depicting the synaptic weights). Innovative fabrication and packaging solutions will be considered in Phase 2 for developing a microsystem with unique low power neuromorphic computing capability with SWaP considerations for small satellites.

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

Neuromorphic computing is expected to enable NASA's growing demands for artificial intelligence (AI) and machine learning (ML) on board space platforms to optimize and automate operations. A hardware based neuromorphic computing utilizing memristors provides a potential low power computing with integrated memory and decentralized operations. Such an architecture could be used for onboard learning to optimize communication and data processing capabilities in a cognitive system meeting the SWaP constraints in space systems.

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

The commercial product from this research is an ultra-power efficient and high-throughput hardware processor system for deep learning in a distributed computing setting. The proposed system will be appliable in areas, including UAVs for the US Air Force, systems for the Army and Navy, and many commercial systems such as communications systems, collaborative robotics, autonomous systems, and IoT.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.03-3084**

SUBTOPIC TITLE: Future Aviation Systems Safety

PROPOSAL TITLE: UAS Hazard Model (UHM)

Small Business Concern

Firm: **Blazetech Corporation**
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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):

As the air space becomes more complex due to the introduction of new vehicles and missions using Unmanned Aircraft Systems (UAS), new methods of ensuring air space safety are needed as the risk for mid-air collisions and potential casualties grows. Risk assessments of UAS in the air space have been performed by US DOT Volpe Center and NASA Langley Research Center. They identified hazards, estimated their probabilities and risk mitigations in case a failure occurs. Many of the risks that UAS pose to the air space and ground communities are evolving.

We propose to develop engineering models of the 3-D, time-dependent hazard trajectory volume that travels with the UAS in case of a failure. This volume is larger than a projection of the crash area on the ground as some UAS may glide for a distance while others may spin before crashing. We will focus on the key failure scenarios addressed in prior studies such that our results complement the state-of-the-art by defining the potential severity of the failure as a function of space and time. The actual severity will depend on the intersection of these hazard volumes with other UAS or vulnerable people or assets. As the UAS follows its trajectory, the hazard trajectory volume of a failure change and the risk changes accordingly.

In Phase I, we will develop engineering models of the dynamics and flow characteristics of six failure scenarios that will relate the hazard volume shape and size swept by the UAV. This model will be tied to key parameters of the vehicle, its operation, and environment. This hazard volume will move and evolve with the UAV from the instant of failure to crash.

In Phase II, we will couple our hazard volume model with probability of failure models to identify, quantify, and prioritize risks to the air space. Furthermore, our model will be tied to real-time data

collected from the UAVs including their identity and locations as function of time, so the hazard volume evolves in time.

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

This fast-running model can be used offline in the development stage of the IASMS. This model will be used in the flight planning stage to give an idea of what density of UAS is acceptable as a function of each UAS's capability and characteristics, as well as environmental variables such as wind velocity and weather. The Hazard Volume model can also be expanded to be used in the IASMS to give risk calculations of the airspace in real time, as a component of an advanced collision avoidance system.

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

The model can be incorporated into any larger system that involves the autonomous management of more than one UAS in close proximity, such as avoiding catastrophic chain reaction events, as well as identifying the risk of using UAS around vulnerable assets and personnel. This model can be used in construction work, emergency responses (e.g.: firefighting, search and rescue).

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.09-2218**

SUBTOPIC TITLE: Small Spacecraft Transfer Stage Development

PROPOSAL TITLE: High Performance Pump-fed Transfer Stage for Venture Class Deep Space Missions

Small Business Concern

Firm: **Flight Works, 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):

Flight Works is proposing to leverage its ongoing development of a high delta-V (> 3 km/s) pump-fed "green" monopropellant transfer stage to obtain an even higher performance, high thrust, pump-fed hypergolic bipropellant stage designed specifically for small spacecraft deep space missions. The costs targeted for such stage would enable dedicated interplanetary missions with CubeSats and Nanosats at a price measured in millions as opposed to high tens of millions.

The proposed concept benefits from the extensive micro-pump technology developed at Flight Works for hypergolic, storable bipropellant propulsion systems, combined with space system-level know-how of its principals. With the technology, a pump-fed monopropellant system outperforms a high-performance pressure-fed biprop system; this performance is further enhanced here with a pump-fed biprop system. The result is a growth in payload capability of over 40%. The other benefit is a low-pressure set of tanks, reducing efforts associated with range safety compliance.

The biprop stage also leverages the commonality with the avionics suite of the monopropellant stage. This approach allows reducing the development scope, costs and risks while providing a high-performance, high-thrust transfer stage optimized for deep space missions.

The high thrust allows for rapid, efficient transfers, compared with electric propulsion systems which require many months to reach the targeted orbit. Also, the system can either stay attached to the small primary payload for long term mission operations or deploy it onto its destined trajectory, thus enhancing mission flexibility.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

With a stage designed to provide over 3 km/s delta-V to a nanosat payload for deep space missions, it can be used for NASA lunar and interplanetary applications. These include missions similar to the NASA Cislunar Autonomous Positioning System Technology Operations and Navigation Experiment (CAPSTONE), or follow-ons to NASA's Mars CubeSat missions MarCO-A and -B. It can also be used for NASA LEO and GEO nanosat missions, whether launched as dedicated or as secondary payloads.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non-NASA applications include commercial and DoD missions requiring high orbital maneuver capabilities. These include missions on small dedicated launch vehicles where additional delta-V is required, as well as space-tug applications on Falcon-9 rideshare launches. The stage can also be used for other applications such as orbital inspectors.
Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.04-2534**

SUBTOPIC TITLE: Guidance, Navigation, and Control

PROPOSAL TITLE: Optical gyroscopes and accelerometers at the fundamental precision limit

Small Business Concern

Firm: **Lenzner Research, 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: 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 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 of a Phase I study on a discrete-components OPO will be applied to two fiber-OPO prototypes in Phase II. 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. 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). With reduced payload, these instruments could also be used in small satellites.

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

Non-NASA applications in existing markets are the uses in 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 observing effects in General Relativity.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z7.04-2415**

SUBTOPIC TITLE: Landing Systems Technologies

PROPOSAL TITLE: High spatio-temporal resolution particle sizer for plume-induced ejecta clouds

Small Business Concern

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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 SBIR Phase I addresses the NASA need expressed in solicitation topic Z7.04, Landing System Technologies, Plume-Surface Interaction (PSI) Instrumentation, Ground Testing, and Analysis. In particular, it addresses “PSI-specific flight instrumentation, with particular emphasis on in situ measurements of particle size and particle velocity during the landing phase.” We will develop a sensor that measures the particle size distribution in PSI ejecta clouds plus the particle concentration

(the ejecta cloud's solid mass density), both with fine spatial and temporal resolution. The Phase I effort will demonstrate high quality lidar backscatter (sidescatter) measurements from visible to long-wave infrared wavelengths over concentration and length scales relevant to measuring ejecta particle size distributions. It will develop the mathematical framework to invert these backscatter measurements to obtain the particle size distribution at each location in the lunar plume ejecta cloud. It will demonstrate that this method may be packaged as a practical instrument for small lunar payloads. The sensor will be combined in Phase II with a particle velocimeter developed by our team under other NASA funding. The work will lead to improved understanding of lunar lander plume ejecta transport. Improvements are sought in the science of soil erosion under extreme conditions, such as supersonic flow, transitionally rarefied gas, low gravity, and unweathered unrounded particulates. The instrument will enable the acquisition by actual landers of empirical data to guide the models and eventually to solve the soil erosion physics. These data will inform NASA's highly advanced flow codes for predicting these phenomena via empirical correlations.

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

The sensor will enable NASA to measure particle-scale ejecta transport physics to calibrate its high-fidelity plume/regolith flow code, the Gas Granular Flow Solver. This will enable NASA to predict blast ejecta effects for any size or configuration of lunar lander and to develop mitigation technologies and strategies.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial space companies need sensors to document compliance with international law regarding blast ejecta. The sensor can also be used to quantify volcanic ash clouds and other dust plume affecting airline transport and Earth-monitoring for climate change.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z4.05-2585**

SUBTOPIC TITLE: Nondestructive Evaluation (NDE) Sensors, Modeling, and Analysis

PROPOSAL TITLE: Adaptive, Velocity-Sensing Receiver for In-Line Inspection of Additive Manufactured Aerospace Parts

Small Business Concern

Firm: **Intelligent Optical Systems, Inc.**
Address: **2520 West 237th Street, Torrance, CA 90505**
Phone: **(310) 530-7130**

Principal Investigator:

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Business Official:

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Address: **2520 West 237th Street, 90505 - 5217**
Phone: **(424) 263-6338**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

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

As the science and technology of additive manufacturing (AM) advance, an increasing number of safety-critical aerospace components will be manufactured by AM. Specific NASA missions with AM components include the Artemis Program's Orion Spacecraft and the Space Launch System, with Boeing as prime contractor. While AM has many benefits, there is a gap in the availability of reliable techniques to qualify the finished parts. Reliable qualification is especially important for safety-critical aerospace applications, as only parts that can be fully inspected can be certified for flight. In a previous NASA SBIR project, we demonstrated the feasibility of filling this gap by applying laser ultrasonic testing (LUT) for nondestructive evaluation of each AM deposited layer in real time as it is formed. This in-line inspection qualifies the part layer-by-layer, directs defect removal during the manufacturing process, and ensures qualified finished parts that require no further testing. In this proposal we describe a new type of laser ultrasonic sensor that will greatly improve the state of the art in inspection performance, leading to improved suppression of mechanical and acoustical disturbances. This performance improvement will in turn enable the implementation of a simpler and more agile beam setup and probe design. At the start of the project, we will be at TRL 3; at the end of the project, we will be at TRL 4.

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

Additive manufacturing is finding broad applications by NASA and its contractors for the fabrication of high-value, safety-critical components. The enhanced in-line AM inspection system described in this proposal will enable the production of fully qualified AM parts to be used in the Orion Spacecraft and the Space Launch System.

The inspection technology described in this proposal is aligned with the NASA Space Technology Roadmaps, and addresses needs described in the recent NASA memorandum "Nondestructive Evaluation of Additive Manufacturing."

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

Aside from space, industries that are adopting additive manufacturing include military and commercial aviation, automotive and consumer products. Aircraft engine suppliers have been investing heavily in capacity for AM parts manufacturing. Key high-value components such as injection nozzles are found multiple times in a turbine engine. The use of AM will reduce engine weight and cost.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S2.04-1261**

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

PROPOSAL TITLE: Polishing of X-Ray Optics

Small Business Concern

Firm: **OptiPro Systems, LLC**
Address: **6368 Dean Parkway, Ontario, NY 14519**
Phone: **(585) 265-0160**

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):

Manufacturing grazing incidence x-ray mirrors costs between $4 to $6 million per square meter of optical surface area. To reduce the cost of making x-ray mirrors, NASA is seeking manufacturing solutions to aid in cost reduction factors of 5 to 50 times. One cost driver is the mandrel-based polishing process that impacts both the inside and outside surfaces of an X-ray mirror shell. Current shells are created through a replication process utilizing an aluminum mandrel. OptiPro is proposing to enhance process solutions to reduce the cost required for polishing both the mandrel and the outside shell surface by maintaining a constant force during polishing, developing new polishing tools, and optimizing the polishing algorithm. The target platform for these improvements will be on OptiPro's bridge polishing platform that has a rotary A-axis to spin the part and a combination polishing head that can handle a range of polishing tools while making it easier to rapidly switch between tools. These improvements will be directly applicable to the polishing being done at Marshall Space Flight Center on various equipment including OptiPro's 6-axis UltraForm Finishing platform. OptiPro Systems will focus on the process evaluation and the interface between the polisher and metrology platform to provide a cost effective deterministic solution. A new force-measurement system will also be evaluated for its potential to provide in-situ process feedback during polishing. New polishing tools will be designed, built, and tested along with the pellet tool developed at MSFC and other commercially available polishing tools. Algorithm changes will be required for polishing the surfaces of the x-ray mirror mandrel and shells and will be demonstrated on a surrogate aluminum mandrel. The results of this Phase I effort will enhance the fabrication at MSFC and provide the concept design requirements of a meter class finishing platform which could be built in a Phase II effort.

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

The proposed system will benefit all projects using x-ray shells and mandrels, both cylindrical and segments, that fit within the working envelope of the proposed machine. Missions including IXPE, LYNX, and ESCAPE will be among those that would benefit from the technology being developed. These improvements will be applicable to polishing being done at Marshall Space Flight Center on various equipment including OptiPro's 6-axis UltraForm Finishing platform and polishing being done at Goddard Space Flight Center.

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

The proposed polishing system and hardware improvements would benefit all types of part geometries including the following:

- Aspheres
- Freeform optics
- Spheres
- Cylindrical optics
- Ogive missile domes

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z3.03-2842**

SUBTOPIC TITLE: Development of Advanced Joining Technologies, Large-Scale Additive Manufacturing Processes, and Metal Recycling Technologies for On-Orbit Manufacturing

PROPOSAL TITLE: Tubular Truss Additive Manufacturing

Small Business Concern

Firm: **Opterus Research and Development, Inc.**
Address: **4221 Rolling Gate Road, Fort Collins, CO 80526**
Phone: **(505) 250-3006**

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):

Opterus proposes Tubular Truss Additive Manufacturing (TTAM), a robotically positioned printhead for in-space additive manufacturing of large, high-performance space trusses, under the subtopic “Development of Large-Scale Additive Manufacturing Processes for On-Orbit Manufacturing.” TTAM solves the challenge of achieving mass efficient large space platforms for space solar power, telescope apertures, and communications and sensing systems, scaling 100’s of meters. TTAM is suitable for lunar and Mars surface structures as well. TTAM is a printhead technology that uses high performance booms as the feedstock instead of solid or tape filament. The baseline TTAM fusing method is removable mechanical fasteners, which inherently require very little energy input. A specialized fastener has been designed that is easily installed or removed by the TTAM printhead; easy repurposing and reuse of struts is a key feature. The fastener also provides a mechanical interface and attachment point for the primary system components. Opterus’ TTAM approach surpasses competing OSAM approaches because it achieves a feedstock packing density of near 100%, uses the high-performance structural materials, enables reusability, and does not rely on high energy inputs.

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

Potential applications include space solar power, electric propulsion, large solar arrays, RF and higher frequency apertures, habitats, and lunar and Mars surface structures.

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

Potential non-NASA applications are similar as commercial interests in space solar power and commercialization of space resources continues. Large solar arrays to power space mobility and resource extraction enterprises are prime applications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H4.05-1777**

SUBTOPIC TITLE: Advancements in Water and Air Bladder Assemblies and Technology

PROPOSAL TITLE: Improved Feedwater Supply Bladder for EVA

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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Phone: **(603) 640-2487**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The Portable Life Support System (PLSS) on the Advanced Space Suit will carry consumable cooling water maintained at ambient pressure within an array of soft-walled, flexible reservoirs known collectively as the Feedwater Supply Assembly (FSA). The FSA system is charged to a high pressure and slowly drains of water making up for cooling system evaporation during the course of an EVA. The system is required to cycle between a full state and an empty state many times with possibly long periods of time between uses delivering clean water to the cooling system. The existing FSA bladder design does not meet these needs. The design includes multiple regions where folds and stress concentrations lead to structural failures over time. Creare's solution incorporates novel geometric design and advanced materials to remedy these failure modes and provide high cycle life, long shelf life, and clean cooling system makeup water. In Phase I, Creare plans to demonstrate key aspects of the design in a subscale prototype system. In Phase II, Creare plans to produce a full-scale prototype and develop plans to integrate the prototype into the existing xPLSS.

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

The FSA bladder system to be developed here offers a robust alternative to storing cooling water in the PLSS. Reducing the dry component volume and mass mean more volume devoted to cooling water, extending EVA mission duration. The robust, lightweight design could also be employed in other high reliability components like drinking water supplies. Future life support applications like hydroponics and aquaculture requiring water and other liquid feed supplies could also benefit from this lightweight, robust liquid storage technology.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Man-portable hydration systems and personal liquid fuel supply benefit from lightweight, robust bladders by reducing carry load. UAVs could utilize the lightweight, robust fuel bladders to reduce airframe mass, boosting power-to-weight ratio and flight duration. Flexible bladders also could offer compliance in the event of a structural failure where a rigid container would otherwise fail.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.08-2740**

SUBTOPIC TITLE: Aeronautics Ground Test and Measurement Technologies

PROPOSAL TITLE: Novel Surface Velocity Sensor

Small Business Concern

Firm: **InnoVital Systems, Inc.**
Address: **3901 Calverton Blvd, Ste 155, Calverton, MD 20705**
Phone: **(240) 790-0598**

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):

Surface velocity measurements are a key component of understanding the flow over an aerodynamic surface and can be challenging in a complex (i.e. bi-directional transient) flow. The proposed technology is a novel surface velocity sensor that is insensitive to inertial loads and thermal effects and can provide magnitude and direction of flow over a surface. The sensing technique uses a plasma field generated between cathode and anode leads that is deflected due to the air flow. A novel configuration of leads enables velocity measurement using a differential response of electrical impedance across the leads. Results from high fidelity simulations validate this novel sensing approach. During the proposed effort, a prototype sensor will be developed and fabricated for proof-of-concept hardware demonstration. Data from benchtop testing with the sensor will be compared with conventional measurements to demonstrate sensitivity to surface flow velocity. The Phase I prototype sensor will be integrated into a blade section and tested in an open-jet wind tunnel. The results of the proposed effort will set the stage for the Phase II program to further refine the sensor to improve sensitivity, develop electronics hardware, and testing in a relevant rotating environment.

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

The proposed sensor technology would be used in NASA testing facilities including wind tunnels and experimental aircraft. Additional applications include challenging testing environments including rotor blade and propeller blade surface flow measurement.

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

The sensor would be used in military and commercial wind tunnel testing facilities used to evaluate performance of systems including fixed wing vehicles, rotary wing vehicles, ground vehicles, and wind turbines. The sensor system would be used in instrumenting rotor blades for Vertical Take-off and Landing configurations and in difficult to instrument areas on advanced fixed-wing configurations.
Duration: **6**

PROPOSAL NUMBER: 21-1- **H5.02-2042**

SUBTOPIC TITLE: Hot Structure Technology for Aerospace Vehicles

PROPOSAL TITLE: Resins for Rapid Manufacturing of C-C Composites

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

Carbon-carbon composites (C/C) are currently used as hot structures in a variety of extreme environments encountered during hypersonic flight, rocket launch and atmospheric entry, descent and landing. Their use is limited by their expensive and time-consuming manufacturing process. Delivery times of over six months from order placement are common, a result of the long manufacturing process and the limited number of suppliers. Building on our demonstrated expertise in carbon

manufacturing and commercialization, in this Phase I project we will properly formulate the resin so that C/C composites can be made in days to weeks, instead of months. The process that eliminates multiple densification cycles, yet results in composites with equivalent mechanical and thermal properties to the current state-of-the-art. With the domestic need for C/C parts increasing, TDA believes that there is a currently an outstanding opportunity to enter the C/C manufacturing market. TDA has a demonstrated history of manufacturing resins with high char yields, and we propose to build on that experience to economically manufacture resins that have been demonstrated to produce strong chars in exceptionally high yield.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed improved C/C manufacturing process would be used for hot structures, including upper stage rocket engines (including those of the Space Launch System), in-space propulsion systems, Lunar/Mars ascent/descent propulsion, nuclear thermal rockets, and hot gas valves. Hot structures allow for reduced vehicle weight and/or reusability in a variety of exploration and sample return missions. TDA's process will shorten development and procurement schedules, thereby providing substantial cost savings to all programs that utilize our C/C.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The Air Force, Navy, Army, and Missile Defense Agency would benefit from improved C/C manufacturing for their hypersonic vehicle programs, which make extensive use of C/C hot structures. The Air Force could also apply our process to their Evolved Expendable Launch Vehicle (EELV) and ballistic missile programs. C/C parts are also of interest to gas turbine manufacturers like General Electric.
Duration: **6**

PROPOSAL NUMBER: 21-1- **H8.01-2139**

SUBTOPIC TITLE: Low Earth Orbit (LEO) Platform Utilization to Foster Commercial Development of Space

PROPOSAL TITLE: Mercurous Halide Crystals Growth in the International Space Station (ISS)

Small Business Concern

Firm: **Brimrose Technology Corporation**
Address: **19 Loveton Circle, P.O. Box 616, Sparks, MD 21152**
Phone: **(410) 472-2600**

Principal Investigator:

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Phone: **(936) 588-6901**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 7
Technical Abstract (Limit 2000 characters, approximately 200 words):

We propose the growth of Acousto-Optic crystals such as Hg2Cl2, Hg2Br2, and Hg2I2. These crystals are very promising material and extremely suitable for the fabrication of Acousto-Optic devices such as Acousto-Optic Tunable Filter, Acousto-Optic Modulator, and Acousto-Optic Q-Switches, etc. The crystal growth process is divided into two stages: One is source material purification and the other is crystal growth. We will upgrade the purification furnace for high-purity level and grow 3 kinds of crystals using the high-purity source material. Consequently, we will produce novel 3 large diameter crystals. Also, we will simulate 3D software for getting the ideal thermal profile for boundary conditions of the ISS. Then, we can develop new crystal growth furnace for the micro-gravity condition. In addition, the development of the growth furnace model has to be considered for micro-gravity environment and the quality of the grown crystal grown in the ISS would be highly improved. The actual growth furnace will be built when the Phase II program is started.

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

AOTF Spectrometer and Imaging Devices for potential NASA Applications include Planetary Missions to Mars, Comets, and Moons Exploration.

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

AOTF or AOM for Non-NASA Commercial Applications include Material Exploration, Target Detection, Industry Processing Monitoring and controlling.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.07-2172**

SUBTOPIC TITLE: In Situ Instruments/Technologies for Lunar and Planetary Science

PROPOSAL TITLE: Miniature High Resolution Planetary X-ray Diffraction Instrument

Small Business Concern

Firm: **eXaminArt, LLC**
Address: **922 San Leandro Avenue, Suite G, Moutain View, CA 94043**
Phone: **(650) 799-2118**

Principal Investigator:

Name: **Philippe Sarrazin**
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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 research targets the development of a next-generation crystallographic instrument for definitive mineralogical analysis. CheMinX is an in-situ **X-Ray Diffraction** and **X-Ray Fluorescence** (**XRD/XRF**) instrument suitable for a range of planetary surface explorations including Discovery-class missions and MER class rovers. This instrument will provide **quantitative mineralogy and elemental chemistry** from r**ocks and soil samples** on Mars, the Moon, Venus, or other rocky or icy bodies, **including Small Bodies like asteroids, comets, and smaller moons**. This SBIR addresses critical improvements in technology compared to the CheMin XRD instrument on MSL, to enable a smaller more capable planetary instrument. The four major improvements of CheMinX over CheMin are **improved XRD resolution, improved XRF performance**, a **much-reduced volume**, and a broader field of application including **Small Bodies**. This SBIR Phase I+II targets the development of CheMinX to TRL 4/5.

This work inherits from 20+ years of development of advanced XRD systems for planetary and commercial applications by the PI and his collaborators.

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

Deployment of XRD or XRD/XRF instrument on rocky planets, moons, and Small Bodies as part of a landed mission with an emphasis on surface mineralogy and chemistry.

Remote XRD/XRF analysis of confined samples with a robotic instrument inside a sample curation chamber.

Planetary analog field research.

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

Next generation of small portable and benchtop XRD/XRF instruments for manual or robotic applications in field and laboratory research and industries such as mining, petroleum, cement, forensics, homeland security, defense, pharmaceutical, etc.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H5.02-2591**

SUBTOPIC TITLE: Hot Structure Technology for Aerospace Vehicles

PROPOSAL TITLE: Low Cost Carbon-Carbon Composites for Hot Structures

Small Business Concern

Firm: **M4 Engineering, Inc.**
Address: **4020 Long Beach Boulevard, Long Beach, CA 90807**
Phone: **(562) 981-7797**

Principal Investigator:

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Business Official:

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Address: **4020 Long Beach Boulevard, CA 90807 - 2683**
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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 here is a novel carbon-carbon composite (CCC) manufacturing method that allows rapid manufacturing of relatively thick carbon-carbon structures and robust through-thickness reinforcement that significantly simplifies the attachment of a hot structure to a cold structure, as encountered in the interface of an aeroshell and the underlying structure in a hypersonic vehicle. This results in the ability to make a highly integrated, load-bearing, unitized skin-stringer-frame carbon-carbon aeroshell that includes a mechanically and thermally advantageous joint to an internal cold structure such as a composite tank. The manufacturing innovations include a precursor resin improvement, a through-thickness reinforcement improvement, and an overall aeroshell design improvement that, when taken together, enable a revolutionary approach to hot structure design and

manufacturing that has the potential to greatly improve performance, robustness, and reliability of such systems while precluding the need for a separate thermal protection system (TPS).

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

Aeroshells for descent/reentry missions, structures for hypersonic vehicles, propulsion structures such as nozzle extensions.

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

Aeroshells, hot structures, and propulsion components for launch, reentry, and hypersonic vehicles.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z1.06-3130**

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

PROPOSAL TITLE: Rad-Hard Ga2O3 Diodes

Small Business Concern

Firm: **Kyma Technologies, Inc.**
Address: **8829 Midway West Road, Raleigh, NC 27617**
Phone: **(919) 789-8880**

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 this Phase I program, Kyma Technologies will advance the state of the art in kV-class Schottky barrier diode devices utilizing Ga_2O_3 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. Phase I will also lay the groundwork for a more substantial modeling/simulation effort in Phase II to assist in rad-hard device design based on the expertise of CFDRC with Kyma feedback.

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, and deep space exploration.

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: 21-1- **A1.01-1814**

SUBTOPIC TITLE: Aerodynamic and Structural Efficiency - Integration of Flight Control with Aircraft Multidisciplinary Design Optimization

PROPOSAL TITLE: Multidisciplinary Design Optimization Framework for DEP Aircraft Including Flight Controls

Small Business Concern

Firm: **Continuum Dynamics, Inc.**
Address: **34 Lexington Avenue, Ewing, NJ 08618**
Phone: **(609) 538-0444**

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):

There has been a recent upsurge in the development of electric vertical take-off and landing (eVTOL) and electric short take-off and landing (eSTOL) aircraft for Urban Air Mobility (UAM) applications. These vehicles center on the use of Distributed Electric Propulsion (DEP) and offer several benefits in terms of faster, safer, quieter, more efficient and environmentally friendly transportation of passengers and goods. These vehicles are nonetheless complex to design, due, amongst others to the greater number of control effectors present relative to traditional fixed- and rotary-wing aircraft. In addition to conventional control surfaces, each propeller can act as a control effector that influences aircraft dynamic behavior. Control effector actuation stems from flight control laws that are developed after the aircraft design has been finalized. As such, flight control laws are not currently accounted for in the aircraft design process. Inclusion of flight controls within multidisciplinary design optimization (MDO) of DEP aircraft can result in more efficient and novel designs. The proposed effort aims to develop a modular MDO software framework for DEP aircraft design that will couple flight controls together with key disciplines such as aerodynamics and structures to meet this need. Resulting designs will leverage the inclusion of open- and closed-loop flight control parameters in the optimization to tailor aircraft sizing and performance. A prototype framework will be developed to demonstrate proof of concept in Phase I. An application case study using notional DEP aircraft configuration as baseline will be performed to demonstrate tool viability and assess efficiency.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The development and application of the proposed tool will directly support NASA's ARMD Strategic Thrust #3 "Ultra-Efficient Subsonic Transports" and Strategic Thrust #4 "Safe, Quiet, and Affordable Vertical Lift Air Vehicles" since the inclusion of flight controls in DEP aircraft design is expected to produce novel, efficient, and cost-effective vehicle designs for both long-haul transportations, as well as inter- and intra-city UAM applications.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

CDI provides engineering services and licenses software to multiple eVTOL companies and industry teams responsible for engineering analyses of large-scale DoD Future Vehicle Lift (FVL) aircraft development programs. The proposed capability will be of immediate use to these entities and will significantly reduce the number of design iterations in their aircraft design cycles.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z2.02-1828**

SUBTOPIC TITLE: High-Performance Space Computing Technology

PROPOSAL TITLE: Radiation Tolerant AI Processing In Space

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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Phone: **(858) 332-0700**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Space Micro Inc. and GSI Technology, Inc. propose the development of a optimal real-time data sorting inference processing unit (IPU) board for Earth observation missions with a need for higher processing power. This computer will have the ability to plug into the main communication bus and offers enhanced parallel processing power, much to the effect of a supercomputer cluster. The main system would have the ability to reconfigure this IPU device to scale up and down, specifying a specific state depending on the needs of the current task. If one desires, performance limitations can be enforced on the parallel processing unit. For added performance and redundancy, multiple processors will be included on the same board, with the capability to stack multiple units together.

As sensors are quickly advancing, they are producing large quantities of data which is revealing the critical downsides of space based platforms: 1) they require large amounts of mission data and calibration data to be downlinked, and 2) their data products cannot be conveyed in near real-time. Both of these issues can be resolved with the use of high performance processors (Mou et al., 2017). Modern satellites are constantly increasing their abilities to acquire large datasets quickly and efficiently, but this is also proving to be a hindrance.

The goal of this proposal, and its subsequent technologies, is to begin the transition from sensor design to mission capabilities through the development of highly integrated, intelligent computational systems.

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

The cross-cutting radiation tolerant space on-board data processing product evolving from this SBIR has the potential to add value to and enable many potential NASA space missions. Some of these future NASA missions include Lucy, Psyche, IXPE, Restore, Hermes, Whipple, TiME, Hera, Chopper, etc. which encompass both Discovery-class and SMEX missions. The NASA Artemis program including both manned (HLS) and unmanned landers and experiments, plus orbital Gateway are potential candidates.

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

This product can be scaled for a wide range of customers, including emerging commercial constellations for space-based Internet service and Earth observation data (OneWeb, Amazon/Kuiper, Starlink, etc.). There are many DoD (Space Force, Air Force, SDA, U.S. Army SMDC, SOCOM, SPAWAR, MDA, NRO) space applications, including a growing DoD interest in the cislunar domain.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z3.04-2593**

SUBTOPIC TITLE: Autonomous Modular Assembly Technology for On-Orbit Servicing, Assembly, and Manufacturing (OSAM)

PROPOSAL TITLE: CrossLink

Small Business Concern

Firm: **Motiv Space 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):

Motiv Space Systems (Motiv) proposes a transformative robotic solution, CrossLink, for On-Orbit Servicing, Assembly, and Manufacturing (OSAM). Crosslink is a fusion of existing and emerging

technologies under development at Motiv. For OSAM activities to realize their full potential, robotic systems of the future must improve in a number of key areas. CrossLink will enable future OSAM activities through:

- Low-Cost, Mobile, Modular Robotic Manipulation System
  - The CrossLink robotic system will be architected utilizing the xLink robotic arm architecture as its basis. xLink is designed to be a highly modular, easy to re-configure system, and as such the previously designed components can be shared across both xLink and CrossLink.
- High Bandwidth, Open Architecture, Plug-and-Play Connectivity (SpacECAT)
  - Based upon Motiv's ground robotics products, an EtherCAT communication architecture will be developed and prototyped on direct path to flight hardware utilizing Motiv's Flight DELTA motor controller. This new SpaceECAT architecture will provide high speed and bandwidth communication across the CrossLink Robotic Arm tools, mobility, and tasks as well as any other on orbit SpaceECAT enabled devices. Furthermore, this will enable the use of Motiv's ROS control tools to be used for flight systems.
- Robotic Mobility and Generalized Tool Utilization
  - The grappling end-effector will enable the mobility and tool use of the CrossLink system. The end-effector acts as both a structural and electrical connection for passing power and communication signals to the spacecraft and other SpacECAT enabled tools/devices.

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

NASA's OSAM programs are developing ever sophisticated robotic technologies and tools. An emphasis on modularity, scalability and affordability is growing within the community. The CrossLink addresses each of these points of emphasis and provides options for NASA in its pursuit of assembly activities on orbit. Specific mission concepts include the In-Space Assembled Telescope, aggregated instrument payloads assembled on truss systems for complex science gathering, assembly of 3D printed structures, Internal Gateway Robotics, etc.

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

As NASA and other government agencies create mission roadmaps for OSAM related activities, commercial entities are building business plans to create an industrial operated sector complete with services. The CrossLink can support mission services including space tugs, material transfer between depots, and on-orbit construction of integrated systems following multiple launches.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.01-1541**

SUBTOPIC TITLE: Advanced Air Traffic Management System Concepts

PROPOSAL TITLE: Weather Guidance for Upper Class E Traffic Management

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3

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

The proposed SBIR develops the first-ever computational-model-based wind turbulence forecasts for ultra-high-altitudes. It applies innovative weather-translation methods to ultra-high weather forecasts to provide an Upper Class E (UCE) Weather Guidance Service (UWGS). UWGS is highly relevant to Subtopic A3.01 because it addresses two key ATM challenges relevant to improving capacity, throughput, and safety of near-future (2025-30) NAS operations in UCE airspace: (1) wind and weather effects in UCE airspace pose significant safety and deconfliction challenges to aviation operations and (2) current weather prediction and translation tools are inadequate to meet these challenges. We address these challenges by first developing an ultra-high-altitude computational wind turbulence forecast model by extending NCAR's gold-standard GTG Class A airspace wind turbulence prediction model. Then, we develop innovative weather translation methods to improve (1) flight intent predictions in UCE airspace, (2) wind hazard alerting, and (3) aircraft separation envelopes, based on wind and aircraft performance, for use in UCE traffic management cooperative separation services. In Phase II, we expand UWGS to address the broader cooperative separation problem in UCE airspace. UWGS supports crucial weather guidance service needs for the ETM Separation Service simulations planned by NASA ATM-X's Collaborative Traffic Management sub-project. UWGS also provides a digital service for potential integration into NASA ATM-X's DIP-TS sub-project's planned Digital Information Platform. Anticipated results of Phase I are a table-top proof-of-concept demonstration based on a UCE flight intent prediction, wind hazard alerting, and separation envelope guidance for a cooperative separation scenario involving at least two UCE aircraft types, which will be chosen in coordination with NASA, FAA, and ETM operators.

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

- Weather Guidance Supplementary Data Service for supporting ETM Separation Service simulations planned by NASA ATM-X's Collaborative Traffic Management
- Digital service for integration into NASA ATM-X's DIP sub-project's Digital Information Platform
- NASA ER-2 high-altitude airborne science aircraft flight planning and dispatching improvements

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

- Flight planning decision aids for UCE and DOD aircraft operators
- Wind-Informed Flight Intent Prediction service for ETM operators
- Upper Class E Wind Hazard Prediction service for ETM operators

- Dynamic, wind- and aircraft-performance-dependent Separation Envelope guidance service for supporting ETM operators' cooperative separation services as well as FAA's regulatory oversight service

Duration: **6**

PROPOSAL NUMBER: 21-1- **H9.07-1892**

SUBTOPIC TITLE: Cognitive Communication

PROPOSAL TITLE: Intelligent Network Slicing and Policy-based Routing Engine (INSPiRE)

Small Business Concern

Firm: **AiRANACULUS**
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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):

AiRANACULUS, and its partners, propose an innovative Intelligent Network Splicing and Policy-based Routing Engine (INSPiRE) Solution to increase mission science data return, improve resource efficiencies for NASA missions and communication networks and ensure resilience in unpredictable space environments. The proposed INSPiRE System is an add-on to the CLAIRE Project, that is developing wide-band spectrum sensing, spectrum-aware routing and cognitive control plane riding on the NASA' s CCSDS Bundle Protocol as an APP. CLAIRE provides spectrum and network

situational awareness to enable link-layer selection and optimization to maximize the data flow. The INSPiRE System utilizes the CLAIRE APP to enable Network Slicing (NS) and Policy-based Routing (PBR). From a logical perspective INSPiRE architecture utilizes the three-state model of network topology, RF performance and PBR – two of these inputs are provided by CLAIRE while the third one defining policy is a flow down from NASA. While the actual path optimizations are complex calculations, INSPiRE abstracts the paths as virtual NSs. INSPiRE brings interesting aspects of 5G networks in the form of Network Function Virtualization, Security, Service Level Agreement (SCI/NET/DET/PNT) and PBR, which allows NASA to leap ahead from link-optimization to secure network optimization. Each NS is end-to-end secure and logically separate tunnel, hence providing security and robustness. Unlike 5G NS which are bound to a specific path and support many applications, INSPiRE NSs are application specific and run across all paths over the node/ satellite constellation. The INSPiRE architecture utilizes the CLAIRE APPs which are embedded on satellite and ground system to determine the topology and measure the RF performance. Collected data is uploaded to the INSPiRE management system where route optimizations are determined based on PBR. These optimizations are transmitted to all CLAIRE APPs which enforce the policy decisions.

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

INSPiRE provides following Capabilities and Applications:

1. Network Slicing provides configuration flexibility to ALL current and future, terrestrial and space-based NASA networks, enabling Service Oriented Architecture and Network Function Virtualization.

2. Policy-based Routing allows NASA networks to control their behavior and over-ride any automated decisions that are made locally hence making them deterministic.

3. Provides Secure Encrypted Network Slices - Allows each of the SCI/ NET/ DET / PNT Services to have separate Virtual Network

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

INSPiRE provides the following Non-NASA Applications

1. Architecture and capabilities are applicable to ALL commercial Terrestrial (3G/ 4G/ 5G / Wi-Fi), Space (LEO/ MEO / GEO/ Relays / Gateways), Backhaul (Optical Fiber / Coax) Networks.

2. Security and Privacy are built in. Hence it is applicable for other Federal Agencies including DoD, DHS, NSA, FAA among others.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.06-2027**

SUBTOPIC TITLE: Vertical Lift Technology and Urban Air Mobility

PROPOSAL TITLE: Integrated magnetics, insulation, and cooling architecture for robust eVTOL motors

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 address the NASA need for advanced technologies that will improve the safety and reliability of the electrical power system/powertrain of UAM vehicles, specifically advancements in thermal management technologies for electric motor systems, Hinetics proposes to develop a new Integrated Magnetics, Insulation and Cooling Architecture (MAGICA) that can help break the trade-off between power density and reliability, and obtain robust, high power motors that can be produced in high volume. This approach reduces electro-thermal stresses at the windings, which are traditionally viewed as the most vulnerable sub-system in motors for electric aircraft. The significantly improved dielectric protection extends the SOA on several fronts including thermal degradation, insulation quality, and partial discharge, preventing winding failure while retaining high power density and system-level benefits. The system offers enhanced electro-thermal performance with the unique infusion of cooling and magnetics, alleviating the iron yoke as a thermal bottleneck, reducing ΔT between the heatsink and coils, and creating sufficient thermal headroom to enhance the coil insulation without degrading motor performance. Combined with modular manufacturing and pre-qualification of the coil assembly offering independent quality assurance, this provides a path to meet NASA requirements for high reliability and safety in cost-effective, mass production.

During Phase I, HINETICS will demonstrate the feasibility of MAGICA through a combination of computer modeling, design optimization, and fabrication and test of a laboratory prototype, which will reduce development risk in Phase II. MAGICA is currently at TRL 2; in Phase II, HINETICS plans to expand the capabilities of the MAGICA into a functional motor prototype at TRL 6. The demonstrated results will offer NASA capability to improve motor performance while prioritizing utmost reliability.

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

When complete, MAGICA will help improve the safety and reliability of the electrical motors used in UAM powertrains. Hinetics has developed a series of machines ranging from the 20-500 kW class, relevant to the NASA Revolutionary Vertical Lift Technology (RVLT) project's concept vehicles, to MW-class high speed machines for the Electrified Aircraft Propulsion program within ARMD. These motors can be readily retrofitted with MAGICA to increase reliability as we scale to volume production.

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

MAGICA enables reliable, safe operation of high power UAM aircraft. This will have uses for Government applications such as civil and military disaster relief, search and rescue, medical

evacuation, firefighting, and commercial applications such as urban air mobility and cargo transport. With little alteration, MAGICA will also be capable of motors for commercial hybrid-electric regional aircraft.
Duration: **6**

PROPOSAL NUMBER: 21-1- **S4.05-2336**

SUBTOPIC TITLE: Contamination Control and Planetary Protection

PROPOSAL TITLE: High Specificity BioAerosol Particle (HS-BAP) Sensor

Small Business Concern

Firm: **Photon Systems, Inc.**
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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 higher performance point detection instruments to measure airborne biological and organic particles within manned spacecraft, spacecraft assembly rooms, and other clean-air environments, driven by planetary protection and other demands. The focus of this effort is to develop a miniature bioaerosol particle (HS-BAP) sensor that detects and classifies biological and other particles with an unprecedented level of sensitivity and specificity in near real time, without reagents or consumables. This effort expands on a long history of particle detector development since the middle 19th century with significant acceleration since about 1990 with further

accelerated after the 9/ll attack and subsequent biological attacks in the U.S. Aerosol sensors include elastic scattering-based sensors, common to most present-day clean room sensors, and include other modes of detection including fluorescence, holography, Raman scattering, mass spectroscopy, laser induced breakdown spectroscopy and other methods. In terms of sensitivity, elastic scattering has the highest cross-sections and produce the largest signals compared to other forms of optical sensors and are the simplest, least expensive, and most compact sensors. However, elastic scattering sensors measure particle density and particle size, but provide no chemical information about the particles themselves. Fluorescence-based sensors have the next highest cross-sections although still orders of magnitude lower than elastic scattering. These sensors are hindered by a technology gap: *the lack of availability of lasers or LEDs with both preferred emission wavelength (<250 nm) and particle irradiance (>50 mJ/cm^2). These are* key features that are necessary to enable both detection and accurate classification of biological particles with an instrument in an easily deployable Size, Weight, Power consumption, and Cost (SWAP-C). This proposal addresses this technology gap.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Contamination control starts with air quality since contamination of surfaces cannot be controlled without control of contamination within the surrounding air. Major applications of the proposed technology for NASA include measurement and identification of particulate contaminant within spacecraft assembly and other NASA cleanrooms for return samples as well as continuous air quality measurement aboard long duration manned spacecraft missions.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non-NASA applications include continuous sampling of air at major population hubs by governmental or private entities to measure and control hazardous biological, bioagent, or other particulates. Other commercial applications include all other clean room or clean air quality applications such as sensitive production in pharmaceutical, chemical, pharmaceutical, and other related industries.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z3.03-3164**

SUBTOPIC TITLE: Development of Advanced Joining Technologies, Large-Scale Additive Manufacturing Processes, and Metal Recycling Technologies for On-Orbit Manufacturing

PROPOSAL TITLE: In-Space Inductive Foundry: Recycling, Sorting and Casting

Small Business Concern

Firm: **Yolo Robotics, LLC**
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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):

Yolo Robotics LLC proposes developing the core technology for an inductive foundry to recycle, sort, and “free-cast” metals in space. The system consists of three perpendicular electromagnetic arrays that are independently commutated to induce arbitrary eddy currents and forces to melt and manipulate metals. This technology applies well-understood phenomena in a completely novel way for a substantial technological advance. Its compact, integrated hardware has no moving parts, an infinite workspace, and scales to match material throughput to available power. Current state of the art recycling and manufacturing is precise but slow, static, and life limited. The inductive foundry produces basic feedstocks (ingots, bars, plates, filament) and complex shapes (brackets, tools, extrusions) significantly faster than additive or subtractive manufacturing. The rough products generated by our in-space inductive foundry can either be used in low-precision applications (radiators, scaffolding, tanks) or more complex applications using additional manufacturing processes in space. The inductive foundry is the ideal tool for remote and continuous in-space recycling and manufacturing. It has immediate applications on the ISS, a sustainable business case to manage orbital debris, and is a foundational element of the cislunar economy. This Phase I effort shall study the system feasibility and demonstrate the proof of concept for maturing inductive foundry technology to TRL-3.

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

For NASA, the initial application of the induction foundry is to convert waste streams into useful feedstocks in support of remote and novel missions. At small scales, NASA can create a raw material reserve for repairs and new parts on the ISS and remote outposts. At larger scales, this technology can recycle orbital debris, convert rocket bodies, or even upcycle the ISS if otherwise deorbited. In the future, induction foundries will be a key element in cislunar and lunar infrastructure construction and operation.

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

For non-NASA applications, recycling with the induction foundry enables new options for the cislunar economy and beyond by breaking the launch bottleneck. Traditional aerospace now has the option to build large components on-orbit from recycled scrap without the cost and risks of deployables. Recycling enables grand commercial endeavors like power satellites, hotels, and asteroid refinement.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H6.23-3322**

SUBTOPIC TITLE: Spacecraft Autonomous Agent Cognitive Architectures for Human Exploration

PROPOSAL TITLE: Sigma as an Augmented Cognitive Architecture for Human Exploration Missions Beyond Cislunar Orbit

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):

Deep space exploration missions involving humans present many obstacles that must be overcome in order to provide the crew with the necessary resources and abilities to make the mission successful. Along with the many concerns surrounding astronaut health and safety during long duration space flight is the ability for astronauts to work autonomously with limited assistance from mission control. In an effort to resolve the critical problem of communication delays to and from Earth and provide the crew with the support they need to carry out their mission, nFlux proposes an autonomous cognitive agent built from the capabilities of Sigma to assist astronauts during deep space missions. Sigma is a cognitive architecture and an integrated computational model of intelligence that combines four decades of research in cognitive architectures, probabilistic graphical models and deep learning that can be used to build autonomous intelligent agents. In particular, Sigma leverages factor graphs towards a uniform grand unification of not only traditional cognitive capabilities but also critical non-cognitive aspects, creating unique opportunities for the construction of new kinds of cognitive models that possess a Theory of Mind and are perceptual, autonomous, interactive, affective, and adaptive. Sigma's graphical architecture has recently been extended to handle neural networks. Sigma has quite general parameter learning capabilities, in that probabilistic, neural, and reinforcement learning capabilities all emerge from a local gradient-descent-based learning mechanism operating at the code of the architecture. The aspiration for uniform grand unification, plus this unique blend of

capabilities, make Sigma a well-equipped candidate to tackle the challenge of intelligent agents for deep space exploration.

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

The proposed solution is applicable in other areas of NASA aside from deep space exploration. Such areas include research conducted at the Human Centered Design Group at NASA JPL investigating astronaut autonomy and the Michoud Assembly Facility where space systems are manufactured and assembled. Additionally, the procedure monitoring technology can assist astronauts with research and complex tasks that are conducted in the International Space Station.

