NASA SBIR 2023-I Solicitation

PROPOSAL NUMBER:	23-1- **A1.04-1156**
SUBTOPIC TITLE:	Electrified Aircraft Propulsion
PROPOSAL TITLE:	Enhanced Motor Performance via Two-Phase Thermal Management

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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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Thermal management presents a significant constraint on the achievable efficiency and power density of MW-scale electric motors for aircraft propulsion. High temperatures within the windings limit the maximum power density, reduce the lifetime of the winding insulation, and

increase electrical losses lowering efficiency. Innovative thermal management strategies can significantly enhance the performance of motors for electrified aircraft propulsion.

In this SBIR program, Advanced Cooling Technologies, Inc. will develop an innovative two-phase thermal transport system for high power electric motors that will augment traditional cooling solutions by efficiently extracting heat from difficult to cool areas. The two-phase thermal transport system will be fully passive, lightweight and scalable. The proposed technologies will reduce the operating temperature of the motor windings allowing for increased power density and efficiency.

Potential NASA Applications (Limit 550 characters):

The two-phase thermal management technology proposed here is relevant to several strategic thrusts outlined by NASA's Aeronautics Research Mission Directorate: "Ultra-Efficient Commercial Vehicles" and "Transition to Low-Carbon Propulsion". NASA envisions a significant shift in commercial aircraft to ultra-efficient airframes and propulsion concepts utilizing electric or hybrid electric propulsion. Improved thermal management of the proposed technology will enable significant increase in the power and torque density of electric motors.

Potential Non-NASA Applications (Limit 400 characters):

The proposed technology is applicable to various motor architectures and sizes. It will find use in passenger aircraft, unmanned aircraft, and electric vertical takeoff and landing aircraft. In addition to the aviation industry, the need for high-performing motors in electric automobiles is rapidly growing as nearly all sectors of the transportation industry begin to electrify.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S11.01-1346**

SUBTOPIC TITLE: Lidar Remote-Sensing Technologies

PROPOSAL TITLE: CoDLiR: Compact Digitizing Lidar Receiver

Small Business Concern

Firm: **Nalu Scientific, 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):

A reduction in space and power requirements for each channel of a LiDAR system would allow for a system with significantly more channels and/or a system small enough to fly on CubeSat scale vehicles. The primary method by which the CoDLiR will accomplish this goal is the integration of feature extraction, digital processing, and bias control onto one single low-power chip. For a full-scale detector, multiple channels (up to 64) would be serviced by a single chip. NSL has extensive experience with single-photon detection with extremely high timing resolution through our work with HEP collider and astrophysics experiments. We are currently developing a range of application specific integrated circuits (ASICs) for DOE Office of High Energy Physics (HEP) projects that have channel counts ranging from 4 to 64 per ASIC, which could be modified for this task specifically. These system on chip (SoC) ASICs implement built-in digital signal processing (DSP) and control interfaces that can enable precise time of flight (ToF) measurements of back-scattered laser light pulses with low light for use in orbiting or aerial LiDAR applications.

Potential NASA Applications (Limit 550 characters):

Future NASA scientific missions will require remote sensing equipment with lower power, smaller form factors, increased robustness, and higher sensitivities. Integration of LiDAR systems into a system-on-chip ASIC would achieve these goals and be of interest in numerous applications. Possible uses range from high-beam-count orbital LiDAR imaging systems to high-precision and low-power imaging sensors for planetary missions.

Potential Non-NASA Applications (Limit 400 characters):

A low SWaP-C, accurate LiDAR can be used in autonomous vehicles, both automobile and aerial systems, would benefit significantly from reduced power and size made possible by increased integration, lower return signal power requirements, and increased precision. Our technology would provide a product that could be also utilized by various industries interested in orbital geospatial mapping.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S11.01-1960**

SUBTOPIC TITLE: Lidar Remote-Sensing Technologies

PROPOSAL TITLE: Fiber-based laser transmitter at 0.95 µm band for water vapor LiDAR application

Small Business Concern

Firm: **AdValue Photonics, Inc.**
Address: **2700 East Bilby Road, AZ, AZ 85706**
Phone: **(520) 790-5468**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Based on our proprietary award-winning fiber laser technology, AdValue Photonics proposes to develop and demonstrate a novel water vapor LiDAR transmitter at 0.9 µm – a high-energy, high-peak-power, narrow-linewidth, fiber-based laser transmitter – which enables water vapor DIAL measurements in the 0.9 µm band. In the Phase I program, we will focus on the feasibility investigation of such a fiber-based, energy-scalable, pulsed laser transmitter at 935 nm for water vapor DIAL measurements. In the Phase II program, we will experimentally demonstrate this

enabling technology by developing a deliverable prototype transmitter unit of such a high-pulse-energy narrow-linewidth laser at 935 nm laser at the end of the Phase II program.
Potential NASA Applications (Limit 550 characters):

The proposed laser transmitter system in this SBIR program is a fiber-based laser solution for airborne water vapor DIAL measurements – different from the current design of NASA's HALO system – offering many advantages, such as higher efficiency, smaller SWaP, coherent detection capability, wide wavelength selectivity, compactness, and robustness. These advantages are all vital for airborne or spaceborne atmospheric water vapor measurements.

Potential Non-NASA Applications (Limit 400 characters):

In addition to the specific NASA applications for airborne or spaceborne atmospheric water vapor measurements, a high-energy, high-peak-power, fiber-based lasers operating in the NIR spectral range could be an immediate alternative to a bulky Ti:sapphire laser for many spectroscopic applications.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S11.01-2002**

SUBTOPIC TITLE: Lidar Remote-Sensing Technologies

PROPOSAL TITLE: Ozone Lidar Utilizing 308 nm and 355 nm Compact Fiber-Based Lasers

Small Business Concern

Firm: **AdValue Photonics, 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):

Both stratospheric ozone and tropospheric ozone significantly affect lifeforms on Earth. They influence the environment, the atmosphere, and the global climate. The science community has spent tremendous efforts for the observation of ozone concentration in the atmosphere. Differential absorption Lidar (DIAL) technology has played a critical role in obtaining range-resolved ozone profiles in the atmosphere. In this proposal, we aim to design and build a compact, robust, reliable, efficient, anti-vibrational, and easy-to-maintain stratospheric ozone Lidar with AdValue Photonics' unique single frequency tunable UV lasers at 308 nm and 355 nm based on all-fiberized master oscillator power amplifier (MOPA). The proposed Lidar will have the advantage of being suitable to various observational platforms with harsh environment and limited resources.