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

Currently, operators and technicians are guided through procedures via written and electronic manuals, remote assistance from a human counterpart, or augmented reality. nFlux's procedure monitoring solution aims to improve such technology by providing real-time procedure assistance to augment workers to increase performance and systematic efficiency.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H9.07-2179**

SUBTOPIC TITLE: Cognitive Communication

PROPOSAL TITLE: Lunar Network Autonomous Routing (LEARN)

Small Business Concern

Firm: **EpiSys Science, Inc.**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5

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

Lunar communication architecture comprises of various types of connections such as Earth to Satellite links, Lunar Orbit and Surface networks, etc. Lunar networks have multiple agents with different specifications, requirements, and interactions. These heterogeneous networks introduce many deficient factors including unscheduled and unpredictable behaviors, intermittence and interference, high latency tolerance data. Therefore, a novel, LCA-native network management solution needs to effectively address these variables. In this work, we propose to develop, emulate, test, verify, and validate an innovative novel Artificial Intelligence (AI)-based **L**unar n**E**twork **A**utonomous **R**outi**N**g (LEARN) technology. LEARN gives an autonomous lunar network management solution in two main categories; (i) optimized various data routing (ii) intelligent packet scheduling and resource control to select data packets, traffic data flow, route, resource and communication modes. We consider the delay-tolerant networking (DTN) architecture and protocol to maintain some of the issues and our LEARN technology will bring intelligent network routing and scheduling beyond DTN. To this end, we adopt a systematic and modular approach to build a Multiple Agent Deep Reinforcement Learning (MADRL) framework for LEARN. We have proposed approaches to address LEARN's challenges including (1) the significance of temporal dimension (e.g., operating in different time regime), (2) new nodes entering or nodes leaving the network, (3) disruptions, anomalies and unpredicted behaviors and surprises, (4) diverse nature of nodes, their resources, and requirements, (5) periodic patterns (e.g., orbital info.), and (6) mission schedules. Our proposed solution is founded on our ongoing work to design and demonstrate a AI solution capable of outperforming traditional communication networking protocols. Finally, we propose to develop a MADRL (Ray RLlib)-CORE - based testbed to demonstrate our algorithms.

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

DTN exploits store-and-forward techniques in networks to compensate for delay and intermittent link connectivity. DTN is broadly used in various space missions: low-Earth exploration, Earth-ISS and Earth-Moon connections. Protocols are used to best suit the operation within each environment with a new overlay network protocol inserted between the applications and locally optimized communications stacks. Improving DTN by an autonomous AI engine will reduce latency deploying space missions.

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

SpaceX Starlink and Amazon Kuiper are recent programs for space-based broadband internet services. Our proposed LEARN is a step to intelligently route, schedule and control in such networks. It's AI-based solution can benefit from deep learning advancements to account for all conditions and constraints, e.g. fuel, latency, orbits, and policies in such large constellations.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H4.05-1347**

SUBTOPIC TITLE: Advancements in Water and Air Bladder Assemblies and Technology

PROPOSAL TITLE: High-Purity, Defined-Envelope Pressure Bladder

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):

The NASA Portable Life Support System (PLSS) for the Exploration Extravehicular Mobility Unit (xEMU) incorporates a Feedwater Supply Assembly (FSA) to store consumable cooling water. The FSA must accept a total of 12 lbs of pure water prior to each Extra-Vehicular Activity (EVA), then supply this water to the cooling loop at ambient suit pressure during the EVA, functioning reliably for up to 15 years of service. To meet these requirements, NASA has specified multiple ultra-pure fluoropolymer bladders captured in restraints providing overpressure tolerance to 38 psi. The assembly must also conform to a defined geometric envelope. Unfortunately, designs to date have failed, for two primary reasons. First, typical constructions involving a lay-flat bladder captured within a sewn textile restraint do not use space efficiently enough to store the required volume within the available space. Second, wrinkles that form as the bladders inflate cause the fluoropolymer membrane to tear. Other challenges include robust mounting to a rigid structure and visual access for inspection. New thinking is required to achieve a viable design.

RAPA Technologies has developed a novel *defined envelope pressure bladder* that meets all specifications for the FSA. The design combines the benefits of a flexible bladder with the strength and convenience of a rigid tank, providing an ultra-pure, ambient-pressure reservoir with high overpressure tolerance, high volumetric efficiency within the available envelope, near-zero dead volume, optical transparency for visual inspection, simplified mounting, and low mass. In Phase I we will demonstrate the performance, overpressure resistance, and cycle life of this novel bladder system. In Phase II, we will develop and deliver multiple qualification FSA units tailored for use in the NASA xEMU.

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

Our defined envelope bladder system will meet all requirements for the FSA, a critical component of the NASA xEMU. It will also make a natural choice for many other fluid handling applications in space, and can can be used to store water, process chemicals, and waste streams. As NASA pursues

manned missions to the Moon, lunar orbit, and Mars, the need for bladders that are reliable and stable for years-long missions will continue to grow.

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

The recent proliferation of unmanned drone aircraft presents a need for tanks that can supply fuel in any orientation and operate in high and low G maneuvers. We believe that our unique design may also find use in specialized commercial, industrial, medical, and military settings for applications such as fuel tanks, chemical transport, sample storage, and hydration bladders.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.04-1898**

SUBTOPIC TITLE: Guidance, Navigation, and Control

PROPOSAL TITLE: Theoretical and Experimental Investigation of Quantum Noise Induced Sensitivity Limit of a Fast Light Ring Laser Gyroscope

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):

In a Fast-Light Ring Laser Gyroscope (FRLG), the group index is vanishingly small. The Sagnac effect induced shift in the resonance frequency of each of two counter-propagating lasers, for a given rotation rate, is amplified by a factor equaling the inverse of this group index, compared to that for a conventional ring laser gyroscope (RLG). This scale factor enhancement coefficient (SFEC) can be as high as a million. If the quantum noise limited uncertainty in the laser frequency for an FRLG is the same as that for an RLG for otherwise identical operating parameters, this would imply that the factor of enhancement in measurement precision (FEMP) for an FRLG is the same as the SFEC. However, based on analogy with similar effects in a parity-time symmetric system, it has been suggested that the quantum noise limited uncertainty for an FRLG may be larger than that for an RLG, due to the so-called Petermann factor, thereby reducing the FEMP to a value smaller than the SFEC. We will carry out theoretical as well as experimental work to establish the maximum possible value of the FEMP that can be achieved under experimentally achievable conditions. In one track, we will carry out two new types of theoretical modeling for the FRLG to determine how the FEMP varies as a function of the operating parameters: one based on propagating the field using a quantum-enabled finite division time domain technique in the presence of random spontaneous emissions of photons, and the other based on re-ordering the operators in the temporal correlation function. In the second track, we will use a robust version of a Rb based superluminal laser, which employs a cavity enclosed in a vacuum chamber and highly stabilized pump lasers, to measure the value of the FEMP. The measurements will be compared with the theoretical models, and used to guide modifications thereof until agreement is achieved. This will pave the way for further refinement and miniaturization of the FRLG in Phase II.

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

- Improved space vehicle positioning and navigation
- Ultra-precise pointing and platform stabilization for telescopes
- Space vehicle health monitoring
- Tests of general relativity via measurement of gravitational frame dragging effect

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

- Improved positioning and navigation of missiles
- Positioning and navigation for atmospheric and ground vehicles in GPS-denied environments
- Guidance of unmanned underwater vehicles (UUVs)
- Guidance of smart ammunitions
- Advanced laser beam pointing/steering systems

Duration: **6**

PROPOSAL NUMBER: 21-1- **H9.05-2243**

SUBTOPIC TITLE: Transformational Communications Technology

PROPOSAL TITLE: A Charge Ramping Quantizer

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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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):

Pacific Microchip Corp. proposes to develop an ADC implementing fundamentally new architecture employing a single stage voltage-to-charge-to-digital converter based on a charge ramping quantizer (CRQ). The CRQ removes traditional barriers such as large number of comparators (Flash architecture), slow binary search (SAR architecture), power hungry and slow continuous-time comparators and large silicon area consuming time-to-digital converters (temporal ADC). By removing these barriers and taking full benefit of modern CMOS processes, the CRQ offers a high sampling rate at greatly reduced power consumption. A single sub-ADC based on this architecture demonstrates over 4 times speed improvement compared to a SAR ADC. The project will target 8-bit resolution and 56GS/s rate. Instead of overdesigning, when seeking to maximize the performance, the ADC will rely on parameter calibration using a built-in CPU. On-chip phase locked loops (PLLs) will be used for clock synthesis. For convenient interfacing with field programmable gate arrays (FPGAs) at up to 64x8.8Gb/s, the ADC will include a JESD204B standard compliant interface. Phase I work will provide the proof of ADC feasibility – critical blocks will be implemented and verified at the targeted technology node. At Phase II, a silicon proven prototype ADC will be provided.

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

- Space-based wireless satellite-to-satellite communication systems
- Space-to-Earth communication systems
- Earth observation instrumentation

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

- Future communication systems
- Multiple input multiple output (MIMO) systems
- Synthetic aperture radars (SARs) in active sensors
- Passive microwave sensors
- Receivers for SDRs and 5G communication systems
- Fiber optic communication systems for 100-400Gb/s
- Surveillance instruments
- Communication and navigation satellites
- Test instruments such as digital sampling scopes

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.05-1953**

SUBTOPIC TITLE: Computational Tools and Methods

PROPOSAL TITLE: An Intelligent Framework based on Parametric Reduced-Order Model Database for Uncertainty Quantification in Aeroelasticity

Small Business Concern

Firm: **CFD Research Corporation**
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Phone: **(256) 726-4800**

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 goal of the proposed effort is to develop an intelligent framework based on parametric reduced-order models (ROM) for uncertainty quantification (UQ) in aeroelasticity (AE). Leveraging significant achievements by the proposing team in prior research, this Phase I effort represents a significant contribution to UQ adoption for AE analysis in NASA, and includes several emerging techniques: a data-driven, non-intrusive process for holistic UQ analysis and software organization; fully automated generation of parametric state-consistent ROMs and stability characteristics in broad stochastic domain; stochastic models to establish uncertain input-output mapping; uncertainty propagation and interval analysis for statistical characterization; and a modular software framework with seamless interface with NASA FUN3D to streamline the entire process. The feasibility of the proposed technology will be demonstrated for AE problems of NASA interest (e.g., flutter onset). Beyond Phase I, efforts will focus on AE UQ engine optimization in terms of execution efficiency, robustness, and autonomy; and refinement of the AE UQ environment and FUN3D integration; and process automation of modeling, simulation, and UQ for technology insertion and transition; and extensive software validation and demonstration for AE UQ of realistic aircrafts of current NASA interest.

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

The developed technology will enable NASA to (1) characterize flutter onset and other AE phenomena and determine critical aerodynamic and structural conditions; (2) guide CFD/AE computation and flight testing; and (3) develop advanced aerostructural control strategies and vehicles of salient reliability and efficiency. It will markedly reduce development costs and cycles of aerospace vehicles. NASA projects like High Speed ASE, MUTT, and MADCAT 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, real-time flow and structural control and optimization, uncertainty quantification and reliability analysis, and others. The proposed development would provide a powerful tool for accurate and fast ROM generation and UQ analysis.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.03-2120**

SUBTOPIC TITLE: Propulsion Efficiency - Propulsion Materials and Structures

PROPOSAL TITLE: Computational design of CMAS-resistant multiphase thermal and environmental barrier coatings for CMCs

Small Business Concern

Firm: **QuesTek Innovations, 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: 1
End: 2
Technical Abstract (Limit 2000 characters, approximately 200 words):

Although ceramic matrix composites (CMCs) have been a material of interest for gas turbine components with operating temperatures 100-150 °C higher than typical superalloy materials, the temperature capability of CMCs is still limited by the lack of environmental durability of coatings. One of the main degradation mechanisms at high temperature (>1200 °C) is due to calcia-magnesia-alumina-silicate (CMAS) deposit. Under this SBIR program, QuesTek Innovations LLC will utilize its expertise in Integrated Computational Materials Engineering (ICME) and Materials by Design® approach to design multilayer thermal-environmental barrier coatings (T-EBCs) with improved environmental durability for enhanced performance of advanced CMC engine components. While EBC such as ytterbium disilicate is promising for protection against volatilization of thermally grown oxide, it is ineffective as a long-term protection against CMAS attack. Phase I will focus on development of a multiphase TBC with desired properties such as high reactivity with CMAS, high fracture toughness, low thermal conductivity and small coefficient of thermal expansion. This multiphase TBC acts as sacrificial layer by promoting reactive crystallization to mitigate CMAS infiltration and protect underlying materials from CMAS attack. QuesTek will leverage computational thermodynamic models and databases to predict CMAS-coating interactions and develop a CMAS-resistant multilayer T-EBC capable of extended performance at temperatures at or above 1482°C by the end of Phase II. The proposed integrated computational and experimental approach will accelerate material and architecture design to balance multiple competing performance requirements by reducing the need for time-consuming experiments.

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

Potential NASA applications will be propulsion components (nozzles, turbine vanes and blades, combustor liner, exhaust nozzle) for subsonic and supersonic fixed and rotary wing aircrafts and combustor panel components on hypersonic vehicles.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Potential non-NASA applications will be turbine components in future civilian aircraft propulsion systems (e.g. future generations of turbofan engines similar to CFM LEAP and GE9X) and turbine components in industrial gas turbine plants.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z10.01-1226**

SUBTOPIC TITLE: Cryogenic Fluid Management

PROPOSAL TITLE: RCS Gas Generation System

Small Business Concern

Firm: **Gloyer-Taylor Laboratories, LLC**
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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 phase I effort a design for a gas generation system architecture tailored for RCS gas accumulators on lander vehicles with ultra-low mass and thermal mass BHL components will be produced and PDR for the system will be conducted. GTL will modify its existing gas generation system for demonstration and component comparison testing. GTL will study the validity and applicability to lander systems of three potential gas generation system architectures.

Given GTL's experience with cryogen, gas generation, and launch systems, the phase II will enable two milestones to be achieved for this system architecture: 1) expanding the systems to produce oxygen and hydrogen gas, and 2) prepare the system to be flight tested aboard GTL's ACE-Disruptor rocket. These milestones will both broaden the system architecture's capabilities and provide a clear path to TRL 7.

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

Many NASA launch vehicles, transfer stages, or landing crafts could potentially benefit from this gas generation system architecture. This technology would be able to replace traditional, high volume, high mass pressurant tanks systems with a standalone gas generation system.

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

Much the same as with the NASA applications, this technology is widely applicable to a large number of DOD and private aerospace companies. Any in space system could potentially employ a gas generation system to replace traditional propellant systems.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A2.03-1735**

SUBTOPIC TITLE: Advanced Air Mobility (AAM) Integration

PROPOSAL TITLE: DIGEST a ReplicANT Framework for AAM

Small Business Concern

Firm: **ANT Automation, LLC**
Address: **996 Balmoral Drive, Pittsburgh, PA 15237**
Phone: **(412) 736-9170**

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):

The envisioned future outlook for Advanced Air Mobility operations covers increasing autonomy and operational tempo across various environments, including major metropolitan areas and the surrounding suburbs.
There will be a need for accommodating new modes of transportation to the currently available systems in a given city. We predict the number of interactions between agents will climb in orders of magnitude in the future. In terms of the demand, access to these modes of transport will also increase, which will push for safety, security, and efficiency improvements. When we compare the current transportation methods and Air Mobility's impact, all the possible interactions are hard to describe, plan, and simulate. These perceived challenges are just the tip of the iceberg for logistics, technology, and resource allocation.
The computer gaming industry has grown to become a large and vital market, spending an exorbitant amount of money developing new game engines. The final product's price is inconsequential

compared to a professional 3D simulation/visualization/animation tool and its development costs. The idea of using gaming platforms' potential for other purposes than gaming seems clear to us.
To this end, we propose the selection of an appropriate gaming engine platform using the relevant metrics for a project we have called DIGEST (DIgital Game Engine data acquisition and Screening Tool). Also, we plan to combine our knowledge in industrial automation and simulation to create a functional Digital Twin and Synthetic Environment prototype in Phase I of a model city integrated with an Orchestration Simulation Tool (OST) for Advanced Air Mobility planning solutions in combination with other modes of transportation, considering safety, security, scalability, jurisdiction, and area of application, while reducing time and cost of deployment. All these factors done right will ease the acceptability of such large changes in drivers, passengers and the community at large.

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

NASA will use this framework to test, simulate and validate, helping to achieve public acceptance of AAM for multimodal transport operations for a city-wide system. This new paradigm for Advanced Air Mobility is known as Digital Twin and Synthetic Environments. NASA would benefit from data gathering, assets localization, on-time routing, automated traffic control, and multiple stakeholders connecting to such a platform with their own needs, with different time tables and technologies. This proposal is the stepping stone towards a larger vision.

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

We believe that major populated cities in the United States will need to oversee, connect, and control human and machine interactions in the case of three-dimensional transportation systems such as Advanced Air Mobility. The AAM core system will offer APIs, libraries, and plugins to third parties, thus creating a marketplace correlated to each stakeholders' and locality's needs and laws.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z12.01-1706**

SUBTOPIC TITLE: Extraction of Oxygen and Water from Lunar Regolith

PROPOSAL TITLE: Lunar ISRU Contaminant Tolerant Scroll Vacuum Pump (CTSVP)

Small Business Concern

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

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 seeks to develop novel oxygen extraction concepts that allow for the production of oxygen on the surface of the Moon using Lunar regolith. As part of this system, it's possible the in-situ resource utilization process may require a pressurized volume to be evacuated to prevent the loss of products to the vacuum of space. For this reason, NASA has expressed the need for a contamination-tolerant vacuum pump that can pump down this pressurized volume to prevent having to exhaust these consumables to the vacuum of space. This pump will have two firm requirements:

1. Capable of evacuating a 50 L volume from an initial pressure of 5 psia down to 5 torr in less than two minutes when discharging against a pressure of 1 atm
2. Capable of pumping corrosive trace substances including HCl, HF, and H_2S without adversely affecting performance or life

To accomplish this, Air Squared is proposing the development of a robust, oil-free contamination tolerant scroll vacuum pump (**CTSVP**) utilizing experience from tritium handling and International Space Station projects. This approach focuses on a material selection for contamination tolerance on only three components allowing non-wetted components to be optimized for size, weight, and power savings and long life.

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

- Lunar surface ISRU rocket fuel and consumable production
- Future Mars surface ISRU rocket fuel and consumable production
- Support human exploration of the solar system with reduced logistics and long term habitation solutions

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

- Hazardous materials handling in industrial chemical processing
- Corrosive working fluids handling for semi-conduction industry
- Commercial exploration of the Lunar surface

Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.05-2018**

SUBTOPIC TITLE: Fault Management Technologies

PROPOSAL TITLE: Mission-Informed Fault Management

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):

As we strive to create space systems that are more capable and conduct manned and unmanned missions further from Earth, pre-mission planning will be insufficient to handle uncertainty in operations. This is further exacerbated by communications limitations coupled with the absence of human mechanics onboard to handle issues that may arise over the course of a mission. These realities compound mission risks. In particular, mission control may not have accurate enough situational awareness to be able to provide timely decision support. To address such risks and account for the uncertainty of extended-duration operations, NASA needs robust and explainable fault management solutions that incorporate machine forethought, where the platform responds appropriately to situations that can impact platform health and mission reliability.

Metron proposes to develop a full-system fault management solution for autonomous space platforms. Our solution will address the technical challenges of providing short-term fault mitigation that evaluates long-term platform considerations, preemptively planning fault mitigation procedures, and properly responding to faults when mission goals and fault mitigation procedures come in conflict. Our fault management solution fuses fault detection, diagnosis and mitigation with current mission primitives, priorities, and platform capabilities. It will respond to system degradation, faults, and lost platform capabilities in such a way that preserves mission-relevant capabilities by leveraging an expert system ontology for self-assessed capability analysis, adaptive search techniques for fault mitigation, and statistical and symbolic fault detection and identification. This solution will provide high-level functions normally performed by human operators, such as determining the ideal machinery plant alignments to facilitate a given mission, fault diagnosis and recovery, and reconfiguring of the machinery plant alignment for increased performance.

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

The fault management solution we are developing would expand the operational envelope of NASA space environment research by enabling faults to be accurately detected, identified, and mitigated, potentially saving lives and infrastructure. Within NASA's projects this work would contribute to the Lunar Gateway, Artemis, the ISS, or habitats on the Moon or Mars as a full-system fault management solution.

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

The commercial need for our fault management solutions for unmanned maritime systems has been clearly and publicly highlighted by both defense and the oil and gas industry. Specifically, in the maritime and offshore energy industries there are thousands of highly complex, unmanned, fixed and mobile platforms hosting an array of systems that can benefit from extensions of this SBIR technology.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.03-2244**

SUBTOPIC TITLE: Technologies for Passive Microwave Remote Sensing

PROPOSAL TITLE: A 10GHz 4k Frequency Bin Polarimetric Spectrometer 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):

Spectrometers currently employed or under development by NASA are based on a PCB including FPGAs and a number of other discrete components. An ASIC based spectrometer offers a great reduction in weight, volume and power consumption compared to the FPGA based implementation. This proposal aims to prove the feasibility (Phase I), develop and test (Phase II) a 10GHz 4K frequency bin polarimetric spectrometer ASIC.

The ASIC will digitize two 10GHz RF signals using 6-bit 20GS/s ADCs, channelize each input signal's spectrum into 2^{12} (4096) frequency bins, and then accumulate either spectral power or the Stokes parameters for each bin. In order to implement the required functionality and meet the specifications, the proposed ASIC will include state-of-the-art ADCs, a PLL, poly-phase filter based FFT cores, an accumulation block, a data readout function, a digital control unit and testing features. Tolerance to at least 200krads of TID radiation and immunity to the SEEs will be achieved by employing radiation hardening by design, by layout, by system level techniques, and also by applying an ultrathin gate oxide technology for implementation. The power consumption will be reducible by allowing specific applications to switch off portions of the spectrum, reduce the bin count and the sample rate.

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

- Various mm-wave and submm-wave radiometry and radar instruments, such as PSR
- Mission examples: CubeRRT, SMAP

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

- Specialized spectrometer instruments for temperature, magnetic field, and water vapor mapping
- Generic spectrometers and spectrum analyzers
- Radio astronomy

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z3.03-2482**

SUBTOPIC TITLE: Development of Advanced Joining Technologies, Large-Scale Additive Manufacturing Processes, and Metal Recycling Technologies for On-Orbit Manufacturing

PROPOSAL TITLE: Microwave Plasma Assisted Metal Separation for Recycling in Zero Gravity

Small Business Concern

Firm: **Microtech Energy, LLC.**
Address: **3740 Edenderry Drive, Troy, MI 48083**
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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):

Recycling of materials is needed to reduce the logistical constraints and enhance the capabilities of deep space missions. Recycling of polymers has been shown successfully in zero gravity but there are no current techniques available for metal recycling. Current terrestrial methods for metal recycling are difficult to adopt to intravehicular (IVA) and extravehicular (EVA) environments.

Microtech Energy proposes to use microwave plasma technology to design and develop a metal recycling process for zero gravity environment. The proposed recycling process would be able to separate multiple aerospace grade metals/alloys (aluminum, stainless steel, titanium, etc.) by melting in both IVA and EVA environments. The plasma, acting as an efficient microwave absorber, provides rapid heating of the target as well as high temperature capability. This recycling process is also expected to be clean.

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

The proposed metal recycling system can be used on International Space Station, Lunar Base Camp, Exploration Crew Module and other deep space missions and can supply feedstock to in-space manufacturing projects.

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

The metal recycling system using microwave plasma will compete with some of the current terrestrial metal separating techniques. The new system will be better than these separation methods because it would combine separation and melting in one process resulting in a more efficient process. Moreover, use of low cost magnetrons will allow an inexpensive metal recycling system to be developed.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H10.01-1925**

SUBTOPIC TITLE: Advanced Propulsion Systems Ground Test Technology

PROPOSAL TITLE: Hybrid Additive Manufacturing of Integrated Sensing (HAMIS) System

Small Business Concern

Firm: **RC Integrated Systems, LLC**
Address: **20100 South Western Avenue, Suite A5, Torrance, CA 90501**
Phone: **(760) 383-1218**

Principal Investigator:

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Business Official:

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Phone: **(760) 383-1218**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3

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

To meet the NASA need for measurement of pressure, temperature, and strain in high temperature and/or harsh environment to support rocket propulsion systems ground test, RC Integrated Systems LLC (RISL) proposes to develop a novel Hybrid Additive Manufacturing of Integrated Sensing (HAMIS) System, providing high-resolution simultaneous measurement of pressure, temperature, and strain in high temperature and/or radiation environment. HAMIS is based on additive manufacturing (AM) of passive wireless sensors using high-temperature refractory materials, capable of being bonded to the inner surface of high temperature gas pipes to measure temperature, pressure, and strain. HAMIS sensors can withstand temperatures up to 5000 degrees F. AM approach enables flexible fabrication of miniature (4 mm by 4 mm by 0.8 mm) sensors. In Phase I, RISL will identify sensor types, number, placement, connectivity, and data handling and processing; determine processes and procedures for sensor manufacturing, insertion, and emplacement; demonstrate its feasibility through modeling; RISL will also develop a breadboard system to demonstrate the HAMIS concept. In Phase II, RISL will develop a HAMIS prototype with representative sensors of each type and test each under simulated laboratory conditions with the goal to achieve technology readiness level (TRL)-5.

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

HAMIS can be incorporated into Stennis Space Center (SSC) rocket ground test facility to enhance Chemical and Advanced Propulsion technology development and certification. The HAMIS system can also be incorporated into SSC's Nuclear Thermal Propulsion Ground Test Exhaust Capture System for measurement of engine exhaust gas temperature and pressure. This development will support multiple NASA missions including human mission to Mars.

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

The proposed sensors can be used for applications including oil, gas, and geothermal well drilling and production, as well as CO_2 gas sequestration. Other applications include monitoring gas temperature and pressure in turbine engine in coal-fired power plants, natural-gas-based power plants, geothermal plants, as well as other power-generation facilities throughout the nation.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S4.04-1402**

SUBTOPIC TITLE: Extreme Environments Technology

PROPOSAL TITLE: Phase change lubricant for superlubricity of sliding contacts in extreme space environment

Small Business Concern

Firm: **ATSP Innovations**
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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 subtopic S4.04 Extreme Environments Technology and specifically the listed interest in long life bearings, tribological surfaces, and lubricants. NASA is interested in expanding its ability to explore deep atmosphere and surface of giant planets, moon surfaces, asteroids, and comets through use of long-lived (days or weeks) balloons and landers. Dragonfly will launch in 2026 and arrive in 2034 on Titan. Mars sample return is a proposed mission to return samples from surface of Mars to Earth. The Artemis program will land the first woman and next man on Moon by 2024. Conceptual landing probes for Europa have been proposed. However, the missions would experience extreme conditions: temperatures ranging from -220°C on Europa, -200 °C on Ganymede to -180°C on Titan. In addition, the instrument will go through high cosmic radiation environments with long duration of the mission. At these extreme conditions, traditional oil lubricants and greases are

infeasible, resulting in dry sliding conditions with significant detrimental effects on component performance. The reliable operation of moving parts and tribological components (e.g., bearings, gears, sealings, etc.) in the cryogenic environment is a key for successful accomplishment of future NASA missions. Therefore, selection and design of new lubrication and protection are imperative for each application. Tribological experiments are therefore necessary to simulate relevant environments to mitigate mission risk. This proposal offers a unique solution: aromatic thermosetting copolyester (ATSP) coating on ATSP coating sliding is shown to have low coefficient of friction (COF) and "zero wear" from -196°C to 300°C. This excellent tribological performance leads us to introduce ATSP-based coatings for Europa cryogenic environment conditions. we will investigate the tribological performance of ATSP-based composites using flat pin-on-disk experiments under conditions in combination with radiation effect.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

ATSP-based tribological products have wide temperature range (-196 to 300°C) with low wear and friction and have applicability for devices used in future missions to Titan, Europa, the Moon, and Mars. Addressable missions include the Dragonfly mission, mechanical components in observatory platforms, Mars sample return, and lunar terrain vehicles. The reliable operation of moving parts and tribological components (e.g., bearings, gears, sealings, etc.) in such extreme environments is key for successful accomplishment of future NASA missions.

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

ATSP-based tribological products are applicable for Aerospace, Automotive, Space Exploration, and Energy. The tribo-pair concept developed in Phase I potentially offers world leading reduction in friction and wear across a very broad range of temperatures. Reductions in COF and wear enable more stable performance and longer lifetimes - providing an attractive option for many device conditions.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z7.01-2997**

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

PROPOSAL TITLE: High Accuracy, Low-Cost Fiber Optic Recession and Temperature Sensor System and Data Acquisition System for Thermal Protection Systems

Small Business Concern

Firm: **K Sciences**
Address: **4440 Evangel Circle, Huntsville, AL 35816**
Phone: **(256) 682-4743**

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):

K Sciences proposes the development of a novel prototype, fiber optic recession and temperature sensor (FORTS) designed specifically to support NASA's thermal protection systems (TPS) for future planetary missions. This proposal of the FORTS system details an erosion measurement system and method which is capable of precisely determining the change in length of ablative heat shielding and in addition providing an optical measurement of high temperature erosion environments applicable to thermal protection systems in ablative heat shields and solid and liquid rocket motors. The minimally intrusive fiber optic probe can be designed to closely match the TPS ablation properties and extremely elevated temperature environment. The FORTS is capable of continuous, real-time, high-speed, monitoring of the recession rate and ablation zone temperature in entry vehicles, projectiles, and hypersonic flight vehicles. The supporting data acquisition (DAQ) system will be designed to be modular to accommodate various TPS configurations and missions requiring various combinations of sensor inputs. The FORTS system provides an innovative approach to meet NASA's requirements and is anticipated to perform a continuous recession rate measurement through any TPS thickness, at a length resolution of ±1 mm, an ablation temperature measurement from 600 °C to 4500 °C, with a minimally intrusive sensor probe <500 μm cross-section and post manufacture component installation, and high temperature operation and survivability.

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

The sensor proposed will provide a method to acutely and directly measure the surface wear, erosion, ablation, etc., in challenging environments. The core mission of NASA often involves development and exploration within these necessary conditions. This may include the proposed application to thermal protective shielding or may also include nozzle erosion, solid rocket fuel regression, and aircraft braking wear.

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

K Sciences is in discussion with various automobile and tractor trailer brake system manufacturers.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.12-1826**

SUBTOPIC TITLE: Modular and Batch-Producible Small Spacecraft

PROPOSAL TITLE: Rapidly Reconfigurable Small-Sats for Enhanced Mission Capabilities

Small Business Concern

Firm: **NOVI, LLC**
Address: **2800 Shirlington Road, Suite 801, Arlington, VA 22206**

Phone: **(202) 213-2846**

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):

NOVI's offering is aimed at providing NASA with a modular and easily reconfigurable spacecraft bus that uses a customizable chassis structure in conjunction with a common set of avionics components and sub-systems for rapid and flexible deployment of payloads / constellations. The proposed approach not only offers new capabilities, timelines and cost paradigms for fielding CubeSat and ESPA-class spacecraft for a wide variety of mission needs and requirements, but also supports existing efforts to create more readily available COTS-based state-of-the-art products that enable modular, plug-and-play functionality.

As part of the proposed Phase I effort, NOVI will:

1. Demonstrate the flexibility and utility of the overall approach by focusing on a complicated and "distributed" payload for in-orbit capture and servicing, and use it to complete the detailed design of a "semi-customized" spacecraft tailored for this use-case;
2. Explore the use of AM to incorporate a high delta-V propulsion system with conformal tanks and propellant feed system elements, as well as an AM-based launch adapter and deployment system; and
3. Develop and trade workflow models for a longer-term manufacturing cell and "production-line" that combines flexible AM structure with an inventory of standardized, batch-sourced components to realize modular, swappable architectures that can rapidly be tailored for novel applications (without the need for significant modifications to existing systems and platforms).

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

NOVI's offerings are part of a broader set of capabilities to realize a new generation of rapidly-reconfigurable small-sats that combine batch-sourced COTS components with highly-integrated AM-based cellular manufacturing to offer a low-cost and efficient approach for rapid constellation deployment and replenishment. The solutions will support multiple NASA initiatives ranging from LEO-based operations to deep space exploration and habitation, with direct applications supporting SMD, STMD and the Earth Science and Heliophysics divisions.

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

NOVI's modular, batch-fabricated small-sats are also targeted towards an emerging class of commercial players aiming to develop and operate LEO constellations for earth observation, broadband connectivity, IoT, weather monitoring, AIS, space-based data storage, and a host of other use-cases (representing a global small-sat market that is growing at a 20% CAGR to reach $5.3B by 2021).

Duration: **6**

PROPOSAL NUMBER: 21-1- **H10.01-2307**

SUBTOPIC TITLE: Advanced Propulsion Systems Ground Test Technology

PROPOSAL TITLE: Thin Film Tungsten for High Temperature Hydrogen Embrittlement Mitigation

Small Business Concern

Firm: **Summit Information Solutions, Inc.**
Address: **3957 Westerre Parkway, Suite 120, Richmond, VA 23233**
Phone: **(804) 201-4399**

Principal Investigator:

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Business Official:

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Phone: **(804) 840-8477**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The failure of metallic parts due to hydrogen embrittlement has been a constant challenge for many industries for decades, and for NASA in particular. The hydrogen embrittlement problems endemic to industries that require heavy use of hydrogen have been solved in various ways. Most of these solutions involve the careful development of alloys that are less susceptible to hydrogen embrittlement. Unfortunately, these alloys often require a sacrifice of some other highly desired material property, such as strength, hardness, ductility, etc. Coatings have also been attempted. However, these coatings and coating techniques have their own drawbacks, which include ceramic coatings that flake off after only a few use cycles and coating techniques that cannot deposit onto a finished part because they require line of sight during deposition. To better mitigate the very pressing hydrogen embrittlement challenge, Summit Information Solutions, Inc. proposes the use of a mature deposition technique that has not seen much use outside of the microelectronics industry. Summit has successfully demonstrated the thin film encapsulate deposition on dummy substrates of Inconel 718 and A-286 stainless steel. These coatings held up in a hot hydrogen at 1,800 degrees C. Summit will demonstrate that this thin film can be deposited onto pipe/tube structures with the same success. Phase II work will involve pull testing in a hot hydrogen environment following the ASTM G142 test protocol

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

The immediate application for a hydrogen embrittlement mitigation layer will be the ground test stand infrastructure that at the NASA Stennis Space Center. Additionally, the technology will be applicable to future nuclear thermal propulsion test infrastructure and engine hardware. This will also have wide NASA applications for everything from other traditional hydrogen embrittlement needs to coatings for high reflectivity X-Ray optical coatings.

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

The proposed technology will be useful for a pipe system that requires internal coating. Biofouling prevention would see a direct benefit. Power generation systems are particularly vulnerable to this biofouling, and it is prohibitively expensive to replace or disassemble these systems to apply a coating treatment. The deposition technology will be directly applicable to these systems.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S4.05-2694**

SUBTOPIC TITLE: Contamination Control and Planetary Protection

PROPOSAL TITLE: Distributed compact plasma reactor sterilization for Planetary protection and contamination control for space missions

Small Business Concern

Firm: **SurfPlasma**
Address: **8722 Northwest 9th Place, Gainesville, FL 32606**
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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):

Prevention of interplanetary contamination is imperative in space research missions to protect the celestial body of interest from earthly organisms (forward contamination) and the Earth from extra-terrestrial agents (backward contamination). With the advent of advanced materials and electronics highly sensitive to currently approved sterilization technologies by the NASA, there is a need for alternative sterilization technologies. Research shows that dielectric barrier discharge (DBD), a type of non-thermal plasma (NTP), has great potential as an alternative method. DBD reactors generate reactive oxygen species (ROS) by ionization of atmospheric air and utilize them for disinfection. Among these, ozone has a high oxidation potential making it more effective in eradicating bacteria and viruses than other disinfectants. SurfPlasma proposes to leverage our plasma generation technologies and experience to create a safe, compact, and energy-efficient ozone-based DBD sterilization system (Active Plasma Sterilizer, APS) with an inbuilt ozone mixing and residual ozone removal system for sterilization in spacecraft facilities pertaining to planetary protection. As part of this project, we will create and test a prototype of the APS utilizing our patented technology—the Compact Portable Plasma Reactor—which is small, portable, modularly scalable, and energy-efficient for ozone generation and distribution, along with a catalytic ozone decomposition system for residual ozone removal. Testing will be performed for determining sterilization efficacy, power consumption, optimal operating conditions, material compatibility, and ozone penetration into complex materials. Further, we will investigate the option to treat excess and residual ozone with ozone catalytic converters. Thus, we will create a safe, low power, modularly scalable, and customizable prototype for the APS and establish its effectiveness and compatibility with materials relevant in space missions.

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

Potential NASA applications pertaining to planetary protection include safe sterilization of sample acquisition equipment, surfaces and space suits pre- and post-launch, personal and office equipment including badges and communication equipment. The equipment can be decontaminated by the Active Plasma Sterilizer (APS) on Earth or on mission in space. SurfPlasma APS would be especially useful for equipment with tortuous and hidden surfaces where UV systems would not be able to penetrate, and heat or harsh chemicals may affect equipment lifetime.

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

Commercialization potential for the technology includes produce preservation maintaining food quality decontaminating spoilage microorganisms. The potential market spans from harvest to distribution to consumer storage of produce. Also, the technology can easily be adapted to decontaminate PPEs of hospital employees and even everyday items such as children’s toys, clothing, bags, shoes, etc.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z4.04-2029**

SUBTOPIC TITLE: Real-Time Defect Detection, Identification, and Correction in Wire-Feed and Fused-Filament Additive Manufacturing

PROPOSAL TITLE: Low Cost Polymer Extrusion Real Time Defect Detection and In Situ Process Control

Small Business Concern

Firm: **Titan Robotics Ltd.**
Address: **702 Clark Place, Colorado Springs, CO 80915**
Phone: **(314) 705-9071**

Principal Investigator:

Name: **BILL MACY**
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Business Official:

Name: **Mr. Rahul Kasat**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Fused-filament fabrication (FFF) has received considerable investment from the aerospace industry because it offers the enticing capability of on-demand fabrication of complex spare parts, while simultaneously expanding the engineering design space and minimizing costs for low-volume part production. This is particularly important to the aerospace industry where storage space for parts is limited, part count is low, and often times getting parts on location (i.e. space, the moon, Mars) is very expensive. NASA has been a major leader in implementing additive manufacturing (AM) in current systems, but adoption is still slow because of post-process inspection requirements. If parts are to be made on-site in non-terrestrial environments post-process inspection may not be available, so closed-loop control of FFF is necessary. Consequently, a significant opportunity exists to develop tools that bridge the quality control gap between current FFF technology and fully-closed-loop systems.

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

3D Printed Hybrid Rocket Grains

- 3 current customers pursuing this application
- Companies are forecasting dozens of machines to meet rate demands
- 3D printing fuel on Gateway, Lunar and Martian facilities > Future “gas stations”

Shelters & Laboratories

- Benefit from the tools, furniture, HVAC, and appliances 3D printed from the lightweight pellet feedstock
- Light weight feedstock can be supplied in bulk to support unlimited applications
- Future waste streams can be converted into feedstock

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

A wide range of markets have turned to pellet extrusion technology for serial production solutions (HVAC, commercial goods, agriculture, foundry, aerospace, and automotive). Each of these markets are leveraging the technology for tooling, prototyping, and low rate high mix product demands.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z1.07-1683**

SUBTOPIC TITLE: Dynamic Energy Conversion for Space Nuclear Power and Propulsion

PROPOSAL TITLE: Supercritical CO2 Brayton Converter for Nuclear Electric Propulsion

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: 2
End: 3

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

We propose to develop supercritical CO_2 Brayton converter technology to help enable nuclear electric propulsion (NEP) for space exploration. This effort will extend spaceflight Brayton technology to significantly greater power levels and higher operating pressures where supercritical fluid properties provide dramatic advantages. The resulting converter will have exceptionally high specific power, creating a new benchmark for space systems. Creare is well suited to succeed because we have a long history developing advanced turbomachines, heat exchangers, and Brayton systems for challenging spaceflight applications. We will demonstrate the feasibility of our approach during the Phase I project by assessing design trades that maximize specific power for the overall system, specifying preliminary design details for the converter assembly, and conducting laboratory tests to verify key features. We will then retire the greatest technical risk for the converter during the Phase II project by fabricating and testing a turboalternator assembly with prototypical features at design operating conditions.

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

There are many NASA uses for our converter technology. Potential applications include nuclear electric propulsion, scientific spacecraft, manned exploration of the Lunar and Martian surfaces, and space station power systems. The most likely heat sources are fission reactors and concentrated solar radiation.

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

Terrestrial versions of our converter can be used to produce electric power for military and civilian applications. The technology can be integrated with nuclear reactors on ships and submarines, as well as utility-grade nuclear reactors. Alternatively, it can be coupled with non-nuclear heat sources such as fossil fuel combustion, biofuel combustion, refuse burning, and concentrated solar energy.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.11-2267**

SUBTOPIC TITLE: In Situ Instruments/Technologies and Plume Sampling Systems for Ocean Worlds Life Detection

PROPOSAL TITLE: Sensors and Sample Processing for Ocean Worlds Life Detection

Small Business Concern

Firm: **Adv Materials Innovations**
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Principal Investigator:

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Business Official:

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Phone: **(858) 437-1276**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3

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

The Adv Materials Innovations team (AMI) will meet this challenge by leveraging its recent work on sensor technology and systems.

Specific tasks for this work will be to achieve 1) Selection of commercially available COTS subsystems, 2) Optimize measurement sensitivity via artificial intelligence (AI),3) Reduced analyte identification time through deep learning algorithms. 4) Low data rate requirement using deep learning data reduction algorithms, 5) SWaP (size, weight and power) optimized sealed system with no moving parts.

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

The search for life on Ocean Worlds (e.g., Europa, Enceladus, Titan, etc.). Support of lunar and Mars exploration missions to detect water and organic materials. System flexibility enables repurposing for future missions.

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

Our initial estimates for sales volume is in the range of 1000’s of units per year, based on sales to the aerospace, refinery, pharmaceutical and chemical markets, where chemical sensors are a portion of this large market. The wearable health sensor market as a whole is shown in Figure 10. Out of this we have derived a $5 million market for our technology.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S4.02-2284**

SUBTOPIC TITLE: Robotic Mobility, Manipulation and Sampling

PROPOSAL TITLE: Six-Axis Force-Torque Transducer for Use in Cryogenic and High-Radiation Environments

Small Business Concern

Firm: **ATI Industrial Automation, Inc.**
Address: **1031 Goodworth Drive, Apex, NC 27539**
Phone: **(919) 772-0115**

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 proposed innovation is a six-axis force and torque sensor that can survive and function in the harsh environments that would be expected during a lander mission to Europa, or a similarly high-radiation, low-temperature environment. This type of mission will expose a sensor to extremely hot and cold temperatures, to near vacuum atmospheric pressure, and to high levels of radiation. The six-axis force and torque sensor developed will include redundant sensing elements for increased mission reliability.

Because ATI has already developed a six-axis force/torque sensor for use on the 2020 Mars Rover, extending that same technology to more extreme environments should be a relatively low-risk endeavor compared to having to develop this capability from the ground up. Being able to operate in such environments would enable currently impossible science to be done, such as real-time feedback of operational loads, thus allowing more advanced exploration of many areas, both extraterrestrial and on Earth.

Most commercially available six degree of freedom force and torque sensors are generally intended for terrestrial use. While ATI has successfully developed a six-axis force/torque sensor suitable for use on Mars (SHA FTS on 2020 Perseverance Rover), additional validation is required to ensure the same fundamental technology would be successful in more extreme environments.

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

There are a number of potential NASA applications for six degree of freedom force and torque transducers which are able survive these harsh conditions. They include:

-Providing loading feedback to a robot arm controller about the arm's end effector, such as a robotic drill or corer. The feedback can allow the operation to be adjusted for best performance.
-Providing loading feedback from an end effector on a teleoperated robotic arm, perhaps on the ISS or another body in space.
-Providing loading feedback for limbs in a Robonaut-type application.

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

Potential non-NASA commercial applications include:

-Robotic arm loading feedback for remote vehicles operating on the moon
-Sensing loads caused by an experiment or operation being conducted in orbit.
-Providing loading feedback experiments and remotely operated vehicles in the cold of the Earth's Polar Regions.
-Deep-sea oil/gas remotely-operated vehicles

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z13.01-3223**

SUBTOPIC TITLE: Active and Passive Dust Mitigation Surfaces

PROPOSAL TITLE: Reduced Graphene Oxide EDS Electrodes from Wet Coating Process

Small Business Concern

Firm: **WattGlass**
Address: **700 West Research Center Boulevard, Fayetteville, AR 72701**
Phone: **(479) 263-0966**

Principal Investigator:

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Business Official:

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Phone: **(479) 263-0966**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

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

The proposed graphene-based electrode materials for electrodynamic dust screens provides a unique approach to deposit both the conductive material and a high dielectric constant insulator in a single wet coating method. The laser reduction of graphene oxide will provide electrodes with improved electrical conductivity over current state of the art, while the non-reduced graphene oxide composite will demonstrate an improved dielectric constant and higher breakdown voltage. The resulting EDS array will exhibit higher flexibility than current ITO alternatives and will be processable on complex or highly curved surfaces. The proposed work will build on WattGlass's existing knowledge base of liquid deposition of thin-film coatings at an industrial scale and our ongoing efforts to utilize graphene oxide to provide static-dissipative coatings for passive dust mitigation. Additionally, this work will utilize WattGlass's developed capabilities to simulate lunar soiling and dust removal in a vacuum environment that includes UV and electron bombardment. At the end of the Phase I, a TRL of 4 is expected with the lab scale validation of an EDS electrode array. This will prepare for the anticipated Phase II research effort, where the electrode material will be further optimized, incorporated into an existing EDS prototype, and improved dust clearing will be demonstrated in one of NASA's lunar or Martian environmental test chambers. A TRL of 6 is expected at the conclusion of Phase II.

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

Electrodynamic dust screens are anticipated to be the main defense for solar arrays, sensor housings, and EMU visors. The proposed transparent graphene-based electrode material's improved conductivity, insulation, and flexibility addresses the limitations of current state of the art EDS systems to provide solutions for these surfaces. Additionally, improved transparent conductive electrode materials will find application in other systems that will be included in all future missions including displays, sensor arrays, and photovoltaics.