The 308 nm laser will be generated from the frequency mixing of 515 nm and 768 nm laser, which are the second harmonic generation of 1030 nm and 1535 nm laser, respectively. The 355 nm laser will be generated from the third harmonic from AdValue Photonics' 1064 nm IR laser. The amplification of the above-mentioned 1030 nm, 1535 nm, and 1064 nm lasers will utilize AdValue Photonics' proprietary silicate glass high peak power large mode field diameter (MFD) ytterbium (Yb) and erbium (Er) doped fiber amplifiers. Subsequently, we aim to implement an ozone lidar with such fiber-based light sources and obtain preliminary observation data. In Phase I of this SBIR project, we will focus on obtaining ozone observations at nighttime. It is well known that solar background radiation can cause Lidars to have low signal to noise ratio (SNR) at daytime. In Phase II, we plan to boost the power levels of the Lidar Transmitter, and possibly integrate etalons and interference filters in the Lidar Receiver to suppress the solar background to eventually obtain reasonable SNRs in the daytime for ozone observations.

Potential NASA Applications (Limit 550 characters):

The proposed compact, robust, reliable, efficient, and anti-vibrational stratospheric ozone Lidars favors NASA's intention to be able to detect ozone concentration in field observations on a variety of carrying platforms. It meets the standard of being small size, weight, and power (SWaP) so that it can survive harsh environment and consume limited resources.
Potential Non-NASA Applications (Limit 400 characters):

The proposed ozone Lidar will greatly increase the temporal and spatial coverage of ozone observations for the better of the environment, the atmosphere, and the global climate. Such demands have progressively become higher from the public community.
Duration: **6**

PROPOSAL NUMBER:	23-1- **S11.01-2397**
SUBTOPIC TITLE:	Lidar Remote-Sensing Technologies
PROPOSAL TITLE:	Lightweight, non-mechanical, polarization-independent LiDAR beam steering system

Small Business Concern

Firm: **BEAM Engineering for Advanced Measurements**
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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):

The purpose of this project is to develop techniques that make it possible to reduce the size and weight of non-mechanical LiDAR beam steering systems. Previous work has shown that LiDAR beam steering with diffractive components based on spatial modulation of geometrical phase is feasible and useful. Most previous work with this technology has concentrated on steering techniques that are polarization sensitive. Under the current project, these techniques will be extended to LiDAR beam steering that is polarization-insensitive. This would allow reduced weight and/or size of such steering systems because it would allow the LiDAR receiver to use all of the optical power returned from a target, rather than only returned radiation of one polarization. Since transitioning from a polarization-sensitive beam steering system to a polarization-insensitive beam steering system would require an increase in the number of optical substrates, the most weight benefit of such a transition would be gained if the substrate weight is minimized. Therefore, an analysis of options for lightweight optical substrates will be performed in order to make it possible to further reduce the weight of future LiDAR systems. Another related technical issue with non-mechanical beam steering is the switching speed among pointing directions. Additional system weight reduction may be possible if switching speed of the pointing system is increased beyond the speed of currently-available optical switches. Methods for leveraging recent developments in liquid crystal technology to increase switching speed will be analyzed, thereby enabling the use of higher pulse rates in LiDAR systems, which may further reduce the size and weight of these systems in some applications.

Potential NASA Applications (Limit 550 characters):

Compact, low SWaP, non-mechanical, hence, robust, LiDARs with reliable and fast data acquisition capability that meet requirements for a space landing vehicle could be used for other NASA missions including asteroid flybys, swarms of cubesats, etc. due to higher precision guidance and navigation systems. An additional potential application of this technology is to transceiver steering for free-space optical communications systems.

Potential Non-NASA Applications (Limit 400 characters):

Numerous non-NASA applications include autonomous navigation systems for cars, drones, and robots, and commercial free-space optical communications.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S11.02-1331**

SUBTOPIC TITLE: Technologies for Active Microwave Remote Sensing

PROPOSAL TITLE: Rydberg Sensor Laser

Small Business Concern

Firm: **Opto-Atomics Corp.**
Address: **1891 North Gaffey Street, Suite 223, San Pedro, CA 90731**
Phone: **(424) 477-5132**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Over the past decade, the Rydberg atom-based RF/microwave sensing technology has emerged as a promising sensing solution for a radar/radio receiver. In the Rydberg-atom-based sensing, highly excited ("Rydberg") atoms are utilized as antennas, which allows sensitive and SI-traceable detection of RF/microwave fields over a wide frequency range (1 MHz to ~100 GHz) with a single probe. However, one of the major hurdles to wide applications and field deployment of the quantum radar/radio technology is its size, weight, and power (SWaP), mostly from its system overhead (e.g., laser subsystem). In particular, the coupling laser driving the "upper" atomic transition in a two-photon excitation scheme of Rydberg atoms is not well-suited for field applications due to its SWaP and vulnerability to environmental perturbations. Furthermore, coupling lasers do not have a compact frequency reference for laser stabilization.

To address the need, Opto-Atomics Corp. (OAC) proposes to develop a Rydberg Sensor Laser (RySL), which will provide a high-power (> 0.5 W), tunable (range > 3 nm) coupling-laser output. One of the main advantages of RySL is that its output is stabilized to a built-in frequency standard, thereby allowing reliable electrometry operation with long-term stability. In addition, RySL design significantly reduces free-space optical components, making the system more compact, reliable, and less sensitive to misalignment and environmental disturbances. In Phase I, OAC will design and assemble key system components of RySL, evaluate their performance, and perform feasibility demonstrations. We will also conduct a preliminary design of the fully-packaged RySL system for future development.