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

The market for transparent conductive films is $4.9B in 2020 growing at a CAGR of 9.2%. Growth is driven by the electronics industry's shift to user-oriented wearable and flexible electronics. Novel materials are anticipated to form more than 25% of the market by 2026, therefore the proposed technology could have significant market value and aligns well with WattGlass's development path.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.05-1293**

SUBTOPIC TITLE: Fault Management Technologies

PROPOSAL TITLE: ARADISS: Adaptive Real-Time Anomaly Detection & Identi↑cation For Space Systems

Small Business Concern

Firm: **Global Technology Connection, Inc.**
Address: **2839 Paces Ferry Road, Suite 1160, Atlanta, GA 30339**
Phone: **(770) 803-3001**

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):

Space missions continue to increase in number, complexity, and time & cost constraints. To lead technological advancements and successfully execute these missions, NASA desires new & robust onboard automated fault management technologies that address the full range of hardware & software faults, are transparent & reusable across platforms. This will lead to reduced costs and improved autonomy, resilience, & mission quality especially in missions that cannot afford comprehensive fault management and have a higher mission risk tolerance.

Global Technology Connection, Inc., proposes ARADISS (Adaptive Real-time Anomaly Detection and Identification for Space Systems) framework applicable to virtually all electrically powered systems. It involves physics-guided machine learning models to detect and simultaneously locate faults. The feature learning ML models continue to learn in real-time to adapts to gradual system degradations which avoid extensive model training requirements. This technique has demonstrated comprehensive fault coverage with a high detection rate and a low detection latency in extensive tests on automobiles. Meaningful physical correlations to battery voltage fluctuations make this approach extremely transparent and immediately transferable to other platforms. These algorithms are computationally inexpensive to run and can be implemented on-board small space missions.

In Phase I, we propose to validate this framework on a UAV and show feasibility demonstration and applicability to future space mission platforms like NISAR, SWOT, Dragonfly, and SPHEREx.

In Phase II, our team will identify a space platform, tune, and test our algorithms in simulated environments for transition and space deployment in Phase III.

Aggressive commercialization activities would be carried out throughout all phases of this program, and Phase III will concentrate on technology transition for NASA and other commercial space applications

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

The US accounts for 74% of the global investment in space exploration. It is expected to grow to over $20B by 2027 from $14.6B in 2017. 63% of the planned 80 space missions over the next decade are government missions. NASA JPL mission types that could potentially benefit from automated fault management technology are **spacecraft, rovers/landers, space instruments, space habitats, and ground systems**. Specific applicable missions are **NISAR, SWOT, SPHEREx, and future rovers/rotorcrafts**. The algorithms can be implemented onboard these platforms

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

Several US companies like Boeing, Lockheed Martin, Northrop Grumman, Raytheon, Space Systems, and SpaceX are active in the development of space technologies like spacecraft, satellites, & instruments and autonomous UAV systems. Our novel fault management technology will enable faster development, testing, and deployment timelines reducing the overall cost of missions.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S4.05-1283**

SUBTOPIC TITLE: Contamination Control and Planetary Protection

PROPOSAL TITLE: Vaporized Hydrogen Peroxide Sterilization System

Small Business Concern

Firm: **Skyhaven Systems, LLC**
Address: **25557 Bella Vista Circle, P.O. Box 770252, Steamboat Springs, CO 80477**
Phone: **(970) 846-0547**

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):

NASA mission planners continue to develop plans for investigating celestial bodies including Europa, Enceladus, and Mars for potential life detection. Contamination Control and Planetary Protection requirements focus on both forward and backward contamination from such bodies where NASA has shown that vaporized hydrogen peroxide (VHP) is an effective method for sterilizing samples and surfaces. However, there are a number of pressing issues NASA mission planners have identified using VHP that include:

1. Delivering VHP to the sterilization chamber
2. Mitigating variability in the peroxide concentration within the sterilization chamber
3. Evacuating VHP from the sterilization chamber once sterilization is complete
4. Ensuring samples have been thoroughly and uniformly sterilized culminating in dry samples that can subsequently be stored for long term transport
5. Minimizing expendable losses of oxygen, water, and VHP
6. Minimizing energy, mass, and volume of sterilization components

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

For NASA applications, Contamination Control and Planetary Protection requirements focus on both forward and backward contamination from such bodies where a number of acceptable processes have been developed for sterilizing spacecraft hardware and sample return materials. Vaporized hydrogen peroxide in particular has been established as an effective sterilant for NASA applications. However, a big challenge is ensuring an effective sterilant is present and efficient for long duration space missions.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial opportunities for the hydrogen peroxide generator may be directed toward medical equipment sterilization. Integrating Skyhaven's compact vaporized hydrogen peroxide generator into a desktop sterilization unit will enable safe and effective sterilization.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z12.01-2092**

SUBTOPIC TITLE: Extraction of Oxygen and Water from Lunar Regolith

PROPOSAL TITLE: A Regenerable Purification System to Remove Sulfur and Halide Impurities

Small Business Concern

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

Phone: **(303) 422-7819**

Principal Investigator:

Name: **Dr. Gokhan Alptekin Ph.D.**
E-mail: **galptekin@tda.com**
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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):

In-situ resource utilization (ISRU) increases the efficiency of space missions by utilizing indigenous resources on a planet or moon to reduce the amount of material that must be brought from Earth. Oxygen is one of the most valuable materials in space operations and is abundant in Lunar regolith (up to 40%). Unfortunately, the lunar regolith beneficiation process for producing oxygen results in process gases that may be contaminated with sulfur (H_2S) and halide (HCl, HF) impurities, all of which must be removed.

TDA Research, Inc. proposes to develop durable, high-capacity regenerable sorbents that can remove sulfur and halide contaminants from the process gas containing the oxygenated species produced from lunar regolith. We will use two regenerable sorbents, one of which will reduce the amount of HCl and HF, while the other will remove the H_2S to parts per billion levels.

In the proposed work we will synthesize new sorbent formulations and evaluate their performance under representative conditions. We will explore the methods to prepare these sorbents on engineered structures to increase their durability and promote better heat transfer during the thermal regeneration process. We will perform a minimum of 500 adsorption/regeneration cycles to demonstrate the life of these sorbents. Finally, we will carry out a detailed engineering analysis and design to assess the technical viability of the concept.

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

The main attraction of our research to NASA is its ability to provide a lightweight, compact, and efficient gas purification system to enable the production of oxygen from Lunar regolith feasible. This will minimize the amount of consumables to be brought from Earth and make the mission more affordable. In addition to supporting the mission to the Moon, the sorbent-based contaminant clean-up process may also applicable to trace contaminant removal from spacecraft cabin air.

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

The sorbents developed in this project will find use in the large environmental emissions control market. The market for materials that remove contaminants from vent air streams and environmental emissions reductions which has annual U.S. sales of $4 billion.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.04-2424**

SUBTOPIC TITLE: Integrated Science Mission Modeling

PROPOSAL TITLE: Innovative System Modeling Methods and Tools

Small Business Concern

Firm: **WarpIV Technologies, Inc.**
Address: **5230 Carroll Canyon Road, Suite 306, San Diego, CA 92121**
Phone: **(858) 605-1646**

Principal Investigator:

Name: **Jeffrey Steinman Ph.D**
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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):

WarpIV Technologies, Inc. proposes to demonstrate the WarpIV Kernel parallel discrete-event simulation engine and its extensive collection of software tools to address the cross-cutting modeling needs of the NASA integrated science mission modeling community.

The WarpIV Kernel is a layered open-system architecture where each layer in the architecture is permitted to utilize (i.e., depend on) services from lower layers, but not the upper layers. With this hierarchical dependency structure, the architecture layers can be thought of as composable libraries that are ready for standardization by the international Modeling & Simulation (M&S) community. Any technology layer could be swapped out and replaced with a different (perhaps optimized for a particular hardware/network configuration) implementation developed by any other organization. The plug-and-play composability design strategy of the WarpIV Kernel promotes composability both for (1) technology insertion and (2) composable plug-and-play software models potentially developed by

multiple geographically distributed organizations to facilitate collaboration. The software abstractions and overall composability methodology support both arbitrary and mixed levels of fidelity for systems and subsystems hierarchically composed of models.

Support for plug-and-play model composability within the WarpIV Kernel simulation engine is essentially complete and could be used by NASA today to support MBSE. However, the set of tools used to (a) construct models and (b) specify their composite structure needs to support MBSE standards such as SysML. The model data, interface, and system-structure metadata that is captured by the WarpIV GUI tools have not yet been translated to SysML format and vice versa, so this step needs to first be evaluated for feasibility and then demonstrated with initial capabilities. This effort will also demonstrate a conceptual spacecraft mission executing with a set of simple composable models in parallel.

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

Any NASA M&S program that requires a usable MBSE capability that implements most (or all) of the major SysML capabilities needed to support MBSE. The discreet-event and entity-centric modeling constructs are ideal for space mission modeling. The direct benefit to NASA will be unifying support for both (1) MBSE-based space mission modeling and (2) computationally intense science modeling. The greatest potential NASA application would be the reuse of composable model code and creation of model and interface packages for use on future projects.

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

The OpenUTF and its WarpIV Kernel open source reference implementation are being prepared for eventual standardization and widespread use across multiple DoD agencies and programs including ARL, DMSCO, MDA, and AMSCO. WarpIV Technologies, Inc. has had several technical discussions with the Navy (and other defense agencies) on MBSE to shift to the more modern WarpIV/SysML paradigm.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.02-2819**

SUBTOPIC TITLE: Quiet Performance - Airframe Noise Reduction

PROPOSAL TITLE: Design Cycle Modeling Tool for Wing-Strut Junction Flow Noise

Small Business Concern

Firm: **Technology In Blacksburg, Inc.**
Address: **265 Industrial Drive, Christiansburg, VA 24073**
Phone: **(540) 961-4401**

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):

NASA's Advanced Air Transport Technology Project has worked with industry over the last decade to develop airframe/propulsion concepts and associated technologies to enable transformative air travel for future generations. Techsburg and AVEC's proposal "Design Cycle Modeling Tool for Wing-Strut Junction Flow Noise" addresses a technology analysis gap in the development of a leading airframe concept, the Transonic Truss Braced Wing (TTBW) aircraft. The aeroacoustic signatures of the large bracing strut and jury member features of this configuration need to be studied with appropriate modeling to enable design cycle input based on far field noise estimates of these features. We propose to produce a database of hemisphere noise levels (1/3 octave band) using PowerFLOW CFD, with an accompanying model based on machine learning for design cycle trades of this noise source. In addition to gaining valuable insight into the aerodynamics and aeroacoustics of wing-strut junction flows, Phase I will conclude with a demonstration of this model.

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

Design cycle modeling of junction flow noise is key in completing the aeroacoustic characterization of the Transonic Truss Braced Wing configuration. In addition, it is also beneficial in many other areas outside the NASA technology pull created by the Transonic Struct Braced Wing. This approach can be easily integrated into existing aeroacoustic software frameworks such as ANOPP2, and can be extended to include sources such as tail empennage junctions, antenna installations, landing gear, and external store hardpoints.

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

Other engineering areas include surface and underwater ocean vehicles, rotating fan shroud modeling, ventilation systems, automotive industry, and design of architectural and civil engineering features such as bridge piers or buildings that form de facto "wing-body" junctions within the water or atmosphere that flows around them.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A2.01-2872**

SUBTOPIC TITLE: Flight Test and Measurement Technologies

PROPOSAL TITLE: LeNgineer's MITA Technology for Flight Test and Measurements

Small Business Concern

Firm: **LeNgineer**
Address: **1313 South Washington Avenue, Titusville, FL 32780**
Phone: **(321) 418-8228**

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):

In the aerospace industry, particularly NASA centers, there is a lack of machine learning and artificial intelligence to provide high resolution modeling processes for decision making, along with network monitoring to identify any issues of the flight system. NASA needs innovative solutions to fulfill requirements, close capability gaps, and provide technological advancements. To address this major issue, LeNgineer has begun the development of an Artificial Intelligence software called Multidisciplinary Instrument Tool and Analysis (MITA), which can be further advanced and customized for integrated use in the in the Aeronautics Research Mission Directorate (ARMD) Integrated Aviation Systems Program (IASP), the Electrified Powertrain Flight Demonstration (EPFD) and Flight Demonstrations and Capabilities (FDC) projects. Currently, there is no software in the market that integrates into NASA systems in such a way that MITA does, making the current process highly inefficient. Without the proper technology for rapid data processing, there is a decrease in efficient data capture and analysis that doesn't allow a system to make accurate predictions. The machine learning and artificial intelligence capabilities of MITA would be able to make predictions and capture/analyze data in a manner more efficient than ever before while decreasing the overall energy consumption. MITA functions as an RTU (Remote Terminal Unit) base to test and analyze the existing launch systems, including those currently implemented at NASA. The RTU delivers and receives information from the system as a multipurpose device for remote monitoring and control of various automation systems. MITA seeks to improve the control of in-flight test conditions, expand measurement and analysis methodologies and improve test data acquisition and management. MITA can detect issues in real-time and has the capability to present solutions or work to resolve the problem.

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

This technology has been researched to be applicable with NASA within the disciplines of flight testing, launch automation, command and control. The tool can also be further customized for specific application of Thermal, Fluids/Computational Fluid Dynamics, Stress/Structure, Trajectory/Design, GN&C, and EMI for in flight analysis. For future applications of this technology, we can expand MITA to be catered to any particular subsystem for a fully functional testing instrument that is specific for a certain design necessary to the flight system.

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

MITA can be applied for environmental, manufacturing, process control, and medical devices. The tool is designed to be a testing schema to analyze systems by taking in multiple data sources to validate itself. MITA is aimed to be distributed among various industries as a basic package that would include all the necessary hardware components and base software for testing, analysis, and predictions.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.07-1353**

SUBTOPIC TITLE: In Situ Instruments/Technologies for Lunar and Planetary Science

PROPOSAL TITLE: Miniature Vacuum Pump for Planetary Atmosphere Aerosol Separator

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

NASA seeks to develop an Aerosol Separator (AS) as the sample inlet for *any mass spectrometer* (MS) operating in a planetary atmosphere containing suspended aerosols, including liquid, icy, and metallic particles. The primary role of the AS is to inertially set apart heavier particles from the gas using the NanoJet technology, and determine aerosol chemical composition, number, and size distribution. The most stressing case for the new AS technology is the unknown 360 nm absorber suspended in acidic aerosols in Venus' clouds. It is also applicable for aerial and surface missions to Titan and Mars and subsonic probe missions to the ice giants. The MS measurements require low gas pressures created by vacuum pumps, and for the planetary missions these pumps must be extremely small and lightweight. To meet this need, on the proposed program, Creare plans to develop and deliver advanced miniature vacuum pumps that are compact, lightweight, and will withstand the challenging sampling conditions presented by acidic aerosols and spaceflight. In Phase I, we will perform life testing of pumps with acidic sampling gases and develop pump and electronics designs for a flight system. In Phase II, we will build and deliver pumps and electronics for use in a NASA test facility. In Phase III, we will deliver components for space missions based on our past successful vacuum systems used on the Mars Science Laboratory and ExoMars MSs.

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

The successful completion of this program will result in miniature vacuum pumps that are tolerant to the most extreme planetary atmospheric environments in our solar system. The vacuum pumps will be ideal for use in an aerosol separator to study planetary atmospheric composition. Potential NASA missions include a mission to study acidic aerosols in the clouds of Venus, aerial and surface missions to Titan and Mars, and subsonic probe missions to the ice giants.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The military and commercial market for the Creare miniature pump technology are for light weight and portable MSs and gas chromatographs for air sampling, radioactive material identification, and homeland security applications.
Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.01-2261**

SUBTOPIC TITLE: Power Generation and Conversion

PROPOSAL TITLE: Pushing Radiation Hardness and Qualification of Ultrathin Silicon Solar Cells

Small Business Concern

Firm: **Regher Solar, LLC**
Address: **7700 South River Parkway, Tempe, AZ 85284**
Phone: **(520) 838-9404**

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):

Regher Solar proposes this SBIR project to mature ultrathin silicon (UT-Si) solar cell technology to achieve TRL 6 and quickly transition to TRL 7,8 followed by injection into both NASA and commercial missions. At present UT-Si cells manufactured by Regher Solar have a 20% 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. With several practically attainable improvements UT-Si solar cells will reach 22% BOL efficiency in 2 years. However, the End-of-Life (EOL) efficiency of UT-Si cells drops substantially when exposed to space radiation making them less attractive for the use in space. If radiation damage is mitigated, UT-Si cells can achieve EOL efficiency of ELO-IMM cells while being as inexpensive as CIGS cells making them the optimum choice for flexible solar arrays among all thin film technologies.

This project will leverage an improved understanding of radiation-induced defects in c-Si that was developed in the last 3 years within the effort to fabricate more radiation hard Si detectors for the Large Hadron Collider. The main proposed innovations include: (1) using defect engineering to passivate radiation induced defects, (2) further reducing solar cell thickness from 20 to 10 microns to improve the effectiveness of passivation, and (3) utilizing active defect elimination methods that can be periodically applied to the solar cells in space.

Phase I of this project will demonstrate the feasibility of the proposed innovations and will conduct comprehensive electron and proton irradiation testing. Phase II will collaborate with blanket manufacturers to package UT-Si solar cells in CICs and blankets and conduct complete qualification to achieve TRL 6. Phase II will also work with development partners to integrate UT-Si cells into ongoing missions and achieve TRL 7,8.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

UT-Si solar cells 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. At the same time UT-Si solar cells have a potential to also meet NASA goals for the long-term operation in high radiation environment (1 MeV 6e15 e/cm2). 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 UT-Si technology is compatibility with high volume manufacturing and a low manufacturing cost. Production of UT-Si solar cells can be quickly scaled to 100 MW/year to meet the demand of the 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: 21-1- **H8.01-1331**

SUBTOPIC TITLE: Low Earth Orbit (LEO) Platform Utilization to Foster Commercial Development of Space

PROPOSAL TITLE: In-space testing of reversible adhesive system

Small Business Concern

Firm: **ATSP Innovations**
Address: **6762 Shadyvilla Lane, Building #3, Houston, TX 77055**
Phone: **(217) 778-4400**

Principal Investigator:

Name: **Jacob Meyer**
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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):

Reversible adhesives are an attractive option for assembly and disassembly of reconfigurable space structures due to the simplicity of the fastening concept. This enables space frame construction concepts where the unit members would quickly bond at the joints. Additionally, persistent asset structures that allow temporary or permanent rigid mechanical attachment at an arbitrary point on their surface at any time may enhance their long term utility. These would allow additional components to be held fast on the exterior surface of the deployed craft without the need for pre-built attachment points. A convenient method for producing this result would be an adhesive that could bond these structures following arbitrary lengths of time while in LEO, lunar, or deep space environments. ATSP Innovations has developed such a reversible adhesive concept based on solid

state bond exchange reactions between polymeric interfaces composed of a novel thermoset resin system called aromatic thermosetting copolyester (ATSP). This concept has been successfully demonstrated on Earth including in radiation environments. ATSP Innovations proposes development of a flight package for a MISSE-FF experiment berth to validate these properties. A compact package that would be exposed to LEO would be designed and fabricated with exposed surfaces of the reversible adhesive for future testing on return to Earth. Prior to flight, mechanical, morphological, and chemical state of samples would be assessed via nanoindentation, 3D laser-based profilometry, and x-ray photoelectron spectroscopy to determine upon return other notable changes in the samples. This project would be the validation of the first polymeric structural adhesive concept usable in a space environment. This concept is potentially usable in any position in the solar system where the temperature is less than 300 °C.

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

This would have direct impact on future in-space assembly efforts. Reversible adhesives would allow future space structures to have more area for potential expansion for changes in scope, configuration, or location of the deployed structure. These may also allow novel sealing concepts for inflatable space structures by use of a reversible adhesive - drastically saving mass from these structures. In addition, assembly of spacecraft on Earth may benefit from the use of a very high temperature adhesive that has now been validated in LEO.

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

Commercial launch industry may benefit from availability of a high temperature adhesive validated in LEO. Future space resource exploitation may also benefit from reconfigurable structures based on reversible structural adhesives. Operators of larger and more permanent deployed structures may benefit from enhanced reconfigurability during the lifetime of the structure.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H3.05-1771**

SUBTOPIC TITLE: Additive Manufacturing for Adsorbent Bed Fabrication

PROPOSAL TITLE: Additively-Manufactured, Net-Shape Adsorbent Beds for Carbon Dioxide Removal

Small Business Concern

Firm: **HiFunda, LLC**
Address: **421 Wakara Way, Suite 210, Salt Lake City, UT 84108**
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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):

This proposal addresses NASA's 2021 solicitation Focus Area 6: Life Support and Habitation Systems, Topic Number H3.05 Additive Manufacturing for Adsorbent Bed Fabrication. Current and future human space exploration missions require an optimized air revitalization system (ARS) that can reduce the system mass, volume, and power, and increase reliability. The ARS systems contains a Carbon Dioxide Reduction Assembly that is adsorbent-based and its performance is limited because COTS sorbent powder materials are used. NASA is interested in new materials and processes that will develop improved 3D-printing processes and paste formulations to increase the technology readiness level (TRL) of 3D-printing or robocasting processes for producing net-shape, monolithic sorbent beds as drop-in replacements for packed sorbent beds such as those in the CDRA. The HiFunda/PADT team is proposing to design hierarchical (meso, macro, micro porosity) zeolite-based, monolithic adsorbent beds for CO2 removal that will be 3D-printed using an aluminosilicate (geopolymer) to bind commercially-available zeolite particles together (3DZeoGeo zeolite paste material and 3D-printing process). The aluminosilicate binder will be cured in situ via chemical reaction that is accelerated by the laser thermal treatment. The 3D-printed monolithic zeolite adsorbent bed will be a drop-in replacement for the existing powder bed with improved mass transfer, heat transfer, mechanical robustness properties. In Phase I, the HiFunda/PADT team will develop and demonstrate robustness and performance of its 3DZeoGeo zeolite paste material and 3D-printing process in a proof-of-concept monolithic adsorbent test vehicle (POC-ATV) that will be tested and characterized for CO2 removal performance, pressure drop, and mechanical strength. The proposed technology will be further refined and demonstrated on an ATV design of interest to NASA and/or aerospace contractors in Phase II.

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

The proposed 3DZeoGeo zeolite paste material and process will be used by NASA and its contractors to provide a practical, fast and flexible route to generate net-shape, monolithic sorbent beds as drop-in replacements for packed sorbent beds such as those in the CDRA. Successful demonstration of the new 3DZeoGeo zeolite paste and process for CDRA will provide many significant benefits to NASA and to the commercial space industry by providing significant reductions in the CDRA system mass, volume, and power, and improved reliability.

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

The proposed 3DZeoGeo technology will find commercial adoption for a number of non-NASA markets to develop custom adsorbent beds for use in automotive aftertreatment (market size of $128.2B in 2025), environmental remediation ($123.2B in 2022), CO2 capture ($8.1B in 2021), wastewater treatment ($65.1B in 2024), and air purification ($13.6B in 2025), as well as other unique applications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.07-1908**

SUBTOPIC TITLE: In Situ Instruments/Technologies for Lunar and Planetary Science

PROPOSAL TITLE: Fabrication of Analytical Instrumentation Assemblies via Additive Manufacturing

Small Business Concern

Firm: **Sears Scientific Consulting, LLC**
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Principal Investigator:

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Business Official:

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Phone: **(408) 391-4641**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

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

We propose to investigate the utilization of additive manufacturing (AM) techniques for the fabrication of analytical instrumentation especially those requiring high or ultra-high vacuum environment to function. This includes particle optic systems such as electron and ion microscopes, X-ray sources, and mass spectrometers. By leveraging AM, the weight, cost, and development time can all be significantly reduced, further enabling the exploration capabilities of NASA programs.

Among AM processes we propose to utilize stereolithographic (SLA) printing due to its ability to provide the highest resolution while producing void-free prints with little built in stress that could later deform the part. The prints will use engineering resins able to survive high temperatures >200˚C to survive the harsh environment of space. In addition to the base material, plating-on-plastic will be used to form thick (50-100μm) copper/nickel layer that further strengthens the part while reducing outgassing to that of other metal surfaces and provides the electrostatic surface. For parts needing to remain electrically isolating, atomic layer deposition of alumna (Al_2O_3) can be used to mitigate

outgassing, or the part can be printed directly into a ceramic-photopolymer resin which is later fired to produce a fully ceramic part.

For this proposal we will design test articles to verify outgassing performance, measure part accuracy, perform electrical testing on ceramic stand-offs fabricated via AM, and produce an assembled mock-up of a focused ion column to vet the assembly methodology and test high voltage stand-off strength.

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

- suitable for lunar, planetary, solar, & satellite instrumentation
- Compact, light-weight Scanning Electron Microscope (SEM) for planetary or lunar surface analysis
- In-situ instrumentation fabrication & repair

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

- Compact, light-weight (<20kg) back-pack Scanning Electron Microscope (SEM)
- Cost reduction of analytical instrumentation including electron and ion microscopes, flood guns, vacuum gauges and gas analyzers
- Custom one-off particle optic assemblies for physics research (design & fabrication as-a-service)
- Low cost vacuum chambers and components for basic research

Duration: **6**

PROPOSAL NUMBER: 21-1- **H10.01-1442**

SUBTOPIC TITLE: Advanced Propulsion Systems Ground Test Technology

PROPOSAL TITLE: Wireless field-ready transducer acquisition device

Small Business Concern

Firm: **Parabilis Space Technologies, Inc.**
Address: **1195 Linda Vista Drive, Suite F, San Marcos, CA 92078**
Phone: **(855) 727-2245**

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 innovation is a device that connects to existing, installed pressure transducers (or other transducers) and allows for remote, wireless reading of these transducers with Bluetooth enabled devices, such as laptops, mobile devices, or other field-deployable computers. When installed, the device will provide a wireless reading of the transducer. This device will have the following features:

- Long battery life, at least sufficient for a full day of testing for most pressure transducers
- “Pass through” signal and power such that the device can remain connected to a pressure transducer when also connected to a wired DAQ
- Adaptability to a variety of output voltage levels
- Adaptability to a variety of input voltages
- Configurable pin-outs
- Compatibility with most existing pressure transducers used for rocket testing
- Memory sufficient for device ID, onboard calibration curves, etc.
- Field-ready sturdy waterproof construction
- Adherence to low-power Bluetooth 5.0 standards
- External on/off switch

Power - This device is now possible due to relatively recent advancements in the reduction of power for short-range communication (e.g. Bluetooth 5.0), analog to digital conversion chips, and the improvement in volumetric storage capacity of lithium battery technology. For instance, a single 18650 cell (one of the most common lithium ion cells on the market) has approximately 9 W-hr of total storage in a 2.6 inch long x 0.75 inch diameter form factor. This is more than sufficient to power a typical pressure transducer for a full working day.

Data - Analog to digital conversion chips are now cheaper and lower power than ever before. Also the recent wave of DIY robotics and control (e.g. Arduino and Raspberry PI systems) have provided a market for inexpensive, low-power, integrated acquisition devices that, while likely not suitable for a final commercial product, are more than sufficient for prototyping and development purposes.

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

The application of this innovation is very broad. This innovation would support testing operations for numerous NASA programs, including programs that are part of the Lunar Gateway architecture. This also includes essentially any NASA program that performs ground testing involving pressure transducers.

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

The commercial or defense market for this innovation is essentially as broad as the market for pressure transducers, which is reportedly a $16B a year market and includes automotive, oil and gas, consumer electronic, and medical sectors, in addition to the aerospace market. The proposed innovation will increase productivity and efficiency across all of these industries.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H10.01-1291**

SUBTOPIC TITLE: Advanced Propulsion Systems Ground Test Technology

PROPOSAL TITLE: High Speed Emission Tomography for Ground Test Facilities

Small Business Concern

Firm: **En'Urga, Inc.**
Address: **1201 Cumberland Avenue, Suite R, West Lafayette, IN 47906**
Phone: **(765) 497-3269**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 7

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

En'Urga Inc. will evaluate the feasibility of utilizing mid-infrared hyperspectral imaging as a diagnostic for ground test facilities that have high-temperature turbulent flows such as exhaust plumes from rockets and advanced propulsion systems. The two key issues that will be addressed during the Phase I research work are: (1) the feasibility of developing a high speed mid-infrared hyperspectral imager for turbulent flows, and (2) the feasibility of obtaining spatially and temporally resolved gas concentrations and temperatures from the mid-infrared hyperspectral images.

Three tasks are planned to be completed during the Phase I work to address the feasibility of the Hyperspectral emission tomography system. The first task is to design and integrate a breadboard version of the hyperspectral imager to measure path integrated emission in the mid-infrared region from reacting flows. The second task is to develop an algorithm to obtain spatially and temporally resolved gas concentrations and temperatures from the measurements. The third task is

to evaluate the system using laboratory-scale experiments. It is anticipated that at the end of the Phase I project, the feasibility of obtaining temperatures and gas concentrations from path-integrated measurements using a mid-infrared hyperspectral imager will be demonstrated conclusively. For Phase II work, a prototype mid-infrared hyperspectral tomographic system will be fabricated and delivered to NASA for use in the ground test facilities at the Stennis Space Center.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed hyperspectral imager will provide planar temperature and gas concentration from turbulent reacting flows in high-speed exhaust plumes. The primary NASA application for the proposed hyperspectral imager is to provide non-intrusive validation data for advanced technologies and vehicles. The Phase II prototype instrument can be directly utilized in the ground test facility at NASA Stennis Space Center.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The primary commercial application of the hyperspectral imager will be to obtain validation data from the plumes of all types of propulsion devices. The data are required to develop advanced propulsion systems, aero engines, and associated technologies. Potential customers include commercial and military aerospace propulsion and aircraft engine organizations and university research laboratories
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z12.01-3222**

SUBTOPIC TITLE: Extraction of Oxygen and Water from Lunar Regolith

PROPOSAL TITLE: Lightweight and Low Stow Volume Solar Concentrator for Lunar Based In-Situ Resource Utilization

Small Business Concern

Firm: **L'Garde, Inc.**
Address: **15181 Woodlawn Avenue, Tustin, CA 92780**
Phone: **(714) 259-0771**

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 objective of the proposed Phase I effort is to develop a lightweight (and ultimately high W/kg) and low stow mirror solar concentrator that can concentrate sunlight light at the lunar surface for use in situ resource utilization (ISRU), specifically for oxygen extraction from lunar regolith. In Phase I, L.Garde, Inc. will (1) design a full scale solar concentrator capable of meeting NASA performance requirements, (2) build a small-scale proof-of-concept prototype, (3) demonstrate the design capabilities through experimental testing. In Phase II, L.Garde, Inc. will develop the full scale system design and build a relevant scale prototype for ground testing and further demonstration of capabilities.

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

The development of a lunar based solar concentrator directly fulfills needs of the NASA plans described in the solicitation topic and will contribute to ISRU technology which is critical for the success of the Artemis program. It has been demonstrated by many scientific groups that water can be harvested from regolith which can be used to sustain life on the lunar surface as well as provide fuel for deep space travel. This technology can also be used concentrate light on solar arrays to generate energy or power.

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

Outside of NASA applications, other government missions that can utilize this technology such as Earth-based concentrated solar power industry, other applications that support “The Green Initiative”, and deployable antennas for military and commercial applications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H12.03-3228**

SUBTOPIC TITLE: Portable Spatial Disorientation Simulator - Trainer

PROPOSAL TITLE: TacGVS - A Wearable Spatial Disorientation Simulator-Trainer

Small Business Concern

Firm: **Human Systems Integration, Inc.**
Address: **153 Washington Street, Suite 4, East Walpole, MA 02032**
Phone: **(305) 926-7928**

Principal Investigator:

Name: **John Phillips**
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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):

Human Systems Integration (HSI), a leading developer and provider of garment-integrated, wearable electronic solutions, will design, develop and field a portable, comfortable, wearable, affordable and robust galvanic vestibular stimulation (GVS) device that will provide a head movement coupled and controlled multi-axis GVS stimulus to create vestibular sensations that mimic those perceived by astronauts in response to active head movements following sensorimotor adaptation to long duration spaceflight. Catalyzed by our Tactical Personal Area Network (TacPAN) platform, HSI has the unique pedigree of having established a US-based supply chain for both electronic textile (eTextile) and Flexible Hybrid Electronics (FHE) smart harnesses as well as for embedding these smart harnesses in multiple electronic garment (eGarment) products. A testament to this pedigree is the fact that in September 2019, the State of Massachusetts, through its Massachusetts Manufacturing Innovation Initiative (M2I2) program, awarded HSI a $1.45M facilities and capital equipment grant to establish a Garment-Embedded Electronics center of excellence. This grant enabled HSI to expand rapid prototyping and manufacturing capabilities at our Walpole, MA, location as well as at a number of our supply chain partnerships.

During this product development program, we will build off of our substantial investment in establishing an eGarment technology and product portfolio, and associated manufacturing supply chain, to develop a disruptive Tactical GVS (TacGVS) system, all in a form factor that does not impact the dexterity, comfort or effectiveness of the astronaut. To develop the TacGVS system,

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

NASA has identified sensorimotor gap (SM-202) as a need to develop and test manual control countermeasures based on human factors aids and that no GVS devices currently on the market portable, rugged enough for field testing or that couple stimulus profiles to head movements. Astronauts training for planetary missions could use TacGVS to train on what to expect with regards to spatial disorientation in realistic mission simulations.

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

Commercial Spaceflight: Efficient and effective preflight sensorimotor training and space motion sickness desensitization would help maximize the participant experience during these shorter missions.

Simulation, training and entertainment: TacGVS could augment this market by providing motion cues congruent with visual motion to increase immersion and lower the incidence of Simulator Sickness.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z7.03-2654**

SUBTOPIC TITLE: Entry and Descent System Technologies

PROPOSAL TITLE: Flexible Gas Barrier to Reduce Hot Gas Ingress at Surface of Hypersonic Inflatable Aerodynamic Decelerator

Small Business Concern

Firm: **Miller Scientific, Inc.**
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Phone: **(928) 779-5000**

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):

HeetShield's objective for this Phase I program is to demonstrate that a Flexible Gas Barrier (FGB) between the outer fabric layers of the Flexible Thermal Protection System (F-TPS) on the Hypersonic Inflatable Atmospheric Decelerator (HIAD) has the potential to reduce hot gas ingress to the interior

fibrous insulation. Reducing hot gas ingress will reduce oxidation/recession of interior fibrous materials and reduce interior convective heating throughout the F-TPS. It is anticipated that the FGB materials will liquefy upon heating, that capillary action will draw it into the crevices in the outer fabric weaves to seal those crevices against mass flow, and that surface tension will hold the FGB in place while it remains in a liquid state. Although weight and bulk of the F-TPS is increased by adding the FGB, adding it is also expected to make the F-TPS significantly more effective such that other components can be made thinner and lighter, delivering a net weight and bulk reduction. In Phase I the feasibility of the FGB will be investigated through a series of tests that expose FGB prototypes to hot flames from a Meker burner and measure gas flow and its effects. F-TPS compatibility will be demonstrated by manufacturing an F-TPS specimen including the FGB, compressing that specimen to the representative volume, and evaluating the specimen for damage. Technical progress, and fabrication/manufacturing issues will be considered to assess hurdles in Phases II and III.

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

Improved HIAD technology will increase mission capabilities for Mars and beyond. HIAD is considered a key technology for human rated Mars Entry Descent and Landing (EDL). The materials developed in this Phase 1 effort will lead to improved Gen-3 HIAD FTPS that can handle higher heat loads and/or pack to a smaller volume. Applications include Mars, Venus, Titan, as well as payload return to Earth from LEO. HEOMD, STMD, and SMD can benefit from this technology for various exploration missions.

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

Methods to reuse spacecraft hardware are currently being developed by many companies including ULA, SpaceX, Blue Origin and Rocket Lab. In EDL areas where the hardware is flying at hypersonic velocities, a HIAD could be a key decelerator technology. This Phase I effort will provide more HIAD design options and expand the mission capability for these companies.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.03-1992**

SUBTOPIC TITLE: Technologies for Passive Microwave Remote Sensing

PROPOSAL TITLE: Wideband THz Local Oscillator

Small Business Concern

Firm: **LongWave Photonics, LLC**
Address: **958 San Leandro Avenue, Mountain View, CA 94043**
Phone: **(617) 399-6405**

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):

In NASA's 2019 Astrophysics Biennial Technology Report "**tunable-bandwidth array receivers for operation at frequencies of 1 – 5 THz**," is described as a tier 2 technology gap priority [1]. Specifically, there is a need "**for LO [local oscillator], sources with output power levels ≥ 10 μW at frequencies above 2 THz,**" pumping "**arrays of 10 to 100 pixels.**" **THz Quantum Cascade Lasers are excellent candidate LOs in this frequency range because of their multi-milliwatt power levels, necessary to pump pixel arrays of superconducting hot electron bolometer mixers, as well as room temperature Schottky diode mixers. Recently, demonstrations of QCLs emission spanning 1.6 to 4.5 THz suggests the possibility of a WIdeband LO (WITLO). In this work LongWave will develop mode matching structures to provide effective anti-reflection coatings for its QLCs. This will enhance output power and wall plug efficiency of its lasers, and enable external cavity tuning. LongWave will develop specifications and a design for integration of this QCL with amplitude stabilization as well as low SWaP cryocooling necessary for future NASA missions.**

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

NASA applications include the use of Wideband THz LO (WITLO) in a reduced sized package as an LO for >2 THz receivers for future SmallSat and space/weight/power constrained missions. Examples include ASTHROS, OST/HERO, a future instrument for SOFIA, as well as future Planetary missions for observation of gasses in the 2 to 5 THz range. A laboratory version of WITLO would be ideal for characterizing novel mixer technology (e.g. MgB_2 mixers, novel Schottky diode receivers) as well as laboratory demonstrations of trace gas detection.

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

Initial applications are research markets for low-pressure gas spectroscopy. The narrow line width and the ability to provide real-time frequency information of THz radiation also has great appeal. For industrial applications, the use of high-reliability, compact Stirling coolers with integrated frequency and amplitude stabilization would increase the usability of these devices

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z1.05-2004**

SUBTOPIC TITLE: Lunar and Planetary Surface Power Management and Distribution

PROPOSAL TITLE: Dual Output Bidirectional Integrated DCDC Isolated SiC-based Power Converter for Space 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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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

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

In the Phase I effort of this this work, we will conceptualize, design, fabricate and validate through simulation and preliminary experiments of a 8 kW-rated silicon carbide (SiC) based galvanically isolated dual-output bi-directional DC-DC power converter circuit that can operate at a wide range of temperatures in space environments. Moreover, the design comes with a high degree of modularity and configurability of a proposed three-port network, where (a) multiple power converter units can be paralleled on the output side to scale up the power level, (b) planar magnetics technology is employed to enhance the power density and (c) power flow can be directed between any two specific ports while being able to bypass the third port. Furthermore, we plan to fabricate radiation hardened versions of the SiC power devices with high resiliency to heavy ion strikes. Thus, the outcomes of the proposed device technology and its demonstration with the proposed power converter pave the way for advanced, more efficient and lightweight space power systems.

The proposed power converter technology: will lead (a) to reducing the weight and volume (both by ~40%) of onboard power electronics through integrating two isolated DC-DC power stages with a projected power density of 1.3kW/L and 2.6kW/kg, (b) incorporating a unique control strategy to enable simultaneous regulated power flow toward both the output ports, while maximizing the converter efficiency not only at full load but also at light loads, (c) bidirectional enabling both DC bus-to-battery (D2B) charging and battery-to-other DC loads (B2D) discharging capabilities, (d) maintaining a rated load efficiency over 96.5% (~2.5% greater than state-of-the-art) across a wide operating ambient temperature range from -70C to 150C, and (e) employing a robust structure of power converter, where the implementation of gate driver and control circuits would be simple, hence leading to improved reliability of the system.

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

Harsh environment SiC power converters have wide applications in (a) spacecraft power management, (b) DC distribution systems in Venus/Mercury/Mars explorers, (c) motor drives, inverters and power supply derivatives in Space Station, satellite power system, and (d) motor drives in 'more electric' technology applied to aircraft generators and reusable launch vehicles. SiC technology also finds unique applications in harsh environment CMOS-based control, driver integrated circuits and sensors, where Si technology has its limitations.

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

Applications of harsh environment SiC power electronics include (a) power management and distribution system in ground/naval/air military vehicles, (b) automotive engine control electronics, (c) electrical actuator and motors drives in commercial aircraft jet engines, (d) compressor in geothermal, oil & gas extraction, (e) deep-well drilling telemetry module and electric actuation in gas turbines.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z1.05-3050**

SUBTOPIC TITLE: Lunar and Planetary Surface Power Management and Distribution

PROPOSAL TITLE: Ultrafast sensors for wide bandgap multi-phase power converters

Small Business Concern

Firm: **Telli Technologies, 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):

Tell-i's goal is to move beyond the conventional protection methods that are not designed for wide bandgap (WBG)-based power electronics converter systems. The state-of-art methods result in non-optimized and over-rated systems where the power density is compromised. Through our deep understanding of high-frequency power circuit components and advanced circuit layout design practices, we propose a novel all-passive, isolated, lossless, non-invasive, single current sensing solution for reliable operation and protection of WBG power electronics converters. Each of these characteristics adds significant benefits. An all-passive sensor requires no active processing or saturable circuitry (and their response time is only limited by how fast electrons can move). Therefore, it can be well suited for detecting fast-changing currents seen during fault conditions. A lossless sensor does not compromise the (conversion) efficiency and thermal management of its system. An isolated sensor simplifies the circuitry should be routed to the main controller. A non-invasive sensor does not affect an optimized circuit layout of the converter. Finally, a single-sensor solution is desirable in terms of costs and, more importantly complexity of the system. This SBIR Phase I proposal is to investigate the feasibility of the proposed all-passive single current sensing solution. The proposed sensor is applicable for isolated and non-isolated DC-DC and DC-AC multi-phase systems.

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

Direct beneficiary of the proposed solution is SmallSat (and even CubeSat) Satellite developers in meeting power management and distribution requirements that have stringent limits on power equipment volume. If the project is successful, it also provides a scalable path for fully integrated and intelligent power electronics modules (i-PEM) using wide bandgap semiconductor devices that finds applications in SEP and fission-based high voltage/power sourced NASA missions.

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

The desire for volume/mass reduction of controllers is forcing the deployment of WBG devices instead of silicon IGBTs. For these new controllers, Telli offers proper sensing solutions for control, protection, and prognostics. These controllers find applications in power management and actuation for renewable energy systems, electric vehicles, industrial electric motors, and avionic engine control.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.03-2757**

SUBTOPIC TITLE: Technologies for Passive Microwave Remote Sensing

PROPOSAL TITLE: Stacked Programmable Analog and Digital Electronic System (SPADES)

Small Business Concern

Firm: **Irvine Sensors 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):

The use of broadband spectrometers is required for Earth-observing, planetary, and astrophysics missions. Efficient use of these types of sensors require the need for high-speed analog-to-digital converters (ADC) in order to convert the analog information from these types of sensors to a digital format. The use of high-speed direct RF-sampling ADCs currently has the ability of directly sampling input frequencies up to and beyond 6.4 Giga samples per second (GSPS). Utilizing direct RF-sampling ADCs can drastically reduce componentry needs, weight and power versus typical limited bandwidth receivers using IF-sampling subsystems or heterodyne architectures. Furthermore, direct sampling systems provide much greater bandwidth and versatility for scientific instrumentation, allowing the software to define functions which would otherwise be defined via a fixed hardware implementation.

ISC seeks to innovate an interleaved ADC architecture by using multiple stacked die within a single package to provide next-generation sampling rates with ease-of-use for a range of applications such as radar, radiometry, spectrometer, and software-defined radio (SDR), which can take advantage of the ultra-wideband analog digitization to reduce front-end complexity by reducing down-conversion stages, intermediate frequency (IF) sampling subsystems, and other components that provide the system with reduced SWaP. To improve interleaved ADC performance, reduce external componentry, reduce layout complexity, and provide excellent temperature and voltage matching of an interleaved ADC, ISC proposes a Stacked, Parallel, Analog-to-Digital, Electronic System (SPADES). The stacking architecture can be applied to both commercial grade parts, achieving 20Gsps and beyond, as well as Space grade parts, achieving 12Gsps and beyond. Successful stacking of ADC chips can increase interleaving to achieve even higher rates.

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

Several earth science measurement based NASA programs continue to look for new devices to increase functionality within the same volume, weight and power constraints. Many of these programs are utilizing SmallSats for these monitoring satellites. Anticipated programs that can be supported by ISC's SPADES ADC are Smart Ice Cloud Sensing (SMICES) IIP, Concurrent Artificially-

intelligent Spectrometry and Adaptive LIDAR System (CASALS) IIP and possible future Landsat missions.

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

Possible non-NASA applications would be for military satellite use or unmanned vehicles (i.e. drones).

Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.01-1788**

SUBTOPIC TITLE: Technologies for Large-Scale Numerical Simulation

PROPOSAL TITLE: SimplifyHPC: A Framework to Simplify HPC Codes Deployment

Small Business Concern

Firm: **EP Analytics, Inc.**
Address: **12121 Scripps Summit Drive, Suite 130, San Diego, CA 92131**
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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):

EP Analytics will develop and commercialize a general-purpose and cross-platform solution that streamlines the deployment of complex modeling and simulation (M&S) applications on a diverse set

of computing resources (local desktop/laptops, all major cloud-service providers and traditional on-premise HPC clusters). The proposed solution, SimplifyHPC, is a desktop application that brings together all the tools necessary for M&S scientist and will consist of a built-in performance monitoring ensuring optimal deployment of applications.

NASA scientists and engineers increasingly rely on large-scale numerical simulations to advance understanding of complex Earth and astrophysical systems and to conduct High-Fidelity aerospace engineering analyses. Building and running most numerical simulation codes, however, are challenging tasks that involve resolving multiple dependencies (e.g., on external frameworks such as PETSc and NETCDF), and selecting optimal runtime parameters (e.g., number of OpenMP threads per MPI rank). Even for expert HPC users, these deployment steps pose significant barriers to executing simulation codes efficiently. EP Analytics proposes to develop an easy-to-use shrink-wrap solution, SimplifyHPC, that is designed to address the aforementioned complexities and remove the barriers to entry for prospective users within NASA and beyond. SimplifyHPC will deploy methodologies to collect lightweight performance reports, which can help uncover needed cost-saving optimizations and ensure efficient execution of HPC applications, thereby adding to the bottom line of SimplifyHPC customers.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The initial target application for SimplifyHPC is GEOS-Chem, an atmospheric chemistry application utilizing data from the Goddard Earth Observing System (GEOS) of the NASA Global Modeling and Assimilation Office. Dr. Daniel Jacobs has already expressed interest in SimplifyHPC. Dr. Jacobs chairs the GEOS-Chem Steering Committee. The committee also includes the following members from NASA: Dr. Christoph Keller (NASA GMAO), Dr. Hongyu Lui (NIA/NASA Langley Research Center), Dr. Andrea M. Molod (NASA GMAO) and Dr. Susan Strahan (NASA GSFC).