Potential NASA Applications (Limit 550 characters):

In the remote sensing of Earth's surface topography and vegetation, RF/microwave sensing over a wide radio spectral range with high sensitivity may allow enhanced characterization of the surface conditions. Other than the target NASA application in microwave sensing, Rydberg sensors can be adopted in other NASA applications such as RF-field metrology (characterization and calibration), RF communication, nondestructive inspection, characterization of blackbody radiation, and others.

Potential Non-NASA Applications (Limit 400 characters):

RF/microwave fields are heavily utilized in many commercial and military applications. For example, a scanned array radar made of Rydberg sensors can provide a performance breakthrough in radar technologies, which will be extremely useful in many military applications. Rydberg atom-based RF/microwave sensors can also be highly useful in industrial applications using RF/microwave.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S11.02-2261**
SUBTOPIC TITLE:	Technologies for Active Microwave Remote Sensing
PROPOSAL TITLE:	Ultra-Efficient UHF Band Power Amplifiers

Small Business Concern

Firm: **Recon RF, Inc.**

Address: **9235 Activity Road, Suite 105, San Diego, CA 92126**
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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):

•In support of NASA’s Ecosystems SAR (EcoSAR) Mission, which is to enable unprecedented two- and three-dimensional fine scale measurements of terrestrial ecosystem and biomass, this project will develop a state-of-the-art (SOA) UHF Band monolithic microwave integrated circuit (MMIC) Power-Amplifier for the EcoSAR instrument’s 32 radar electronics units. This project will significantly advance Power Added Efficiency beyond present day commercial off the shelf offerings operating on the UHF Band, and specifically 335-535 MHz, achieving a TRL 3-4 MMIC power amplifier with over 25 Watts output power, power added efficiency (PAE) of greater than 70%, and power gain of over 35 dB with less than 1 dB gain flatness over the band; consistent with the requirements of EcoSAR. This UHF-band GaN MMIC SSPA performance will be at the very forefront of present-day technology. The efficiency advantages resulting from this project’s custom developed >70% PAE UHF MMIC 25-watt power amplifiers will be multiplied across 32 polarimetric (dual) transmit/receive (T/R) modules which reside inside the aircraft fuselage within a radar electronics unit (REU).

Potential NASA Applications (Limit 550 characters):

The proposed UHF MMIC capable of PAE >70% will enhance NASA's communication and navigation for SWaP-C conscious applications such as:

- NASA Mission/Program: Ecosystems SAR (EcoSAR)
- Electra UHF Navigation Package
- Mars Perseverance Rover
- Mars Curiosity Rover

Potential Non-NASA Applications (Limit 400 characters):

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

- Tactical Radio (Ground, Shipborne, Handheld)
- FirstNet Network
- Commercial 5G New Radio FR1
- UHF Air Traffic Control and Wind Profile Radar

Duration: **6**

PROPOSAL NUMBER: 23-1- **S11.03-1175**

SUBTOPIC TITLE: Technologies for Passive Microwave Remote Sensing

PROPOSAL TITLE: Ultra-low-loss Millimeter-Wave Holographic Antennas for CubeSat Remote Sensing

Small Business Concern

Firm: **Astrabeam LLC**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

The NASA Science Mission Directorate has a critical need for advanced deployable antenna apertures operating at millimeter-wave frequencies from CubeSat platforms. This proposal is to fulfill the technology gap and develop a novel type of ultra-low-loss millimeter-wave metasurface holographic antennas to support a wide range of passive remote sensing applications beyond Ka-band up to 200 GHz. Enabled by a breakthrough dielectric substrate material that is electrically low-loss, thermally high-conductive, and mechanically robust, the proposed holographic antennas will be designed, synthesized, and verified including CubeSat platform effects. Mechanical feasibility, radiometer system architectures, integration with antenna feeds, and fabrication flow will be studied and evaluated in the project. The Phase 1 project goal is to demonstrate the design concept of compact-size, deployable, low-profile, lightweight, easy-to-fabricate and high-performance metasurface antennas, which are also cost-effective and can be an excellent fit for NASA remote sensing and other commercial wireless applications.

Potential NASA Applications (Limit 550 characters):

NASA Science Mission Directorate missions can greatly benefit from adopting and integrating the proposed millimeter-wave metasurface holographic antennas on CubeSat platform for remote sensing applications including weather forecasting, oceanography, ozone, soil moisture measurements, and astrochemistry. The unique attributes (low profile, light weight, ultra-low-loss, easy-to-fabricate) make it an excellent technology to enable cost-effective high-performance antennas beyond Ka-band for CubeSat applications.

Potential Non-NASA Applications (Limit 400 characters):

The technology developed in this Phase 1 project can be adopted as a critical antenna solution to support the increasing demand for high-capacity, high-speed point-to-point wireless backhaul communication, for example, operating at FCC designated D-band to enable beyond 5G (B5G) and 6G high-throughput links in dense urban environments.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S11.04-1934**

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

PROPOSAL TITLE: Combining InP and SiGe Technologies for Low Noise, Low Power Cryogenic Amplifiers suitable for Radio Astronomy Arrays and Quantum Applcations.

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Future earth science and planetary science missions will require large pixels, highly sensitive radio astronomy receiver arrays. Recent breakthroughs in detector technology are leading this growth. To achieve the required sensitivities, the large number of pixels (thousands) in a receiver requires low noise, low power cryogenic amplifier arrays. Lower noise amplifiers result in higher sensitivity arrays. The capacity of cryogenic coolers is limited, requiring amplifiers to have a low power dissipation. Producing cryogenic amplifiers that has both low noise and low power is difficult. Today, cryogenic amplifiers are manufactured using either Indium Phosphide (InP) HEMT devices or Silicon Germanium (SiGe) BJTs. Amplifiers based on InP technology have noise temperatures as low as 1.5K with a power dissipation of 10 mW. SiGe based amplifiers have noise temperatures of 3-4K with a power dissipation of 300 uW. The noise temperature of an amplifier is primarily set by the first stage. The subsequent stages contribute very little to the noise of the amplifier. Therefore, combining InP and SiGe will result in the ultimate low noise, low power cryogenic amplifier. The ideal amplifier will have a InP first stage for low noise and a SiGe 2nd and 3rd stage for low power. The InP stage will be a discrete design for optimum performance. The SiGe stages will be MMIC based design for ease of manufacturing and low cost. Combining these two technologies will result in an amplifier with 2K or less noise with a power dissipation of 500uW or less. Imagine an antenna array of 1028 elements that has a power dissipation of 514 mW. This performance is possible with this innovation. Phase 1 will result in a design of a low noise, low power amplifier based on both theoretical and empirical measurements

Potential NASA Applications (Limit 550 characters):

The 2020 Decadal Review recommended increased funding levels for several of NASA's future missions. The Origins Space Telescope, Lynx Telescope, IR imagers and polarimeters are included in the recommendations. Low-cost infrared detector arrays for space and ground radio astronomy receivers are currently available. These detectors require a low noise, low power cryogenic amplifier. These instruments will greatly benefit from a low power, low noise amplifier array.

Potential Non-NASA Applications (Limit 400 characters):

Several companies (Google, Microsoft, IBM etc) are developing Quantum Computers (QC). The quantum processors operate at milli-Kelvin temperatures. Extremely low noise cryogenic amplifiers operating in the 4-8 GHz band are required. A Quantum Computer with 1 million Qbits will require 100K cryogenic amplifiers. A low noise, low power cryogenic amplifier will allow QC to become a reality.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S11.04-2023**

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

PROPOSAL TITLE: Adaptive Thermal Infrared Band ROIC for Planetary Science Missions

Small Business Concern

Firm: **SAAZ Micro 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):

Electro-Optical and Infrared (EO/IR) detectors sensing in the 400nm to 13 micron waveband are extensively employed in planetary science space instruments. These detectors can be divided into two distinctive subgroups, namely the visible through shortwave infrared (SWIR) band detectors (400nm – 2500nm), and the mid-wave infrared (MWIR – 3um to 5um) and long-wave infrared (LWIR 8um – 13um) thermal bands detectors. Each of these two categories requires a readout integrated circuit (ROIC) optimized for the specific subgroup to efficiently multiplex and readout the photocurrent from the photodiodes.

The first ROIC type optimized for shorter wavelength bands needs to have the following characteristics:

1. Smaller pixel pitch (near 10um) optimized for Nyquist spatial sensing of shorter wavelengths.
2. High gain (smaller well size) to provide good SNR for low flux sensing since these bands have lower irradiance and typically use a narrower bandwidth filter.

The second ROIC type optimized for longer thermal wavelength bands needs to have the following characteristics:

1. Larger pixel pitch (near 20-25um) to match the blur spot size for Nyquist sampling of longer wavelengths.
2. Lower gain (large well size) to provide good SNR for high flux sensing since these bands have higher irradiance and typically use a wider bandwidth filter.

There is an established need to develop a novel ROIC for thermal bands being used for planetary science. Our team has extensive space mission experience to provide NASA with an optimal solution. The proposed ROIC will provide the desired high well capacity, a high frame rate, a large format, space qualifiable design, while simultaneously keeping the cold space power very low. Such as ROIC will be suitable for all typical detector types used for these bands, such as (but not limited to) quantum well IR photodetectors (QWIP), HgCdTe (MCT), and strained-layer superlattices (SLS).

Potential NASA Applications (Limit 550 characters):

. Some of the key NASA applications being addressed by this technology include:

- Landsat upgrade
- Utilizing in SBG type of science missions
- Any NASA planetary science mission requiring MWIR or LWIR bands

Potential Non-NASA Applications (Limit 400 characters):

Some of the key non-NASA applications being addressed by this technology include:

- Overhead Persistent IR (OPIR) space system platforms for DoD
- “New Space” commercial payloads
- Other agency missions, e.g., ISRO missions such as Cartosat and Resourcesat upgrades

Duration: **6**

PROPOSAL NUMBER: 23-1- **S11.04-2312**

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

PROPOSAL TITLE: Scalable Data Acquisition System for MKID Detectors

Small Business Concern

Firm: **Alphacore, Inc.**

Address: **304 South Rockford Drive, Tempe, AZ 85288**
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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):

Alphacore will develop a **low cost**, **radiation-hardened** *Scalable Data Acquisition System (SDAS)* based on an innovative application-specific integrated circuit (ASIC) for Microwave Kinetic Inductance Detectors (MKIDs). The proposed SDAS ASIC will have 4-8 channels for 14-bit accurate Analog to Digital Conversion (ADC) and Digital to Analog Conversion (DAC, for carrier tone generation) with each channel handling >4GHz of bandwidth (instantaneous bandwidth of > 8GHz at 4GS/s per ASIC and tunable bandwidth range of 16GHz) while consuming less than 40 mW per detector readout chain. The SDAS will also have a low power I/O (input/output) user interface with a programmable LVDS. The SDAS ASIC will have several programmable operation modes, with bandwidths of operation of more than 4GHz. In addition, the SDAS will also include flexible intermediate frequency (IF) electronics with a loopback mode for IQ autocalibration and dynamic range measurements. The combination of the digital signal processing and integrated I/O and flexible IF electronics will enable it to serve many millimeter to sub-millimeter-wave experiments.