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

SimplifyHPC will be a general-purpose and cross-platform solution that streamlines the deployment of M&S applications on a diverse set of computing resources (local desktop/laptops, all major cloud-service providers and traditional on-premise HPC clusters) and as such has potential to target a wide range of NASA and non-NASA M&S applications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H6.23-1993**

SUBTOPIC TITLE: Spacecraft Autonomous Agent Cognitive Architectures for Human Exploration

PROPOSAL TITLE: The KFlow Cognitive Architecture

Small Business Concern

Firm: **Stottler Henke Associates, 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 proposed **KFlow** cognitive architecture supports the continuous acquisition, storage, and application of diverse knowledge to provide on-board autonomy and crew assistance during deep space missions.

KFlow comprises a **knowledge repository** and an **intelligent agent**. The repository **stores diverse knowledge objects** that support mission operations, such as system models, planning models, flight rules/notes, and procedures. These knowledge objects are enriched with annotations to support concept-based retrieval and automated reasoning. They are linked to related objects from which they are derived and to supporting datasets, documents, diagrams, and engineering studies (i.e., their knowledge provenance). Using the **TEAM toolkit** will streamline KFlow's development.

The KFlow agent **acquires knowledge** (i.e., learns) by deriving models of system or crew behavior from data, using the models to assess situations and generate procedures, and posing questions to human experts, such as flight controllers, to elicit rationale for other knowledge and hypotheses. The agent **applies knowledge** to respond to crew requests for assistance; estimates crew mental state and intervenes when appropriate; and responds to system failures, hazardous conditions, or new priorities.

KFlow is **innovative** because it provides a framework for managing the multi-step **transformation and flow** of source data, implicit knowledge, and unstructured data into more actionable knowledge that is used to provide automation and crew assistance. KFlow's approach is **pragmatic** because it flexibly tailors its assistance to the depth of knowledge it possesses.

During the project, we will identify KFlow functional requirements, develop a concept of operations & high-level system design, develop test scenarios to clarify requirements and design challenges, create a prototype that illustrates our approach and demonstrates feasibility, and develop a preliminary high-level design & project plan to be implemented during Phase II.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The primary NASA application will be the provision of autonomy and crew support during long-duration missions, especially when continuous and comprehensive Ground support is not feasible or economical. KFlow could also be used on Earth to capture and share expertise between back room and front room flight controllers or between more experienced or specialized controllers and less specialized controllers who handle multiple positions during periods of low activity.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

On Earth, the resulting technology could provide a foundation for autonomous operations and user assistance for knowledge-intensive tasks. Examples include engineering design, planning, military command and control, facility maintenance, smart buildings, laboratory automation, autonomous manufacturing and logistics, smart grids, and other critical infrastructure.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H8.01-2347**

SUBTOPIC TITLE: Low Earth Orbit (LEO) Platform Utilization to Foster Commercial Development of Space

PROPOSAL TITLE: Accelerated Aging of Lightweight High-Strength Mechanical Metamaterials

Small Business Concern

Firm: **Multiscale Systems, 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):

Multiscale Systems is an advanced materials and manufacturing firm commercializing mechanical metamaterial technology. Conventional materials have properties (strength, modulus, density, etc.) directly dependent on their molecular/chemical composition. In contrast, the properties of metamaterials are defined by their geometric and structural design. A common example in aerospace construction where structure is used to modify the properties of a base material is honeycomb. This well-known material exemplifies how geometric design can reduce weight while retaining unidirectional load-bearing capabilities. Contemporary metamaterial design leads to geometric patterning with greater 3D complexity and a corresponding increase of multifunctional capabilities. Consistent with the ISSNL's mission to conduct research for Earth benefit in space, this proposed SBIR effort seeks to conduct accelerated aging experiments to understand how products developed

with metamaterials will perform over time. The insights derived from this research will have a durable commercial effect since it will enable us to quantitatively predict the expected lifetime of these metamaterial-enhanced products. The Phase I effort seeks to conduct all necessary on-ground preliminary work (including design, fabrication, and characterization) leading to Phase II in-orbit experiments. Phase II will utilize existing ISSNL assets and launch services to expose two batches of samples to the austere conditions of space for 6 and 12 months to induce accelerated aging. These samples will be characterized and compared to ground-based controls fabricated during Phase I to quantify how and over what time scale: (1) base material properties degrade; and (2) metamaterial properties degrade. We anticipate the data will reveal distinct outcomes along two failure pathways, which ultimately will have broad impact on our commercialization of this advanced materials technology.

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

Mechanical metamaterials have potential NASA applications wherever lightweight multifunctional materials are needed. This includes: development of Lunar Rover technologies including ultra-lightweight lander system for protection from impact forces; development of materials-based solutions for physical protection during planetary exploration (Moon to Mars Campaign); and development of materials manufacturable in-space or on-site for protected habitable spaces on manned missions or for use in extreme environments (Moon to Mars Campaign).

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

Mechanical metamaterials have potential non-NASA commercialization opportunities in: lightweight structural materials for future mobility: advanced materials for defense (USAF/Lockheed Martin/Boeing dual-use applications); vehicle armor for US Soldier protection (US Army dual-use applications); and low-cost energy-efficient components in cyber-physical and IoT devices.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.02-2242**

SUBTOPIC TITLE: Technologies for Active Microwave Remote Sensing

PROPOSAL TITLE: Dual-channel Multi-Nyquist Zone DAC with Digital Up-conversion

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):

Pacific Microchip Corp. proposes to develop a rad-hard dual-channel 8-bit DAC ASIC sampling at up to 30GS/s and able to operate in several Nyquist zones. The ASIC is targeted for synthesis of the transmitter waveform in radar instruments used for planetary remote sensing applications. Instead of directly synthesizing entire signal bandwidth, a digital up-conversion technique and interpolation with a configurable factor will be used in the DAC. This approach will allow us to translate the signal with narrow bandwidth to any RF frequency within 3 adjacent Nyquist zones of the DAC. The presence of two DACs on the ASIC will make possible to synthesize two waveforms with a small phase error. Seeking to maximize the performance, the DAC will employ calibration using a built-in CPU and finite-state machines. For convenient interfacing with FPGAs at up to 8x8.75Gb/s (4 lanes per DAC), the ASIC will include a JESD204B standard compliant interface.

Phase I work will provide the proof of DAC feasibility – critical blocks will be implemented and verified at the targeted technology node. In Phase II, a silicon proven prototype ASIC will be provided.

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

- Radar instruments in planetary remote sensing systems
- Global precipitation measurement mission
- Global atmospheric composition mission
- Ku- and X-band radars on the SCLP mission
- Ka- and Ku-band radars on the SWOT mission

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

- Future communication systems
- Synthetic aperture radars in active sensors
- Arbitrary waveform generators
- Transmitters for SDRs and 5G communication systems
- Communications test equipment

Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.02-2477**

SUBTOPIC TITLE: Dynamic Power Conversion

PROPOSAL TITLE: Novel Multilayered Metal Insulation Using Custom Standoffs

Small Business Concern

Firm: **Giner, Inc.**
Address: **89 Rumford Avenue, Newton, MA 02466**
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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):

Future far world NASA missions require high temperature thermoelectric power supplies where solar power is unavailable. Current multilayer metal insulation (MLMI) systems reduce parasitic heat transfer to deep space, aiding performance. These MLMI systems have alternating support and reflective layers. These support layers span the shield length, creating a large path for conduction heat transfer losses. Giner's novel design will use custom, low thermal conductivity standoffs which will reduce parasitic heat losses, increasing power supply efficiency. Using these standoffs will decrease parasitic losses by a factor of three compared to current high temperature MLMI systems. Where operating temperature allows, Giner will substitute in more insulating materials, further increasing insulating performance. Giner's MLMI system will allow for extended and expanded mission capabilities for far world NASA missions.

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

The developed technology will enable expanded mission capabilities for all future NASA far world missions that cannot depend on solar energy. These missions could include robotic landers, satellites, rovers, and aerial vehicles for exploring Mars, the Moon, and the outer planets.

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

This technology can be used in cryogenic systems that use vacuum insulation. These systems can include cryogenic tanks, pipes, and other cryogenic equipment. This technology can also be used in high temperature industrial insulation, including petroleum refining and processing.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H6.04-2202**

SUBTOPIC TITLE: Model-Based Systems Engineering for Distributed Development

PROPOSAL TITLE: Simplifying SysML for Accelerated MBSE Adoption

Small Business Concern

Firm: **Aureus Innovation, LLC**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The innovation proposed is a SysML-based modeling profile and interactive model element relationship viewer aimed to significantly improve the learning curve associated with modeling languages deployed for Model Based Systems Engineering.

- **PHASE I:** A heavily simplified UML / SysML profile, inspired by human language, that provides a straight-forward yet extensible means for NASA architects and systems engineers to model complex systems. Along with the modeling profile, templates will be developed to aid the UML / SysML user to create models quickly and consistently. This will be more prescriptive than in current UML / SysML specifications. The profile will be deployed within an existing UML / SysML capable tool.

- **PHASE II:** To accelerate MBSE proliferation, we will create an HTML-based interactive model element viewer that focuses on presenting the relationships captured within the SysML model. Users can select from various visualization techniques that best align with their unique perspective. By deploying in HTML, the viewer can be provided as a plug-in to select commercially available tools or as a web-based dashboard. This will allow the UML / SysML model to be viewed by other roles (domain-specific engineering, non-technical and business leaders, etc.), allowing stakeholders with little or no MBSE experience to provide their valuable input and feedback to the model.

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

As some form of MBSE becomes the norm at NASA and as NASA seeks to perform more distributed development of their missions and systems, the methods and tools to enable MBSE must become significantly easier to learn, deploy and manage. The proposed innovation's simplicity means to bridge the gap left by current methods and will also lend itself useful on many more NASA projects, not just the largest ones as perhaps reserved for SysML in the past. A goal for Aureus is to enable development team efficiency improvements on any NASA project.

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

While this proposal is relevant to NASA and similar agencies and businesses that develop complex technical systems, Aureus has found considerable similarities between product managers and systems architects / engineers, as they perform similar technical duties. This insight will allow the proposed innovation to prove valuable for any development project.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.08-2807**

SUBTOPIC TITLE: Technologies to Enable Cost and Schedule Reductions for Optical System for CubeSats

PROPOSAL TITLE: Adaptive Optics for Low-Cost CubeSat Optical Systems

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

The goal of this project is to develop and demonstrate a compact, modular adaptive optics system with a beaconless wavefront sensor that advances NASA's vision for ultra-low-cost, precision optical systems for CubeSats through the mitigation of adverse effects on imaging quality associated with cost and schedule reduction strategies in the design, manufacturing, and testing of optical components.

Space-based telescopes have become an indispensable tool for exploring the universe, understanding the Earth's environment, and monitoring and planning human activity. CubeSats have emerged as a rapid, affordable alternative to large satellites for the scientific community and industry to perform space-based observations. Despite cost and schedule reductions for CubeSat platforms and launches in recent years, the cost and schedule of precision optical systems for CubeSats remains prohibitive for many applications. This discrepancy is largely due to the long fabrication and testing times of extremely precise, stable, and often custom optical components and assemblies.

Nanohmics, Inc. proposes to develop and test a low-cost adaptive optics system for CubeSat telescopes based on its passive wavefront sensor and a deformable mirror with the goal of improving imaging performance and enabling the use of components with previously unacceptable design and manufacturing tolerances. The system will be readily customizable to support a wide range of optical prescriptions and to support features relevant to deployable and segmented designs. Advanced deconvolution and super-resolution algorithms will further refine wavefront corrections and improve image resolution. During the Phase I program, Nanohmics will establish system requirements for representative low-cost CubeSat telescopes, perform a design trade study, and develop manufacturing and testing plans. The feasibility of the approach will be demonstrated by constructing and characterizing a breadboard adaptive optics system.

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

The initial target market is Earth orbit scientific research within NASA SMD, particularly remote sensing and astronomical imaging. The adaptive optics for low-cost CubeSat optical systems will enable high quality imaging performance from ultra-low-cost optical components. CubeSats have been employed in NASA missions including Polar Radiant Energy in the Far Infrared Experiment (PREFIRE) and Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats (TROPICS).
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Passive, extended-scene plenoptic wavefront sensors integrated into operational imaging turrets on-board ISR turrets for defense applications. Nanohmics sensors are part of an adaptive optics system designed to compensate optical aberrations induced by mechanical deformations during

thermal transients. Additional uses are in environmental sensing and vision systems for self-driving vehicles.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z2.01-1280**

SUBTOPIC TITLE: Spacecraft Thermal Management

PROPOSAL TITLE: Advanced Cooling System for Modular Power Electronics

Small Business Concern

Firm: **Advanced Cooling Technologies, Inc.**
Address: **1046 New Holland Avenue, Lancaster, PA 17601**
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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 order to optimize the performance of advanced modular power system (AMPS) for future deep space exploration missions, Advanced Cooling Technologies, Inc. (ACT) proposes to develop a novel cooling system consisting of multiple thermal management solutions (two-phase thermal plane, conduction enhancement card retainers, etc.), which can minimize the thermal resistance and the temperature drop across the heat transfer path from the semiconductors, to a circuit board, to chassis rails and eventually to the heat rejection system of the space vehicle. The thermal plane will incorporate advanced two-phase concepts to enable high heat flux thermal management and enable a reliable operation (i.e. smooth start-up) in microgravity, etc. In Phase I, ACT will perform a detailed

trade study to optimize the performance, mass, and volume of the embedded heat transfer devices for 3U electronic cards. With a given trade space, multiple versions of two-phase thermal planes will be developed. The best solutions will be integrated into a prototype cooling system designed for AMPS. Both transient and steady-state thermal performance testing will be carried out. The experimental data will be used to validate and correlate a mathematical model, also developed in Phase I. The electricity consumption, total mass, volume and the cost of the proposed cooling system for different modular electronics units will be evaluated and reported at the end of Phase I. Phase II will involve component level optimization as well as system-level modeling and experimental validation. Multiple ground-based validation testing and a potential reduced-gravity flight demonstration will be performed in Phase II.

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

The proposed cooling solution packages can effectively and reliably remove the waste heat from AMPS cards to the enclosure. This will allow for a long duration operation of high power and high-performance electronics in space. The modular electronic units with enhanced cooling performance will be useful for many NASA applications, including human landing systems, cis-lunar Gateway, Mars planetary habitat, etc. The two-phase thermal plane concept is also applicable for high-performance CubeSat thermal management.

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

The proposed cooling system for high power density electronics (e,g, MOSFETs, GTOs, IGBTs, IGCTs) has great market potential. Various “plug-and-play” components developed in this program will be adaptable for many terrestrial I applications, including multifunctional information distribution system (MIDS) for military/DoD communication systems, data center cooling, etc.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.05-1412**

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

PROPOSAL TITLE: Monolithic integration of high-efficiency III-nitride photocathodes and microchannel plates using a novel metallic contact

Small Business Concern

Firm: **Qrona Technologies, LLC**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5

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

Detection of light in the ultraviolet (UV) range (100nm to 400 nm) has a wide range of commercial, scientific and military applications, particularly in those areas where the UV component of light needs to be analyzed in the presence of a large amount of visible and/or infrared (IR) background light. High-performance photodetectors and imagers are essential parts of the enabling technology for future space-borne astronomy. Sensitivity, spatial and temporal resolution, photometric accuracy, and reliability of these photodetectors will be critical when defining, planning, and exploiting future space missions. In particular, for UV spectroscopy and low-light-level UV-imaging applications, there are strong demands for improved detectors which have higher quantum efficiency (QE), lower dark current, and more stable and robust operation. Highly robust, wide-bandgap gallium-nitride (GaN), and its alloys with aluminum and/or indium, are the most promising semiconductors for development of UV photodetectors for applications in space-based UV spectroscopy and imaging. In the Phase I program, Qrona Technologies, in collaboration with the space Science Laboratory at UC Berkeley, will develop and fabricate high-efficiency and high-resolution UV phototubes by depositing high-quality GaN-based photocathode structures directly on microchannel plates (MCPs), using a novel lattice-matched metallic buffer/contact layer. Monolithically integrated semiconductor photocathode/MCP detectors can achieve potentially much higher-performance than conventional phototubes in many applications, including higher detection efficiency, improved spatial and temporal resolutions, more immunity to magnetic fields, and better photoresponse uniformity on large format imagers, as well as reducing the device weight, size, complexity, and fabrication cost.

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

Future NASA planetary missions and astrophysics space telescopes, such as the Large UV Optical Infrared (LUVIOR) surveyor, require significant advances in photodetectors and imagers, particularly in quantum efficiency (QE), resolution, and pixel count, in order to produce major new scientific results. The monolithically integrated GaN-based photocathode-on-MCP detectors, proposed in this project, will satisfy many of these requirements, in addition to providing improved immunity to high temperatures, ionizing radiation and magnetic fields.

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

High sensitivity and reliable UV detectors are needed for many applications, such as high energy physics, medical imaging, and biochemical manufacturing. The GaN photocathodes on metallic substrate can also be used to make high-brightness electron emitters for maskless electron lithography, semiconductor metrology, and electron guns used in free electron lasers and particle accelerator injectors.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.04-2774**

SUBTOPIC TITLE: Nontraditional Airspace Operations

PROPOSAL TITLE: UAM Routing and Scheduling in Dynamic and Discoverable Urban Environments

Small Business Concern

Firm: **OneSky Systems Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 6

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

This proposal will seek to incorporate the operation and constraints discovered via the Discovery and Synchronization Service (DSS) into the Urban Air Mobility (UAM) routing and scheduling problem. In addition, we will advance the DSS capabilities to incorporate additional entity types such as UAM Aeronautical Information Management, Operations, Constraints, UAM Aerodromes, UAM Corridors, and associated resources and tasks. Expanding the role of DSS beyond just operations and constraints, to include geospatial data and services has yet to be explored or demonstrated by the industry.

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

The proposed effort will directly support NASA's AAM National Campaign in allowing stakeholders to better understand the impact of dynamic urban operations and the relevant constraints and the potential impact on efficiency and safety.

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

Applications of technology to facilitate UAM routing and scheduling in dynamic and discoverable urban environments is a need shared by FAA and other equivalent Air Navigation Service Providers (ANSP), Providers of Services to UAM (PSU's) and the UAM operators that want to support complex drone missions in urban environments will need this capability to ensure safe and efficient scalable operations

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z4.05-2054**

SUBTOPIC TITLE: Nondestructive Evaluation (NDE) Sensors, Modeling, and Analysis

PROPOSAL TITLE: Ultrasonic Energy Interaction with Composite Damage in Both Frequency and Time Domains

Small Business Concern

Firm: **Advent Innovations Limited**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

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

With the Artemis program, NASA is returning to manned space flight and plans to send humans to the Moon and Mars in the decades to come. New space vehicles and systems are being developed and tested, and a significant percentage of the structures in these spacecraft will be composite materials. Composites offer high stiffness- and strength-to-weight ratios, but they also exhibit complex damage modes, including voids, delaminations, matrix cracking, fiber breakage, and combinations of all the above. This offers many challenges for ultrasonic nondestructive evaluation (NDE) and structural health monitoring (SHM).

A proper understanding of the physics of a given NDE/SHM method is critical for the meaningful characterization and quantitative assessment of structural health. A need therefore exists to fundamentally understand the interaction of interrogative ultrasonic wave energy with the complex fiber/matrix system and damage types in multi-layered composites. To address this issue, a predictive tool with quantitative computational NDE/SHM capabilities is necessary to the success of future space missions.

In this project, it is proposed to develop a physics-based software package to model ultrasonic energy interaction with composite damage in both the frequency and time domains. The software package utilizes open source code and a fast and efficient Distributed Point Source Method (DPSM) to solve frequency domain ultrasonic wave fields in multi-layered composite structures with and without damage. The objective of this effort is to expand the DPSM capabilities to obtain time domain sensor responses at any location. Parallel computing capability will be implemented to solve the problem at multiple frequencies such that the time domain signal can be computed at any point on the structure. The wave energy-material modeling software package will be an essential tool to optimize sensor locations and minimize the total number of sensors and weight of future NDE/SHM systems.

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

It is anticipated that the first application of the technology will be the integration into NASA's digital NDE/SHM tools for large complex composite space structures, such as the Artemis program's Orion crew module and Space Launch System. As NASA directs efforts into deep space flight, NDE/SHM systems will be needed to provide mission critical information about the structures. For these NDE/SHM systems to be viable, a computational tool, such as the proposed software package, to accurately model the energy-material interaction is essential.

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

Non-NASA applications include large, commercial space launch vehicles that utilize composite materials. The US Air Force, Army, and Navy also have a growing interest in simulated NDE with the concept of 'Digital Twin' and real time material state awareness. Generally, any industry that uses large composite structures that require frequent inspection will benefit from the technology.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z1.05-1497**

SUBTOPIC TITLE: Lunar and Planetary Surface Power Management and Distribution

PROPOSAL TITLE: Heat Energy to Light Advanced Conversion and Transmission System

Small Business Concern

Firm: **Atomos Nuclear and Space Corporation**
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Phone: **(720) 629-9771**

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):

Atomos Nuclear and Space Corporation (Atomos) proposes a completely new method of power transmission as coherent infrared (IR) radiation. HELIACTS (Heat Energy to LIght Advanced Conversion and Transmission System) is a novel power generation, transmission and conversion schema that is inherently solid-state and long lived, more efficient and less massive over-all than systems relying on electromechanical energy conversion and electrical transmission. Narrowband emitters allow thermal energy to be converted to coherent IR radiation, which is transmitted via anti-resonant hollow-core fibers to the load, where it can be optimally converted to support specific load requirements.

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

Atomos' HELIACTS system will enable lunar and Mars surface operations at kilowatt to megawatt level. Furthermore, given the superior efficiencies and mass savings, Atomos anticipates potential application in most mass-constrained high-power applications, including solar electric propulsion and nuclear electric propulsion.

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

Atomos is developing orbital transfer vehicles (OTVs) to reduce the cost of access to space for commercial satellite operators. The technologies developed herein directly relate to efficient and lightweight power generation and distribution systems needed for electric propulsion OTVs. Other applications of HELIACTS include in small mobile power plants, naval power systems, and space-based power.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.08-1736**

SUBTOPIC TITLE: Suborbital Instruments and Sensor Systems for Earth Science Measurements

PROPOSAL TITLE: A versitile system for the multi-angular measurement of the aerosol scattering matrix and aerosol aerodynamic size.

Small Business Concern

Firm: **AirPhoton, LLC**
Address: **1450 South Rolling Road, Baltimore, MD 21227**
Phone: **(443) 543-5016**

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 proposed Multi-angle Phase Matrix Polarimeter (MP2) will be the first field-worthy and aircraft-adaptable instrument for in situ measurements of the aerosol scattering phase matrix that allow for characterization of aerosol physical and optical properties. These measurements can lead to inference of aerosol type with a temporal resolution of minutes.

The MP2 follows from a history of polar nephelometers that illuminate suspended aerosol particles in a chamber and then measure the scattered light as a function of angle. With the MP2 we intend to modulate polarization at the source and then measure not the intensity but the polarization signal at the detector. This can provide measures of six elements of the scattering phase matrix, at multiple scattering angles. Previous polar nephelometer technology has stopped halfway, modulating polarization at the light source, but then only measuring intensity at the detector. Thus, existing

technology has achieved measurements of only two phase matrix elements (P_{11} and P_{12}). The six phase matrix elements will contain unprecedented information about aerosol properties that can be retrieved from inversion software.

Furthermore, the MP2 is designed to be modular with possible connection to an inlet with an aerodynamic sizer. This allows size selection, such as PM2.5, before characterization of the phase matrix. Multiple stacked MP2s, allow for phase matrix measurements for multiple particle size categories.

There are two possible options to achieve the MP2. Option (a) uses multiple light sources (LEDs) and a single polarimeter detector. Option (b) uses a single light source (multi-wavelength laser) and multiple fiber detectors. Each option can achieve the technical objectives. The technical proposed work is to build a tabletop demonstration of both options and then evaluate the best option for Phase II. Options will be evaluated as to technical feasibility, sensitivity, portability, durability and marketability.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The MP2 will support NASA's future polarimeter missions: PACE, MAIA and ACCP. These satellite polarimeters will revolutionize aerosol remote sensing from space. As space sensors attain greater capability, suborbital options must evolve to keep up. Otherwise, you have a situation where the "ground truth" is less believable than the satellite retrieval. The MP2 offers NASA the opportunity for cal/val activity for polarimeters and aerosols that will exceed any of NASA's current plans.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Global interest in aerosol research in air quality and climate is in a growth phase.

The MP2 with its aerodynamic sizing options fits well with the air quality monitoring of PM2.5 and need for particle characterization and source apportionment, internationally. Collocating MP2 at 100s of AERONET stations links column retrievals with particle properties at "nose level".
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z7.03-2885**

SUBTOPIC TITLE: Entry and Descent System Technologies

PROPOSAL TITLE: Improved Solid-State Hydrogen Gas Generator

Small Business Concern

Firm: **Anasphere, Inc.**
Address: **5400 Frontage Road, Manhattan, MT 59741**
Phone: **(406) 595-3286**

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):

Deployable aerodynamic decelerators are an enabling technology for missions to planets and moons with atmospheres as well as for returning payloads to Earth. These decelerators require a gas source for inflation, and the objective is to further advance solid-state hydrogen gas generators.

Anasphere has demonstrated a gas generator suitable for use with Hypersonic Inflatable Aerodynamic Decelerators (HIADs). Subsequent research has shown that a far more mass-efficient design may be built using an alternative construction method coupled with similar but improved chemistry. Phase I work will involve optimizing the chemistry of the system components to ensure that the generators remain compatible with HIADs. Specifically, the new design exposes the HIAD to more species than just hydrogen, and these species will be identified, quantified, and reduced or controlled as necessary. Test generators will be built to demonstrate filtration and cooling technologies required to implement the more mass-efficient design.

Phase II work will include scaling up the new design and subjecting it to extensive environmental tests.
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. An additional application could be the inflation of planetary balloons.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Low-cost access to space will be enabled by HIAD systems which apply this generator technology because HIADs offer a practical means of recovering launch vehicle components such as engines. Commercial space ventures can also apply HIAD technology for the more efficient return of material to Earth.

Terrestrial balloon inflation is another application area.
Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.03-1223**

SUBTOPIC TITLE: Accelerating NASA Science and Engineering through the Application of Artificial Intelligence

PROPOSAL TITLE: Applying Machine Learning Techniques to Airborne Science Planning and Real-Time Column Mole Fraction Estimates for Integrated Path Differential Absorption Lidar

Small Business Concern

Firm: **Spectral Sensor Solutions, LLC**
Address: **10500 Copper Avenue Northeast, Suite I, Albuquerque, NM 87123**
Phone: **(703) 608-2325**

Principal Investigator:

Name: **Jeremy Dobler**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Spectral Sensor Solutions LLC (S3) and our subcontractor, Texas Tech University, are pleased to submit this proposal in response to the NASA SBIR Phase I solicitation, subtopic S5.03 Accelerating NASA Science and Engineering through the Application of Artificial Intelligence. In Phase I we propose to apply modern machine learning (ML) methods to enable real-time flagging of integrated path differential absorption (IPDA) lidar measurements using ancillary data collected inflight. In addition, during Phase I, we propose to leverage significant improvements in research forecast models to build tools to extract data relevant to same-day flight planning tools and inputs required for low-uncertainty, inflight, preliminary data analysis of IPDA measurements. In Phase II we will use ML methods to score the quality of research forecast inputs to preliminary column mole fraction (CMF) retrievals. The IPDA lidars used in the Atmospheric Carbon Transport - America NASA Earth Venture Suborbital Program, the Multi-functional Fiber Laser Lidar (MFLL) and the High Altitude Lidar Observatory (HALO), will provide the primary data for these retrievals. Ultimately, the goal is to demonstrate the feasibility of using high-resolution rapid refresh (HRRR) models to enable improved NASA airborne science mission planning and to demonstrate application of the derived thermodynamic variables to near-real-time CMF retrievals with low uncertainty. Tools developed in this SBIR will provide a significant improvement for future airborne science missions in general through enhanced tools for flight planning, resulting in maximization of science return per flight hour. Additionally, science campaigns using active remote gas monitoring systems will be significantly enhanced through the ability to provide low uncertainty retrievals of column mole fractions for the gas of interest in near-real-time from the remote measurements versus the weeks- or months-long lag currently available for these systems.

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

The proposed work would support future NASA airborne campaign planning by developing 3D insights into the atmospheric state parameters in a manner that can inform decisions both before takeoff and inflight for maximization of science objectives. One example application will be demonstrated where forecast model data is used to enable simulated real-time column mole fractions,

from two different IPDA lidar, with minimal uncertainties using the extensive data set from the Atmospheric Carbon Transport – America, Earth Venture Suborbital mission.

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

Real-time retrieval of column integrated mole fraction could be useful for disaster mitigation. Example applications include forest fire plume tracking, toxic chemical plume tracking, and regulatory monitoring of key sources driving air quality. The enhanced 3D flight planning tools could be adopted by other science agencies which conduct airborne science missions (e.g., NOAA, DOE, USFS).

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.08-2389**

SUBTOPIC TITLE: Suborbital Instruments and Sensor Systems for Earth Science Measurements

PROPOSAL TITLE: Airborne High-Dynamic Range Anamorphic Hyperspectral Imager

Small Business Concern

Firm: **Resonon, 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):

A new design for an airborne, high-performance, hyperspectral imager is proposed for measurement of ocean and cloud radiances. Key components of the new design are the use of anamorphic fore-optics to increase the signal and dynamic range as compared to conventional hyperspectral imager designs, and a unique two-part (butcher-block) diffraction grating that allows the spectral response of the imager to be tailored to accommodate lower signal (and throughput) of ultraviolet and blue wavelengths (~340-450nm). These innovations enable a compact, lightweight, airborne-compatible system that has better spatial resolution, a larger dynamic range, and greater signal-to-noise ratio than conventional hyperspectral imagers of similar size and specification.

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

The proposed technology is designed to measure ocean and cloud radiances from air- or ship-based platforms to provide complementary observations to and enable vicarious calibration of satellite based remote sensing platforms. A particular example is the Ocean Color Instrument (OCI) that is to fly on board NASA's PACE satellite.

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

The proposed technology is suitable for use in a wide range of existing applications for airborne hyperspectral imaging, including agriculture, oceanography, environmental science, land management, pipeline monitoring, search and rescue, as well as defense and security.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H5.02-2095**

SUBTOPIC TITLE: Hot Structure Technology for Aerospace Vehicles

PROPOSAL TITLE: Infiltrated Hafnium Carbonitride Protective Layers for Carbon Composite Hot Structures

Small Business Concern

Firm: **Plasma Processes, LLC**
Address: **4914 Moores Mill Road, Huntsville, AL 35811**
Phone: **(256) 851-7653**

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 development of novel fabrication techniques to manufacture innovative hot structure architectures is important for NASA. Hot structure applications such as blunt body reentry, unpowered atmospheric flight, and powered sustained atmospheric flight at hypersonic speeds are all areas that will benefit from improved material architectures and are key in a multitude of NASA programs. Currently, hot structures are limited to 2900 °F for extended operation and many material systems have limited reusability. The aforementioned applications would benefit from improved hot structures that can continuously operate at temperatures above 2900 °F and can survive multiple flight cycles. A major barrier to realizing advanced hot structures for hypersonic flight is the development of protective coating materials compatible with carbon/carbon (C/C) substrates. Due to their high specific modulus, high fracture toughness and thermal conductivity, good thermal shock resistance, and excellent high temperature strength, advanced C/C composites are the best choice for hot structures for hypersonic flight. Unfortunately, C/C composites start to rapidly oxidize above 370 °C, which restricts their engineering applications in air. Current protective coatings on C/C typically fail at elevated temperatures and/or under repeated cycles due to poor bonding with C/C resulting in poor thermal conductivity between the coating and the C/C substrate. Reactive solution infiltration processing offers a means to produce integrated bond layers that are reactively fused with the C/C substrate. This effort will develop hafnium based reactive solution infiltration to form HfCN bond layers. HfCN offers a high temperature, high conductivity material solution to improve hot structure performance. This bond coat process will offer improvements over state-of-the-art coatings and enable existing high performance topcoat materials to better adhere to C/C facilitating improved reusability of hot structures.

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

Reentry vehicles, access to space, heat shields, crew capsules, boost engine exit cones, altitude control engine nozzles, roll control engine nozzles, reentry aeroshells
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Hypersonic vehicle leading edges, commercial access to space, heat shields, commercial crew capsules, missiles, missile defense interceptors, scramjet inlets, hypersonic airplanes
Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.08-2742**

SUBTOPIC TITLE: Command, Data Handling, and Electronics

PROPOSAL TITLE: PCB "Boardlets" for Modular, Scalable High-Performance Printed Circuit Assemblies"

Small Business Concern

Firm: **Indiana Integrated Circuits**
Address: **1400 East Angela Boulevard, Unit 107, South Bend, IN 46617**

Phone: **(724) 244-4560**

Principal Investigator:

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Business Official:

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Phone: **(574) 217-4612**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The team of Indiana Integrated Circuits, LLC (IIC), and Calumet Electronics Corporation (CEC) propose the development and demonstration of an innovative approach for modularized, highly-scalable, high-performance printed circuit board (PCB) assemblies. By extending the chip-to-chip edge-interconnect technology known as “Quilt Packaging” from microchips to PCBs, multiple “boardlets” can be assembled into a mechanically robust PCB system comprised of disparate process technologies and substrate materials. Such an approach can be applied to optimize PCB systems for yield, cost, security, manufacturability, and highly customizable rapid manufacturing for a wide variety of NASA, defense, and commercial applications. Quilt Packaging® (QP), is implemented using solid metal interconnection which protrude from the vertical side of a chip, allowing for virtually seamless edge-to-edge connection which is extremely low-loss and extremely wide bandwidth. Preliminary work by IIC has shown potential for similar edge-to-edge implementation between PCBs, eliminating or dramatically reducing the need for typical sockets, wiring and cabling while simultaneously improving electrical performance

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

IIC’s PCB QP providing a reliable, scalable, modular approach to very dense I/O PCB interconnections.. By partitioning a traditional PCB system into boardlets and then “quilting” them back to together, one can optimize for manufacturing yields as well as mix-and-match disparate substrate materials for cost reductions and design re-use. Applications such as command and control electronics, sensing, communications, and power management and distribution can be positively impacted by miniaturizing and ruggedizing the PCB-to-PCB interfaces.

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

Beyond NASA and military/aerospace applications, the PCB boardlet approach can be applied to many commercial systems. These include automotive, big data, biomedical, and power/energy management, among others. The key benefits from using this technology include increased speed and power carrying capability per a given substrate size.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.09-1429**

SUBTOPIC TITLE: Vehicle Sensor Systems to Enable Situational Awareness

PROPOSAL TITLE: Autonomous Decision Support System for Sense and Avoid (ADeSSSA)

Small Business Concern

Firm: **GreenSight Agronomics, Inc.**
Address: **12 Channel Street, Suite 605, Boston, MA 02210**
Phone: **(617) 633-4919**

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):

GreenSight proposes ADeSSSA, the Autonomous Decision Support System for Sense and Avoid, a novel approach for unmanned aircraft sense and avoid, combining wide field of view visual sensors with acoustic sensing to improve the effectiveness of the resulting implementation while reducing its Size, Weight, Power and Cost implementation. GreenSight intends to use a mix of deep learning techniques to build an ideal classifier that ingests samples that combine the visual and acoustic sensors into a visual representation. ADS-B transponder data is incorporated as both a source of low-false positive data and as a filter to facilitate automated gathering of training data.
ADeSSSA is designed to accommodate low SWaPC applications such as unmanned aircraft as small as 2kg, a niche that is currently unoccupied. There are no practical sense and avoid systems on the

market for platforms this small, which is currently hurting the growth of the commercial UAS market, and slowing NASA and the FAA's efforts to build an integrated next generation airspace which integrates these smaller aircraft. GreenSight maintains a network of over 100 automated UAS which currently operate daily in the US, Canada, Europe and Japan. Once ADeSSSA is ready for field use, GreenSight can immediately deploy the system to its entire network, instantly becoming the most widely deployed UAS SAA system in the world and enabling it to rapidly mature with extensive field testing to find and correct weaknesses in the implementation.

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

ADeSSSA addresses NASA requirements to enable low-SWaPC sense and avoid technology, as well as furthering efforts to modernize the national airspace and integrate unmanned aircraft with the current manned aircraft-centric system. ADeSSSA enables next generation Urban Air Mobility and Advanced Aerial Mobility systems, while also furthering the ability of commercial UAS in markets where fear of collisions is restricting flight operations that are otherwise safe.

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

ADeSSSA has extensive applications in both military and commercial UAS. GreenSight envisions integrating the system with all of its existing UAV products, from the 2kg Dreamer to the 200kg EndureMax. Beyond this, GreenSight intends to commercialize and sell ADeSSA for unmanned aircraft of a variety of sizes operating in mixed airspace, becoming the global standard for onboard UAV sense and avoid.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z13.03-2419**

SUBTOPIC TITLE: Lunar Dust Mitigation Technology for Spacesuits

PROPOSAL TITLE: Improved Environmental Protection Garment (IEPG) Fabric

Small Business Concern

Firm: **Armorworks, Inc.**
Address: **6150 West Gila Springs Place, #26, Chandler, AZ 85226**
Phone: **(602) 684-5291**

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 Extra-vehicular Mobility Unit (EMU) suits for exploration of lunar and Martian surfaces cannot resist to cut/puncture due to current outer layer materials and design. Dust mitigation is also an important and unmet feature of current Extra-Vehicular Activity (EVA) suit technology. Force Engineering Inc. proposes to develop an innovative shell fabric and dust mitigation technology for spacesuit outer layer to improve Environmental Protection Garments (EPG) using fiber and fabric structures originally developed for textile and composite armor applications with similar protection and abrasion resistant requirements. We aim to leverage our soft body armor and E-Textile technology assets to create multifunction textile structures that provide for redundant circuit and real time health monitoring and diagnostic capability, as well as the capability to dissipate electrostatic charges and move power and data across the spacesuit, replacing heavy cables and connectors that are known failure points.

Force Engineering Inc will develop a new garment protection system that will achieve these two stringent goals, while maintaining comfort and mobility. Our team will combine several well-developed technologies into a practical outer layer design, which will provide excellent protection from dust, fire, thermal, ultraviolet (UV) radiation, impact penetration and cut/puncture. The new garment protection system will be integrated to minimize weight and maximize flexibility such as to not prohibit, degrade, or interfere with the use of equipment. Prototypes will fabricate and puncture, dust, and abrasion tests will be conducted for proof-of-concept.

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

Weight savings by creation of smart/multifunctional textile and composite products that enable lighter weight electronics, communication, and power transfer in a damage tolerant, redundant circuits.

Astronaut health monitoring using eTextile. Improved spacesuit capability to integrate redundant textile-based sensor, power, data busses for a wired and continuously monitored astronaut and spacesuit. Ability to detect real-time degradation and damage to spacesuit, gloves, and other garments and to manage garment life, maintenance, and condition.

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

Sensor and electronics integration in soldier helmets, body armor, and other wearable gear to save weight. Wearable eTextile technology for commercial wearable electronics and flexible electronics to create smart fabrics and integrate electronics and microprocessor capability into garments for productivity, entertainment, remote sensing medical diagnostics capability.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z10.04-2326**

SUBTOPIC TITLE: Materials, Processes, and Technologies for Advancing In-Space Electric Propulsion Thrusters

PROPOSAL TITLE: Materials and Process for Additive Manufacturing of Large Diameter Hall-Effect Thrusters.

Small Business Concern

Firm: **Elementum 3D**
Address: **400 Young Court, Unit 1, Erie, CO 80516**
Phone: **(720) 545-9016**

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):

Existing magnetic materials and manufacturing methods are inadequate for producing large-diameter Hall-effect thrusters (HETs) with adequate mechanical strength while achieving the desired magnetic properties. Cobalt-iron soft ferromagnetic alloys are desirable for soft magnetic applications, including Hall-effect thrusters, due to their unparalleled magnetic saturation, elevated permeability, high curie temperature, and extreme strength.

Unfortunately, these alloys suffer from manufacturability problems due to low ductility and an inability to produce such alloys in large form factors. While Co-Fe soft magnetic products can be readily produced in sheets, production of large billets results in weak, brittle, and inhomogeneous materials

Elementum 3D is proposing to develop an additive manufacturing (AM) process and material feedstock, suitable for fabrication of large-diameter HETs, from cobalt-iron based soft magnetic material. The ability for AM to produce these large structures directly from powder feedstock would overcome the unavailability of sufficiently sized iron-cobalt billets. Other AM advantages for production of Co-Fe soft magnetic products include, a favorable fly-to-buy ratio, improved design freedom, and an increase in thrust-to-weight ratio.

The principle objective of the Phase I effort is to research, develop, and demonstrate a soft magnetic feedstock material and additive production process that is suitable for production of large-diameter Hall-effect thrusters, meeting the magnetic and mechanical performance targets.

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

The major NASA applications include: Hall-effect thrusters, grapple fixtures, tool changers, and general purpose switchable magnets

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

Some non-NASA applications include: airplane engines, privately owned spaceships, and transformers for power systems

Duration: **6**

PROPOSAL NUMBER: 21-1- **H8.01-1714**

SUBTOPIC TITLE: Low Earth Orbit (LEO) Platform Utilization to Foster Commercial Development of Space

PROPOSAL TITLE: LEO Manufacturing of 3D Printed Covetic Nanomaterials for Advanced Electronics

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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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

This program will develop an in-space material manufacturing approach to leverage the unique capabilities of the International Space Station. Specifically, one such, exemplar novel class of material, covetics (nano-carbon-infused metals), are inherently challenging to produce terrestrially but have great commercial potential due to their enhanced physicochemical properties as compared to conventional metals, such as high thermal (50% higher than Cu), high electrical conductivity (40% higher than 6061 Al), and high strength (30% higher yield strength than Cu). Therefore, Faraday Technology and the University of Texas in Dallas will develop a material manufacturing process to directly print these next generation covetic materials in Low Earth Orbit (LEO) via an electro-codeposition approach. This work will build on the University of Texas's direct Cu printing platform which has been demonstrated at pre-commercial scale the potential to print large area circuit board lines utilizing a localized pulse electrodeposited (L-PED) technique. Additionally, this work will build on Faraday's electro-codeposition process activities that include depositing carbon materials into copper. In Phase I we will establish the viability of directly printing covetic materials by developing the direct write hardware and the electro-codeposition electrolytes to deposit electrochemically reduced carbon materials into a copper matrix in an orientation opposite or perpendicular to gravity such that we can demonstrate at the lab scale, the potential to form covetic materials with enhanced electrical, thermal, and mechanical properties. This demonstration would enable a preliminary market need assessment (Phase I) and zero gravity flight demonstration (Phase II), which could establish a commercial market for in-space manufacturing of these exciting covetic materials. If successful the results of the Phase I/II program will set the stage for LEO commercialization of this manufacturing process.

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

Next generation materials like covetics have the potential to meet many of NASA continual needs on-board the space station and within their spacecraft systems. These materials could be utilized to make spot structural repairs, be printed in to forms like electronic components (i.e., resistor or capacitors), or be utilized as heat exchange materials. Regardless, an approach to on-demand manufacturing of state of the art materials and components on-board the ISS has a wide commercial impact.

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

At the successful completion of this program, we envision our initial entry point for the technology will be the electronics industry (communications, computers, satellites, etc.) due to their need for lightweight high conductivity materials. The second market will focus on the transportation sectors, who strive for high strength to weights ratios.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.08-1956**

SUBTOPIC TITLE: Suborbital Instruments and Sensor Systems for Earth Science Measurements

PROPOSAL TITLE: The Holographic Multi-wavelength Imaging Extinctiometer (HoloMIE): A new cloud probe for characterizing cloud particles and measuring spectral extinction

Small Business Concern

Firm: **Handix Scientific, LLC**
Address: **5485 Conestoga Court, Suite 104B, Boulder, CO 80301**
Phone: **(720) 724-7658**

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):

Airborne measurements of cloud particle size, shape, and optical properties such as extinction cross-section are critical for validating satellite remote sensing measurements and weather and climate models. To address the current and future needs of the scientific community making and using these measurements, we propose a multispectral single-particle holographic imaging system which offers several advantages over current techniques. Our approach exploits a novel property of holographic imaging to directly calculate extinction cross-section at multiple wavelengths. Single-particle holographic measurements avoid the computationally expensive processing required by other holographic instruments. The overall project objective is the development of a new instrument capable of imaging cloud droplets and ice crystals and performing spectrally resolved cloud extinction measurements. Here in Phase I, to de-risk the overall project, we propose the development and testing of a simplified breadboard optical system focusing on holographic measurements at a single wavelength with flowing particles to verify the performance of the instrument using several particle standards of known shapes, including those mimicking cloud particles in a laboratory setting.

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

This project would be highly beneficial to NASA ESD to enhance the characterization of cloud microphysical properties. The instrument would be suitable for deployment on platforms including the DC-8, P-3, B-200, WB-57 and Global Hawk. The instrument is also well suited to validate remote sensing observations and model results, employing identical wavelengths for its imaging and extinction measurements as are used on CALIOP and other LIDAR systems, including those deployed on NASA's airborne science fleet.

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

The proposed instrument would be invaluable to other entities performing airborne cloud measurements including DOE, NCAR, NOAA, and NSF domestically and NRC (CA), FAAM (UK), SAFIRE (FR) DLR (DE), and others internationally. Future conversion of this technique to a ground-based instrument for characterizing coarse mode aerosol would have broad applications beyond atmospheric science.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H3.02-2153**

SUBTOPIC TITLE: Microbial Monitoring for Spacecraft Cabins

PROPOSAL TITLE: Novel microbial detection technology for long-term spaceflight missions

Small Business Concern

Firm: **HJ Science & Technology, Inc.**
Address: **1933 Davis Street, Suite 210, San Leandro, CA 94577**
Phone: **(408) 464-3873**

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):

HJ Science & Technology, Inc. proposes to develop a miniaturized and automated instrument that enables quantification and identification of environmental microbial contamination for long-term spaceflight missions. This technology supports NASA's efforts in TX06 Human Health, Life Support, and Habitation Systems with a focus on microbial monitoring of their Environmental Control and Life Support Systems (ECLSS). Our proposed instrument autonomously and rapidly concentrates and purifies cells from potable water, habitat surfaces, and air environments with same log10 level recovery efficiencies. As such, our instrument prepares elutions with sufficient cell densities for practical microbial quantification using established non-gene-based metabolic assays. Furthermore, our instrument integrates with emerging gene-based technologies utilized for identification of environmental microbes in spaceflight settings. Our novel ChargeSwitch Concentration and

Purification (CSCP) technology is the key innovation to enable practical environmental monitoring by bridging the gap between large-volume sample inputs and small-volume analysis methods. In Phase I, we will adapt our CSCP technology to perform sample processing required to integrate samples collected from relevant ECLSS environments with T-ATP microbial assays and MinION sequencing. In Phase II, we will construct and deliver a fully integrated prototype that enables quantification and identification of environmental microbial contamination.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed instrument is ideal to support NASA's efforts in TX06 Human Health, Life Support, and Habitation System by enabling microbial monitoring of their ECLSS. Specifically, our CSCP technology enables highly sensitive, rapid, and real-time microbial monitoring for relevant ECLSS environments in order to better meet NASA's inflight microbial acceptability limits. Ultimately, this instrument directly aids in achieving suitable habitation and life support systems for NASA"s astronauts in long-term spaceflight missions.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Our CSCP technology is ideal for monitoring environmental cleanliness in industries such as food processing, pharmaceuticals, and healthcare. These capabilities also naturally extend to pathogen detection within water and food supply chains. Compared to existing technologies, CSCP enables real-time microbial sensing for more timely decisions addressing compliance, supply chain, and human health.
Duration: **6**

PROPOSAL NUMBER: 21-1- **S2.04-1436**

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

PROPOSAL TITLE: Laser Fabrication with Integrated Metrology for Low-Cost Free-Form Optics

Small Business Concern

Firm: **Momentum Optics, LLC**
Address: **2113 Seaway Court, Longmont, CO 80503**
Phone: **(801) 815-9981**

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):

Free-form optics can improve sensors and instruments by enabling compact designs with fewer parts and enhanced performance. As such, they are poised to impact many NASA missions from remote sensing and communications using small satellite constellations to future x-ray observatories like Lynx and AXIS to coronagraphs within HabEx and LUVOIR.

However, free-form optics manufacturing is expensive and requires lengthy production time hindering the adoption of this new design paradigm. A significant problem with modern optics manufacturing tools is the use of open-loop control which leaves the desired ultra-precise surfaces susceptible to malformation due to non-deterministic effects. It is only through multiple iterations of machining and in-process metrology that is possible to reach nanometer precision. These manufacturing challenges are exacerbated by free-form optical designs that rely on difficult multi-axis sub-aperture machining or tool rastering and protracted 3-D surface characterization techniques.

The technical objectives in this project open the opportunity for low-cost, free-form optics manufacturing by integrating an in-situ optical metrology system into a newly-developed laser-based machining tool to achieve nanometer (x, y, z) root mean square precision over a 160 cm^2 glass workpiece. The metrology system will overcome the current challenges of characterizing free-forms with large spherical departure (>1mm), small inflection points, and asymmetries. The approach of measuring optical properties, in contrast to the – as usual – physical shape, will also ensure the parts are functionally deployable. The overall project outcome will be an optics manufacturing technology akin to the significance of CNC machining ushering in a new generation of rapid, cost-effective, and high-precision manufacturing that will be transformative to the optics industry.

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

-Affordable free-form optics with shorter lead-times for CubeSats.

-Improved remote sensing with fast, free-form optics having a wider field of view (FOV), less stray light, and greater operational temperature stability.

-X-ray telescopes will benefit from a reduction in assembly time/costs by, for example, fabricating mirrors with integrated spacers or monolithic mirror segments with slightly different grazing angles.

-Compact coronagraphs with increased FOV, improved higher-order aberration correction, and fewer optical surfaces.

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

-Within the aerospace and defense industries, free-form optics can improve free-space optical communications, heads-up displays, and laser defense systems.

-Free-from optics enable more compact sensors in consumer electronics (cell phones, AR/VR, fitness tech), the vision systems of automobiles and robots, and minimally invasive medical endoscopes and laryngoscopes.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.02-1963**

SUBTOPIC TITLE: Technologies for Active Microwave Remote Sensing

PROPOSAL TITLE: ShaMAn - Shape Memory Alloy Antenna

Small Business Concern

Firm: **L'Garde, Inc.**
Address: **15181 Woodlawn Avenue, Tustin, CA 92780**
Phone: **(714) 259-0771**

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 the proposed effort a design for a 1 square meter aperture V-band antenna will be carried out. It is based on shape memory alloy and antenna surface measurements on similar antenna showed that surface accuracies on the order of (1/20)th of the wavelength at V-band are possible. The antenna ribs are made of deployable shape memory alloy material enveloped by gold-plated molybdenum mesh. The SMA antenna ribs are trained to seek a memorized parabolic shape when brought to its trigger temperature. Based on design and analytical modeling with data taken from measurements and tests in the laboratory, a 1 square meter aperture, F/D=1 antenna can be packaged to fit within a 1.5U stowed volume. The power required to bring the antenna shape memory alloy ribs range between 5 Watts to 24 watts depending on whether the entire rib lengths are SMA or only those sections of the ribs that are folded for stowage are SMA and heated.

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

The V-band antenna proposed can be used by NASA for its earth directed or interplanetary missions like the Europa Mission. In particular, it can be used for data relay and near-Earth data communications, unmanned aircraft communications, other NASA science missions. It can also be used for technology demonstration, satellite constellations and remote sensing in general. The very compact nature of the proposed antenna design will enable stowage of a 1 square meter V-band antenna into 1.5U volume. NASA's InVEST program can benefit as well.

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

Antennas working in the V-band can be used by the DoD and the commercial sector for high capacity terrestrial based millimeter wave communications systems. It can also be used for high capacity communication between satellites in a constellation. Because at this frequency there is strong absorption band in water, it provides protection against snooping by ground-based systems.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z5.04-2219**

SUBTOPIC TITLE: Technologies for Intravehicular Activity Robotics

PROPOSAL TITLE: Adaptive Robotic Gripper

Small Business Concern

Firm: **Harvest Moon Automation, Inc.**
Address: **19 Franklin Road, Winchester, MA 01890**
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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):

Harvest Moon Automation is developing a two phase gripper that is extremely compliant and flexible when it engages an object and then becomes rigid allowing it to pull or rotate the object. When it engages the object the gripper forms itself to the object and gently pushes away other obstructions such as wires and tubes. After it engages the object, it enters the second phase, whereby it becomes rigid. This allows the gripper to pull or rotate the object.

NASA will depend upon intravehicular activity robots (IVA) robots such as the NASA Astrobee and Robonaut 2 to perform payload operations and spacecraft caretaking on Gateway, the orbiting facility that will be positioned near the moon. Fine grasping tasks such as plugging and unplugging electrical and fluid connectors will be difficult for current state of the art grippers. The connectors will be nestled among other connectors, wires and tubes. The HMA adaptive robotic gripper has narrow and flexible fingers that allow it to be easily maneuvered around obstacles to the connector. After grabbing the connector the fingers will stiffen so that they have a rigid hold on the connector. The two phase gripper can be easily maneuvered to the connector in its flexible phase and then wrap around the connector and become rigid in its second phase allowing the robot to rotate and push/pull the connector into position.

The unique advantages of the HMA adaptive gripper is that it is a simple design that is easy to position and activate. Unlike a precision gripper with rigid fingers that move through a defined profile, the adaptive gripper has very flexible fingers that do not move through a defined profile. When actuated the flexible fingers conform to the profile of the object that it is gripping. Precise positioning of the adaptive gripper relative to the connector is not required. The adaptive gripper has the dual advantages of having flexible fingers that become very rigid when grabbing and moving the object.

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

NASA applications include IVA robots using the adaptive gripper for fine grasping tasks during general maintenance, in particular the plug/unplug of electrical and fluid connectors. The gripper will also allow IVA robots to perform payload operations and spacecraft caretaking. This includes housekeeping, stowage, surface sample aggregation, science measurements and operations. Beyond Gateway these similar applications are needed on robots in future lunar and planetary surface activity.

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

The adaptive gripper has many potential applications in the commercial markets. Currently, the agricultural industry is an area very interested in this technology with focus on picking strawberries. Nuclear power plant maintenance with its hazardous environment is another industry. The e-commerce is growing dramatically and has interest in automated pickers for order fulfillment.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.09-2769**

SUBTOPIC TITLE: Cryogenic Systems for Sensors and Detectors

PROPOSAL TITLE: High temperature superconducting magnet operating above 15 K for ADR cooling

Small Business Concern

Firm: **Solid Material Solutions, LLC**
Address: **55 Middlesex Street, Suite 205, North Chelmsford, MA 01863**
Phone: **(978) 455-7182**

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):

This Phase I program will develop a coil design and deliver a prototype that proves the feasibilty of exceeding the requirements set forth in topic area S.109 for Sub-Kelvin Cooling ADR (Adiabatic Demagnetization Refrigeration) Coils. It will utilize a new type of small diameter wire based on the Bi2212 high temperature superconductor (HTS), that has recently been developed to wind the ac stator coils of compact, lightweight motors for hybrid electric airplane propulsion. These wire types with < 0.16 mm diameters now exhibit 3 times higher current density than standard wires and they are in forms that are applicable to ADR magnets. For ADR usage, this wire design will be applied in long insulated lengths to wind coils with the capability to operate at the specified higher operating temperatures, small winding currents, high current densities and with low losses in ramped fields. This wire type is also applicable to Actuators and Other Cryogenic Devices that are described in this topic area. As a first step in Phase I, the capability to produce long lengths of a specific small cross-sectioned 2212 wire design for ADR will be established based on current wire capability, and a demonstration test coil built. The wire design will include axial twisting and unmerged filaments for reducing ramped field loss, thin insulation, and current densities to meet specifications for up to 20K operation at 4T field, as requested for next level ADR coil advances. Coil fabrication techniques will be established, both with the Bi2212 ceramic in its high Jc, reacted form during windings well as in a pre-reacted form. A short length, full radial build coil deliverable will be built, tested and provided to NASA for evaluation and validation, attaining a TRL of 4 upon completion. In Phase II a full scale coil system will be developed and delivered.

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

A new type of 2212-based superconducting coil that will operate in the 15 K to 20 K temperature range for its utilization in next generation ADR magnet systems sought by NASA for some space-based instruments, as compared to the present 10 K range, and exceeding the requested > 15 K specified.

Additional potential applications at NASA include: i) Space based magneto-strictive actuators and valves ii) Specialty small sized light weight, high power density motors for example for pumping liquid cryogens iii) Magnetic shielding.

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

Summary: i) Small hand-held magnets to replace permanent magnets, thereby enabling field level adjustment and turning off the magnet for medical applications, ii) Specialty, very low loss cables produced by cabling, for ac and ramped field magnets in motors, generators, and ultimately, transformers, iii) specialty actuators

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z2.02-2105**

SUBTOPIC TITLE: High-Performance Space Computing Technology

PROPOSAL TITLE: Highly Parallel, Fast Memory Access for RISC-V Many-Core Processors

Small Business Concern

Firm: **Lewiz Communications, Inc.**
Address: **738 Charcot Avenue, San Jose, CA 95131**
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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):

High performance computing system requires many-core processor with network-on-chip (NOC) interconnecting the cores. A major issue is the competition of the many cores for access to memory. Example of this can be seen in GPU designs. In addition, systems traveled to remote planets perform large data analytic, image processing, autonomous applications remotely. These are not suitable for general cache-based designs, causing cache miss often and thrashing performance. NOC designed for cache system are also not suitable for large data transfers from accelerators of such applications and high-speed peripherals (PCI-express, Ethernet) to memory. Space travel further requiring fault tolerant (FT), ECC capabilities. Current solutions for RISC-V do not address all of these issues. **2021 NASA SBIR topic Z2.02** calls for "a **fault-tolerant RISC-V processor IP core** … that is **augmented to provide data parallelism**, which is needed to accelerate image processing and science data processing." LeWiz developed a 64-bit FT RISC-V processor core in a previous NASA SBIR Phase 1 for many-core CPU architecture. This work will enhance its NOC design and implements new, highly parallelized NOC based FT memory controller supporting multi-banks, high bandwidth memory where large number of independent access channels are available, more suitable for large data processing. ***This augmentation will provide the best, highly parallelized data access for many-core processor using state-of-the-art DRAM technology meeting NASA topic requirements***

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

space/deep-space travel, exploration. Results can be used on spacecrafts, satellites, orbiting stations, robots, autonomous systems in space, Moon, remote planets. Applications include flight control, navigation, instruments, communication, high performance computing systems. Aircrafts also benefit from the technology created.

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

Commercial spacecrafts, satellites, orbiting stations, missiles, weapon systems, communication systems, high performance computing for Department of Defense, Missile Defense Agency, Navy, Air Force, and commercial companies (Boeing, SpaceX, Lockheed, etc.) are potential applications of the technology

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.01-2227**

SUBTOPIC TITLE: Advanced Air Traffic Management System Concepts

PROPOSAL TITLE: Infrasonic Detection of Atmospheric Turbulence

Small Business Concern

Firm: **American Daedalus, LLC**
Address: **5711 76th Avenue East, Puyallup, WA 98371**
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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):

American Daedalus proposes to investigate the feasibility of infrasonic monitoring as a method of detecting aircraft-scale turbulence. An infrasonic sensor network monitoring acoustic energy below 20Hz could fill gaps in existing turbulence detection systems, thus providing the basis for a service that improves the efficiency, capacity, and safety within the air traffic management system. The objective of Phase I is to implement an infrasonic processing system that classifies infrasound as originating from a region of aircraft-scale turbulence. Previous theoretical and observational studies have found that infrasound associated with atmospheric turbulence exhibits a power-law spectrum with low overall coherence, a feature shared by infrasonic emissions from atmospheric convection. Therefore the initial classifier design will compare infrasonic signal characteristics with convective indicators such as NEXRAD and lightning strike data. The existence of aircraft scale turbulence will be determined by collecting in situ pilot reports in the region of the infrasonic sensor array. The classifier will be applied to data measured by an array of three highly sensitive, NASA-developed electret microphones. An off-the-shelf spatiotemporal database containing infrasonic analyses and meteorological data will enable an innovative data analysis with two aims. First, the performance of the classifier will be gauged by a sensitivity analysis and by studying missed events/false alarms for physical insight. Second, the detected turbulence events will be used to develop a more complete model of infrasonic emissions from aircraft-scale turbulence. This technology has the potential of becoming the only persistent method for monitoring of turbulence associated with clouds and in clear air, thus lessening the impact of a weather phenomenon which costs the aviation industry an estimated $150M to $500M per year due to factors like scheduling delays and injury compensation.

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

The proposed research supports ARMD Strategic Thrust 1's goal to "Achieve safe, scalable, routine high tempo airspace access for all users." With passenger capacity increasing eight-fold by 2050 and climate change driving significant increases in clear-air-turbulence production, this Phase I effort is a first step in demonstrating a persistent, timely, and reliable atmospheric turbulence remote sensing capability supporting ATM system's challenge to meet increased airspace capacity requirements while improving efficiency safely.

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

Government operations requiring accurate and timely turbulence data include air traffic management, weather prediction, public safety, and defense operations. Additionally, the U.S. commercial aviation

industry is a competitive, cost-driven market with estimated annual turbulence costs of $150M to $500M due to injury compensation, aircraft damage, scheduling delays, and fuel expenditures.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.08-2159**

SUBTOPIC TITLE: Command, Data Handling, and Electronics

PROPOSAL TITLE: Radiation Hardened Low Temperature Time-Mode Data Converters for Sensor Readout

Small Business Concern

Firm: **Prixarc, LLC**
Address: **2673 Commons Boulevard, Suite 55, Beavercreek, OH 45431**
Phone: **(937) 782-8206**

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Summary Details:

Estimated Technology Readiness Level (TRL) :

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

NASA's space-based observatories, flyby spacecraft, orbiters, landers, and robotic and sample-return missions require robust command and control capabilities that can operate without elaborate environmental protection housing under extreme environments. Prixarc aims to develop and commercialize a custom application-specific integrated circuit (ASIC)-based 64-channel Time to Digital Converter (TDC) with 6 ps timing precision, radiation hardness to 1 Mrad (Si) and operational temperature range from −150 ^{o}C to +125 ^{o}C for NASA planetary missions. In this work, the development of mixed-signal data converter ASICs to operate at low and near cryogenic temperatures

is an important contribution and novelty. Mixed-signal structured ASIC architectures are relevant to increasing science return and lowering costs for missions across all Science Mission Directorate (SMD) divisions. The proposed TDC with high time precision, high radiation hardness, and high channel count is possible because of two novel aspects: (i) stochastic TDC design, and (ii) a specialized fully depleted silicon-on-insulator (FDSOI) complementary metal–oxide–semiconductor (CMOS) fabrication process (28 nm FDSOI CMOS process from ST Microelectronics).
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

A TDC measures the time interval between start and stop pulses from the amplifier/discriminators connected to detectors. For example, the Cassini Plasma Spectrometer (CAPS) included an ion mass spectrometer (IMS) that provided species-resolved measurements of the flux of positively charged atomic and molecular ions as a function of energy/charge versus aperture entry direction. The time-of-flight spectrometer in the IMS utilized TDCs.

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

TDCs are used in many fields such as Positron Emission Tomography (PET), LIDAR optical time-of-flight measurements, high-energy nuclear physics detector interfaces, digital phase lock-loops (PLLs), and photonic integrated circuits (PICs). The detector electronics of space telescopes, e.g. James Webb Space Telescope operate at low temperatures where the proposed circuits are useful.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.06-2325**

SUBTOPIC TITLE: Space Weather Research-to-Operations/Operations-to-Research (R2O/O2R) Technology Development

PROPOSAL TITLE: Parallelization Toolkit for NASA CCMC

Small Business Concern

Firm: **Continuum Dynamics, Inc.**
Address: **34 Lexington Avenue, Ewing, NJ 08618**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

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

High Performance Computing (HPC) models of heliophysics plays a critical role in many aspects of space weather, from understanding fundamental physics to predicting real-world events. HPC models of heliophysics can also support the development of space weather mitigation technologies and decision making. NASA currently employs HPC models, such as ENLIL, to model the physics of the Sun. However, ENLIL cannot currently fully exploit the parallel processing capabilities of the modern multi-core compute nodes, nor can it utilize the GPU accelerators now common on NASA's HPC clusters. Maintaining a mission critical code like ENLIL can be a challenge, as both the number of man hours required to enable the code to properly exploit new hardware is non-trivial, and the HPC environment itself is continually evolving. A new Domain Specific Language (DSL), together with a source-to-source translator, is proposed that will allow mission critical NASA codes, like ENLIL, to be written in a form that allows for improved portability between various HPC environments and hardware (including GPU accelerators), and reduce the level of skill and effort required to maintain and extend such codes. A proof-of-concept prototype of the language and source-to-source translator will be developed in Phase I and demonstrated using an in-house CFD solver. The deliverable in Phase I is a report detailing the findings of Phase I, along with a plan for Phase II development. In Phase II, a fully working language specification and source-to-source translator will be developed and demonstrated by rewriting ENLIL. The deliverables for Phase II are progress reports and a rewritten version of ENLIL that can exploit modern, heterogeneous HPC platforms, and will be easier to maintain as the HPC environment continues to evolve.

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

The proposed work will result in the modernization of ENLIL, a mission critical code used by the NASA CCMC for modeling heliophysics. By improving the performance, portability, and ease of maintenance of ENLIL, the proposed work will support NASA's role under the National Space Weather Strategy and Action Plan, and have a beneficial impact on NASA's space weather forecasting and mitigation capabilities.

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

The Domain Specific Language (DSL) and translator may be applied to any Cartesian grid based PDE solver. In addition to space weather modeling, the tools developed under this work will potentially have application in the financial industry. Since the proposed DSL reduces the skill and effort required to write portable HPC code, the tools developed here may be useful for academic teaching/research.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H5.01-2376**

SUBTOPIC TITLE: Lunar Surface Solar Array Structures

PROPOSAL TITLE: Motorless Extension, Leveling, and Tracking (MELT) Array System

Small Business Concern

Firm: **Dynovas, Inc.**
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Phone: **(508) 717-7494**

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3

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

Dynovas' Motorless Extension, Leveling, and Tracking (MELT) array system eliminates motors from all operations of a modular lunar surface solar array. The elimination of motors with the MELT array system can: increase weight efficiency to exceed 75 W/kg, increase volume efficiency to exceed 20 kW/m^3, and be compatible with any array power module design (e.g., Dynovas' MAD Energy array, NGC UltraFlex array, DSS ROSA array, etc.) while providing a dust resistant method of deployment. The MELT array system utilizes smart material actuators (e.g., piezoelectrics and/or shape memory alloys) in a "caterpillar" configuration to achieve both the necessary deployment force and translational distances for extension, rotation, and leveling. The actuation devices will be mounted to a bi-stable composite substrate. The bistable composite substrate will provide rigidity in the stowed and deployed state such that the force on the actuators is negligible except when actuating. Minimizing the force on the actuators except when operating will minimize the power draw and maximize the lifetime of the motorless system.

When realized, the MELT array system will provide NASA and space exploration OEMs with a modular and scalable base system for the 10 m extension, 360° rotation for sun tracking, and 15° terrain leveling with a dust resistant universal motorless actuation package. The MELT array system smart material caterpillar also provides cross-cutting benefits to the array, including: inherent load limiting via voltage input, ability for integration of structural health monitoring capabilities within the composite, active vibration tuning for dampening and dust mitigation, and general applicability to other deployable structures.

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

The maturation of the MELT array aligns with critical NASA technology milestones for human exploration and operations, such as: asteroid redirect, lunar surface missions, Mars-to-moon

missions, Mars surface missions. The specific market for lunar missions by NASA includes the Artemis, VIPER, CLPS, Moon-to-Mars, and Orion programs/missions. By aligning the maturation of the MELT array system with NASA's lunar program, Dynovas estimates that up to 10s to 100s of arrays may be built to support landing, exploration, and orbiting of the Moon.

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

Non-NASA markets for the MELT array system include commercial spacecraft OEMs and power generation for satellite networks, orbiting debris removal, and experimentation satellites. Non-space-based markets could include remotely operated electrically driven vehicles or deployment with Special Operators or forward deployed military facilities for on-demand power.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.06-1579**

SUBTOPIC TITLE: Particles and Fields Sensors and Instrument Enabling Technologies

PROPOSAL TITLE: Fail-safe Cold Cathode Ionizer

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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Phone: **(978) 738-8265**

Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA has expressed a need for advanced neutral particle ionizers to enable the next-generation of neutral particle detectors such as mass spectrometers for the study of Earth-Sun interactions and planetary atmospheres. To fulfil this need, Physical Sciences Inc. (PSI) proposes to develop a fail-safe field emission-based cold cathode ionizer for use in space-based instrumentation.

The cold cathode ionizer features ultra-low electron extraction voltages down to 2 V, emission current densities up to A/cm^2 across mm^2 emission surfaces, instantaneous switching and negligible thermal load. A unique property of PSI's proposed cold cathode ionizer is its extreme resistance to the most common failure modes associated with field emission devices. The device is designed with recovery from mechanical and thermal shock as well as resilience against exposure to debris or contamination that might be encountered during its service lifetime. The slow degradation of materials and surfaces encountered in space are inherently compensated for in the design.

In Phase I of the program, PSI will demonstrate the principle of the ionizer, raising its technology readiness level (TRL) from 2 to 3. The cathode fabrication process will be developed and cathodes integrated into a demonstration device for evaluation of critical components and operating parameters. Phase I will culminate in production of a detailed preliminary design for a flight-worthy prototype ionizer. In Phase II, ionizer requirements and capabilities will be finalized. A flight-worthy prototype will be constructed and evaluated. The Phase II program will be exited with the ionizer at TRL 6 and with the prototype delivered to NASA for further evaluation. Following Phase II, PSI will work with NASA to identify opportunities to incorporate the new enabling technology into instrumentation for upcoming missions such as Geospace Dynamics Coupling (GDC), and opportunities for NASA-sponsored technology demonstration flights.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed solution for a cold cathode-based ionizer will find its widest use as a component in mass spectrometers destined for planetary exploration and study. These include the study of Earth, its interaction with the sun and the effects of space weather on its upper atmosphere. It will also find use in missions to sample the watery plumes of the Ocean Wolds such as Europa and Enceladus. Similar capability will enhance efforts to study Mars, Titan and other planets and moons, possible watery plumes or their atmospheres.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Large area cold cathode ionizers have applications in display technology and medical imaging techniques such as time- and spatially-resolved X-ray imaging, which take advantage of electron beam pixilation and instant switching without external beam blanking components. Terrestrial and defense-related mass spectroscopy and communications applications will benefit as well.
Duration: **6**

PROPOSAL NUMBER: 21-1- **H12.01-1768**

SUBTOPIC TITLE: Radioprotectors and Mitigators of Space Radiation-Induced Health Risks

PROPOSAL TITLE: FAST Technology for Reversing Immune Dysregulation During Spaceflight Missions

Small Business Concern

Firm: **Sachi Bioworks**
Address: **6205 Lookout Road, Unit A, Boulder, CO 80301**
Phone: **(720) 361-2159**

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 long space exploration missions, astronauts are subjected to increased amounts of radiation exposure, which can lead to Acute Radiation Syndrome (ARS). While specific haemopoietic protein variants have been used as medical countermeasures (MCM) for ARS, several recent studies have identified need for inclusion of other targets to provide more effective radiation-exposure treatment. Recent multi-omics studies and radiobiological insights have also provided new gene targets to act as radiation MCM. Using a range of different proteins poses significant challenges and associated logistical challenges in their safe transportation and storage during space travel. Existing genetic manipulation methods are laborious, expensive, and inefficient. We propose to address this market and technology void by rapid design, build, and test of molecules using a proprietary FAST platform to target *any gene* in *any organism*. Our platform generates FASTmers (nucleic acid-nanoparticle-based high-throughput synthesis, purification, and delivery) to up- or down- regulate any desired gene. In our preliminary work, we have designed, built, and tested FASTmers in an accelerated fashion for several radiation markers. Eg., GM-CSF FASTmer demonstrated large-scale immunomodulation and specific haemopoietic protein regulation in human PBMCs during acute radiation exposure (3Gy). During this proposal, we will use individual FASTmers targeting specific genes related to ARS, and evaluate their efficacy using specific haemopoietic proteins and cytokine markers. Based on their efficacy, the top-ranked candidates will be evaluated as a combination therapy. Using detailed fractional factorial design and ensuing statistical analysis, we will identify the: 1) top ***therapeutic targets*** for ARS, both in monotherapy and combinations; and 2) ranked FASTmers as ***therapeutic assets*** for mono- and combination therapy, to further test and validate in animal and clinical testing (Phase II SBIR).

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

Our proposed work will result in rapid development of radiation countermeasures (single targets for first-in-class, and combination targets for best-in-class) for deployment in deep-space missions. These will be developed using our proprietary FAST platform for high-throughput, rapid, and targeted gene manipulation (reversible) of immune and other hematopoietic proteins, to utilize our own body to create these protective enzymes to counter and repair the damage caused by deep space radiation.

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

Due to desirable attributes such as cloning-free, simple, high-throughput, low-cost, and rapid deployment, Sachi's FAST technology is preferred by biopharma and drug-discovery companies. We conservatively estimate that we can serve 5-10 drug-discovery contracts/therapeutic lead targets and assets during the first year of formal launch (2021).

Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.03-1845**

SUBTOPIC TITLE: Energy Storage for Extreme Environments

PROPOSAL TITLE: Solid-state Sodium-ion Batteries for Extreme-Environment Energy Storage

Small Business Concern

Firm: **Aegis Technology, Inc.**
Address: **12630 Westminister Avenue, Suite G, Santa Ana, CA 92706**
Phone: **(714) 554-5511**

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):

Future NASA science missions will require more advanced energy storages based on secondary battery systems that are capable of operating at temperature extremes up to 500 °C for Venus missions (Venus surface conditions having high temperature of 486 °C). In this SBIR project, Aegis Technology Inc. proposes to develop a novel class of all-solid-state Na-ion batteries (ASSNiBs) based on a novel cell structure design in corporation with a high-performance solid electrolyte that has been well developed in Aegis. This electrolyte can provide not only high ionic conductivities, but also high temperature stability, and good compatibilities with the designed electrodes. By co-sintering the electrolyte with the properly processed high energy electrodes, interfacial resistance issues oftentimes encountered in conventional solid-state batteries can be effectively addressed, resulting in

more desirable battery performance such as enhanced energy densities, excellent high temperature stability, and improved cyclability. In addition, the proposed ASSNiBs can be processed using an industrially mature multilayer ceramic capacitor (MLCCs) processing technology, allowing for a cost-effective and scalable production. The Phase I will focus on the feasibility demonstration of the proposed technology, through material design, processing, prototyping and characterizations. Proof-of-concept small-scale ASSNiB cells will be prototyped and demonstrated. In Phase II, further optimization, scaling up, and characterizations will be carried out, which would be directed toward a final demonstration of full-size battery cell and the establishment of the full-size cell fabrication process, paving the way to the successful development of a commercially viable battery product attractive for NASA and other military/civil applications.

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

High temperature capable, high-energy-density, high-reliability ASSNiBs, once successfully developed, will find wide applications in advanced energy storage systems for future NASA Science Missions in extreme environments, and Electrified Aircraft Propulsion (EAP) in NASA's Aeronautics Research Mission Directorate (ARMD) to possess sufficient range, safety, and operational economics for regular service. Other potential NASA applications will include power sources for extravehicular activities, landers, and rovers, etc.

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

This class of ASSNiBs will find numerous applications in military systems (such as energy storage for air/land/sea vehicle, and silent watch) and commercial systems (such as geophysical exploration, deep oil/gas well drilling, electric vehicles), providing the benefits of high temperature reliability, long working time, excellent safety, low energy consumption and greenhouse gas (GHG) emissions.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.09-2030**

SUBTOPIC TITLE: Small Spacecraft Transfer Stage Development

PROPOSAL TITLE: TopFuel Integrated Lunar Transfer Stage

Small Business Concern

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

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

During the proposed Phase I research and development effort, the project team will integrate previously demonstrated technologies into a low-cost solid rocket motor to serve as a cis-lunar transfer stage to guide and propel small spacecraft on Trans Lunar Injection (TLI) trajectories. The resulting solid rocket motor will meet requirements for Mass Fraction and Specific Impulse that will enable it to achieve the NASA targeted lunar orbits. Key stage component will be fabricated and demonstrated in hot-fire, static testing. The Phase I project will demonstrate the solid rocket motor design fits within the constraints of a particular small launch vehicle. The proposed project team will develop a plan for a follow-on Phase II flight demonstration program.

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

Cislunar transfer stage for small spacecraft

Small orbital launch vehicles

Hypersonic propulsion testing

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

DoD small spacecraft and technology demonstration missions

Air Force operationally responsive space launch

Commercial small satellite launch

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.03-2541**

SUBTOPIC TITLE: Propulsion Efficiency - Propulsion Materials and Structures

PROPOSAL TITLE: Additive Manufacturing of NiTiHfZr SMAs for Improving Propulsion Systems Efficiency

Small Business Concern

Firm: **3Dnol, LLC**
Address: **2865 North Reynolds Road, Suite 220, Toledo, OH 43615**
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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 proposal serves as the feasibility study for the Additive Manufacturing (AM) of shape memory alloys (SMAs) developed by NASA researchers. The work plan is designed in a way to evaluate the technical advantages of the NASA technology toward AM, modify the ingot production procedure as needed, collect additional required characterization data, investigate commercial routes for reducing the fabrication cost, and to design the next milestones toward powder preparation and process parameter development. After evaluating the IP provided to us by the NASA team, we selected a representative composition for further evaluation. Based on our team experience with the binary NiTi and NiTiHf alloys we expect minor differences in the processing of the selected NiTiHfZr alloys and the other alloys in this category. The work plan is summarized as below:

Samples will be fabricated based on the selected composition via the induction melting technique. A series of heat treatments based on the NASA IP will be performed on the samples. Surface quality, internal defects, and homogeneity of the samples will be evaluated via optical microscopy, SEM, and EDS. Heat-treated samples will be analyzed in a series of thermomechanical and microstructural analysis. The transformation temperatures as well as precipitates will be analyzed using DSC, TEM, and XRD characterization. Thermomechanical properties of the samples will also be evaluated via compression test and isobaric compression test at different stress levels. The homogeneity and potential defects will be analyzed in these steps and the obtained data will be evaluated with reported data by the NASA team.

A comprehensive report will be prepared. The 3Dnol team will request meetings with the NASA researchers to get input on the potential desired properties for the next step. Measured properties as well as any required modifications will be recorded as a major component in fabricating repeatable and predictable AM fabricated parts.

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

Actuators for deployment mechanism of protective shrouds and seals for booster ring segments of rockets, variable geometry chevrons for jet noise reduction, adaptive components for gas turbines, and more recently torque tubes for shape morphing airfoils, are a few examples. Other applications include actuators for extreme conditions (e.g. actuators used on NASA's Mars Exploration Rover mission), self-actuated actuators (e.g. lightweight self-activated noise mitigation systems for airplanes), and deployable mechanisms such as solar sails.

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

SMAs hold a significant promise in simplifying and improving various actuation, biomimetic, damping, and energy harvesting systems. One major application is the biomedical implant market through stiffness modulated implants, patient-specific bone implants, and self-expanding cardiovascular stents. The auto industry, oil and gas, and energy applications could also benefit from AM fabricated SMAs.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.02-2447**

SUBTOPIC TITLE: Technologies for Active Microwave Remote Sensing

PROPOSAL TITLE: Low-Power W-Band Transceiver using COTS Solutions

Small Business Concern

Firm: **Metacept Systems**
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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: 2
Technical Abstract (Limit 2000 characters, approximately 200 words):

There is a growing demand for spaceborne active radar sensing systems that make use of RF frequencies across nearly all the microwave bands. This Phase I proposal explores the use of millimeter-wave (mmW) FMCW radar transceiver for an altimeter for spacecraft descent guidance and landing. In addition, the proposal will touch on other architectures using the low-cost W-Band building blocks downselected and simulated for this Phase I effort.We propose to identify and downselect available commercial-off-the-shelf (COTS) W-Band MMICs, ideally using surface-mount technology (SMT), in the form of FMCW (Frequency Modulated Continuous Wave) Radar Transceiver building blocks. In a Phase II, the bare die would be packaged into SMT packages with an external waveguide interface and employ low-cost mature manufacturing techniques. This approach allows much shorter design development and characterization times for the difficult mmWave design risk efforts, while taking on a manageable amount of technical debt and risk for the ADC, DC and Baseband electronics sections in the form of existing COTS solutions. This Phase I effort will serve two main benefits: provide a risk reduction effort by characterizing the building blocks of a 94 GHz solid-state based FMCW Radar transceiver while also allowing future coupling of a dynamically steerable, waveguide-fed metasurface antenna to evolve into a manufacturable commercial product.In other non-NASA applications, a W-Band radar transceiver with a steerable aperture could be the critical building block for high-resolution imagery and target tracking in what the DoD calls DVE (Degraded visual Environments). The specific DVE application is for rotary-wing and is referred to as “brown-out” and this type of radar has been prohibitively expensive as most helicopters require several instances of this radar per aircraft to be useful.

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

- Spaceborne Collision Avoidance Systems (for Aircraft and Rovers)
- Spacecraft Altimeter and Velocimetry
- Earth Science Precipitation Instruments (cloud and Rain detection)
- DVE (Degraded Visual Environments) Mapping and Real-Time Imaging
- Ground (FOD) Control on Flight Line
- Precise Distance Measurements in Dusty and/or humid Atmospheres
- Level Sensing for any materials (liquids in tanks with foam/vapor)
- Robotic Sensors

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

- DoD DVE (Degraded Visual Environments) Mapping
- Ground (FOD) Control in Airports and Other Facilities
- Precise Distance Measurements in Dusty and/or humid Atmospheres
- Level Sensing for any materials (liquids in tanks with foam/vapor)
- Medical and Security Imaging
- Commercial Collision Avoidance Systems
- Robotic Sensors

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z3.05-2626**

SUBTOPIC TITLE: Satellite Servicing Technologies

PROPOSAL TITLE: Robotic Arm Force Torque Sensing System (RAFTSS)

Small Business Concern

Firm: **Motiv Space Systems, Inc.**
Address: **350 North Halstead Street, Pasadena, CA 91107**
Phone: **(626) 737-5988**

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):

Motiv Space Systems (Motiv) proposes a novel, space-rated, load sensing system that will enable the next generation of space-borne robotic end effectors: The Robotic Arm Force Sensor Torque Sensing System (RAFTSS).

Because the RAFTSS is designed with robotic, space-based applications as the primary application, it will advance the current state of the art in on-orbit servicing, assembly, and manufacturing. The novel solutions in the RAFTSS system includes:

1. Wide-Range 6-Degree-of-Freedom (W6D) FTS. This sensor can be conceptually thought of as the “wrist” sensor. It can sense a broad range of imparted loads incurred during servicing and contact/capture operations (tens to hundreds of Newtons) with overload capabilities of 100 times the sensing range.
2. Point of Application (POA) 3-DOF load sensors. These sensors can be thought of as the “fingertip” sensors of RAFTSS that are integrated directly into a tool or end effector gripper. Their load sensing ranges and axes can be tailor designed to directly measure minute loads imparted by delicate servicing operations or low mass payload acquisition operations (tens of Newtons).
3. Co-located electronics that not only condition the RAFTSS signals, but also processes and resolves the loads into meaningful operational loads at the point of interest (i.e. at the end effector).

This collaborative sensing approach addresses the primary challenges typically associated with force torque sensing systems. More specifically, designing systems capable of achieving accuracies and sensitivities at levels sufficient to support mission objectives while being robust enough to handle overload conditions typically associated with launch environmments and large masses integrated at the distal end of robotics has been challenging.

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

Force torque sensors are critical components in autonomous, or semi-autonomous, robotic systems. As NASA pushes towards an increased use of autonomous robots in space, the RAFTSS will solve the pressing need for high sensitivity with high overload capability seen in almost every space robotics application. The NASA based market includes a broad swath of mission applications from on-orbit manipulation including assembly and sample transfer operations to mobile rovers on the surface of the Moon or Mars driving exploration and science.

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

The non-NASA space market includes both private space companies and foreign space agencies. Private companies are increasingly taking roles in on-orbit assembly, debris removal, and satellite servicing tasks. These tasks require the use of advanced robotic systems which could benefit from the inclusion of the RAFTSS system.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.08-3107**

SUBTOPIC TITLE: Technologies to Enable Cost and Schedule Reductions for Optical System for CubeSats

PROPOSAL TITLE: Additive Manufacturing for CubeSat Optics

Small Business Concern

Firm: **Nanovox, LLC**
Address: **15985 Northwest Schendel Avenue, Suite 201, Beaverton, OR 97006**
Phone: **(503) 703-3260**

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 reduce the design cycle time and cost required for optimizing long focal length optical systems within the constraints of 12U and smaller CubeSat platforms, a scalable, low-cost additive manufacturing (AM) platform, capable of fabricating high-performance freeform three-dimensional (3D) gradient index (GRIN) optics will be demonstrated. The freeform 3D-GRIN optics are capable of implementing high order functions, including optical power and aberration correction, within a single achromatic monolithic element, making them ideal for reducing the size and weight of dioptric and catadioptric optical systems. The complex optical functions embedded in the freeform 3D-GRIN optical elements reduce the manufacturing tolerance requirements of custom freeform or aspheric mirrors or allow for simple flat and spherical folding mirrors to be used in long focal length optical systems. The ability to fabricate optics on-demand allows for systems to be optimized quickly, even after opto-mechanical assembly and characterization.

In Phase I, existing optical design and multi-metric stochastic optimization tools will be used to perform structural, thermal, optical performances (STOP) analysis, refine the trade space, and then design, optimize, and simulate long focal length optical designs that meet the specified application requirements. Also, in Phase I, proof-of-concept 3D-GRIN elements will be fabricated and characterized, allowing for the input design parameters to be validated. The prototype optical elements will be made available to NASA for test and characterization.

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

The innovation benefits optical missions that require more compact and lightweight optics, including for planetary CubeSats remote sensing, Habitable Exoplanet (HabEx), Large UV/Optical/Near-IR Surveyor (LUVOIR), Laser Interferometer Space Antenna (LISA), Balloon Planetary Telescope, Origins Space Telescope (OST), NIR LIDAR Telescope missions, as well as optical communications.

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

Commercial applications include commercial satellites, cell phone cameras, microscopy, medical imaging (endoscopes, colonoscopes, etc), solid state lighting optics, holographic displays, military head-mounted night vision, riflescopes, UAV sensors, and missile applications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H5.01-1976**

SUBTOPIC TITLE: Lunar Surface Solar Array Structures

PROPOSAL TITLE: Sun Flower: Systems Design and Technology Maturation of a Sustainable Lunar Power Generation Architecture

Small Business Concern

Firm: **Trans Astronautica Corporation**
Address: **11404 Camaloa Avenue, Lake View Terrace, CA 91342**
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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 Sun Flower proposal is responsive to SubTopic H5.01 Materials, Materials Research, Structures, and Assembly: Lunar Surface Solar Array Structures, and addresses NASA's need for "structural and mechanical innovations for 10 kW relocatable solar arrays near the South Pole for powering in situ resource utilization (ISRU) equipment, lunar bases, dedicated power landers and rovers." We propose an effort to define and mature the TRL of a lunar power capture and storage system, suitable for the support of landers and rovers in virtually any type of lunar terrain, including PSRs in polar latitudes. The Sun Flower system architecture provides high duty cycle solar power by using low mass deployable towers to elevate solar reflectors above topographic features.

The key objective of this focus area is to provide simultaneous power generation in PSRs. Each Sun Flower tower will support a reflector of a mass value optimized for the tower's height, which redirects solar energy to the lunar surface to be collected. The Sun Flower system is flexibly designed, from a 10 meter tower prototype for testing in Earth's gravity, to towers optimized for the lunar surface of heights ranging from 100 to 800 meters. The array will utilize UltraFlex technology for deployment.

Our goal as a Phase I effort is to identify the key systems and hardware required to demonstrate the Sun Flower's structural deployment. Our team proposes three primary technical objectives as proposed deliverables. First, a comprehensive design and analysis package will be delivered for a full-scale lunar power generating system. Second, a prototype build of a modular section of the tower's design will be fabricated and assembled. Finally, we propose a functional test of the modular section's deployment. Our goal for this demonstration as part of our Phase 1 effort is to construct a system capable of being tested in an Earth gravity environment to demonstrate the design concept's deployment and retractibility.

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

The Sun Flower system will benefit the Artemis program by providing a consistent source of power generation, specifically in critical PSRs. This will be a necessity in supporting key operations of the program, including rovers, ice mining, and landers. This effort will advance the TRL of these technologies and provide a path toward efficient lunar missions starting in 2028 without dependencies on high cost, high mass power generation approaches.

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

The efficient power generation offered by the Sun Flower will be a valuable commodity to commercial operations on the Moon, including tourism and resource extraction. The low-mass towers will lower the cost of supplying power to such commercial operations. We are currently working with Blue Origin, who intends to buy lunar water made possible by TransAstra's Sun Flower and mining systems.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z10.01-2328**

SUBTOPIC TITLE: Cryogenic Fluid Management

PROPOSAL TITLE: Integrated Brayton Cryocooler for LOx and LH2 Applications

Small Business Concern

Firm: **Concepts NREC, 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: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA is in need of affordable and robust cryogenic cooling solutions for use in space applications. Specifically, in support of its Artemis program, NASA seeks innovative integrated refrigeration cycles for a combination of hydrogen and oxygen liquefaction on the lunar surface (topic Z10.01). Based on initial estimates, nominally 300 W of cooling is needed at 90 K and 20 K to support at least 11.7 metric tons per year (3.3 kg/hr of oxygen and 0.4 kg/hr of hydrogen). Currently, Concepts NREC (CN) is working towards the demonstration of a high-capacity reverse-Brayton cryocooler based on the needs of several high-temperature superconducting and liquefaction applications. On the proposed NASA Phase I project, CN proposes to leverage its high-capacity Brayton cryocooler development effort by pursuing a novel integrated system capable of supporting oxygen and hydrogen liquefaction needs on the Moon. Beyond providing an integrated solution, the proposed system will dramatically increase the current state-of-the-art in space-based cryogenic cooling capacity. CN proposes to focus its Phase I efforts on cycle and configuration analysis and optimization, consistent with the Z10.01 solicitation expectations. In collaboration with NASA personnel, CN will select the optimum configuration for maturation in Phase II. During Phase II, the lowest Technical Readiness Level (TRL) component will be selected for further development.

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

Liquefaction of cryogenic propellant is a critical component of future exploration efforts, currently pursued within the Artemis program. Leveraging CN's existing Brayton cryocooler developments, CN anticipates this program to lead to a significant increase in the cooling capacity of space-based cryocoolers. The increase in cooling capacity, combined with the integration of LOx and LH2 refrigeration capabilities, will allow NASA and its prime contractors to conduct ISRU and ZBO operations in orbit, on the moon and on Mars.

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

Developments on this program are expected to be directly applicable to superconducting needs of other government applications (defense) as well as the commercial industry. Specifically, multiple Navy applications exist in minesweeping, degaussing, and ship-board power transmission. Furthermore, superconducting motors for wind turbines are actively being pursued in the renewables market.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H3.05-2629**

SUBTOPIC TITLE: Additive Manufacturing for Adsorbent Bed Fabrication

PROPOSAL TITLE: Robocast Zeolitic Lattices For Reversible CO2 Sorbent Monoliths

Small Business Concern

Firm: **Robocasting Enterprises, LLC**
Address: **5660 Pino Avenue Northeast, Albuquerque, NM 87109**
Phone: **(505) 883-0555**

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's current systems controlling CO2 levels in a cabin's atmosphere are problematic. Currently, packed beds of granules of zeolite are used as sorbents for CO2 in NASA CO2-removal assemblies. Problems and inefficiency associated with packed beds are related to random packing of granules and resulting poor thermal management and poor mechanical stability. A much improved system is envisioned if the basis for the sorbent bed is a 3D-printed monolithic lattice.

For this project the extrusion–based additive manufacturing (AM) technique known as robocasting will be used to create prototype lattices of zeolite 13X and zeolite 5A that are much more robust and efficient for reversibly adsorbing and desorbing CO2. Success requires the development of zeolite paste feestocks that are suitable for the robocasting process and also have the ability to partially sinter into robust structures while simultaneously retaining high surface area and microporosity. Studies for the development of effective sintering aids (inorganic binders) will be completed in order to suitably partially sinter zeolite particles together at temperatures of preferably <700C. Optimization of fugitive binder systems for creation of zeolite pastes with rheological properties appropriate for robocasting will also be completed and the successful fabrication and sintering of zeolite lattices demonstrated.