Alphacore's proposed ultra-low power, rad-hard SDAS system will provide exceptional value to NASA by delivering a combination of performance, robustness, and flexibility with the minimum size, weight and power (SWaP). Alphacore's SDAS will include a high-performance DDS (Direct Digital Synthesizer), an integral part of any KID array readout system needed to provide the gigahertz stimulus to the detectors. Alphacore's key innovations include 1) silicon proven innovative calibration methodologies for ADCs operating in harsh (radiation) environments, 2) small area, ultra-low power polyphase filter bank using re-quantization technique, 3) Low power programmable-*eye*-LVDS based SERDES, and 4) silicon proven ultra-low power all-digital DDS.
Alphacore's **existing circuit** blocks can be leveraged in this work to mitigate risk in designing a complex high-performance ASIC.
Potential NASA Applications (Limit 550 characters):

Alphacore's Rad-Hard, Low-Power SDAS ASIC for MKID/TES detectors will support NASA radiometer microwave sensors for a wide range of Earth observation applications and future missions described in decadal surveys. The developed ASIC can be easily scaled to support larger kinetic inductance detector arrays. The SDAS ASIC can be used in instrument upgrades on NASA's current millimeter-wave and submillimeter-wave balloon programs such as EXCLAIM and TIM, and future proposed missions PICO (CMB probe mission) and the Origins Space Telescope (OST).

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications for this technology include scientific experiments, such as future cosmic microwave background (CMB) experiments, axion searches and weakly interreacting massive particle searches. On the commercial side, SDAS can support readout for large array MKIDs used to provide visibility through degraded visual environments such as dense fog in many applications.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S11.05-1627**
SUBTOPIC TITLE:	Suborbital Instruments and Sensor Systems for Earth Science Measurements
PROPOSAL TITLE:	The Airborne Multiangle Aerosol Size Spectrometer: A next generation aerosol probe

Small Business Concern

Firm: **CloudSci, LLC**
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Phone: **(608) 220-0844**

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):

Atmospheric aerosol have important impacts on climate and air quality and affect efforts to retrieve information regarding the Earth's surface, including oceans. Airborne measurements of aerosol size are critical to understanding physical drivers over time and space, and to validate satellite and other remotely sensed observations. The current state of the art instrument for measuring aerosol size on aircraft is now almost 50 years old, and a replacement is badly needed. We propose development of a next-generation aerosol probe that leverages two scattering measurement techniques to reduce uncertainties -- the Airborne Multiangle Aerosol Size Spectrometer. Integrated side scattering provides sizing information for submicron particles and small angle light scattering provides sizing information for supermicron particles. In this project, we will also determine if the complementary techniques can provide additional information regarding particle shape and refractive index. The goal is to provide a near aircraft ready prototype instrument capable of supporting aerosol measurement requirements for the next decade, integrating modern flow control, electronics, and data processing/output capabilities.

Potential NASA Applications (Limit 550 characters):

The airborne probe would be core measurement instrumentation for suborbital aircraft campaigns examining air quality, climate, and aircraft emissions, and satellite validation. Specific missions with relevance include PACE Satellite mission (ocean biology, aerosols, clouds), the upcoming ACCP Mission (aerosols, clouds, convection, precipitation), TEMPO (geostationary air quality observations), and CAMP2Ex (tropical meteorology and aerosol science).

Potential Non-NASA Applications (Limit 400 characters):

A next-generation aerosol sizing probe would be a core component on research aircraft operated by other US and non-US agencies, including DOE, NCAR, NOAA, DLR (Germany), FAAM (UK), and SAFIRE (France). The optical technology at the heart of the probe could be adapted for ground/laboratory use, opening more applications: air quality monitoring, clean room monitoring, and academic aerosol research.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S12.01-1988**

SUBTOPIC TITLE: Exoplanet Detection and Characterization Technologies

PROPOSAL TITLE: Radiation Resistance Enhanced Class AB Amplifiers for Space Coronagraphic Instruments

Small Business Concern

Firm: **Sunlite Science & Technology, Inc.**
Address: **4811 Quail Crest Place, Lawrence, KS 66049**
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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):

Space electronics must have certain radiation hardness to meet a mission's life span. In addition, the size, weight, and power (SWaP) are usually constrained. This project aims at developing a radiation harden class AB high-voltage (HV) amplifier-array integrated circuit (IC) that will be an ideal component to be selected to build a miniaturized deformable mirror (DM) driver for a space coronagraphic instrument (CGI). Class AB operation will ensure low-static dissipation and high driving efficiency, which will make it feasible to integrate over 100 HV amplifiers in a single chip. To enhance radiation resistance, the following measurements will be taken for prototyping a proposed IC; 1) both low- and high-voltage bipolar transistors are the first favored selection, 2) MOS transistors featuring thin gate oxide layers are preferred, 3) transistors with much higher than required voltage-ratings are the another preferred selection, 4) layout techniques for improving radiation resistance, 5) a bias for ensured class AB operation will provide an additional performance adjustment, and 6) hermetic IC package will provide an additional radiation shielding. By the end of the Phase I, HV amplifiers configured with bipolar transistors will be evaluated at gate level, and an IC containing 128 HV amplifiers will be fabricated for driving electrostrictive lead magnesium niobate (PMN) actuators. This IC that contains 650V MOS transistors for 100V operation, is served to evaluate the electrical performance for driving a PMN DM, and will be an important reference to design and fabricate radiation harden amplifier-array ICs in Phase II.

Potential NASA Applications (Limit 550 characters):

The to be developed HV amplifier array IC in Phase I can be used to build a miniaturized DM driver for testing CGIs in ground testbed. Further to be developed amplifier-array ICs featuring radiation harden will be an ideal component for coronagraphic instruments which will be included in NASA's space missions such as Roman Space Telescope, HabEx and LUVOIR.