Furthermore, an objective is to build and demonstrate the incorporation of heating elements into a zeolite assembly that will induce rapid and complete desorption of CO2. The specific target goal is to be able to heat a zeolite monolith in-situ up to 300C

The final deliverable for Phase I will be the demonstration of a stack of lattice monoliths 25-50mm in diameter made with zeolite 13X and/or zeolite 5A that meets the material targets for strength, CO2 adsorption capacity, and pressure drop and incorporates a heating element capable of 300C.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Air Revitalization System (ARS) : NASA aims to use the 3D-printed sorbent beds as drop-in replacements for packed sorbent beds such as those found in the Carbon Dioxide Removal Assembly (CDRA) on the International Space Station (ISS) and for future NASA missions. Success will also have implications for water removal and humidity control of confined atmospheres.

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

The most likely Non-NASA applications will be for catalyst supports and gas separators for industries involved with air separation, petroleum refining, petrochemicals, refrigerants, and natural gas. Other potential applications are feasible for the disinfection and purification of water for the creation of potable water in developing countries.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H3.02-2497**

SUBTOPIC TITLE: Microbial Monitoring for Spacecraft Cabins

PROPOSAL TITLE: Fluorescence Spectroscopy Imager for Microbial Monitoring of Habitat Surfaces

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

Future missions will benefit from a device that can quickly and accurately assess the microbial status of habitat surfaces. Current state of the art technology relies on sampling surfaces and performing

molecular processes on the samples to determine the microbial burden. Nanohmics proposes to create a handheld, consumable-free device that provides microbial mapping using a fluorescence spectroscopy imager. Additionally, the ultraviolet light source used for fluorescence excitation can also be used for disinfection, which can reduce the need for microbial monitoring. The core technology is based on a visible-spectrum imaging spectrometer developed under NASA SBIR funding, relying on a ~1 gram micro-optical chip to provide complete spatial-spectral registration with real-time data capture. This lightweight, low-power device can easily be integrated into new or existing platforms to enable autonomous microbial monitoring that eliminates the need for manual sample collection, preparation, and processing. In the Phase I program, with feedback from the technical monitor, we will select relevant microorganisms and collect fluorescence spectroscopy of the target microorganisms on relevant surfaces. This data will be used to develop classification methods and inform the design of a prototype microbial mapping device.

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

A compact fluorescence spectroscopy imager is an ideal nondestructive examination (NDE) tool that provides real time measurements of bioburdens. For inspections, the device could improve the detection threshold, identify and quantify the contamination, and create a map of contamination hot spots. The device is also well suited to in situ applications. It could be an enabling element in a system that can verify the required level of cleanliness of a sample-handling facility for Martian samples.

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

A compact fluorescence spectroscopy imager has multiple applications in medical, defense, and industrial markets. This device could be used in hospitals to map pathogens on surfaces and validate the efficacy of disinfection systems to reduce hospital-acquired infections. This device could also be used for bio-agent sensing for defense applications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.05-2406**

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

PROPOSAL TITLE: Combinatorial Screening for Advanced Scintillation Detectors

Small Business Concern

Firm: **Superimaging Display, Inc.**
Address: **43239 Osgood Road, Fremont, CA 94539**
Phone: **(510) 573-3913**

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 modern detectors for X-ray, Gamma ray, and other high energy particles in space require advanced scintillator sensor with combination of superior luminosity, high material density, high speed with low latency, fine energy resolution, long radiation hardness and lifetime. Unfortunately, none of the existing single scintillator has all these desirable properties, which compromises the detector performance.

The project aim is to identify advanced scintillation sensors with superior overall properties than existing detectors. The primary objective of the Phase I project is to develop and demonstrate an effective combinatorial synthesis and high throughput screening method to rapidly prepare and search for advanced scintillators. We will verify the accuracy of the proposed combinatorial scintillator R&D approach in Phase I, by applying it on multiple well-studied, state-of-the-art scintillators.

In Phase II, we will apply the set of unique high throughput scintillator R&D tools to conduct a comprehensive synthesis and screening for advanced scintillator crystals based on semiconductors and rare-earth doped metal halides and oxides, with superior overall properties for various high energy radiation and particle detection applications of interests to NASA and multiple commercial sectors.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Scintillator based high energy X-ray and Gamma Ray detectors are finding increasing applications in Astrophysics, Earth Science, Heliophysics, and Planetary Science. Scintillators are the “eyes” of the high energy photon and particle detection systems and its qualities directly affect the detector performance. The identification and development of heavy, fast, robust, bright and efficient scintillation crystals will greatly benefit the future generations of NASA detectors for its various missions.

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

Advanced scintillation detectors can also be applied in many commercial radiation detections applications, including various medical imaging detectors (X-ray Radiography, CT, PET etc.), and sensors for security screening, and manufacturing quality control. They will help detect *interior* disease, defects, or identities of targets without need to open up human body, cargo, or manufacturing parts.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.11-3012**

SUBTOPIC TITLE: Artificial Intelligence (AI)/Machine Learning (ML) for Small Spacecraft Swarm Trajectory Control

PROPOSAL TITLE: Plan Generation for Autonomous Small Spacecraft Swarms

Small Business Concern

Firm: **Emergent Space Technologies, LLC**
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Principal Investigator:

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Business Official:

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Phone: **(301) 345-1535**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3

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

Small satellite (smallsat) swarms and constellations are widely used in low Earth orbit (LEO), and government operators have expressed interest in missions at higher altitudes and in proximity operations. These new mission regimes are more challenging and require greater onboard autonomy capabilities to act and plan without a ground system in the loop. To address this need, we propose to develop an onboard planning capability for smallsats. This software enables constellations or swarms to respond dynamically to failures and opportunities independent of ground systems. The innovation addresses specific gaps in the state of the art identified in our subtopic to enable operation of swarms without the need for ground system commanding. We identify two critical qualities the planner should have. First is the ability to construct a plan that incorporates likely exception information as a safety check. This reduces the frequency of replanning and builds in robustness to exceptions that are well-understood by the operator. The second quality is a standard interface with specialized “subplanners” for functions like maneuvers, constellation design, and so on. This second ability ensures the planning software can interact flexibly with external software, which may be mandated for particular applications. Subplanners are also an appealing approach for decomposing a large planning problem into more tractable sub-problems. The proposed Phase I work will develop a proof-of-concept planner and demonstrate its operation in conjunction with Emergent’s flight software for autonomous mission execution.

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

NASA has expressed interest in missions involving cooperating small satellites above low Earth orbit, which will benefit from onboard planning. More conventional NASA missions can also benefit from greater onboard autonomous features, including planning. We are targeting future NASA space missions such as Landsat Next (Earth Science), Lunar Gateway and LunaNet (Exploration), Solar-Terrestrial Observer for the Response of the Magnetosphere, HelioSwarm, and Auroral Reconstruction CubeSwarm (Heliophysics).

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

Various non-NASA government entities have expressed interest in small satellite missions in environments that will benefit from onboard planning. These include Air Force Research Laboratory's Cislunar Highway Patrol System, and the Space Development Agency's Tracking and Transport Layer.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.05-1389**

SUBTOPIC TITLE: Computational Tools and Methods

PROPOSAL TITLE: Adaptive Mesh Redistribution for Structured Overset Grids

Small Business Concern

Firm: **Pointwise, Inc.**
Address: **213 South Jennings Avenue, Fort Worth, TX 76104**
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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 Pointwise mesh generation software has been integrated with NASA's PEGASUS overset grid assembly software and has the capability to redistribute structured grid points to improve overset grid interpolation accuracy. In the proposed effort, Pointwise mesh redistribution capabilities will be enhanced to support solution-based mesh adaptation.

Specifically, the target size field will be extended to support anisotropic metrics, such as those generated by shocks in the flow field, to improve computational efficiency. Mesh redistribution efficiency and robustness will be improved when adapting grid blocks with strong stretching in one or two directions as is often the case for near-body grids generated using hyperbolic marching algorithms. Finally, to meet NASA's application needs, the redistribution methods will be parallelized to operate efficiently with large (200+ million cell) grid systems.

The proposed mesh adaptation technology will improve the accuracy of overset grid simulation by controlling solution error at a fixed computational cost. Furthermore, by simultaneously adapting to the solution and to overset assembly information, the entire overset grid system can be optimized for solution efficiency and accuracy. Such improvements will enable NASA modeling and simulation personnel to more efficiently complete mission objectives such as air vehicle performance validation.

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

NASA has developed extensive overset simulation tools with application in air vehicles (both fixed and rotating wing), space vehicle launch, assent, and entry, parachute deployment, and complex moving-body problems. The proposed technology will work seamlessly with all of these applications.

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

Military applications include vehicle aerodynamics and store separation. Civil applications include vehicle aerodynamics, propulsion integration, rotorcraft, medical device, power generation, and complex moving-body problems. There is essentially no market limitation for the overset method.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z3.04-2299**

SUBTOPIC TITLE: Autonomous Modular Assembly Technology for On-Orbit Servicing, Assembly, and Manufacturing (OSAM)

PROPOSAL TITLE: Autonomous Cobots to Enhance Situational Awareness

Small Business Concern

Firm: **TRACLabs, Inc.**
Address: **100 North East Loop 410, Suite 520, San Antonio, TX 78216**
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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):

NASA envisions OSAM solutions that involve heterogeneous teams of coordinated service robots. It will be infeasible to effectively coordinate such teams using existing teleoperation techniques. To alleviate this issue, TRACLabs is proposing a framework to enhance perceptual feedback and decrease the cognitive load on operators by building upon ideas from active perception, sliding autonomy and task-level commanding. The resulting system, which we call ACES (Autonomous Cobots to Enhance Situational Awareness), will autonomously position additional robots or sensor systems not currently engaged in a task to autonomously obtain additional meaningful percepts to enhance situational awareness, thus increasing the likelihood of successful task completion.

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

Multi-agent systems will play a vital role in future exploration, construction, assembly, and maintenance tasks. To support the control an automation of these systems tools to enhance situational awareness will be needed. The proposed effort will help address these needs in several NASA efforts including: ISS robots like Astrobee, R2, and SSRMS, Lunar Gateway, Artemis, OSAM missions (OSAM-1, OSAM-2), NASA in-Space Assembled Telescope (iSAT), and Orbital Debris Mitigation.

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

Several Non-NASA applications of the proposed work exist, including projects at Space Force Space and Missile Systems Center (SMC) and
the AFRL Resilient Autonomous Navigation Guidance and Robotic Systems (RANGRS) program. Additionally, the DARPA
Robotic Servicing of Geosynchronous Satellites (RSGS) program is also likely interested in the proposed effort to increase operator situational awareness.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z5.04-1958**

SUBTOPIC TITLE: Technologies for Intravehicular Activity Robotics

PROPOSAL TITLE: Collaborative Sensing and Mapping for IVA Robots

Small Business Concern

Firm: **Metis Technology Solutions, Inc.**
Address: **2309 Renard Place Southeast, Suite 200, Albuquerque, NM 87106**
Phone: **(505) 299-1509**

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):

Metis Technology Solutions proposes a collaborative sensing and environmental modeling approach for IVA robots such as Astrobee and Robonaut 2. IVA robots are intended to autonomously manage habitats and spacecraft, such as Gateway. To do this effectively, IVA robots must be able to collect, fuse, and share information with other IVA robots, as any human team would do to accomplish a task. Metis proposes an *online collaborative process* or a service occurring on the spacecraft, where any IVA robot, both free flyer and humanoid robots, can contribute new data to a central server for data fusion. The fused data can then be modeled, analyzed, and shared with the other IVA robots through the same central server, thus allowing IVA robots to manage and navigate independently, and as part of a team. Metis proposes to do this by first enabling Collaborative SLAM for Astrobee, an on-line vision-based mapping process that not only establishes the proposed architecture, but also augments Astrobee with the ability to update SLAM maps without the need for ground station involvement. In addition, fusion and co-registration of other IVA robot sensor data (i.e. CO_2 data, acoustics data) with SLAM maps will be investigated as they are key to spacecraft maintenance tasks. The technology developed not only solves an operational limitation for Astrobee, but also fills technical gaps identified by the proposed Game Changing Development (GCD) Integrated System for Autonomous and Adaptive Caretaking (ISAAC) project.

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

The system can be directly utilized by Astrobee to overcome an operational limitation and demonstrate collaborative sensing and modeling using multiple Astrobee robots or a combination of Astrobee robots and Robonaut 2. It can be applied to any autonomous system, with one or multiple

agents, for exploration and management of an environment such as teams of ground-based robots managing an area on the moon or mars. Teams of non-autonomous systems also benefit where data from human operated vehicles with sensor payloads are gathered and utilized.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed system can be applied to any autonomous system, with one or multiple agents, for exploration and management of an environment. Collaborative sensing and mapping can be utilized by mobile agents (human operated or autonomous) for exploring and managing environments where environmental information is captured for the first time and needs rapid distribution.
Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.10-1838**

SUBTOPIC TITLE: Atomic Quantum Sensor and Clocks

PROPOSAL TITLE: 850 nm Narrow Linewidth Laser for Atomic Sensors

Small Business Concern

Firm: **Freedom Photonics, LLC**
Address: **41 Aero Camino, Santa Barbara, CA 93117**
Phone: **(805) 967-4900**

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):

In this program, a compact laser source for atomic sensing will be developed using Freedom Photonics' advanced hybrid integration technology. The package will combine multiple components of existing atomic sensors to reduce size, weight, and power of the overall system. Application requirements will be gathered from NASA and commercial partners with complex laser source requirements for atomic sensors. Freedom Photonics will develop custom solutions for each component suited to the requirements specified using our suite of commercial and in-house modeling tools. Using hybrid integration these components will be combined into a high-performance laser module.

In Phase 1 of this program, Freedom Photonics will design the components of the compact laser source. The hybrid integration approach will be implemented at the target wavelength to ensure feasibility of the proposed solution. At the end of Phase 1, we will have demonstrated a path forward to combining the components and will be ready to procure and being fabrication of the components at the start of Phase 2.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This program is targeting NASA applications related to geodesy, gravimetry, and climate monitoring. The laser source will be targeting specifications for atomic clock and atomic interferometers used in gravity sensors.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

High performance laser solutions for atomic sensors are useful for various other commercial and defense applications such inertial measurement units, magnetometers, and atomic clocks. Furthermore, the same hybrid integration approach can be leveraged for other applications such as LiDAR and optical communications transceivers.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z7.04-1969**

SUBTOPIC TITLE: Landing Systems Technologies

PROPOSAL TITLE: Modeling Sensor Radiance Modifications due to Dust Clouds from Plume Surface Interactions

Small Business Concern

Firm: **CFD Research Corporation**
Address: **6820 Moquin Drive Northwest, Huntsville, AL 35806**
Phone: **(256) 726-4800**

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):

Dust and regolith particles liberated by Plume-Surface Interactions (PSI) during spacecraft propulsive landing on the unprepared regolith of the Moon, Mars, and other destinations result in damaging debris and navigation sensor impairment. Obscuration of landing area features and the deterioration of sensor signals as they propagate through plumes gases, dust clouds, and dense high-speed near-surface sheets of regolith particles constitute serious risks for safe navigation and landing hazard detection systems. In this effort, CFD Research will team up with University of Central Florida to develop a computational modeling capability for predicting the adverse effects on sensor radiances as they propagate through the plume gas and particle cloud regions between the lander and ground. Existing two-fluid gas-granular simulation tools that provide the spatial definition of lander plume gas and particle cloud obscurants will be coupled with an advanced atmospheric radiative transfer simulation tools capable of accounting also for polarization over a wide spectral range from millimeter through infrared waves of interest. Line-by-line spectral properties for gases, and accurate T-matrix based absorption and scattering cross sections for the particulate clouds will be utilized to account for the complex lunar or other planetary regolith shapes and material properties. Application testing and validation of the resulting sensor signal propagation predictive capability will be performed against the UCF developed EjectaSTORM sensor system which is currently being tested in terrestrial landing experiments on a Masten lander and destined to deliver flight data on a future CLPS lander mission. The resulting tools will be delivered to NASA as an open-source tool for ready utilization to support safe landing sensor system development for lunar and Martian landers, including the Human Lander System.

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

Immediate NASA applications include support the broad range of sensor development for Autonomous Landing and Hazard Avoidance sensor development spearheaded by the Safe & Precise Landing Integrated Capabilities Evolution (SPLICE) project. Definition and mitigation of PSI induced sensor degradation will be crucial for robotic landers such as the Commercial Lunar Payload Services (CLPS) landers, for the Human Lander System (HLS), and future robotic and human Mars landers.

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

Non-NASA applications include support for landers and commercial partners developing Human Lander Systems. Other applications include sand/dust related military and civilian applications such as rotorcraft sand/dust brownout and engine dust ingestion, and chemical, petrochemical and fossil-energy applications where modeling multiphase granular flows is critical in design/analysis of these systems.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z4.05-1367**

SUBTOPIC TITLE: Nondestructive Evaluation (NDE) Sensors, Modeling, and Analysis

PROPOSAL TITLE: Ultra-Wide Bandwidth, Conformal Strain Sensors for Nondestructive Evaluation Applications

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: 4

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

This NASA Phase I SBIR program would develop ultra-wide bandwidth, conformal nanomembrane based strain sensors for nondestructive evaluation applications, using silicon on insulator techniques in combination with nanocomposite materials. The team has recently demonstrated the conformal strain sensors with a frequency response from DC to 5MHz. The team will perform synthesis of sensor skin materials with optimized transduction, hysteresis and environmental properties, specifically for structure health monitoring of aerospace structures such as multi-wall pressure vessels and micrometeoroid shielding. The team will fabricate patterned two-dimensional sensor arrays and internal electronics using optimized materials. Calibration of sensor elements will be conducted. Support electronics will be developed to acquire, multiplex, store and process raw sensor array data.

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

The anticipated initial application of the ultra-wide bandwidth strain sensors for nondestructive evaluation applications is for NASA's aerospace structure monitoring. The commercialization potential of the proposed technology lies in four areas, namely 1) single strain sensor, 2) conformal strain sensor arrays for nondestructive evaluation applications, 3) broader strain sensor arrays, and 4) data analysis module.

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

Primary customers would be university, government laboratory and industry researchers. Use of developed ultra-wide bandwidth strain sensor technology first by NASA, and then by the broader research community, as well as the developers and users of aerospace, hydrospace, land vehicle, civil structure and biomedical flow systems, is envisioned.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.03-3026**

SUBTOPIC TITLE: Accelerating NASA Science and Engineering through the Application of Artificial Intelligence

PROPOSAL TITLE: Machine Learning-Accelerated Grid Environment

Small Business Concern

Firm: **Emergent Space Technologies, LLC**
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Phone: **(301) 345-1535**

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):

NASA satellites are generating over 4TB of data each day. Analyzing this data in-orbit is becoming increasingly important for the purposes of accelerating scientific discovery and enabling opportunistic science. State-of-the-art artificial intelligence (AI) and machine learning (ML) data science applications require significant resources to run computationally intensive algorithms and models. To

facilitate intensive data analysis in a resource constrained environment such as space, we need to utilize resources efficiently and at scale. Current solutions to this problem require downlinking full datasets to perform ground-based processing or running low computational footprint algorithms that are less effective than state-of-the-art solutions. In this proposal, we explore the capabilities and benefits of developing MAGE (ML Accelerated Grid Environment). MAGE is a software framework and API that facilitates ML training and inference distributed across a networked constellation or swarm of satellites to enable resource intensive ML models to run at the extreme edge. This solution makes complex data processing at the edge possible by running on AI accelerated hardware and distributing ML processing and storage across a grid of compute and storage nodes. Collectively, these nodes comprise a grid computing environment that can be tasked by spacecraft to run resource intensive applications. MAGE reduces the need to downlink full data sets, allows prioritization of data downlinking, enables proliferation of complex autonomous space-based systems, and provides a mission agnostic environment for processing and storage. Utilizing a system such as MAGE would allow NASA to perform efficient, scalable, mission agnostic AI and ML processing at the edge for any scientific mission.

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

The NASA Magnetospheric Multiscale Mission (MMS) downlinks ~2% of the data it acquires as part of its mission. MAGE would enable missions such as this to perform processing in-orbit to mitigate data loss, improve and accelerate discovery, and prioritize data for downlinking. MAGE also enables the proliferation of complex autonomous decision making systems including instrument calibration, attitude adjustments, object detection and avoidance, swarm reconfiguration, and reacting space weather events.

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

MAGE is a natural fit for swarm and constellation missions such as the Space Force Space and Missile Center's Space Combat Cloud where it could support constellation-wide processing, storage, and information dissemination. Our company also works with the Air Force Research Lab on constellation R&D where MAGE could support intelligence, surveillance, and reconnaissance applications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.12-2060**

SUBTOPIC TITLE: Remote Sensing Instrument Technologies for Heliophysics

PROPOSAL TITLE: Meta-optical spectral imaging via computation for compact lightweight hyperspectral imaging

Small Business Concern

Firm: **Tunoptix, Inc.**
Address: **3515 South Massachusetts Street, Seattle, WA 98144**
Phone: **(206) 288-3867**

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):

Achieving NASA's strategic goal of 'Expanding Human Knowledge through New Scientific Discoveries' requires high-performance instrumentation capable of operating under extreme conditions while maintaining a low size, weight, and power. Hyperspectral imaging (HSI) systems represent a class of instruments that have played a significant role in previous NASA missions in remote sensing and planetary surveying on Earth and other planetary systems. The HSI systems on these missions have relied on bulky optics that also require large system sizes to achieve high spectral resolution. The large size and mass of these spectrometers represent a significant barrier to widespread adoption due to the opportunity cost of the space, weight, and power consumption.

Tunoptix proposes to utilize meta-optics in conjunction with computational imaging to drastically reduce the SWaP of HSI systems while maintaining high spectral and spatial resolution. A meta-optic consists of an array of subwavelength scatterers, which locally control the amplitude, phase, and spectrum of incident light with high spatial resolution. A metasurface is optically thin, with an active layer thickness of of less than a micrometer, and total optical thickness on the order of millimeters.

Tunoptix will develop a HSI system based on an optical front-end and computational back-end. This approach leverages the unique ability of meta-optics to implement near-arbitrary optical functionalities to implement a well-conditioned wavelength-dependent transformation on incident light. This will then be decoded using a low latency postprocessing algorithm to extract a high-fidelity hyperspectral image. With this method, Tunoptix well demonstrate a compact, snapshot polarization independent HSI system with F/1.8, a 10 cm x 8 cm x 4 cm form factor, and a mass of less than 1 kg operating over a bandwidth of 350-1050 nm, and with over 40 channels.

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

A drastically lower SWaP snapshot HSI system would reduce the opportunity cost for their adoption in a wider set of NASA missions and applications. In particular, applications of a low SWaP, snapshot HSI system would include satellite-based and rover-based imaging and spectroscopy of planetary surfaces, airborne remote sensing of coastal and oceanic regions, and in-field inspection of mission-critical satellite systems.

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

The primary applications for an HSI system in the private sector would be in quality control and inspection for industrial settings, and plane-based or drone-based surveying. In these applications, the design would increase throughput of the customer's processes while maintaining spectral and spatial resolution and relaxing stabilization tolerances when compared to pushbroom HSI systems.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S4.02-1170**

SUBTOPIC TITLE: Robotic Mobility, Manipulation and Sampling

PROPOSAL TITLE: Low SWaP Flash LiDAR for Fast Traversing Rovers

Small Business Concern

Firm: **Advanced Scientific Concepts, LLC**
Address: **135 East Ortega Street, Santa Barbara, CA 93101**
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Principal Investigator:

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Business Official:

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Phone: **(805) 966-3331**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

ASC has developed the Global Shutter Flash LiDAR (GSFL) technology that is ideal as a navigation and hazard avoidance sensor for fast traversing robots and rovers. The GSFL provides real time 3D imaging by capturing a full frame of 128 X 128 pixels per laser flash. With a frame rate of 30 frames per second, the GSFL provides an organized 3D point cloud which translates into non distorted 3D real time video. Scanning LiDARs and stereo vision systems cannot compete with this technology. The GSFL can image through dust that may be encountered on planetary surfaces where a scanning LiDAR and stereo vision systems cannot. The GSFL can operate in direct sunlight and total darkness including the rover's shadow. Stereo vision systems cannot operate in either lighting environment. The GSFL has no moving parts which allows the system to have minimal Size, Weight, and Power (SWaP) and has a much higher reliability than a scanning LiDAR. ASC has designed and delivered

the GSFL technology for terrestrial applications and space for both radiation tolerant and radiation hard environments. ASC has the expertise in house to design, develop, and deliver GSFL hardware including application specific algorithms to support fast traversing rovers and robots. For this SBIR phase I, ASC will work with NASA and develop the mission requirements and CONOPS for the robot or rover. From the CONOPs, ASC will derive the system requirements and system architecture by utilizing tools including the link budget and z-max for the optical design. A concept design will be completed in phase I. This will include the hardware design including the optics and also the software architecture and algorithm selection. For phase II, ASC will demonstrate the technology using a robot with a GSFL and a simulated planetary field with rocks as hazards. The robot will demonstrate navigation and hazard avoidance in the simulated field.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Two ASC GSFL cameras were included in the OSIRIS REx mission. ASC's GSFL is also included in the NASA/Boeing CST100 manned space capsule. The GSFL will support rendezvous and docking with the International Space Station. ASC is currently under consideration by multiple suppliers to support Entry Descent, and Landing for NASA's Commercial Lunar Payload Services. ASC is also being considered to support NASA's New Frontiers Dragonfly mission to Saturn's moon Titan.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

ASC has delivered GoldenEye Rad Hard GSFL cameras for 3 different missions. The missions and customers are not disclosed. ASC is working with Aerospace under a CRADA to enhance the GSFL technology for tracking Resident Space Objects (RSO) and space situational awareness. ASC is currently proposing the GSFL camera to the Japanese IA procurement division.
Duration: **6**

PROPOSAL NUMBER: 21-1- **H3.07-3144**

SUBTOPIC TITLE: Flame-Retardant Textiles for Intravehicular Activities (IVA)

PROPOSAL TITLE: Flame Retardant Polyamide Fibers for Space Crew Clothing

Small Business Concern

Firm: **Materials Modification, Inc.**
Address: **2809-K Merrilee Drive, Fairfax, VA 22031**
Phone: **(703) 560-1371**

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):

NASA's vision is to establish human outpost stations on the Moon and further explore Mars and other destinations out of the Lower Earth Orbit. To meet these future space missions, NASA is developing next-generation spacesuits as a part of the Deep Space EVA system called xEMU. The xEMU is the precursor for the future Mars Extravehicular Mobility Unit, mEMU. Spacesuits are the most iconic and critical components of missions to protect astronauts from the harsh space environment.

The spacesuit materials should be resistant to dust, abrasion, wear, tears, and punctures, and above all, should be flame resistant. The current flame-retardant textile fibers are based on inherently flame-resistant materials such as aramids or flame-retardant treated cotton, rayon, and wool. However, these materials are not strong, flame-retardant in the enriched atmosphere of 36% oxygen at a pressure of 8.2 psi (56.5 kPa). Therefore, NASA seeks to develop a non-toxic, inherently strong, flame-retardant (in 36% oxygen), and comfortable fiber to use for crew members' next-to-the-skin clothing.

In the proposed effort, **non-toxic flame retardants will be incorporated into the fiber-forming polymers during polymer synthesis**. The novel flame-retardant polymers will be extruded into fine textile fibers. The physical and mechanical properties of the fabrics produced from these novel flame retardant polymeric fibers will be evaluated. The flame resistance of the fibers and materials in an atmosphere containing 36% oxygen will be demonstrated.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The new yarns and fabrics are required to send astronauts safely and comfortably to the Moon to later establish a sustainable human presence beyond low Earth orbit. Beyond the Moon-Mars beckons with demanding requirements potentially met by MMI's innovation.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed fibers can be used in personal protection suits for warfighters, fire-fighters, and industrial workers.
Duration: **6**

PROPOSAL NUMBER: 21-1- **H9.07-2521**

SUBTOPIC TITLE: Cognitive Communication

PROPOSAL TITLE: Unified Analytics Engine

Small Business Concern

Firm: **ATLAS Space Operations**

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Phone: **(231) 598-6184**

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):

ATLAS' vision is to guarantee the US Government (USG) access to space through the ability to leverage a global hybrid network of USG and commercial antennas using a highly innovative machine learning scheduler of schedulers. Built on ATLAS' commercially available product, the prototype for this effort is a data analytics engine to support the ATLAS Cognitive Constellation Management Scheduler. Leveraging the power of data science and machine learning to facilitate decision making in the scheduler, the unified analytics engine prototype will transform raw data from billions of data points to increase network performance measured by the results of the taskings enhancing reliability and resiliency.

The main goal of this project is to leverage streaming and real-time data, in addition to billions of historical data points and state of the art data analytics to create detailed performance metrics per site, per customer, per satellite and even per hardware unit, per software patch, and per configuration. The ability to slice and dice per site, customer, etc., tied in with modern approaches to outlier identification, anomaly detection, and time series analysis can empower a suite of insights. This includes use cases such as hardware failure prediction for maintenance optimization and downlink throughput maximization.

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

The proposed solution will improve the efficiency and resiliency of the satellite communications infrastructure by enabling NASA to smartly leverage their networks and a global hybrid network of satellite communications ground stations. This product will apply data science and machine learning to support decision making in the cognitive scheduler to facilitate RF antenna utilization and reliability.

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

Commercial applications are very similar to USG applications in that the demand for data from space is increasing, ground stations are limited, and adding capacity is costly. Maximizing the use of existing infrastructure offers significant cost savings and effective use of underutilized assets. Therefore, the non-NASA applications of this technology are essentially the same.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.09-1352**

SUBTOPIC TITLE: Cryogenic Systems for Sensors and Detectors

PROPOSAL TITLE: High-Performance Recuperators for Low-Temperature Turbo-Brayton Cryocoolers

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

Future astrophysics missions require efficient, low-temperature cryocoolers to cool advanced instruments or to serve as the upper-stage cooler for sub-Kelvin refrigerators. Potential astrophysics missions include Lynx, the Origin Space Telescope, and the Superconducting Gravity Gradiometer. Cooling loads for these missions are up to 300 mW at temperatures of 4 to 10 K, with additional loads at higher temperatures for other subsystems. Due to low jitter requirements, a cryocooler with very low vibration is needed for many missions. In addition, a multistage cooler capable of providing refrigeration at more than one temperature simultaneously can provide the greatest system efficiency with the lowest mass. Turbo-Brayton cryocoolers have space heritage and are ideal for these missions due to negligible vibration emittance and high efficiency at low temperatures. The overall size, mass, and performance of Brayton cryocoolers are highly dependent on the technology employed in the recuperative heat exchangers (e.g., recuperators). On the proposed program, Creare plans to develop an advanced compact, lightweight recuperator focused on the low temperature range of the Brayton cryocooler. In Phase I, we will perform design assessments, fabrication trials, and demonstration testing. In Phase II, we will build and demonstrate an advanced recuperator for cryocoolers operating at temperatures down to 4 to 10 K.

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

The successful completion of this program will result in an extremely efficient low-temperature cryocooler with negligible vibration. This type of cryocooler is ideal as the upper-stage cryocooler or primary cooler for cooling advanced, low-temperature space instruments. Potential NASA missions include Lynx, the Origin Space Telescope, and the Superconducting Gravity Gradiometer.

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

The military market for the cryocooler technology is for cooling hyperspectral imaging systems on space-based observation, surveillance, and missile defense systems. Commercial applications include cooling communication satellites; superconducting instruments, digital filters, and magnets; low-temperature gas-separation systems; hypercomputers; and superconducting quantum interference devices.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.08-1769**

SUBTOPIC TITLE: Suborbital Instruments and Sensor Systems for Earth Science Measurements

PROPOSAL TITLE: Compact Imaging Spectropolarimeter Based on Multifunction Meta-optic

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):

Metamaterial optics provide dramatic reductions in size and weight compared with traditional optics. Nanohmics is developing a low-SWaP imaging spectropolarimeter using an ultrathin, microfabricated multifunction meta-optic. Because of their extremely low size and mass, these low-aberration optics will be ideal for sensors and imagers in SWaP-constrained vehicles, such as for suborbital Earth science measurements including atmospheric aerosol absorption and scattering. The proposed imaging spectropolarimeter combines a single multifunction meta-optic with a commercial off-the-shelf (COTS) focal plane array. The team recently demonstrated a multifunction meta-optic that focuses light and simultaneously analyzes both spectrum and polarization state, including all 4 Stokes parameters, degree of linear polarization (DoLP), angle of linear polarization (AoLP), and other parameters used by NASA to study light scattering in the atmosphere. Phase I will demonstrate the feasibility of low-SWaP, high-performance suborbital sensors based on multifunction meta-optics by fabricating a breadboard imaging spectropolarimeter using a single meta-optic. Laboratory testing will advance the breadboard to TRL 4. The team will build upon recently developed design, simulation, and fabrication methods. Phase II will include laboratory and airborne testing of a TRL 5 prototype and will extend operating spectral band from near-infrared (NIR) to include visible (VIS). The team will plan for low-cost suborbital monitoring within NASA's Earth Science Division (ESD) and Science Mission Directorate (SMD). Longer term, imaging spectropolarimeters can leverage multifunction meta-optics in all spectral bands, making them valuable for NASA imaging and monitoring missions – both suborbital and in space – and applications in the military, industrial, energy, medical, and consumer sectors. Standard microfabrication techniques will keep costs low and accelerate commercialization.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The low-SWaP imaging spectropolarimeter will provide low-cost suborbital monitoring for NASA ESD and SMD, including Earth science atmospheric composition monitoring. Mounted on airborne and other suborbital vehicles, it can provide measurements of spectrally resolved atmospheric aerosol absorption and scattering – initially in the NIR spectral band but extensible to VIS, mid-wave infrared (MWIR), and other spectral bands – to provide data for satellite validation and finer scale process studies made possible by increased spatial resolution.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The advanced capabilities and low SWaP of sensors based on multifunction meta-optics will make them valuable for a wide variety of applications and customers, including the military, industrial, energy, medical, and consumer sectors. With size and mass less than 10% of that of existing spectropolarimeters, they will be suitable for observation satellites and unmanned aerial vehicles (UAVs).
Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.04-3261**

SUBTOPIC TITLE: Integrated Science Mission Modeling

PROPOSAL TITLE: A Library of Reusable NASA SysML Models

Small Business Concern

Firm: **Tietronix Software, Inc.**
Address: **1331 Gemini Avenue, Suite 300, Houston, TX 77058**
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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 demonstrate the feasibility of building a NASA-wide SysML Reusable Library Architecture and Management Tool. The need for a library of re-usable model elements is critical in order to support future space missions by making model development cost effective. NASA centers are using Model Based System Engineering (MBSE) and creating Systems Modeling Language (SysML) representations of their systems. The proposed NASA-wide reusable SysML library effort will investigate the feasibility of consolidating these multiple models to better understand and prepare for model reuse across the agency. An effective SysML reusable library is one that provides the user with the ability to locate model elements relevant to their needs. There needs to be a library architecture with a taxonomy that supports the multiple NASA space system models. There needs to be a library management tool to allow storing, searching, and accessing the SysML model taxonomy that returns models or model elements that pertain to the user's modeling needs. The proposal will deliver a blueprint of a taxonomy that will support the different types of model elements and additional facets, building off our initial efforts with preliminary library architecture and facet

identification. The envisioned library will expand the taxonomy to include additional classification for space systems, e.g., satellites and autonomous systems.

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

NASA's Gateway and Artemis program as well as its ambitious program of innovative planets robotics missions will rely on effective MBSE effort. The Phase I proposed concept will be developed to support new manned space vehicles and planetary surface habitats that NASA plans to develop, as well as Lunar habitat and advanced ISU structures and robotics systems. In the short term, the system can be used for NASA projects such as CubeSat missions, Gateway Lunar Rover, advanced life support systems, and Crew Health and Performance system.

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

The Department of Defense (DoD) have large complex systems that use the MBSE approach and can therefore benefit from a library of reusable SysML models. Our system can significantly reduce the costs related to developing new complex systems in DoD funded projects. Our concept can be also used in a broad range of commercial areas, such as automotive, airline and power plant systems.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.03-3308**

SUBTOPIC TITLE: Energy Storage for Extreme Environments

PROPOSAL TITLE: High Temperature All Solid-State LiAl-CO_2 Batteries for Venus Missions

Small Business Concern

Firm: **Talos Tech, LLC**
Address: **274 Quigley Boulevard, New Castle, DE 19720**
Phone: **(302) 332-9236**

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 planet Venus is an interesting target for scientific exploration. However, long-duration missions to the surface of Venus present a significant challenge to the power system due to its ambient temperature (390 to 485^{o}C) and high average surface pressure of carbon dioxide (92 bar). Therefore, conventional power technologies including photovoltaic power systems and the conventional batteries could not meet the requirement for Venus surface application. **TalosTech LLC** and **University of Delaware** propose to develop a high temperature all solid-state LiAl-CO_2 battery with superior specific energy by using a high performance cathode, an innovative tri-layer solid state electrolyte framework, LiAl metal anode, and ambient carbon dioxide at Venus surface as a reactant. During Phase I, the team will demonstrate the feasibility of the high temperature all-solid-state LiAl-CO_2 battery with superior specific energy (948 Wh/kg). The successful development of this technology will provide a high energy battery operating 100-600^{o}C, which can be operated on the Venus surface for more than 60 days.

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

Because of the benefits of the proposed battery system in terms of superior high energy, low cost, simple system, high stability, long life, wide operation temperature, and low self-discharging rate, it can be used on the Venus surface for both short and long durations. This low-cost and simple system also can be used for other planetary exploration missions where there is enough CO_2 in ambient atmosphere.

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

This proposed LiAl-CO_2 battery system can efficiently convert CO_2 into solid carbon or CO with generating electricity efficiently. The LiAl-CO_2 primary battery can be redesigned to Na/K-CO_2 battery which could provide 1) a cost-effective and eco-friendly CO_2 fixation strategy 2) high efficiency renewable energy storage method.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z4.04-2281**

SUBTOPIC TITLE: Real-Time Defect Detection, Identification, and Correction in Wire-Feed and Fused-Filament Additive Manufacturing

PROPOSAL TITLE: Wire-Feed Additive Manufacturing Process Control Solution with Defect Detection, Identification and Correction

Small Business Concern

Firm: **Applied Optimization, Inc.**
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Phone: **(937) 431-5100**

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 research objective for Phase I is to demonstrate feasibility to: (1) Incorporate sensor data feedback and utilize software tools and computation resources to demonstrate feasibility of a real-time closed-loop solution for WAM; (2) Evaluate the potential impact of the detected build defects on WAM part performance; (3) Detect, identify, and correct build defects for the WAM fabrication of a square coupon of alloy 316 stainless; and (4) Develop a Phase II plan. There are five deliverables: (1) Demonstrate sensors capable of operating in the build environment and software tools that can be integrated in the WAM printing workflow; (2) Generate safe processing window and a process map for WAM; (3) Demonstrate the timeliness of defect detection, its impact on part performance, methods for defect correction; (4) Validate the ability to detect, identify, and correct build defects; (5) Develop Phase II plan to apply the WAM real-time, closed-loop solution to full scale production for a large, complex part of current interest to NASA.

The significance of proposed work to WAM is due to five innovations: (1) An intra-layer controller will be used to maintain smooth metal transfer; (2) Lack-of-fusion and porosity defects will be detected and identified on the basis of anomalies in the in-situ sensing data and melt pool objective metrics, which are dimensionless ratios of melt pool dimensions, overlap between tracks, remelt depth, etc. These objective metrics will be generated using WAM process simulation results and its calibration data; (3) Impact of defects will be calculated as reduction in dynamic properties; (4) Modification of print parameters to correct defects will be obtained using WAM melt pool objective metrics; (5) Local or spot melting will be used to correct lack of fusion and porosity. The purpose these innovations is to allow physics-based knowledge gained via real-time process control for one part to be reused to produce another part.

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

The proposed work on physics-based, closed-loop control of WAM has direct applications in NASA for the production of low-cost liquid rocket engines and large rockets. In addition, the ability to correct defects has next generation applications under the Space Technology Mission Directorate efforts for Lunar and Mars missions for in-space repair, on-orbit assembly, and space-based AM structures due to limitations on the ability for post-deposition inspection and rework to correct defects.

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

The proposed work on physics-based, closed-loop control of WAM has direct non-NASA applications such as the sustainment and repair of commercial jet engine components, airframe rib-web structural parts, and complex structures with internal channels. New applications are for functionally-graded, multi-material components, and for WAM with advanced materials (e.g., high entropy alloys).

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z8.11-2180**

SUBTOPIC TITLE: Artificial Intelligence (AI)/Machine Learning (ML) for Small Spacecraft Swarm Trajectory Control

PROPOSAL TITLE: TeamAstro: Coordination and Sensing for a Team of Spacecraft Swarm

Small Business Concern

Firm: **EpiSys Science, 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):

We believe that increased autonomy and intelligent computing via multiagent AI will "further reduce the burden and cost of the ground segment and mission operations in CubeSats" through "onboard data processing, autonomous systems, and navigation" as quoted in the 2016 Study Report *Achieving Science with CubeSats: Thinking Inside the Box*. The Decadal Survey identified scientific observation and sample return as a priority. We propose our new TeamAstro as a multiagent AI for spacecraft team coordination and sensing for science return. TeamAstro contributes to increased capabilities on each spacecraft and as a team of spacecraft swarm, increased autonomy in decisions and local actions, and thus minimized communication and control bottleneck with Earth. Our innovation TeamAstro constitutes (1) a derivative of a single DeepMind's MuZero for spacecraft application with

stringent space domain constraints of orbits, fuel, etc.; (2) enabling *heterogeneous* single MuZero agents to work *together as a team*, constituting our new TeamAstro, via attention mechanism and coordination graph learning, while keeping MuZero's rules-discovery and Monte-Carlo Tree Search (MCTS) value search, and (3) a design reference Mars mission of TeamAstro for coordinated remote sensing between multiple spacecraft. Based on the goal configuration of the spacecraft swarm and the baseline trajectory in training datasets, TeamAstro will design detailed trajectories considering the observation/control uncertainties and constraints to reconfigure the original swarm configuration to a new one. In this case, the actions would be the thrust firing sequence of each swarm spacecraft at each time, the states would be the spacecraft position/attitude and their velocities, and the reward would be defined based on the achievement of the goal configuration. The training can be performed on the ground beforehand so that the new-optimal policy can be executed on board with a limited computational resource.

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

Our innovated TeamAstro multistep lookahead rules-discovery multiagent algorithm will be of interest to commercial SmallSat companies as it enables more autonomy and decision making on board for both payload operations, sensor operations, energy/fuel management, and self-preservation. We plan to team up with DigitalGlobe or Teledyne Brown Engineering to improve on on-board autonomy and decision making to more efficiently return observations valuable to NASA. Together we will approach NASA via Commercial SmallSat Data Acquisition (CSDA) Program.

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

There is a growing need for satellite swarms for regional-coverage satellite constellations, which require a smaller number of satellites and reduced system costs. Target applications are remote sensing and docking, local high-speed Internet access constellations, localized high-bandwidth disaster response coverage, and localized bandwidth support for logistics.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z4.05-2305**

SUBTOPIC TITLE: Nondestructive Evaluation (NDE) Sensors, Modeling, and Analysis

PROPOSAL TITLE: Rapid Inspection of Additively Manufactured Aerospace Components

Small Business Concern

Firm: **Radiation Monitoring Devices, Inc.**
Address: **44 Hunt Street, Watertown, MA 02472**
Phone: **(617) 668-6801**

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):

Additive manufacturing is of great importance to many NASA missions due to its versatility and fast fabrication capability. In particular the fabrication of Inconel steel as well as plastic parts are relevant to the production of aerospace components. These parts often can contain voids and intra-granular impurities that lead to critical flaws that reduce performance in terms of strength and durability. These critical flaws can be volumetric or fracture-like in nature and are difficult to detect in the finished part. The goal of the proposed research is to develop a non-destructive method to not only detect and quantify these defects, but also to correlate the results to the expected strength and fatigue life of the part. To accomplish this, we will utilize complementary non-destructive evaluation (NDE) modalities and machine learning (ML) to document critical flaws. The analysis of scanned parts will be independently performed, and the data will be correlated to the NDE observations. The data from a large number of additively manufactured aerospace components will be used to create a training set for machine learning to provide a high-speed inspection process. The Phase I program will demonstrate feasibility of our novel method whereas the Phase II program will logically extend Phase I research to implement a practical system.

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

The evaluation technique along with the machine learning algorithm we propose is a viable method for rapid inspection of additively manufactured aerospace components post production. The development of this technology will not only address immediate needs relevant to NASA missions, but will also have substantial impact on non-destructive inspection in general.

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

Additive manufacturing is a rapidly growing fabrication method which is applicable to many industrial applications. This novel evaluation process to be developed under this program will have immediate benefits to other original equipment manufacturers (OEMs) by removing the need to inspect components by destructive means.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z7.01-2905**

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

PROPOSAL TITLE: PIC Optical Network for High-Efficiency Navigation Doppler Lidar

Small Business Concern

Firm: **Psionic, LLC**
Address: **1100 Exploration Way, Hampton, VA 23666**
Phone: **(833) 774-6642**

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 Navigation Doppler Lidar (NDL) is used during the phase of Entry Descent and Landing (EDL) in which terrain-relative decisions and final preparations for landing are made. Lander maneuvers include vehicle reorientation to facilitate surface relative sensing, using propulsion to divert away from sensed hazards, or navigate to designated landing site. During EDL, precise knowledge of the spacecraft state, as well as the properties of the landing area, are critically important. An innovative NDL is proposed that significantly reduces power, mass, and volume, while improving system performance, meeting or exceeding requirements for precision GN&C. The proposed innovation fuses a high power capable electro-optic system-on-chip into the NDL fiber lidar network to create a unique lidar ideally suited for ranging and 3-axis velocimetry. Additionally, more options are available in terms of telescope mounting, redundancy, and sensor measurement availability during different stages of a landing trajectory.

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

The NDL is one of several sensors base-lined at NASA for lander GN&C subsystems, as it shows great promise to aide in navigation of the vehicle autonomously to lunar touchdown. The significant innovative advances proposed here reduce size, mass, and power, increase sensitivity, and offers more options that will cover a wider range of vehicles and trajectories. The compactness also opens possibilities for applications in rendezvous and docking, or small lunar hoppers.