Potential Non-NASA Applications (Limit 400 characters):

The to be developed HV amplifier array IC will be a potential candidate to be selected for building a DM driver in an adaptive optics system where the size, weight, power, and radiation resistance are a concern. Such systems include but be not limited to space-based optical communication.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S12.03-1142**

SUBTOPIC TITLE: Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical to Mid/Far-Infrared Telescopes

PROPOSAL TITLE: Cellular Optimization of Additively Produced Mirror Substrates for In-space Imaging

Small Business Concern

Firm: **Cornerstone Research Group, 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):

Cornerstone Research Group (CRG) will develop add-on capability for an existing in-house design tool for generation of lightweight telescope mirror substrates with optimized stiffness, mitigation of disrupting vibrational modes, and consideration of the thermal environment. Leveraging the production capabilities offered by additive manufacturing technologies and materials, CRG will establish a computational design process specifically suited for optical substrates. By performing topology optimization of conformal lattice structures, the overall mass

can be significantly reduced while also driving the design to geometries exhibiting vibration damping by taking advantage of unique design methodologies. During Phase I, CRG will add objectives and constraints specifically for mirror substrate design based on identified requirements. Prototype structures will be fabricated using additive manufacturing and experimentally evaluated and compared to traditionally designed structures.

Potential NASA Applications (Limit 550 characters):

- Telescopes addressing COR, ExEP, and PCOS program missions
- Monolithic and segmented mirror substrates for in-space telescopes
- Lightweight telescope structures supporting enhanced stability
- Launch and propulsion structures requiring vibration mitigation

Potential Non-NASA Applications (Limit 400 characters):

- In-space laser communication assemblies
- Automotive and transportation structures design
- Unified structural and thermal heat exchangers

Duration: **6**

PROPOSAL NUMBER: 23-1- **S12.03-1272**

SUBTOPIC TITLE: Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical to Mid/Far-Infrared Telescopes

PROPOSAL TITLE: Metalens Near InfraRed Telescope

Small Business Concern

Firm: **Relative Dynamics, Inc.**
Address: **14400 Sweitzer Lane Suite 125, Laurel, MD 20707**
Phone: **(240) 241-4721**

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):

NASA needs system technology solutions that enable or enhance telescopes for missions of any size (from balloon or CubeSat to Probe or Flagship) operating at any wavelength from UV/optical to mid/far-infrared. Relative Dynamics Inc. proposes the Metalens Near InfraRed Telescope (MeNIRT) solution. RDI will design and analyze the overall telescope system. The telescope system is the optics (lens and metalens) and a carbon fiber/metal hybrid opto-mechanical structure. Metalenses are flat lenses that use metasurfaces to focus light. The metasurfaces are a series of artificial antennae that manipulate the optical response of the incident light, including its amplitude phase and polarization. Metasurfaces have provided a new approach to recasting optical components into flat devices without performance deterioration. Carbon fiber composites have high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion. RDI will investigate two methods for engineering the CTE 1) adjusting the chemical composition of the carbon fiber and the resin 2) adjusting the direction of the carbon fiber laying.

- MeNIRT provides a lightweight telescope that greatly eases mass limitations with a path to optical to mid-IR diffraction-limited performance over the wide temperature range. Using flat optics and athermalized continuous carbon fiber telescope structure greatly reduces coefficient of thermal expansion (CTE) limitations and gravity sag.
- Using flat on-axis optics, MeNIRT does not have a telescope central obscuration. The Metalens is manufactured for mass production using standard silicon lithography. The new commercial design tools for silicon flat optics in combination with the continuous carbon fiber structure provide a straight-forward method for design, manufacture, and test.
- MeNIRT provides a path to flat optics and athermal telescopes for science missions with wavelengths from the ultraviolet to the far-infrared.

Potential NASA Applications (Limit 550 characters):

Metalenses are potentially revolutionary in optical imaging due to their flat nature and compact size, multispectral acquisition and even off-axis focusing. Metalenses can be used in many NASA science missions (e.g., cameras, spectroscopy from UV to microwave, lidars) and spacecraft technologies using optics (e.g., star trackers, optical communication and navigation). Near-term NASA applications are IR, MIR and NIR optical systems for large spacecraft and UV to microwave systems for CubeSat and small satellite optical systems.

Potential Non-NASA Applications (Limit 400 characters):

$10 billion+ market with applications in machine vision, robotics, and industrial systems. Government and commercial imaging satellite optics. Future high volume applications include cellphone camera modules, wearable displays for augmented and virtual reality, machine vision, automotive and security cameras. Start-up companies: Tunoptix: https://www.tunoptix.com/; Metalenz: https://metalenz.com/

Duration: **6**

PROPOSAL NUMBER: 23-1- **S12.03-2442**

SUBTOPIC TITLE: Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical to Mid/Far-Infrared Telescopes

PROPOSAL TITLE: Improved Computer Generated Holograms for Testing Aspheric and Freeform Optics

Small Business Concern

Firm: **Soter Technology, LLC**
Address: **907 Octorora Place NE, Leesburg, VA 20176**
Phone: **(571) 748-4016**

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):

The most practical industrial method for measuring aspheric and free-form parts includes the use of Computer-Generated Holograms, diffractive elements that approximate the ideal method of using Kinoform surfaces. Computer Generated Holograms approximate Kinoforms by using binary diffraction maps, however this approximation leads to errors bleeding into the ideal fringe map when using a CGH for aspheric correction. Traditionally these errors are removed by using processes that decrease aspheric correction capability and increase alignment difficulty, and thus time. We propose a method that would allow us to use Computer Generated Holograms with lower required resolutions than the traditional Computer Generated Hologram test methods. This would decrease the alignment times, and increase the possible aspheric departure of the parts under test, decrease costs and increase capability. The outcome of this will decrease the time and cost of producing aspheric optics, and increase the availability of higher departure aspheric and free-form optics which require even more specialized testing equipment, reducing their cost up to the limits of the CGH. Our plan is to extend analytical simulations of an improved CGH, print a CGH to test the effectiveness of this method, and compare the results to traditional methods for CGH correction.

Potential NASA Applications (Limit 550 characters):

NASA has displayed continued interest in large, highly aspheric and free-form mirrors and lenses, and a method to test more aspheric surfaces while also decreasing alignment costs would be highly advantageous to the manufacturing of these surfaces.
Potential Non-NASA Applications (Limit 400 characters):

CGHs are a key technology for testing aspheric and free-form optics. This method would provide the industry with an easier method for measuring aspheric surfaces, at lower cost, and providing the capability to measure more challenging aspheres and free-forms. This will assist NASA programs, DoD programs, IC programs, and the US commercial earth observing satellite market.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S12.04-2561**

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

PROPOSAL TITLE: Wideband Inorganic Freeform Optics

Small Business Concern

Firm: **Nanovox, LLC**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

To address the need for smaller, lighter, and less expensive optics for NASA instruments, a novel optical technology platform based on using additive manufacturing (AM) of custom-engineered nanocomposite materials will be demonstrated. It will be shown that custom optical materials with precise index and dispersion values that can be used to fabricate aberration-free freeform gradient index (GRIN) optics, allowing for the creation of compact optical systems with fewer optical elements to be realized in the ultraviolet, visible, and infrared spectral regions.

The ability to synthesize and deposit composite blends of optical feedstock with precise optical properties, and the drying and densification processes will be demonstrated. The goal is to create fully inorganic freeform GRIN optics with the precise optical properties required for NASA instruments.

Potential NASA Applications (Limit 550 characters):

Applications include space exploration, remote sensing, astronomy, and Earth observation. In space exploration, they improve the performance of telescopes, spectrometers, and cameras. In remote sensing, they enhance the accuracy of measurements for atmospheric, land, and ocean studies. In astronomy, they enable high-resolution imaging and spectroscopy of distant objects. In Earth observation, they improve imaging and sensing capabilities for monitoring natural resources, climate change, and environmental hazards.

Potential Non-NASA Applications (Limit 400 characters):

Markets for compact optics with reduced aberrations include consumer electronics, such as smartphones and augmented reality headsets, as well as medical devices for diagnostic and surgical applications, industrial inspection systems, metrology, and high-resolution microscopy, and in autonomous vehicles, LiDAR systems, and aerospace industries.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S12.06-1036**

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

PROPOSAL TITLE: Superconducting Magnetic Shielding Using Additive Manufacturing

Small Business Concern

Firm: **Applied Nanotech, 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):

Transition edge sensors (TES) used in microcalorimeter arrays for X-ray photon detection are inherently susceptible to variations in the magnitude of magnetic fields since their detection principle is based on the transition between the normal and superconducting states. Optimal performance require efficient magnetic shielding to provide a low magnetic field environment. Bergen *et al*. provide magnetic field specifications with respect to SPON TES arrays. These specifications may become even more stringent for larger arrays. Current superconducting shield often consists of a superconducting cup arrangement as is the case proposed for the Lynx X-ray Microcalorimeter. Although this design reduces the number of joints, it is limited to the forming process and thereby the size and complexity of the shape that can be realized. Novel concepts for improving superconducting magnetic shielding such as superconducting inks or additive manufacturing are of interest for detector focal planes with challenging shielding

geometries and other requirements. Novel concepts for improving superconducting magnetic shielding such as superconducting inks or additive manufacturing are of interest for detector focal planes with challenging shielding geometries and other requirements. Applied Nanotech proposes to use additive manufacturing (AM) for producing magnetic shields for shielding large and challenging shielding geometries. Our approach will be to apply a superconducting layer onto a substrate material such as amumetal, aluminum or polyimide (e.g. Kapton®).

Potential NASA Applications (Limit 550 characters):

Currently, NASA needs advanced detector technologies in the UV through to gamma-ray for applications in astrophysics, earth science, heliophysics, and planetary science. Supporting technologies that would help enable the x-ray Surveyor mission requires the development of x-ray microcalorimeter arrays with much larger field of view, ~10^5 to 10^6 pixels, of pitch ~25 to 100 μm, and ways to read out the signals. Modular superconducting magnetic shielding is sought that can be extended to enclose a full-scale focal plane array.

Potential Non-NASA Applications (Limit 400 characters):

Indium ink will have other applications beyond superconductivity and magnetic shielding. Indium-based inks developed for superconducting applications will also be useful as a solder and interconnects for high density, hybrid electronics packaging, for both superconducting and non-superconducting packaging applications. Quantum Computing applications are also being developed.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S13.01-1783**
SUBTOPIC TITLE:	Robotic Mobility, Manipulation and Sampling
PROPOSAL TITLE:	Vertical Motion Control System for Cryobots

Small Business Concern

Firm: **Stone Aerospace, Inc.**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

This proposal responds to NASA SBIR 2023 Focus Area 4: Robotic Systems for Space Exploration. The subtopic S13.01 describes a need for technologies that provide improved robotic mobility for ocean world deep ice drilling and sub-ice ocean access. In particular, the need for innovations concerning “tethers and tether play-out and retrieval systems” are mentioned, as are component technologies for subsurface ocean access systems for ocean worlds like Europa and Enceladus. We propose to develop a Vertical Motion Control System (VMCS) which will pay out, and when needed spool in, an onboard tether from an ice penetrating robot (cryobot) on an ocean world. Ocean worlds remain of critical interest for astrobiology, however these off-world bodies of water are difficult to access as they lie below kilometers of ice. Any cryobot mission runs the risk of premature termination if the vehicle encounters an open void, water-filled cavity, or sub-surface ocean due to uncontrolled free fall of the vehicle. A VCMS is a means of proactively controlling the cryobot's descent. This will be of particular utility at the ice-ocean interface where the cryobot can convert to a defacto instrumented sonde for depth-registered characterization of the subsurface ocean. There are further advantages to a VCMS being bi-directional, the most obvious use of which would be to retreat upward through the ice column in the event that an impassable object is encountered and to then use steering hot water jets. This proposal addresses robotic mobility and access to sampling by offering a solution to one of the critical hurdles for cryobots capable of melt-penetration deep drilling of ice on Europa or Enceladus. We are proposing a VMCS consisting of a parallel-axis spooler, and a levelwind system, sized for a 1.6-mm-diameter Vectran tether (tensile strength: 4,315 N). For a 15-km mission, this spooler is 54 cm long. This design can be modified for shorter or longer tether lengths as needed.