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

The reduced size and increased efficiency of the proposed architecture will also offer a reduction in cost and an increase in reliability. For those reasons, commercial lunar landers will benefit from this development. On earth, the new architecture opens many possibilities and applications in autonomous navigation of air and land vehicles, for the consumer and for the military.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.08-2979**

SUBTOPIC TITLE: Suborbital Instruments and Sensor Systems for Earth Science Measurements

PROPOSAL TITLE: A Particle Phase Spectrometer for Cloud Microphysics Research

Small Business Concern

Firm: **SPEC, Inc.**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 7
Technical Abstract (Limit 2000 characters, approximately 200 words):

Satellite microphysics retrievals rely on in situ measurements to tune and validate their algorithms. Particle imaging probes have been the most reliable in situ instruments for identifying the shapes of cloud particles, thereby distinguishing (non-spherical) ice particles from (spherical) water drops. However, improvements in the pixel resolution, number of gray-levels and software processing of the particle images are required to take these measurements to the next level. Here we describe a new optical probe that vastly improves the ability to automatically identify and classify ice particles and water drops in mixed-phase clouds. The Particle Phase Spectrometer that SPEC will design and test in the laboratory in Phase I will integrate three optical instruments into a single package: 1) a very high-resolution (1-µm pixel resolution) digital camera imaging system, 2) a 10-µm 2D-Gray optical array probe and 3) a forward scattering probe that sizes particles from 2 to 50 µm. The Particle

Phase Spectrometer will provide unprecedented, high-resolution digital images that will be capable of distinguishing spherical from non-spherical cloud particles as small as 10 microns.

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

The Particle Phase Spectrometer will provide vastly improved ice particle and water drop size distributions in mixed-phase clouds, which constitute about 40% of clouds globally. The Particle Phase Spectrometer will also distinguish spherical from non-spherical particles in cirrus and sub-visible cirrus clouds. The improved microphysics retrievals from satellites will aid NASA in monitoring our changing climate.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The microphysical measurements will be used to validate satellite retrievals and improve calculations of radiative forcing by clouds, a critical factor in monitoring climate change. There will be a substantial benefit to both industry and society from an improved understanding of climate change.
Duration: **6**

PROPOSAL NUMBER: 21-1- **H12.03-1100**

SUBTOPIC TITLE: Portable Spatial Disorientation Simulator - Trainer

PROPOSAL TITLE: Galvanic Disorientation Simulation Trainer (GDST)

Small Business Concern

Firm: **Soterix Medical, 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):

Astronauts experience changes in vestibular function while in a microgravity environment, which leads to illusory motion causing spatial disorientation upon g-level transitions. This impairs piloting performance during landing and will pose further safety risks in future lunar and planetary missions while landing and performing tasks post-g-level transitions. We propose a wearable device that applies galvanic vestibular stimulation (GVS) to induce spatial disorientation in response to head-tilt, to artificially replicate the sensation astronauts experience upon g-level transitions. GVS waveform parameters will depend upon tilt orientation and angular velocity as detected by an IMU. The device will comprise multiple electrodes capable of inducing illusory motion in both pitch and roll axes. It will be used by NASA and other government and private agencies to train astronauts in performing shuttle landings and other tasks while experiencing head-tilt contingent spatial disorientation. During Phase-1 we will adapt an existing portable constant current stimulation design (that incorporates an in-built IMU) into a first functional GVS disorientation trainer. The current prototype is single channel, wirelessly charged, has data logging capability and provides full control via a bluetooth connected smartphone app. We will adapt it into a 2-channel version to allow simulating pitch and roll tilt and incorporate additional features to fully meet the stated deliverables of the solicitation. Phase-1 will establish a laboratory version of the disorientation trainer culminating in pilot testing with up to 3 participants. We expect a TRL of 4 by the end of Phase-1 and TLR 6 by the end of Phase-2. This technology addresses NASA's Human Research Program's need for improving human behavioral performance and risk reduction. It will improve astronauts' performance during landing and tasks post-g-level transitions.

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

We expect NASA to use our device for training astronauts as well as intermittently afterwards for performance maintenance, since all other proposed solutions for spatial disorientation (e.g. preconditioning astronauts for landing by creating artificial gravity in space using a centrifuge) are impractical for multiple reasons. Efforts are underway to form a permanent human presence on the Moon. This will require many well-trained shuttle crew members, increasing the usefulness of our technology.

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

In the advent of a lunar economy, private companies will train astronauts with our device to perform landings and post-g-level transition tasks. Also, our technology will be used for training military and commercial pilots for spatially disorienting flight maneuvers. Furthermore, our programmable GVS-IMU device can be developed into a balance prosthesis for those with certain vestibular disorders.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z7.04-1831**

SUBTOPIC TITLE: Landing Systems Technologies

PROPOSAL TITLE: Multiphase Hypergolic Combustion Simulation Tool Based on Algebraic VOF and Compressible Flamelet Methodologies

Small Business Concern

Firm: **Streamline Numerics, 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 innovation proposed is an advanced multiphase hypergolic combustion simulation capability in a computational fluid dynamics (CFD) tool called Loci-STREAM, to improve the understanding of hypergolic ignition and transient flame dynamics which would enhance NASA's ability to simulate engine-start, main-stage and shutdown characteristics of hypergolic engines. The key objectives of this work are: (1) demonstration of the suitability of compressible flamelet-based models for gas phase combustion of hypergolic propellants, (2) development of a spray combustion capability based on Lagrangian Particle (Droplet) Tracking algorithm, droplet evaporation models, and secondary breakup models, and (3) development of the foundation for modeling impingement of liquid hypergolic propellant jets based on an algebraic volume of fluid (VOF) method. The computational modeling capability resulting from this work will enable us to define the interrelationships between operational parameters (e.g., flows, pressures, timing, etc.) and combustion chamber dynamic responses. The results will help designers and modelers understand relevant environments and inform test engineers of instrumentation best practices to capture relevant behaviors. The user community will also benefit by preventing damage to hardware and designing safer and more efficient start-up sequences. Specifically, the following application areas will benefit immediately from this project: (a) NASA's ability to simulate engine start, main-stage and shutdown characteristics of hypergolic engines, (b) NESC's material compatibility assessment effort involving flammability and ignition susceptibility of titanium in NTO environments, (c) NESC effort to test different materials for O-rings for compatibility with hypergolic propellants, (d) Transient modeling in Draco and SuperDraco engines developed by Space-X, (e) Improved combustion instability predictions for existing and future hypergolic propellant engines, etc.

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

(a) NASA programs such as Orion Multi-Purpose Crew Vehicle, Commercial Crew Program, Mars 2020, Europa Clipper, International Space Station and the NESC.
(b) NASA's ability to simulate engine-start, main-stage and shutdown characteristics of hypergolic engines.

(c) NESC's material compatibility assessment effort involving flammability and ignition susceptibility of titanium in NTO (Nitrogen tetroxide, a hypergolic oxidizer).
(d) NESC effort to test different materials for O-rings for compatibility with hypergolic propellants

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

(a) Draco and SuperDraco engines developed by Space-X.
(b) Agile Space Propulsion's Advanced Space Engine (ASE) line of MON-25/MMH thrusters.
(c) Aerojet Rocketdyne's R-4D family of hypergolic engines (MMH & NTO oxidizer).
(d) Army's Impinging Stream Vortex Engine (ISVE)
(e) Improved combustion instability predictions for existing and future hypergolic propellant engines.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A2.02-2693**

SUBTOPIC TITLE: Enabling Aircraft Autonomy

PROPOSAL TITLE: LiDAR-Supported Emergency Landing System for AAM Vehicles

Small Business Concern

Firm: **Barron Associates, Inc.**
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Phone: **(434) 973-1215**

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 air transportation system is on the verge of drastic change. Enabled by technological advances in areas including electric propulsion, and machine learning, emerging vehicles have the potential to drastically lower transportation costs. Vertical takeoff and landing (VTOL) capabilities enabled by distributed electric propulsion (DEP) are expanding operational flexibility, and will allow vehicles to takeoff and land in nearly any area, including dense urban areas. With autonomous and highly augmented operations on the rise, companies such as Uber and Amazon envision Advanced Air Mobility (AAM) Operations including both high-density Urban Air Mobility (UAM) and rural area operations. These AAM operations will provide rapid “air-taxi” and cargo services. Future vehicles and operations will give rise to a wide variety of new safety issues as well as require new approaches to address long-standing issues that have, to date, been handled by well-trained human pilots. Among the most important is the ability to safely conduct an emergency landing. The proposed autonomous LiDAR-supported Emergency Landing System for AAM (LELSA) emulates the perception, cognition, and decision making of expert operators to provide an onboard capability for crewed and uncrewed aircraft to accomplish the complex emergency (precautionary or forced) landing task autonomously. This LiDAR (Light Detection and Ranging) enhanced autonomous emergency landing system leverages both existing data and data acquired through in-flight perception (LiDAR) to: (1) locate potential emergency landing sites; (2) continuously generate precautionary and forced landing plans that maximize both the quality of LiDAR-based site assessment updates and the likelihood of a safe landing; (3) continuously update its on-board site assessments based on incoming LiDAR data (newly acquired knowledge); and (4) provide emergency flight plan information to the existing on-board flight computer.

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

The LELSA system directly addresses interests of the Integrated Aviation Systems Program including providing perception as well as “cognition and multi-objective decision making” capabilities (intelligent planning and execution) and a “higher degree of resilience to off-nominal conditions” (minimum risk emergency recovery). The research conducted in support of product development is relevant to NASA ARMD’s Strategic Thrusts 5 (RSSA) and 6 (Assured Autonomy). LELSA naturally fits into the NASA Advanced Air Mobility National Campaign.

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

The proposed research has a high-transition potential to other government agencies and commercial users. Among commercial users, the target market is the AAM vehicle designers and operators who require a compact off-the-shelf emergency landing system that can be easily customized to vehicle-specific performance parameters.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z1.06-1965**

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

PROPOSAL TITLE: High-Voltage Gallium Oxide Devices for Space Power Electronics

Small Business Concern

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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):

Future NASA science and exploration missions require significant performance improvements over the state-of-the-art in Power Management and Distribution (PMAD) systems. Space qualified, high voltage power electronics can lead to higher efficiency and significant SWaP-C advantage at the system architecture level and serve as an enabling technology for diverse applications.

Gallium Oxide (Ga_2O_3) is an ultra-wide bandgap semiconductor technology with superior electronic properties for high-voltage power applications. Ga_2O_3 devices offer higher temperature operation, lower on-resistance, higher breakdown voltages, and higher power conversion efficiency than Silicon power devices. However, their performance in the space environment, including high-energy radiation and wide temperature fluctuations, is largely unknown. A thorough characterization and design effort is essential for advancing this technology to meeting NASA requirements.

CFDRC, in collaboration with the University at Buffalo (UB), Vanderbilt University, and KYMA Technologies, will utilize a proven experimental and physics-based modeling approach to address this challenge. In Phase I, we will perform irradiation testing for single event effects (SEEs) of recently demonstrated 8kV β-Ga_2O_3 power MOSFETs from UB and generate measurement data for radiation tolerance. Detailed TCAD modeling of SEEs will be performed for insight into physical mechanisms behind 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 identify radiation and temperature dependent mechanisms, and device structure/process modifications for improved radiation tolerance will be investigated. Promising solutions will be prototyped and tested. Participation by KYMA in Phase II and beyond will ensure manufacturability of the space-qualified, β-Ga_2O_3 power MOSFET technology.

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

Radiation tolerant, high voltage/high temperature Ga_2O_3 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 Ga_2O_3 power electronics are applicable in DoD space systems (communication, surveillance, missile defense), commercial satellites, and nuclear power systems. High-voltage/high-temperature tolerant Ga_2O_3 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: 21-1- **H8.01-2824**

SUBTOPIC TITLE: Low Earth Orbit (LEO) Platform Utilization to Foster Commercial Development of Space

PROPOSAL TITLE: International Space Station Utilization for Commercialization of Electromagnetic Pulse (EMP) Resistant Materials

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):

GeoPlasma Research proposes to develop innovative coatings on different substrates including those currently used for space vehicles, satellites, missile systems, and avionic enclosures to address the urgent shielding needs against an Electromagnetic Pulse (EMP) attack, a threat recognized by The

White House and the House Armed Services Committee. EMP is an instantaneous energy field set off by a high altitude nuclear explosion enabled by missile flight or from a satellite. A widespread EMP effect could lead to possible long-term disruption of the nation's critical communication, transportation, and military infrastructure. NASA and US military in-space assets are also vulnerable to the effects of EMP. The current state of the art to protect against an attack is with massive shielding such as a Faraday Cage, concrete structures, and buried cables. These solutions are cost prohibitive and impractical for space assets and a multitude of terrestrial infrastructures. Specialized coatings will allow effective shielding of space assets and a more localized and cost-effective shielding for sensitive terrestrial hardware. Development of these coatings will be grounded in fundamental physics using an Artificial Intelligence (AI) based deep generative design framework that is capable of evaluating novel materials on various substrates. The primary focus of this proposal is to provide shielding capability optimized using simulation, fabrication, and testing for 1) mitigating deleterious damage to hardware from both, EMP and the harsh space radiation environment, 2) increased bond strength between coating and substrates 3) improved durability for long term space applications as will be demonstrated on NASA's MISSE platforms, and 4) light weight, low cost and ease of manufacturability. This comprehensive approach augmented by NASA's on orbit test bed will lead to potential commercial opportunities relevant to NASA, DoD, and civilian infrastructure applications.

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

The technology will benefit NASA by protecting satellites, space transportation vehicles and large space structures including Orion, Commercial Crew, Landers, and Lunar Gateway. The lightweight EMP resistant architecture, coupled with low cost manufacturing can be a significant shielding advancement for Lunar nuclear reactors. The technology can also be extended to deep space radiation shielding against GCRs and secondary particles. The anticipated NASA market will include all applications related to long-duration human travel beyond LEO.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed coating architecture has considerable interest from commercial entities supplying missiles and defensive kill vehicles. Their immediate need is for lightweight avionics boxes to protect against an EMP threat and the space radiation environment. This technology can also be leveraged into other commercial applications including neutron source containment and accelerator facilities.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z4.06-3171**

SUBTOPIC TITLE: Manufacturability Assessment as a Design Constraint for Advanced Tailorable Composites

PROPOSAL TITLE: Process Simulation & Optimization for Advanced Tailorable Composites

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 proposed innovation is a process simulation workflow for process optimization and part quality prediction of composite parts to enable tailored manufacturing processes. The proposed workflow will map physics-based process simulation of outcomes and defects with the simulation of the effects of the outcomes on part quality. Experimental linking of the two for composites has been performed in research settings, indicating promise and interest in such an integrated tool. The innovation proposed here will not only link process simulation and outcome simulation in a physics-based workflow capable of representing a wide variety of processes, it will develop the uncertainty quantification capability needed to create a robust tool capable of predicting process windows. Phase I will focus developing and validating a methodology and workflow with which to approach this problem for an example defect, proposed to be porosity that will be further developed in Phase II and expanded to other defects. Future project vision involves turning into a software tool and/or integrating capability as a feature in existing software tools like RAVEN or COMPRO for ABAQUS or ANSYS.

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

Potential NASA applications exist for aerospace groups interested in advanced tailorable composites, but as the the framework is expanded to include a wide variety of composite processes, any NASA user manufacturing composites could use the process optimization for part and process design. The ability to predict defects and the effect of defects on part performance can be used reduce risk, improve cycle time, or meet performance property requirements for costly, cutting edge parts and processes.

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

The mapping of process simulation and effect of defects analysis with robust uncertainty quantification will create a framework useful among to all composites manufacturers and researchers, including US military, OEMs and Tier 1 composite manufacturers, engineering simulation software developers, and universities.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.01-2682**

SUBTOPIC TITLE: Advanced Air Traffic Management System Concepts

PROPOSAL TITLE: Low SWaP-C RemoteID Device for UAS

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 8

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

The FAA has recently promulgated a rule for RemoteID for UASs, whereby the UAS is required to broadcast information about its ID, location, time stamp, and ground station location. This rule can be viewed as a part of the initiatives such as the AAM, UTM, and Agility Prime which are now underway at the FAA, NASA and USAF, where unmanned and manned traffic share the national airspace in a safe, reliable and efficient manner. Specifically, the RemoteID rule calls for the creation of FRIAs (FAA-Recognized Identification Areas), where manned traffic can be notified about the operation of UASs. In addition, groups involved in AAM have noted the need for being able to inform legacy users of the airspace (i.e., legacy manned aviation) of unmanned air traffic operating in their vicinity. KalScott has developed and tested a prototype of a such device that alerts pilots of unmanned operations in their vicinity, using legacy VHF airband voice comms (118-136Mhz).These messages can be readily heard by local air traffic and controllers using current (legacy) VHF airband communication radios, thus enhancing the overall safety of the system. Under this proposed SBIR, we will complete the development of the device to meet all the emerging RemoteID, UTM and AAM specifications, conduct FCC and FAA certifications via ground and flight tests, and ready the device for serial production. In Phase I, the final technical changes will be implemented and detailed tests will be conducted. In Phase II detailed ground and flight tests to support certification will be conducted, and a robust, verifiable and certifiable supply chain and manufacturing process will be created. For this project, KalScott has assembled a team that includes a reputed avionics design firm, and discussions are underway with a leader in the cellular communications industry for marketing the device.

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

NASA, along with the FAA is currently planning several methods to integrate UAVs safely into the national airspace. The proposed device will be vital part of the emerging UTM network and procedures.

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

The UAS operator community (both industrial and hobby) will benefit greatly from this device as it will allow even the smallest UAV to become compliant with the FAA's RemoteID rule, which goes into effect in 2021. Data from this device can also feed into other vehicle IoT networks to enable other new applications such as just-in-time precision delivery of goods and services.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H9.05-1639**

SUBTOPIC TITLE: Transformational Communications Technology

PROPOSAL TITLE: Parabolic Antenna Lens

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):

Data transport between space platforms and Earth is vital to NASA mission success as well as commercial enterprises ranging from remote sensing to satellite-based television, radio, or data services. Throughput and data capture in all cases is subject to the availability and performance of ground network equipment—commonly a parabolic antenna. Efficiency across designs of parabolic antennas is typically in the 50-60% range due to a variety of losses, resulting in a loss of roughly half its theoretical potential to send and receive signals. Our proposed innovation is the application of a metasurface lens which augments the performance of the antenna by compensating for the phase and amplitude errors, engineering a medium with specific refractive indices at specific points on its surface. Metamaterials, composed of periodic subwavelength metal/dielectric structures that resonantly couple to the electric and/or magnetic components of the incident electromagnetic fields, exhibit negative and near-zero refractive indices to correct for phase and amplitude errors.
A metasurface lens, created from a single-layer or minimal-layer stack of planar metamaterial structures with subwavelength thickness, can introduce a spatially varying electromagnetic response, molding wavefronts into shapes that can be designed at will, correcting the phase and amplitude response of a signal. The metasurface antenna lens is expected to result in efficiencies of 80-80% or greater depending on the antenna design. In this Phase I effort the material characteristics required for the textile metasurface will be determined through analyses, as will the approach for mounting, installation, and integration of both a textile and planar lens. Performance will be characterized through modeling and simulation. The result of the effort will be an analysis and simulation-based recommendation for a prototype design and its expected performance.

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

Application of the Parabolic Antenna Lens (PAL) to NASA ground terminal antennas and supporting commercial service providers has direct benefit to communications performance for missions. PAL can be beneficial across the full spectrum of NASA projects and missions, but may be most impactful for missions working to overcome the challenges of communicating from deep space distances. NASA could apply this innovation to existing ground terminals, without investing in new expensive infrastructure.

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

Two non-NASA markets utilize antennas which could benefit from PAL: (1) consumer equipment, and (2) the network infrastructure market. In the consumer equipment market, satellite TV or internet subscribers are target customers, motivated by a desire for uninterrupted access to content. For network infrastructure users, reliable data access represents a positive impact to revenues.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z2.01-1700**

SUBTOPIC TITLE: Spacecraft Thermal Management

PROPOSAL TITLE: Miniature passive thermal control valve for mixing or splitting single-phase fluid

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's Jet Propulsion Laboratory (JPL) developed mechanically pumped single-phase fluid loop (MPFL) thermal system for the Mars Science Laboratory (MSL) rover fluid loop that used mixing or splitting passive thermal control valve (TCV) to control the fluid flow path during different environmental scenarios. NASA has also used passively actuated TCVs in the MPFL for the past robotic space missions like Mars Pathfinder (MPF) and Mars Exploration Rovers (MER). The challenging requirements and higher cooling demands of these space missions result in increase in vehicle power and mass of the system. Therefore, the NASA is seeking for an innovation that reduces the mass/volume and increases the flow capacity of TCVs.

Kalsi Engineering will develop a miniature passive TCV utilizing its experience in developing many innovative product lines covering a wide range of sizes/pressure class by accounting and validating scalability of key design parameters by analysis and testing. The developed TCV will passively actuate in a response to a change in temperature of the working fluid and will control the fluid flow path. The same concept will be used to develop mixing and splitting TCV. The TCV will be used in MPSL systems of various NASA's space applications. The TCV developed by KEI will be lighter, smaller in size, and will have an increased flow capacity. The key components of the proposed concept include spool/plug, thermal actuator, and drive mechanism. The TCV development will include rigorous design, analysis, and testing of each components of the valve.

The Phase I deliverables will include first principles based detailed analytical model of the TCV, prediction of the valve spool flow characteristics and fluid forces using computational fluid dynamics (CFD) analyses, and verification of the spool flow characteristics and fluid forces using separate effects testing. The Phase II will include more rigorous testing and design refinements to deliver a functioning prototype.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The developed thermal control valve (TCV) will be used in mechanically pumped single-phase fluid loop (MPFL) thermal systems of various NASA's space missions/programs like, Europa Clipper, Mars

Perseverance Rover, Orion, and any future Mars, Lunar, and deep space manned/robotic exploration missions.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The developed thermal control valve (TCV) will be commercially used in mechanically pumped single-phase fluid loop (MPFL) thermal systems of various Non-NASA space exploration missions conducted by other space agencies like European Space Agency, Canadian Space Agency, and Indian Space Research Organization. Another potential application of TCV is in microsatellites thermal control systems.
Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.04-2932**

SUBTOPIC TITLE: Guidance, Navigation, and Control

PROPOSAL TITLE: LiDAR-based Navigation and Mapping for Rendezvous, Proximity Operations, Docking

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

High-fidelity relative navigation and three-dimensional mapping are key competencies to achieve a variety of mission objectives in Earth, Lunar, and eventually Martian Orbit. Developing autonomous and reliable Rendezvous, Proximity Operations, and Docking (RPOD) technologies will play a key role in the ability to build infrastructure in orbit by providing autonomous satellite inspection and servicing capabilities, among many other applications. Astrobotic, a Pittsburgh, PA-based space robotics company, proposes to further develop existing in-house technology to create the Astrobotic LiDAR-Inertial Navigation (ALIN) software package. This modular and versatile software leverages LiDAR Simultaneous Localization and Mapping (SLAM) to provide navigation and mapping capabilities. ALIN will specifically target applications requiring high fidelity relative navigation solutions to non-cooperative dynamic spacecraft, such as the inspection and servicing of satellites. Phase I will yield a prototype system featuring a space-relevant compute platform capable of real time data collection from a terrestrial grade scanning LiDAR and analysis of the system to provide a clear path forward for achieving real time mapping and relative navigation on space hardware. Phase II, if awarded, would focus on optimizing algorithmic localization, mapping performance, and timing to meet RPOD-specific mission requirements. Specifically, development would focus on improving localization and mapping under the challenging circumstances of a very sparse scene with a single dynamic LiDAR-observable object being observed from a non-inertial reference frame, as is the case in most RPOD missions. The results of a Phase II will demonstrate the viability of the ALIN software package in simulation, and with follow-on investment the system could be infused into a flight program.

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

The proposed Phase I work will lead to a prototype LiDAR-based navigation and mapping solution geared toward the satellite servicing and inspection industry. Phase II will begin working towards the development of the sensor as a flight-ready module and conducting extensive testing on flight-ready hardware. The resulting technology could become flight ready in a Phase III, providing the opportunity for early mission infusion and to perform testing and data collection on smaller cubesat style missions or on the ISS.

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

Robust GPS-denied localization and mapping capabilities have strong potential in the private sector filling the need to inspect and understand the severity of damage in hard-to-access locations. A navigation system that can safely operate in dark, unmapped locations could advance understanding of the types of necessary maintenance in facilities where GPS is not available.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H9.03-2975**

SUBTOPIC TITLE: Flight Dynamics and Navigation Technologies

PROPOSAL TITLE: Relative Orientation and Navigation (RONin) System

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):

Unlike many terrestrial applications that can take advantage of the Global Positioning System (GPS) for positioning, navigation, and timing (PNT), most space-based missions cannot use GPS. Moreover, future space-based missions will likely require multi-platform instruments, such as multi-static radar systems, to share timing. The distributed time synchronization system developed during this effort will prove to be enabling of such missions. Specifically, a novel closed-loop clock phase and clock phase rate adjustment mechanism is proposed that can provide better than 0.5 nanosecond accuracy over a wireless network of instruments. The feasibility of the proposed approach will be investigated using both simulations and hardware experiments using existing hardware. At the conclusion of the effort, a prototype design and associated algorithms will have been developed and evaluated in preparation for fabrication, assembly, testing and demonstration during a follow-on effort.

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

The Simultaneous Localization and Time Synchronization (SLATS) system is directly relevant to any positioning, navigation, timing and communication (PNT-C) system that must operate under GPS-denied conditions. This includes distributed sensor systems and collaborative manned and unmanned operations, including multi-static and bi-static radar systems.

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

Potential civilian applications for the SLATS system include emergency responders and search-and-rescue operations. Eventually, the ad-hoc RF ranging algorithms and sensor can be used by smartphones to collaboratively determine their locations in urban and suburban environments when GSP-challenged or denied.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.01-3185**

SUBTOPIC TITLE: Aerodynamic and Structural Efficiency - Integration of Flight Control with Aircraft Multidisciplinary Design Optimization

PROPOSAL TITLE: Integrated Flight Control Design and Multidisciplinary Optimization

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Multi-disciplinary optimization has emerged as a key technology required to make increasingly more sophisticated electric and hybrid-electric aircraft that require advanced CONOPS such as urban air mobility and distributed electric propulsion. Current MDO design results may take into account many disciplines in the design resulting in an optimized aircraft, only to be locally re-optimized based on engineering performed post-aircraft configuration lock related to flight control, resulting in less efficient and less capable aircraft.

Electric and hybrid-electric aircraft with distributed propulsion provide significant advantages such as significantly reduced stall speeds and dramatically increased power efficiency (>50%) (X-57). Software weighs nothing, so there always a push to move the problem downstream for controllers to manage in software, effectively trading bits for atoms. The net result may be the control system requires faster than available actuation, inadequate control authority, or large feedback gains to stabilize unstable dynamics. These issues are costly to uncover late in the system development, since typically flight controller work takes place after the configuration and outer-mode-line (OML) has been locked. It is essential to the success of hybrid and urban air mobility aircraft to include controllability of the aircraft within the aircraft optimization design.

After decades of designing and flying flight controllers for new types of hybrid and distributed propulsion aircraft, our goal is to get add a controllability component to MDO to ensure the aircraft designed make the right trades and adjustments for flight controls. Rather than throw a controller MDO cycle into the middle of the aircraft MDO, the controllability problem is broken down into a series of targeted hierarchical *Components* that contribute to the monolithic optimization suitable for the nonlinear and linear solvers in OpenMDO.

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

The proposed controllability component has far-reaching benefits, since it will become clear later in the development of new types of aircraft that control's-related constraints were accounted for. This will accelerate the urban air mobility research and distributed electric thrust by providing new designs that are more capable than ever before.

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

It often takes many years beyond aircraft MDO before the control-related issues become clear and there's not enough programmatic time or money to compensate. This has the potential to save many companies and programs. Applications include UAM aircraft, STOL distributed propulsion aircraft, and delivery drones more effective and with more stability and maneuver margin.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z3.04-2263**

SUBTOPIC TITLE: Autonomous Modular Assembly Technology for On-Orbit Servicing, Assembly, and Manufacturing (OSAM)

PROPOSAL TITLE: Decluttering Earth Orbit to Repurpose for Bespoke Innovative Technologies (DEORBIT) System for Low-Earth Orbit

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):

The Decluttering of Earth Orbit to Repurpose for Bespoke Innovative Technologies (DEORBIT) system enables increased transportation and manipulation of materials in Low-Earth Orbit (LEO). It is designed to operate on its own to calculate critical information about an unknown object in space, where it can than maneuver and mobilize the component or call on other assets from a multi-vehicle system to help perform the activity. The system is able to clear and qualify a build zone in LEO to enable safer fabrication in support of successful On-orbit Servicing, Assembly, and Manufacturing (OSAM). The system further adapts to the manufacturing process to help manipulate components in the construction process, adding value and safety both before and after the start of OSAM procedures. This makes the DEORBIT system a robust dual-purpose technology that enables more efficient OSAM processes and mitigates risks that exist in the localized build site to increase safety and feasibility in the environment.

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

DEORBIT addresses current needs for debris mitigation in space while also enabling safer and more effective OSAM practices. By locating and removing unwanted or unknown items from targeted zones in LEO, the technology is able to certify the build site for activity while also staying involved in later processes. This leads to a versatile tool for use in practices that expand beyond LEO, where the movement of resources into targeted areas allows for allocation of necessary supplies to arrive ahead of an incoming crew, shifting the risk profile.

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

The ability to clear zones in LEO and support manufacturing activities reinforces renewable initiatives for debris and materials in microgravity while opening the environment to greater expansion for technologies that require free space to operate. DEORBIT allows more controlled rendezvous efforts that enable greater movement of components and people as human expansion continues deeper into space.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H6.22-1464**

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

PROPOSAL TITLE: Neural Network Gravity Field Model

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):

Neural-inspired computing has significant implications for spacecraft onboard processing. The same innovations that currently allow consumer devices to process large data streams in real-time will, in the future, enable spacecraft to do the same, make intelligent decisions, and achieve mission objectives that are impossible with current ground-in-the-loop systems. However, new algorithms must be developed to reformulate space-related mathematical problems into a form that can take advantage of these computer hardware advances.

We propose to develop a framework for high-fidelity force fields to be modeled as artificial neural networks (ANNs). Force model evaluation is a fundamental limiting computational step in many astrodynamics algorithms, including mission planning, navigation, maneuver design, and operations planning. Engineers are typically forced to choose between accuracy and speed. Onboard implementations currently require the dynamical models to be greatly simplified to run within limited computational resources. The proposed innovation will be developed for use both on the ground and in space, benefitting space mission design, navigation, and operation. The innovation is relevant and advantageous for current computer systems, and it will become even better over time based on the direction of computer chip research and development.

When used on the ground, the proposed innovation will improve the fidelity and computational performance of standard human-in-the-loop mission design and navigation. When trained on the ground and evaluated onboard a spacecraft, the innovation will enable higher-accuracy onboard operations for lower computational demand than existing capabilities.

In the future, when neuromorphic processors are available onboard spacecraft, the framework created by the proposed innovation will allow spacecraft to retrain a dynamical model based on data received in-space.

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

The proposed innovation will provide capabilities to satisfy mission requirements for autonomous operations at the Earth, Moon, Mars, and throughout the solar system. These mission capabilities will benefit HEOMD and SMD as they provide for mission enabling capabilities related to space mission planning and operations. Tasks such as stationkeeping, constellation maintenance, collision-avoidance, and autonomous scientific operations will all be more accurate and require less computer resources.

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

Any current or future mission that needs to model gravity fields on the ground or onboard spacecraft will benefit from the proposed innovation. This includes constellations of satellites providing global connectivity, remote sensing missions, as well as national security missions. This work will enhance the underlying fundamentals of how key mathematical formulations are executed.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z3.03-1339**

SUBTOPIC TITLE: Development of Advanced Joining Technologies, Large-Scale Additive Manufacturing Processes, and Metal Recycling Technologies for On-Orbit Manufacturing

PROPOSAL TITLE: In-Space Recycling System Using Electromagnetic Levitation and Induction to Process Metal into Rods

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):

The proposed In-Space Recycling System builds upon the proven terrestrial application of electromagnetic levitation furnace technologies and the ISS Materials Science Laboratory - Electromagnetic Levitator heritage with the intent to reduce contact (with some aspects fully contactless) in metal recycling and reuse. Per the noted NASA TX12.4.6 Repurpose Processes gap and need for on-orbit servicing, assembly, and manufacturing (OSAM) our approach transforms spent components and larger structures into repurposed, useful products for on-orbit additive manufacturing, construction, and refueling.

We propose the use of multiple, software-controlled electromagnetic induction coils for the generation of gradients and minimums for 3 axis positioning control, movement through the heating elements, and into a desired shape. An array of sensors will determine accuracy of shape and position, enabling contactless heating and transport of the metal sample through the entire process.

Eight critical steps define the technical workflow:

1. Delivery of cold heterogeneous material by 3rd parties (space tugs, cutting spent stages not simulated in this proposal).
2. Introduction of heterogeneous material to foundry.
3. Heating, melting
4. Control of molten material in 3 axis space
5. Refining and alloying of varied metal types and materials (post Phase I).
6. mixing of material to a homogenous state.
7. Movement from levitation furnace to adjacent chamber(s) (post Phase 1).
8. Manipulation of molten metal and cooling into ingot or rod (post Phase 1).

The input simulants will represent the varied dimensions and mass of rough-cut raw materials from spent upper stage or structure-scale space debris. The output will be a uniform metal rod or ingot as feedstock for use in multiple potential applications such as construction, additive manufacturing, and as a propellant for spacecraft.

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

Our proposed solution enables NASA to directly support on-orbit development of the stated OSAM Missions, provide construction materials for persistent platforms, support Moon to Mars vehicle assembly, and provide fuel for any mission that makes use of metal-based fuel. In addition, the proposed solution builds upon the ISS MSL-EML, therein advancing the technology of this legacy experiment for future researchers and experimentalists.

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

Our solution enables ADR (Astroscale, Altius, Northrop Grumman) spacecraft to use propellant produced from captured debris, thus removing propellant capacity as a lifespan constraint while dramatically lowering cost per removal mission. We will supply platform builders and operators (Nanoracks, Axiom, DoD) with feedstock for construction, additive manufacturing, and an on-orbit source for fuel.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A2.01-2849**

SUBTOPIC TITLE: Flight Test and Measurement Technologies

PROPOSAL TITLE: A New Multi-Domain Sensing System for Fault Detection and Remaining Useful Life Prediction Monitoring of Lithium-ion Batteries in Hybrid and/or All-Electric Propulsion

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 seeks intelligent monitoring and prognostic for hybrid and/or all-electric propulsion systems. A key component of these systems is the energy storage sub-system in which Lithium-ion batteries occupy a prominent place. We propose a novel, accurate and cost-effective Multi-Domain Sensing System for Lithium-ion batteries capable of detecting thermal runways earlier and predicting Remaining Useful Life (RUL) more accurately than existing methods. This technology has the capability to detect incipient faults inside Lithium-ion cells in their early stages. This will enable the effective deployment of modern protection mechanisms that are proactive and act to isolate faults with sufficient time before catastrophic effects are detected. This capability is further exploited in our system to tackle the important problem of predicting the RUL of a Lithium-ion battery in a way that promises higher levels of accuracy. All this is accomplished within an Artificial Intelligence and Stochastic-based framework that will take Lithium-ion battery monitoring and prognostics to the next level. The early detection of faults combined with the more accurate prediction of their RUL will ensure lives and assets are protected while improving the operational and ownership cost of energy storage systems based on current or future Lithium-ion batteries.

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

Our technology can be used to enable proactive protection strategies to safeguard lives and assets because it can detect internal incipient Lithium-ion battery faults earlier than current methods. Thermal

runway precursors can be detected on time to avoid catastrophic accidents. Our technology also enables a new level in Lithium-ion battery prognostics and condition-based monitoring making it critical in applications where Lithium-ion batteries are used, such as the NASA X-57, vertical takeoff and landing systems, and other space platforms.

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

Hybrid/all-electric aircrafts, renewables, electric vehicles use Lithium-ion batteries for better levels of performance. The auto industry has invested $200 billion in vehicle electrification in the next four years according to AlixPartners, and this relies on Lithium-ion batteries, which are prompt to spontaneous failures, requiring better mechanisms to detect faults and predict RUL accurately.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.01-3062**

SUBTOPIC TITLE: Lidar Remote-Sensing Technologies

PROPOSAL TITLE: Compact Transmitter for Methane and Wind Measurements

Small Business Concern

Firm: **Beyond Photonics, LLC**
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Phone: **(303) 475-2088**

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):

Even though gaseous methane (CH_4) is a comparatively sparse constituent in Earth's atmosphere, it is the third most impactful greenhouse gas after water vapor and carbon dioxide, and the second most important in terms of anthropogenic drivers. Methane is some 60 times more effective than CO_2 in absorbing long-wavelength radiation, because the methane absorption lines in that part of the spectrum are less saturated and have less overlap with water vapor lines. Natural and agricultural sources of methane continue to dominate, but are difficult to separate and quantify. World-wide, rice cultivation, biomass burning, ruminant farm animals, and fossil fuel mining and usage have long been the most powerful drivers, but with climate change these sources could be dwarfed in the future by the release of enormous quantities of methane from melting permafrost and/or methane hydrates currently buried deep in ocean sediment. Innovative new remote sensing technologies need to address the atmospheric methane concentration measurement problem for NASA and other applications.

Beyond Photonics proposes to investigate specific very compact pulsed oscillator/amplifier designs near the 1.645-micron wavelengths of interest by NASA for atmospheric methane (CH_4) and potentially coherent winds in the same nominal wavelength region. Specifically, methane concentration measurement from operational platforms of NASA's choice will be our focus; this application puts particular emphasis on decreasing size, weight, and prime power (SWaP) and eliminating active laser component cooling. Particular emphasis will also be placed on ensuring that the laser/lidar designs are compatible with scaling to space qualification in future programs. Emphasis will also be placed on technical approaches with good operational flexibility in terms of pulse energy and duration, frequency agility, and application to other IR and SWIR wavelengths.

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

Potential NASA applications include quantification of atmospheric methane sources and sinks on a finer spatial scale than currently possible, immediately valuable for climate model improvement and atmospheric sciences. Coherent winds can be readily added to such an instrument for further functional enhancement and utility. Single frequency Q-switched Er:YAG lasers developed in this effort will also be applicable to aerosol backscatter measurement and Doppler winds measurement applications.

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

Non-NASA applications greatly interest Beyond Photonics in terms of low cost, compact DIAL product development, as evidenced in our use of company IRAD to further the proposed effort. These laser/lidar technologies relate to development of robust high-efficiency remote sensing instruments for commercial and military use including spectroscopy, aerosol backscatter measurements, and wind sensing.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H3.07-1485**

SUBTOPIC TITLE: Flame-Retardant Textiles for Intravehicular Activities (IVA)

PROPOSAL TITLE: Next Generation, Fire Resistant HybridSil Polyamide Fibers for IVA and Space Habitat Apparel

Small Business Concern

Firm: **Nanosonic, Inc.**
Address: **158 Wheatland Drive, Pembroke, VA 24136**
Phone: **(540) 626-6266**

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):

Through the proposed NASA SBIR program, NanoSonic and Virginia Tech will create highly flame resistant, environmentally robust HybridSil® polyamide fibers that will provide the next generation of fire resistant textiles employed within apparel fabrics used during intravehicular missions and space habitat occupation. NanoSonic's HybridSil polyamide fibers will be molecularly engineered for exceptional flame resistance through the covalent integration of precisely tailored, phase separated polysiloxane domains that rapidly transition to insulating ceramics upon fire exposure, as well as provide increased hydrophobicity for improved water repellency / hydrolytic durability, and enhanced softness for elevated comfort. During the Phase I effort, NanoSonic will synthesize a series of segmented HybridSil polyamide thermoplastics using pilot scalable synthetic procedures and empirically optimize fundamental structure-property interdependences affording optimal combinations of fire resistance, mechanical strength, and environmental durability. Down-selected HybridSil polyamides will be processed into fibers by the Chemical Engineering Department of Virginia Tech and tested for flammability within an atmosphere of 36% oxygen and pressure of 8.2 psi.

This NASA SBIR program will build from NanoSonic's high flex, fire resistant HybridSil technology, which has undergone extensive fire evaluation (ASTM E-1354, ASTM E-1321, ASTM E-84), passed the full-scale ISO 9705 room corner burn test for qualification as a "fire restrictive material" per the IMO and has an established health rating of zero. HybridSil resins have a current production capacity of 8,000 lbs. / day, a MRL of 6, and have been integrated onto combat active DoD platforms. NanoSonic is currently working with Lockheed Martin Missile and Fire Control to transition a related high temperature, fire resistant HybridSil material to Phase III pilot scale manufacturing.

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

NanoSonic's flame resistant HybridSil polyamide fabrics will have direct integration potential within apparel fabrics used during intravehicular missions and space habitat occupation.

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

Broad secondary, non-NASA applications for NanoSonic's flame resistant (FR) fabrics exist within the military and civilian FR fabric industries.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.10-1555**

SUBTOPIC TITLE: Atomic Quantum Sensor and Clocks

PROPOSAL TITLE: Low SWaP UHV chamber for atom interferometer

Small Business Concern

Firm: **Q-Peak, 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):

To meet NASA's interest in advancing quantum sensing technologies, the development and maturation towards space application and qualification of atomic systems are needed. Atom interferometers have unmatched precision for in-situ measurements of local gravity acceleration. The Size, Weight, and Power consumption (SWaP) of existing atom interferometers is a major obstacle for employing them in NASA missions. One of the main components of an atom interferometer is an ultra-high vacuum (UHV) system. UHV chambers are typically the heaviest components of atom interferometers. A light, compact, and energy-efficient UHV system will be highly beneficial for NASA missions.

In this proposal, Q-Peak is addressing the need for lighter, compact, energy-efficient UHV systems suitable for atom interferometer. In particular, we propose to use an aluminum alloy that is 30% lighter than stainless steel to reduce an UHV chamber weight. The aluminum alloy can be machined using a

metallic powder bed fusion process that removes the constraint of traditional manufacturing considerations. Furthermore, Q-Peak will focus on developing passive pumping based on non-evaporable getter pumps. Passive pumping can reduce the energy consumption of an UHV system. Other aspects of the UHV system suitable for atom cooling experiment will be addressed: bonding vacuum windows to the aluminum alloy, energy-efficient and reliable alkali-atom sources, and so on. The developed UHV system will find direct application to atom interferometers, drastically reducing their SWaP without compromising residual gas pressure and optical access.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Keeping track of the actual spacecraft position is a key part of navigation for any spacecraft. Accurate in situ gravimetry based on atom interferometry can be used for satellite-based global gravity field mapping. Atom interferometry is a potential technology to gather the type of data currently produced by NASA's Gravity Recovery and Climate Experiment Follow-On mission. Europa Clipper can use an atom interferometer for determining the most likely locations to gain access to subsurface material.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Stable and precise accelerometers and gyroscopes are required for navigation and can be used for ships and planes. They are especially advantageous in situations when GPS signal is absent and a high accuracy is required. Such devices can be of great value to the US Navy.
Duration: **6**

PROPOSAL NUMBER: 21-1- **Z2.02-1101**

SUBTOPIC TITLE: High-Performance Space Computing Technology

PROPOSAL TITLE: Fault Tolerant Computing based on a Reconfigurable Hardware/Software Architecture

Small Business Concern

Firm: **Resilient Computing**
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Phone: **(406) 451-8138**

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):

Computers that operate in space are exposed to a harsh radiation environment that causes material degradation and intermittent crashes. Current solutions to this problem include “hardening” a computer by altering the underlying semiconductor material and using non-standard circuit designs. These approaches make these rad-hard computers expensive and with performance that lags commercial computers by ~20 years. There is currently a demand from the aerospace industry for new computers that can match commercial performance while achieving the reliability needed in a space environment at a price that is not cost-prohibitive for the wide-scale adoption. This project builds on over 10 years of NASA-funded research at Montana State University on a computer architecture called RadPC. RadPC implements a comprehensive set of fault mitigation strategies on a commercial Field Programmable Gate Array (FPGA). Various sub-systems of RadPC have been demonstrated on high-altitude balloons (8x), on sounding rockets (2x), on the International Space Station, and on two small satellite missions. RadPC has also been selected for a lunar surface demonstration through the Artemis program. Through this past research, the architecture of RadPC has been refined into one that achieves the performance, reliability, and flexibility to support future space missions. However, the current prototype form of RadPC requires manual construction of the system at each step of the design process. This manual and tedious construction of the current RadPC system makes it difficult for RadPC to be adopted as a commercial product. The aim of this SBIR project is to investigate the automation of the development process for RadPC so that a developer can write programs for the RadPC architecture without being burdened with the underlying fault mitigation procedures that are being implemented.

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

- Replace ~20 year old rad-hard processors with a lower-cost, higher performance, commercial-based technology.
- Execute computationally-intensive algorithms such as real-time science data processing, autonomy, and navigation.
- Provide control & data handling for NASA small satellites.

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

- Provide small satellites computing with increased reliability and performance, but at a price-point below current rad-hard computers.
- Implement Earth image processing (climate monitoring, disaster mitigation, agriculture).
- Enable communication networks.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.02-1999**

SUBTOPIC TITLE: Quiet Performance - Airframe Noise Reduction

PROPOSAL TITLE: Flat-Package MEMS Fuselage Microphones for External Airplane Fluctuating Pressure Field 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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Phone: **(812) 204-9206**

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 Interdisciplinary Consulting Corporation (IC2) proposes to develop an ultra-low-profile, ultra-smooth sensing surface, instrumentation-grade microphone for in-flight aeroacoustics measurements using microelectromechanical systems (MEMS) piezoelectric sensing with backside electrical contacts and advanced packaging technology. This work is aimed at fulfilling the aerospace industry's need for economically viable sensing technology that meets required metrics for flight testing for a broad class of fluctuating pressure measurement use cases including noise source location, noise shielding effects, noise source interaction effects (such as engine/airframe interactions), boundary layer measurement/characterization, and high-gradient flow investigations; essentially, any on-body fluctuating pressure field problem of interest whether it includes propagating acoustics, hydrodynamic pressure fluctuations, or a combination of both. The proposed flat-pack microphones will be batch fabricated using micromachining technologies to enable low cost per device, tight phase matching, and consistent device performance. Silicon vias will be integrated into the sensor structure to enable backside electrical connection to the piezoelectric ring. The sensors will be mounted into ultra-low profile (≤1.0 mm thick) flat-pack housings along with low-power signal conditioning electronics, analog-to-digital conversion electronics, and custom fairings to enable measurements with minimal disturbance to the flow. The digital data output capability of the microphones may be serialized and converted to an optical signal for transmission through the airplane fuselage, thus eliminating the need to drive analog signals over long cables, the need to penetrate the fuselage with every signal cable, and the need for a lightning arrester for every channel to mitigate the potential impacts of a lightning strike while in flight.

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

The proposed instrumentation technology has the potential to be **usable in multiple NASA ground- and flight-test facilities** as well as **implemented across government-owned, industry and academic institution test facilities**. The target application for entry into NASA is instrumentation for

full-scale flight tests for noise source localization to evaluate noise shielding effects and engine/airframe interactions and to perform fluctuating boundary layer pressure measurement/characterization.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The initial target market is in-flight pressure sensors for the aerospace industry (commercial & government/military), or use in flight-test R&D. The Boeing Company is in a prime position as an initial market customer for the proposed innovation. Additional possible customers or parallel market entry targets comprise aircraft manufacturers as well as engine developers.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S4.03-2920**

SUBTOPIC TITLE: Spacecraft Technology for Sample Return Missions

PROPOSAL TITLE: Design, Fabrication, and Testing of an Ascent Vehicle Reaction Control System

Small Business Concern

Firm: **Ultramet**
Address: **12173 Montague Street, Pacoima, CA 91331**
Phone: **(818) 899-0236**

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):

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 design, fabricate, and hot-fire test a foam-based ignition system for hydrazine.

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: 21-1- **S3.05-3098**

SUBTOPIC TITLE: Terrestrial Balloons and Planetary Aerial Vehicles

PROPOSAL TITLE: Techniques to Support the Aerial Deployment and Inflation of Venus Aerobots

Small Business Concern

Firm: **GSSL, 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 proposed effort focuses on Deployment and Inflation, two critical Entry, Descent, and Flight phases required for successful Venus Aerobot missions. While suitable platform designs must be optimized for the science portion of the flight, they must first survive both the deployment and inflation phases. Phase I develops techniques for providing a controlled low g deployment and facilitating the inflation process by helping to align the multi-cell envelops to help mitigate potential damaged from excessive deployment shock loads or flagging during inflation. Phase I culminates with hangar tests of off the shelf deployment hardware with representative Aerobot envelop configurations to help determine the feasibility of the approach. Phase II will focus on creating mission specific prototype hardware and validating the techniques with a flight test.

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

Primary application is a Venus Aerobot Mission, but technology will be applicable to other planetary balloon efforts. Current NASA efforts are focused on developing prototype platforms for future mission opportunities, but are primarily focused on the science phase and the Aerobot's ability to perform the desired altitude maneuvers and suitable mission duration.

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

The techniques developed under this effort also apply to the fast-growing commercial operation of high-altitude platforms, specifically those requiring aerial deployments and inflations

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z3.04-1174**

SUBTOPIC TITLE: Autonomous Modular Assembly Technology for On-Orbit Servicing, Assembly, and Manufacturing (OSAM)

PROPOSAL TITLE: Evolvable Control and Testing Technologies for OSAM Robots

Small Business Concern

Firm: **ATA 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: 2
End: 3

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

OSAM promises not only to be an enabler of missions involving large space structures, but also provides opportunity for reduced cost and risk, improved mission resilience and flexibility, and extended life through servicing, particularly in comparison to the current monolithic single-launch paradigm. However, several technical hurdles will need to be surmounted before the use of autonomous robots and systems to realize OSAM can become feasible. In particular, on-orbit assembly and manufacturing activities introduce significant uncertainty into structural behavior and integrity, and this uncertainty cannot be fully characterized a priori. To address this issue, ATA Engineering proposes to develop methods and software to identify post-build structural parameters and update OSAM robot control systems to ensure stable and robust autonomous operations. The proposed technologies utilize and interface with the robotic systems but are agnostic to their mechanical design and control system architecture, making the proposed solution particularly adaptable in this rapidly progressing field.

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

OSAM activities are associated with NASA's ambitious plans for science missions and space exploration in the coming decades, as evidenced by pursuit of the OSAM-1/2 missions, sponsoring of the iSAT study, and organization of the OSAM National Initiative. Lunar missions will also benefit, as robotic construction of the lunar gateway is one of many envisioned features of the Moon to Mars campaign. Reduced uncertainty in these and future systems will enable improved control and robustness for assembly and manufacturing robots.

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

The defense industry will benefit from the ability to build large-aperture antennas and telescopes as well as platforms for space situational awareness, servicing, and other applications. In the commercial market, satellite developers are also interested in large antenna construction, and space resource mining would benefit from OSAM platforms.

Duration: **6**

PROPOSAL 21-1- **Z4.06-1281**

NUMBER:

SUBTOPIC TITLE: Manufacturability Assessment as a Design Constraint for Advanced Tailorable Composites

PROPOSAL TITLE: Manufacturing Assessment of Tailorable and Ultra-Thin TuFF Composites

Small Business Concern

Firm: **Composites Automation, LLC**
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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 develops ultra-thin and tailorable composites made from the ***T***ailorable ***u***niversal ***F***eedstock for ***F***orming (*TuFF*) material developed under a recent DARPA program. The short fiber *TuFF* material allows in-plane extension of up to 40% to create highly steerable tapes and ultra-thin ply areal weights of 8gsm and above. The materials can be processed using conventional autoclave with mechanical properties equivalent to continuous fiber composites. The effort will evaluate a new *TuFF* fabrication approach to create prepreg with locally tailored fiber orientations and evaluate steerable *TuFF* tape for automated tape placement (ATP) to create highly optimized structures to exploit maximum mass benefit potential of composites.

Preliminary experiments have demonstrated sheet/prepreg creation of aligned short fibers with locally varying fiber orientations and unidirectional short fiber tape allowing steering radius of 1-2 orders smaller compared to continuous fiber tape. Both approaches will be investigated in the proposed Phase I SBIR to create composite coupons and demonstrate the ability to control fiber orientations locally expanding the design capability of composites.

The effort will result in novel manufacturing capabilities based on the *TuFF* technology allowing fabrication of tailorable and ultra-thin composites. This will enable optimum design configurations for load-bearing structures reducing material weight with improved damage tolerance using conventional composites fabrication processes including autoclave and tape placement processing.

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

NASA has shown interest in applying thin-ply, tailorable technology in various programs. The thin-ply approach has the potential to reduce cost by 25% and weight by 30 percent compared to existing propellant tanks. Minimum weight solutions and the potential for material reuse with thin-ply and tailorable composites are also critical for deep-space habitation structures and can be used in many smaller size components such as attachment brackets, hinges, clevises, etc.

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

The general approach and specific technologies developed in this SBIR can be applied to other military platforms and commercial applications (aerospace, automotive, wind etc). These applications may require additional material testing and R&D to meet certifications and particular application requirements.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.09-1943**

SUBTOPIC TITLE: Cryogenic Systems for Sensors and Detectors

PROPOSAL TITLE: Miniature 2-Stage Hybrid (M2H) Cryocooler

Small Business Concern

Firm: **Wecoso, LLC**
Address: **6741 Brentwood Drive, Huntington Beach, CA 92648**
Phone: **(714) 222-0424**

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):

West Coast Solutions (WCS), Creare LLC, and the Georgia Institute of Technology (GT) propose the development of a Miniature 2-Stage Hybrid (M2H) Cryocooler in response to Topic S1.09, Miniaturized/Efficient Cryocooler Systems. Extending from our prior NASA and ongoing Missile Defense Agency (MDA) SmallSat Stirling cryocooler developments, we propose to add a second stage to address the topic requirements for a highly-miniaturized, two-stage cryocooler. In Phase I we will mature the concept design of a Stirling/pulse tube hybrid expander that achieves extreme miniaturization by leveraging our high resonant frequency mechanism and low impedance regenerator designs. Based on initial modeling results, the WCS M2H Cryocooler will weigh less than 1.5 kg while simultaneously providing a minimum of 1 Watt of net refrigeration at 80K and 2 Watts of refrigeration at 140K. The projected input power is 32 WAC while operating in a 300K heat rejection environment, which translates to 15.6% of Carnot efficiency.

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

The immediately benefitting NASA applications are midwave to longer wavelength infrared sensors requiring two stages of cryogenic refrigeration. Typically this means that the FPA is cooled to one temperature, say 80K, while the optics are cooled to higher yet still very cold temperature, say 140K to 160K, to reduce the background signal from the otherwise warm optics. With this technology readily extensible to 30K detector cooling, this proposal also supports VLWIR sensor cooling.

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

The non-NASA applications are essentially the same, but for different missions. Whereas the NASA applications are expected to support IR spectrometers for Earth imaging, planetary exploration on small satellites, etc., DoD is very interested in this technology for ballistic missile launch detection and other traditional military applications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.04-2421**

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

PROPOSAL TITLE: High Speed and High Timing Resolution Cycling Excitation Process (CEP) Sensor Array for NIR LIDAR

Small Business Concern

Firm: **Imaging Nanosystems, Inc.**
Address: **9191 Towne Centre Drive, Suite 355, San Diego, CA 92122**
Phone: **(619) 940-7803**

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):

LIDAR detectors are essential for both the spaceborne and airborne systems in many NASA missions. Detectors working at 1064nm wavelength are particularly important to work with YAG-based lasers, the main light source in operation. Therefore, NASA has identified the need of a 1064nm detector with enhanced photon detection efficiency (PDE), low dark noise, and low excess noise.

To achieve the goal, Imaging Nanosystems proposes a device that employs the Cycling Excitation Process (CEP), a highly efficient carrier multiplication process to amplify the photocurrent. The device combines (i) a thin layer of disorder material as the CEP gain medium deposited directly on (ii) an InGaAsP light absorption layer, and (iii) using a conduction band offset epitaxial stack to produce the properties of self-quenching and self-recovering, thus saving the need for active quenching circuits.

In this Phase I program, we will design a single photon detector based on the analysis of the absorption layer combined with the CEP gain medium by 1D and 2D simulations. The 1D simulation would complete the device structure with all layers, and the 2D analysis would consider the mesa height, field distribution, gain uniformity, and any field-crowding effect which may introduce early breakdown and gain nonuniformity. Additionally, a simple prototype device, integrating the gain medium layer with the light absorption layer, will be designed, fabricated and characterized to demonstrate single photon detection capability and low dark count rate.

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

The proposed detector is suitable for 1.064um space-based cloud profiling lidar applications. With high timing resolution and single photon detection it would find use in atmospheric profiling, planetary surface mapping, and vegetation/canopy lidar. Another application is 3D imaging flash lidar technology in NIR wavelengths, which can provide precision and hazard avoidance capabilities for landing missions to the planetary bodies and enable spacecraft autonomous rendezvous and docking with satellites or asteroids (e.g. in the Artemis program).

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

The high sensitivity, low noise detectors will serve applications in 3D sensing, LIDAR receivers, quantum communication and computation, night vision, deep space communication, and biological and medical imaging. The LIDAR receivers can be used for DOD (e.g. military autonomous vehicles, target identification) and commercial (e.g. autonomous driving, consumer devices) applications.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H9.03-2520**

SUBTOPIC TITLE: Flight Dynamics and Navigation Technologies

PROPOSAL TITLE: Real-time Hazard Detection via Deep Learning

Small Business Concern

Firm: **Astrobotic Technology, Inc.**
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Phone: **(412) 682-3282**

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):

On-board hazard detection is critical to the success of landed missions, as available orbiter data does not capture the lunar terrain at a resolution that enables identification of potentially mission-threatening rocks and craters on the centimeter-scale. Current state-of-the-art technologies in hazard detection typically use LiDAR data to address low/variable illumination conditions during landing operations, however the option to include image data can result in a hazard detection solution that is more frequently updated at a higher resolution. The proposed work applies a deep learning approach to this problem, as the highly parallelizable nature of learning-based computations naturally extends to hardware acceleration, enabling additional computational power to compute and combine hazard maps across both LiDAR and camera data. The output of this development will be a demonstration of the feasibility and performance of a deep-learning based hazard detection system that leverages both LiDAR and image data to achieve mission-speed performance on path-to-flight hardware.

The proposing team is currently developing a LiDAR-based hazard detection module for Astrobotic's Griffin Mission One to deliver NASA's VIPER rover to the lunar south pole, planned for late 2023. Techniques developed in the proposed work will benefit from the V&V infrastructure developed for this and future missions. Additionally, Astrobotic will leverage the LunaRay Suite, which is capable of generating and verifying accurate terrain data, including terrain models, photometrically accurate image data, as well as simulated LiDAR data at input locations, times, and viewing positions. As such, a large and widely varied training dataset will be produced, enabling the training of a robust network. By providing a robustly trained solution on relevant hardware, the proposing team seeks to drive forward the market of applied deep learning technologies in the space industry.

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

As landing precision requirements continue to grow with increasingly complex mission scenarios, customers will look to a flexible solution which utilizes as much data as possible to produce an accurate solution. Astrobotic's own participation in NASA's CLPS program will provide an internal customer enabling demonstration of this technology on a landed mission. With flight heritage and demonstrated successes, this system will become a sensor considered as a strong option for future missions through the CLPS and Artemis programs.

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

The ability for an airborne system to track objects in real-time may be of interest to the DOD to gain intelligence and ensure troop safety in uncertain environments. The DOD may be interested in a hazard detection system for missions landing in uncertain areas as well. Hardware acceleration for deep learning applications would find a host of applications, such as in the autonomous vehicle sector.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H9.05-2907**

SUBTOPIC TITLE: Transformational Communications Technology

PROPOSAL TITLE: Quantum Field Communications

Small Business Concern

Firm: **NanoMEMS Research, 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):

In this SBIR Phase I project, the principles of a novel true random signal generator will be addressed with the goal of proving the concept. The concept has the potential for enable secure communications while exhibiting low power dissipation, and is a strong contender for being the basis of a transformational communications technology. In particular, the concept has the potential to implement the same function with at least three orders of magnitude lower power consumption than conventional IC technologies, i.e., CMOS, which suggests applicability for minimizing system's Size, Weight, and Power (SWaP). The concept exploits the quantum mechanical field existing in a cavity due to vacuum fluctuation and random Brownian motion. The concept may be realized both using established semiconductor manufacturing know how and infrastructure as well as emerging graphene technology

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

1. Transformational Communications Technology.
2. Systems optimized for energy efficiency (information bits per unit energy)
3. Secure Communications
4. True Random Number Generator
5. Graphene-based electronics

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

1. Transformational Communications Technology.
2. Systems optimized for energy efficiency (information bits per unit energy)
3. Secure Communications
4. True Random Number Generator
5. Graphene-based electronics

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z10.01-2800**

SUBTOPIC TITLE: Cryogenic Fluid Management

PROPOSAL TITLE: RCS Tank Operations Using Cryocoolers

Small Business Concern

Firm: **Sierra Lobo, Inc.**
Address: **102 Pinnacle Drive, Fremont, OH 43420**

Phone: **(419) 332-8690**

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 proposed RCS gas generation system integrates with existing active CFM hardware to manage temperature and pressure for the propellant, vaporizer, and RCS tanks. Innovative integration with the waste heat and cooling power of the cryocoolers, an essential part of CFM hardware for long duration, cryogenically propelled missions, enables the propellant to be vaporized and heated to the required 300K and 3000psi at the necessary rates (0.1g/s for hydrogen, 0.3g/s for methane, and 0.5g/s for oxygen). Utilizing the cooling power of the cryocooler means any remaining gaseous propellant in the vaporizer tank after transfer to the RCS accumulator can be chilled and condensed. Chilling and condensing the propellant prepares the vaporizer tank for the next transfer from the propellant tank and reduces the need to vent the vaporizer tank between fill events. This limits propellant loss by reducing the number of venting events throughout the mission. Managing RCS gas generation through an on-board cryocooler reduces the mass and power requirements of the gas generation system and reduces the mass of needed propellant by reducing the number of propellant venting events.

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

- Extended cryogenically propelled lunar and Mars missions
- ISRU systems
- High-pressure gas filling for long-term, cryogenic propellant storage in space

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

- cryogenic storage dewars for medical systems
- pressure and temperature control of storage dewars used to transport cryogens

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.06-1131**

SUBTOPIC TITLE: Vertical Lift Technology and Urban Air Mobility

PROPOSAL TITLE: Advanced High Voltage Protection for Vertical Lift Technology

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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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

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

Cornerstone Research Group, Inc. (CRG) proposes to leverage recent technology advancements with digital high voltage fault protection of industrial AC and DC grid serviced infrastructure to enable safe, reliable electric propulsion power systems for urban air mobility. CRG is currently working with a Silicon-Carbide (SiC) switching technology partner for a DoD Phase II effort focused on building a full-scale hardware system to demonstrate the ability to protect aircraft secondary electrical grid for the V-22. SiC provides ultra-high speed micro-second switching with 1,500 VDC and 1,000 VAC switching capability along with series electromechanical switch providing galvanic isolation. Electronic and electromechanical switching combine to warrant established reliability fault protection for emerging aerospace high voltage electric power systems. CRG's track record of innovation in power and energy technology development including hybrid power systems, high efficiency power converters, and battery packs coupled with our partner's expertise in SiC solid state relays and fully digital circuit breaker technology will deliver successful development of a high voltage digital circuit breaker protection system meeting NASA's mission goals for safe and reliable advanced air vehicles.

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

- Safe, reliable, vertical lift technology
- Fault protection for high-power advanced vehicles
- Software defined electrical grid distribution
- Digitally controlled high energy systems

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

- Next generation electric vehicles
- Commercial vertical lift aircraft
- Digital management and protection of micro-grids

Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.07-2280**

SUBTOPIC TITLE: Electric Power Generation Via Thermionic Conversion for Hypersonic Applications

PROPOSAL TITLE: MEMS Solid State Semiconductor based Thermionic Converter (“mSSTiC”)

Small Business Concern

Firm: **Innoveering, 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 response to *NASA SBIR 2020 Phase I Solicitation Topic A1.07 "Electric Power Generation Via Thermionic Conversion for Hypersonic Applications"*, Innoveering and the University of Michigan have teamed to submit a proposal to design and develop our novel **M**EMS **S**olid-state **S**emiconductor based **T**hermi**o**nic **C**onverter ("mSSTiC") system. The Ph I goal is to design the mSSTiC into a testable prototype capable of generating a few W/cm^2 via its location at strategic locations within the hypersonic platform generating very high internal temperature gradients (DT): isolator exit, combustor, nozzle throat. The Innoveering team's innovative mSSTiC system shall meet all of NASA's requirements by providing efficient, reliable electrical power generation, utilizing an array of MEMS (MicroElectro-Mechanical Systems) based thermionic converter modules situated in an array configuration surrounding an internal component within the hypersonic platform.

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

Potential NASA application of our team's mSSTiC technology could be to integrate it into the TPS or hot structure of a hypersonic platform, placed near and around the circumference, or perimeter, of the combustor or nozzle, allowing it to absorb maximum heat flux to optimize its power generation. The current NASA Hypersonic Technology Project may allow for an opportunity to assess mSSTiC integration. This technology can be used
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Commercial and dual applications of this technology could include electrical power supplies for satellites, fuel cells and combustion engines. The 20-year market outlook for hypersonic technology is driven by NASA and the Nation's needs for hypersonic vehicles and platforms. A simple, robust and operational power generating system offers a technological advantage for enhanced vehicle performance.

Duration: **6**

PROPOSAL NUMBER: 21-1- **A3.04-2394**

SUBTOPIC TITLE: Nontraditional Airspace Operations

PROPOSAL TITLE: Weather-Aware UAM System Capacity Manager

Small Business Concern

Firm: **AvMet Applications**
Address: **1800 Alexander Bell Drive, Reston, VA 20191**

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

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

To facilitate efficient, weather-resilient UAM operations, airspace capacity management rules and airspace rationing algorithms will need to be developed and tested under a variety of inclement weather impacts, urban airspace layouts, and traffic demand scenarios. We are therefore proposing to design and build an efficient, modular, weather-aware UAM System Capacity Manager (USCM): a superfast-time, adaptable UAM system simulator with a path to a real-time Decision Support Tool (DST) capability.

USCM will store UAM route network and vertiport data ("templates") including throughput under various weather conditions, buildings, and UAM vehicle information by vehicle class. It will also use as input the UAM operators' business rules as well as airspace rationing and vertiport landing slot allocation rulesets and, lastly, traffic demand as it evolves during the day. Weather forecast will be ingested and translated into operational impacts on UAM airspace objects (traffic corridors, vertiport approach zones); derived metrics such as ride quality may also be generated. All this information will be loaded into the superfast-time UAM simulation model, the Evaluator. A single UAM system simulation run will then be triggered or, if warranted, multiple runs will be launched in parallel in the cloud, accounting for weather forecast uncertainty range and exercising the respective range of operational outcomes such as UAM network delays and closures. Rule-driven UAM system response options will also be evaluated, for instance ground delay programs or pre-planned traffic reroutes. Results will be available near-instantly.

As the standalone off-line simulation model is validated and evolves into a DST, it would contribute to maintaining efficient UAM, help coordinate operational responses between UAM vehicle operators, streamline weather-constrained urban airspace management and facilitate interaction with vertiport demand-vs-capacity management tools – in real time.

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

The proposed innovation will support NASA's Advanced Air Mobility development goal of facilitating a dynamic, weather-resilient urban air transportation system. The USCM simulation platform, with its modular design and open architecture, will be able to fit into NASA's other UAM simulation testbeds and interoperate with e.g. NASA's weather-avoidance models and UTM simulators. In a future DST capacity,

the proposed USCM or its modules could be utilized in NASA's DST-related research tools and real-time human-in-the-loop simulation experiments.

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

As a DST, USCM will help coordinate operational responses between UAM vehicle operators in real time. As an offline simulator, USCM will help develop & refine UAM airspace design, operational rules, and congestion management techniques that provide maximum efficiency under a variety of weather conditions for a variety of UAM locations. Other UAM vendors will benefit from our simulation services.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S4.04-2183**

SUBTOPIC TITLE: Extreme Environments Technology

PROPOSAL TITLE: Further development and demonstration of S-band Venus Capable Radio Transmitter

Small Business Concern

Firm: **InnoSys, 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):

The objective is to develop and demonstrate the feasibility of an S-band communication radio capable of operation at extreme high temperatures and pressures in hostile and corrosive environments. Based on our recent R/R&D success of a 2.385 GHz power amplifier stripline-based microwave integrated circuit (MIC) employing 500C capable SSVD^{TM}, for this Phase I SBIR, we will further address the 500C high temperature survivability of substrate material and associated striplines and circuit components which are also MIC and S-bands compatible. The goal is to realize and achieve an S-band communication receiver and transceiver capable of operation at extreme environments at least to 500C could be built in the Phase II effort. This proposed study directly addresses NASA's interest and need in expanding the ability to explore deep atmospheres and surfaces of Moon, planets, asteroids, and comets through use of long-lived balloons and landers. The proposed development will ensure that S-band power amplifiers and the associated critical passive circuit components are developed and implemented including the filtering, impedance matching, etc. functions of the MICs. The result and outcome will be a complete S-band integrated communication transceiver that will support extreme temperature operations without additional environmental protection such as special housings in the extreme environments of NASA missions. Although applicable to other missions, we will focus on Venus mission and the requirements for Venus' surface working condition. This mixer part of this work will also address the manufacturability of the MIC suitable for the Venus environment and ensure the radio to have high integration, high performance, high function, high reliability, small form factor, and low mass.

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

Anticipated outcome is long-life robust and reliable extreme environment communications and electronics. Once developed, there will be a family of RF and microwave integrated circuits and associated subsystems suitable for communications, radars, and related systems that can operate in extreme environment including Venus missions, atmospheric probes for giant planets. It will open up other applications including uncooled communications and electronics capable of warm environment operations of 50 to 300C in untreated air ambient.

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

The breath of the radio and associated electronics is broad and diverse for commercial applications in computing, signal processing, power electronics, RF transceivers, and in harsh environment, high to extreme temperature, and uncooled electronics for satellite communications, nuclear facilities, power plants, scientific research communities, material and geothermal processing industries, etc.

Duration: **6**

PROPOSAL NUMBER: 21-1- **H6.22-3312**

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

PROPOSAL TITLE: Record-SWaP Photonic Cognitive System: Photonic Tensor Cores for Spacecraft & Autonomous Systems Data Processing

Small Business Concern

Firm: **Optelligence, 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):

Smaller matrix multiplication for less complex inference tasks are still challenged by a non-negligible latency predominantly due to the access overhead of the various memory hierarchies and the latency in executing each instruction in the GPU. Given this context of computational hardware for obtaining architectures, it is necessary to explore and reinvent the operational paradigms of current computing platforms when performing matrix algebra, by replacing sequential and temporized operations to memory, with massively parallelized distributed analog dynamical units, towards delivering efficient post-CMOS devices and systems summarized as non-von Neumann architectures. *Within this paradigm shift the 'wave' nature of light and related inherent operations, such as interference and diffraction, enable seamless mathematical operations (e.g. multiplication) to be executed in the optical domain. Hence, photonic processors can play a major role in enhancing computational throughput and concurrently reducing the power consumption of neuromorphic platform.*

Future technologies should perform computing tasks in the domain in which their time varying input signals lay, thus exploiting and leveraging their intrinsic physical operations. There are 3 key innovations that we are considering combining in this PTC AI system, these include the (1) PTC architecture itself, which allows for a modular and scale design and incorporates multiplexing schemes such as WDM offered in photonics [Sorger Appl. Phys. Rev. 2020], (2) Photonic nonvolatile but programmable memory (P-RAM), allowing to re-write the B-matrix of the VMM or, exemplary, the kernel of a CNN. The nonvolatility and retention of state in the photonic system allows for compute-in-memory functionality, thus bypassing the memory-access bottlenecks known in Van-Neumann architectures. And (3) If the data entering the PTC happens to be electronic and digital, then DAC is needed such as a photonic parallel binary-weighted DAC.

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

The Cognitive Communications Project, through the Human Exploration and Operations Mission Directorate (HEOMD) Space Communications and Navigation (SCaN) Program, is one potential customer of this to-be-developed PTC ML system.

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

Dual use is for DOD and National Security applications (NSA) such as deep-surveillance, UAV navigation/ranging and data pre-processing at the edge of the network. The global IT market is $5.9T (data 2018), whereas photonics technologies capture about 10%. Since *Optelligence LLC* is in R&D, the average R&D investment fraction is ~15% ($~100B), with an estimated U.S. share of about 25% ($25B).

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z7.03-1703**

SUBTOPIC TITLE: Entry and Descent System Technologies

PROPOSAL TITLE: Entry and Decent System Technology – Phase I SBIR

Small Business Concern

Firm: **Valley Tech Systems, Inc.**
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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 is advancing inflatable aerodynamic decelerators (IAD) to deliver payloads to Mars, Venus, and Titan, as well as payload return to Earth from low Earth orbit. Current IAD gas inflation technologies are typically high pressure stored cold gas architectures. These systems are large, bulky, and have

life-cycle downsides such as inherent shipping complications, deployment reliability, and safety concerns. To address these deficiencies Valley Tech Systems has developed a comprehensive IAD mission scalable solid propellant proportional gas generator system design that applies our new DOD and NASA SBIR developed lightweight long duration hot gas valve technology. During this Phase I SBIR we are proposing continuing of our technology development to better meet the IAD mission with a new miniaturized rotational valve architecture. The resulting SBIR development technology will reduce System Weight and Power (SWaP) by 2x while capable of scaling across all future NASA and commercial applications. The phase I program will conduct technology trades, engineering design and analyses, life cycle risk planning with a hot fire demonstration of the new rotational hot gas valve materials and manufacturing technology.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- NASA Planetary IAD Applications: Mars, Venus, Titan
- NASA and Commercial Earth Launch System Component Recovery

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

- Advanced Missile Defense Exo Payload control for interceptor and booster ACS

Duration: **6**

PROPOSAL NUMBER: 21-1- **H10.02-2583**

SUBTOPIC TITLE: Autonomous Operations Technologies for Ground and Launch Systems

PROPOSAL TITLE: Intelligent Soft Actuators with Self-Diagnosis Capabilities

Small Business Concern

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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 project aims to utilize a new soft actuator technology to create an intelligent actuator with self-diagnosis capabilities. Specifically, Artimus Robotics will develop and demonstrate the use of embedded capacitive sensing in their core technology, HASEL actuation technology, to predict and avoid failure. HASEL actuation technology is an electrically controlled, analog, and highly compliant soft actuation system that can be customized for a variety of performance requirements, functionalities, and use cases.

HASEL actuation technology with self-diagnosis capabilities will directly address a request of this subtopic: development of technologies for enhanced logistics and reliability - Intelligent devices (sensors, actuators, and electronics with self-diagnosis capabilities, calibration on demand, self-healing capabilities, etc.).

This intelligent actuator will have applications in various ground and launch systems where electromechanical devices are used. With the self-diagnosis capabilities, the HASEL actuator will be instrumental in contributing to Autonomous Operating Technologies in environments where human intervention is not feasible. The self-diagnosis capabilities will help reduce operation and maintenance cost as it is expected that the self-diagnosis capabilities will be used to inform and mitigate impending failure events while still conserving operation conditions, and thus extend lifetime of the device to increase utilization.

The key technical objective is to demonstrate the ability to extend the lifetime of a HASEL actuator by monitoring the impedance, recognizing predetermined indicators of failure, and adjusting the driving signal accordingly. The intelligence of the HASEL actuator will be realized through temporal impedance measurements and informed through extensive experimentation to build out large datasets required to find statistically significant indicators of failure.

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

Artimus Robotics intends to implement HASEL actuation technology into AOT ground systems that do not currently support Health Determination and Fault Management, enabling prediction, prognosis, and anomaly detection of system and component failure/degradation. An intelligent HASEL actuator with self-diagnosis capabilities will allow actuators used in space applications to adapt to their ever changing environments and prolong its lifetime.

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

Artimus Robotics will commercialize a HASEL conveyor brake to replace current pneumatic systems that limit control and integration into the industrial internet of things. This product will provide automated conveyor systems, and by extension, industrial markets, with

componentry that is electric, intelligent, and controllable enabling self-diagnosis for failure and anomaly prediction.

Duration: **6**

PROPOSAL NUMBER: 21-1- **Z5.04-2957**

SUBTOPIC TITLE: Technologies for Intravehicular Activity Robotics

PROPOSAL TITLE: DISCO-RECOVERY: The Recursive Organization of Dynamical Systems in Vehicular Caretaking

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 next generation of NASA missions such as Gateway will benefit from having effective intravehicular (IVA) robotic caretakers that can support science operations and can tend to the

spacecraft when only intermittently crewed. While a number of NASA robotic systems such as Astrobee or Robonaut 2 have been developed to function as such potential caretakers, many technical questions remain on how to effectively coordinate their activities in conjunction with each other, with the spacecraft command and controls systems (environmental, power, avionics, thermal, propulsion, etc.), and with the activities of human crew (when available). In response to this need, TRACLabs proposes to develop a software framework that draws upon principles of dynamical systems theory to ground ontological representations that can support autonomous caretaking and payload activities. We call this system DISCO-RECOVERY (*DISCrete-event Ontology for the RECursive Organization of VEhicular & Robotic activitY*). The goal of this work will be to investigate how these typically disparate formalisms can complement each other and support a common framework for expressing the behavior of the systems (robots and spacecraft) that must be coordinated to ensure proper operation.

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

The proposed effort will specifically targets the operations of spacecraft such as Gateway that may only be crewed as little as one month a year. The goals of DISCO-RECOVERY have much synergy with the ongoing NASA *Integrated System for Autonomous and Adaptive Caretaking* (ISAAC) effort, though will generally be useful for further cislunar and lunar missions (e.g., Artemis). Having transitioned past SBIRs to a Phase III status, we are optimistic that this work will inspire similar investment by NASA programs.

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

We will market DISCO-RECOVERY first to existing TRACLabs customers in aerospace, energy, automotive, and defense sectors as autonomous maintenance, operations, and coordination between heterogeneous teams of robotic and electronic assets is a key goal in each of these sectors, including via "lights-out" factories.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S2.02-3221**

SUBTOPIC TITLE: Precision Deployable Optical Structures and Metrology

PROPOSAL TITLE: Novel CTE Tuning of Ultra-Stable ALLVAR Alloy Struts for 10m to 20m Telescopes

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):

This NASA SBIR Phase I proposal is in response to the need for Ultra-Stable Telescope Structures at 10m to 20m length scales and is designed to scale ultra-stable ALLVAR Alloy struts from cm-length to m-length scales. Additionally, a novel method for tuning a strut's CTE without changing the strut's length will be validated for their potential use in space-telescope structures critical to NASA's future missions. Telescopes used for astrophysics, exoplanet, and planetary studies require picometer stability over several minutes to hours. Building large support structures with picometer level stability is a challenge with currently available materials such as carbon fiber composites due to their high cost and moisture expansion. ALLVAR Alloys offer a new material solution for thermally stable structures. They exhibit negative thermal expansion and can compensate for the positive thermal expansion of other materials to stabilize a telescope. Bars with thermal stability approaching Zerodur's® have previously been made by joining ALLVAR Alloys to commercially available Titanium alloys and struts exhibiting pm-level stability have been fabricated and tested. This Phase I project is designed to leverage this previous development to create the first large scale ultra-stable ALLVAR Alloy structures and develop a brand-new method for tuning its CTE. If successful, this new technology could enable CTE tuning of fully assembled ultra-stable structures in-situ. The Phase I project would fabricate and characterize a ~2m long strut segment in preparation for larger scale manufacturing and testing in a Phase II project.

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

New large-scale materials with picometer stability and CTE tunability can potentially improve support structures for optic systems critical to NASA's Science Mission Directorate including LUVIOR, OST, and HabEx. ALLVAR Alloys are a truly cross-cutting technology that can impact ultra-stable coronograph hardware, support structures for deformable mirrors, telescope steering, and star trackers, and other applications in NASA's Science Mission, Space Technology, and Aeronautics Mission Directorates.

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

ALLVAR Alloy's unique negative thermal expansion properties can compensate for thermal focus shift in refractive infrared optics allowing infrared optics manufacturers to reduce the size and weight of their optics. Negative thermal expansion washers and spacers can also enable constant force fasteners that do not loosen under repeated thermal cycles.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.04-1792**

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

PROPOSAL TITLE: GeSiSn PIN detector arrays for beam alignment in coherent Doppler LiDAR systems

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 key future earth science mission for NASA focuses on the global characterization of vertical profiles of horizontal wind magnitude and direction. The “3D Winds” mission targets both coherent and direct detection Doppler wind lidars to complement one another in a hybrid lidar system in low Earth orbit. Optimum performance of a coherent Doppler wind lidar system necessitates the use of an optical beam alignment architecture, such as one of those previously described.

In this proposal, Freedom Photonics outlines a path towards improved optical alignment within an existing coherent Doppler lidar system at NASA Langley Research Center through the development of an inexpensive alignment detector system with high bandwidth and quantum efficiency, which is responsive at target wavelengths between 1.9 and 2.2 μm. Prototype Germanium Silicon Tin (GeSiSn) PIN detector arrays developed on a synergistic program are already responsive out to 2.2 μm wavelengths. Critically, the GeSiSn material can be grown directly on Si substrates, which are inexpensive to process and allow for growth on large-diameter wafers and thus large high-resolution arrays and/or large detector apertures. This program will leverage Freedom Photonics’s extensive experience in the design, fabrication, and manufacture of complex photodiodes and systems, as well as existing materials to support a rapid development effort. The overall goal of this SBIR program,

through Phases I, II, and III, is to develop, transfer to manufacturing, qualify, and transition to NASA deployment, as well as other government and commercial markets, a low cost, radiation hard, high quantum efficiency shortwave infrared photodiode array using the GeSiSn materials system, grown on a Silicon substrate.

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

Within NASA, this technology will address the urgent need for low-cost, large size, and high sensitivity SWIR photodiode arrays, addressing applications in LiDAR, hyperspectral imagers and other optical sensors, Night Vision Systems, Airborne ISR, missile tracking, through-fog observation, Driver Vision Enhancement and optical communications.

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

Following production ramp up driven by these initial NASA and Government requirements, we intend to also address the commercial markets. SWIR beam alignment arrays and cameras have commercial applications in automotive, medicine, agriculture, semiconductor inspection, spectroscopy, telecommunications and security and surveillance.
Duration: **6**

PROPOSAL NUMBER: 21-1- **A1.08-2592**

SUBTOPIC TITLE: Aeronautics Ground Test and Measurement Technologies

PROPOSAL TITLE: High-Repetition-Rate, Two-Line Kr Tagging Velocimetry for Full Boundary Layer Velocity Profile Measurement in a Single Tunnel Test

Small Business Concern

Firm: **Spectral Energies, LLC**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

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

NASA aero-science ground test facilities, including transonic, supersonic and hypersonic wind tunnels, provide critical data and fundamental insight required to understand complex phenomena and support the advancement of computational tools for modeling and simulation. In these facilities, high-repetition-rate (10 kHz–1 MHz) full boundary layer velocity profile measurement techniques are needed to track the turbulent boundary layer dynamics. Current state-of-the-art boundary measurement capabilities are really limited. This proposal offers an integrated package of truly cutting-edge, high-repetition-rate (up to 1 MHz rate), two-line KTV system for full boundary layer measurement within a single tunnel test. The proposed KTV technique will also avoid any potential model damages. The concepts and ideas proposed are ranging from proof-of-principles demonstration of novel methodologies using a pulse-burst laser pumped two-OPO system for boundary profile measurement in realistic tunnel conditions. The proposed high-repetition-rate KTV technique which is suitable for other flow parameter measurements is a state-of-the-art technique for analysis of unsteady and turbulent flows.

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

The proposed high-speed burst-mode OPO based two-line KTV technique is suitable for most wind tunnel facilities for full boundary layer velocity profile measurements, including NASA 31” Mach 10 facility, the 11-Foot Transonic Unitary Plan Facility, the Transonic Dynamics Tunnel, and 8- by 6-Foot Supersonic Wind Tunnel, National Transonic Facility (NTF), 0.3-meter Transonic Cryogenic Tunnel (TCT), and NASA HYPULSE Mach 5-25 Shock Tunnel.

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

The proposed real-time turbulence boundary layer flow tracking system could be applied in many R&D areas, such as gas turbine engines, hypersonic scramjets, hypersonic vehicles, aerospace capsules, and unmanned flights. The potential non-NASA customers could be from research facilities in DoD, DARPA, DOE and other Government agencies and universities.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S1.05-1159**

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

PROPOSAL TITLE: Silicon Carbide Grid Fabrication and Vibration Qualification

Small Business Concern

Firm: **PhotonFoils**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5

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

Single crystal silicon carbide has properties useful to a wide variety of NASA applications, such as X-ray and EUV filters, charge particle filtering, transducers, and ion propulsion. Compared with other commonly used materials, SiC has higher strength, lower weight, higher X-ray transparency, higher stiffness, higher thermal conductivity, lower ion erosion, and higher temperature capability.

PhotonFoils will produce prototype single crystal silicon carbide grids of a size and geometry suitable for planned X-ray microcalorimeters, namely X-IFU and LXM. Smaller grids will also be prepared for statistical pressure strength characterization, and for vibration testing to the NASA GEVS acceptance and qualification levels. Phase I will prepare an 88mm grid per the X-IFU TF4 88mm design rules, while Phase II will prepare 100mm and 126mm grids suitable for the X-IFU TF5 filter and the LXM DMS filter, respectively. Phase II will prepare 2-Level LXM grids analogous to the 2-Level silicon grids used for SXS. Phase II will perform GEVS vibration testing on large filters in vacuum, with geometries and sizes relevant to X-IFU and LXM launch requirements.

The proposed grids improve the durability, transmittance, and thermal uniformity of microcalorimeter filters and cooled detector blocking filters. They address identified technical deficiencies and risk items for X-IFU and LXM, namely excess power consumption and fragility.

The process used to make the grids can also be tailored to creating large area single crystal SiC membranes, with terrestrial applications such as low-scatter X-ray windows, instrumented X-ray windows, high temperature transducers, and high beam power components.

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

X-ray microcalorimeter filters, cooled detector blocking filters, grids for EUV telescopes, small telescope entrance filters, charged particle mass/energy filters, neutral atom detectors, ion propulsion, X-ray filter wheel components, stronger substrates for coded apertures, transducers

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

Safe laboratory X-ray source windows, support grids for X-ray filters, energy dissipation grids for e-beam characterization tools, X-ray transparent substrates for high power optical elements (e.g. Fresnel and Laue lenses), thermal dissipation supports for EUV lasers, low-scatter X-ray windows, instrumented diode X-ray windows, high-power x-ray beam splitters

Duration: **6**

PROPOSAL NUMBER: 21-1- **S3.03-1126**

SUBTOPIC TITLE: Energy Storage for Extreme Environments

PROPOSAL TITLE: Advanced Primary Cell Model

Small Business Concern

Firm: **Cornerstone Research Group, Inc.**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

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

NASA scientific exploration missions require battery systems to power equipment and telecommunications critical to mission objectives. NASA's mission profiles demand the highest achievable specific energy as well as operability under extreme conditions of temperature, vacuum, and radiation. While rechargeable battery technologies continue to advance the state-of-the-art to meet NASA's needs, existing primary battery cell technologies (e.g. Li-CFx) can presently address NASA missions. However, maximizing the utilization of the stored energy will need improvements in state-of-charge (SoC) and state-of-health (SoH) determination/prediction.

Li-CFx cells have attractive characteristics for NASA missions, including very high specific energy, self-heating during discharge, and radiation tolerance. However, discharge rate capability is limited, and the discharge voltage profile is a weakly correlated to SoC. Hybridization of the Li-CFx chemistry with MnO2, has improved discharge rate capability, but SoC determination and prediction remain areas needing improvement, particularly under conditions relevant to NASA missions.

An opportunity exists to advance the state-of-the-art in Li-CFx modeling by using thermodynamic computation along with multiple correlating measurements to determine and predict SoC and SoH to maximize NASA mission performance with this cell chemistry over a wide operating window. CRG proposes to develop an Advanced Primary Cell Model based on coupled thermodynamic and transport calculations combined with multiple monitoring inputs as feedback control. The Advanced Primary Cell Model will enable NASA to maximize mission operations by optimally managing primary cell battery systems over the breadth of mission operating conditions.

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

- Accurate primary cell SoC and lifetime determination/prediction over a wide temperature range
- Primary cell SoC/SoH determination from degradation mechanisms

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

- Military man-portable energy storage management
- Aerospace reserve battery management
- Medical device battery management

Duration: **6**

PROPOSAL NUMBER: 21-1- **H6.04-1677**

SUBTOPIC TITLE: Model-Based Systems Engineering for Distributed Development

PROPOSAL TITLE: INsight to Diverse Information using Graphs and Ontologies (INDIGO)

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):

INsight to Diverse Information using Graphs and Ontologies (INDIGO) will allow multiple stakeholders across program roles and engineering disciplines to easily find and visualize information represented in different modeling languages and formats, manipulated with different tools and environments, stored in multiple repositories, and distributed across multiple organizations. By combining description logic reasoning, subgraph pattern matching, and distributed ontology technologies, INDIGO will pull information from these disparate sources and present it in the context of the stakeholder that requested it and in a form that supports the activities they are responsible for performing. INDIGO will provide transformative new capabilities to support multi-disciplinary collaboration and multi-model visualization. INDIGO will deal with very large amounts of modeling data and associated information (such as analysis results) spread across multiple repositories. INDIGO will benefit stakeholders by helping them with understanding, verifying, and validating this information to support their respective efforts in the system development.

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

INDIGO addresses the NASA need for "Tools or systems that allow models to be shared across development environments and trace the resulting system model back to contributions from multiple partners while maintaining information security." Large international NASA programs such as Gateway and Artemis require collaboration between many diverse stakeholders, including subsystem vendors, integrators, and operators. These will face the model interoperability and data aggregation challenges addressed by INDIGO.

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

The non-NASA markets are those with systems that are analogous to those in the NASA market, mission-critical cyber physical systems with significant functionality captured in software. Themost near-term is the collection of Army efforts that comprise the Future Vertical Lift modernization priority.

Duration: **6**

PROPOSAL NUMBER: 21-1- **S5.05-2487**

SUBTOPIC TITLE: Fault Management Technologies

PROPOSAL TITLE: Neuromorphic Machine Learning for Fault Management for Space Vehicle Applications

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):

Natural Intelligence Systems (NIS) is proposing the research and development of a Fault Management (FM) machine learning (ML) system for use by NASA, government agencies, and commercial companies for spacecraft, transportation, and industrial applications. In this Phase 1 SBIR proposal NIS will develop and demonstrate the feasibility for using its Neuromorphic Machine Learning (NML) system to detect fault-indicative behavior while monitoring multiple inputs of a system. In Phase 1 NIS will develop a major capability of a Fault Management system, which is the ability to monitor and predict the health of a major subsystem using the system's ML model. This is the foundation for a predictive FM system that reports potential failures before they occur. NIS will use its AWS cloud Platform-as-a-Service NML System product as the development system.

The S5.05 Fault Management Technologies topic is meant to drive the development of new FM technologies. By funding this SBIR, NASA will enable the development of a suite of capabilities that result from the computational and mathematical models of this NML system. The 3rd wave properties that result from this combination of the neuromorphic model and its algorithms, the data representation and the hardware architecture enables the system to learn patterns with minimal data during training. The system does not require huge datasets with all possible failure occurrences to be gathered for training. The system is able to continuously perform unsupervised learning while inferring, thereby enabling new patterns and anomalies to be identified and classified as unknowns. The classifications can be explained, and the explanations traced back to the input features and their

ranges, thereby allowing unknown classes to be understood and labeled. The system is insensitive to noisy or missing data which is critical for FM systems as sensors degrade or fail in the space environment. These are FM technology weaknesses NASA seeks to overcome.

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

A Fault Management system based on the Natural Intelligence Systems Neuromorphic Machine Learning system will enable NASA to address several key Fault Management technology issues and limitations. FM systems implemented using the NML system will improve spacecraft resilience against faults and failures, increase spacecraft autonomy with greater onboard fault estimation and response capability, reduce and mitigate interruptions and faults, and decrease labor and time required to develop and test FM models.

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

Natural Intelligence Systems is pursuing the development of advanced situational awareness and health management systems with 3rd wave AI properties using a hardware accelerated Neuromorphic Machine Learning system on an AWS PaaS product platform for monitoring applications. Many applications exist in the transportation, aviation, manufacturing, machine tooling, and security industries.

Duration: **6**