Potential NASA Applications (Limit 550 characters):

The Vertical Motion Control System an enables robotic exploration missions on icy ocean worlds. Any ice-penetrating cryobot mission in a thick ice shell risks free fall and subsequent mission failure if the vehicle encounters an open void, water-filled cavity, or sub-surface ocean. The VMCS will proactively control the vehicle descent speed and mitigate these hazards. The VMCS could also enable a robotic explorer to descend into and ascend out of fissures on Enceladus, or a robot that “rappels” into cave skylight openings on Mars or the Moon.

Potential Non-NASA Applications (Limit 400 characters):

The VMCS can be built into scientific instrumentation and sampling packages to enable onboard, load bearing tether spooling and make possible deployment through or operation within physically-constrained environments such as ice boreholes. Mobile robotics that employ strength and/or data tethers such as Autonomous Underwater Vehicles, Remotely Operated Vehicles, and aerial drones may also benefit.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S13.01-2632**

SUBTOPIC TITLE: Robotic Mobility, Manipulation and Sampling

PROPOSAL TITLE: Multipurpose Agile Range Mapping and Optical Surface Examination Tool (MARMOSET)

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 4
Technical Abstract (Limit 2000 characters):

We propose to advance from TRL4 to TRL5-6 in Phase II a novel Multipurpose Agile Range Mapping and Optical Surface Examination Tool (MARMOSET) for lunar, Mars, and other planetary surface operations, including base camp construction, site surveying, sample and resource prospecting and acquisition, maintenance, in-situ manufacturing, and science tasks. MARMOSET evolved from two former NASA PIDDP efforts and a just-completed Phase I/II SBIR aimed at rover mobility and science operations on Mars. However, this technology is directly applicable to lunar and other planetary surface operations.

MARMOSET employs a novel agile laser pattern projector to acquire dense 3D point clouds with sub-mm resolution from up to 10m using structured illumination and a camera, or to measure

range at up to 1M points simultaneously from up to 1km using encoded laser beams and a fast detector. In both modes, MARMOSET computes each point in parallel, works in darkness or daylight, and takes under 1s to acquire and process the data. MARMOSET uses robust space-proven components and acquires data without moving parts.

MARMOSET can acquire and process data internally, is networked, and is powered using a single low-voltage supply. Its modular architecture facilitates integration with various robotic platforms. It could be used as part of a rover's vision system, as an end effector, or even as a hand-held tool.

We developed a low-SWaP stand-alone commercial prototype that weighs under 2kg, fits on a camera tripod, and consumes ~20W of power, and used it to acquire and compute ~1M point clouds of nearby targets in well under a second. We have also made progress integrating the many-beam lidar mode.

During the Phase I and follow-on Phase II efforts we will extend ranging distance, implement robotics software framework interfaces, implement a rad-hard-compatible electronics design, fully integrate the lidar mode, and demonstrate MARMOSET operation on a test rover at JPL and at a lunar-analog field site.

Potential NASA Applications (Limit 550 characters):

MARMOSET's many-beam range mapping could speed up autonomous surface traverses, sample site surveying, and in-situ resource identification on the Moon, Mars, and other orbiting bodies, while dense sub-100um resolution point clouds could enhance hazard assessment, end effector positioning, and surface inspection, or provide 3D data for in-situ manufacturing. Due to its low SWaP, MARMOSET could be used as an end effector, a handheld tool for lithology, or eventually, even an agile sensor for EDL, spacecraft proximity and asteroid operations.

Potential Non-NASA Applications (Limit 400 characters):

Due to its low SWaP, dense point clouds, agility, parallel processing, dynamic range, and no moving parts, MARMOSET could lead to transformative solutions for many commercial applications in space and on Earth including surface inspection, robotic location, mapping, and object identification, aerial surveying, aircraft and spacecraft landing and docking systems, and autonomous vehicle navigation.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S13.01-2723**

SUBTOPIC TITLE: Robotic Mobility, Manipulation and Sampling

PROPOSAL TITLE: Radar Vision Systems for Enhanced Robotic Mobility, Precise Navigation, and Multi-Vehicle Coordination

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):

Aloft Sensing Inc. (Aloft) proposes to adapt and establish the feasibility of our scalable Radar Vision Systems (RVS) for operation on solar system bodies. RVS consist of state-of-the-art multichannel mm-wave radars coupled with our patent-pending position, navigation, and timing algorithms (AloftPNT). Demonstrated through simulations and field experiments, these systems achieve both accurate self-contained navigation and high-resolution perception sensing.

Our navigation approach utilizes the radar signals themselves to achieve micon levels of relative positional accuracy and constrain the drift associated with onboard IMUs. This provides accurate navigation over long durations without external support infrastructure.

The precision position updates further maximize radar coherence to enable high-performance imaging (centimetric resolutions) and advanced interferometrics (e.g., height profiles of obstacles), both from a single platform and across distributed platforms. The latter is achieved via AloftPNT's intrinsic ability to establish precise relative positioning and timing between vehicles operating in coordination.

Together, RVS's navigation and sensing capabilities provide an effective tool for mobility of surface and aerial vehicles operating autonomously in new environments. Because RF signals easily penetrate dust and atmospheric percipatates that obscure other sensing modalities, they are particularly applicable to exploring planetary surfaces.

To establish the feasibility of applying RVS to the planetary domain, Aloft proposes to 1) simulate AloftPNT performance in relevant scenarios, 2) adapt RVS and AloftPNT based on these

simulations, 3) demonstrate operation with our mm-wave testbed, 4) update the hardware designs for the space environment, and 5) establish a Phase 2 implementation and test plan. The end result is an RVS architecture tailored specifically for robotic mobility on solar system bodies that is ready for further development on a Phase 2.

Potential NASA Applications (Limit 550 characters):

The Aloft radar vision system technologies demonstrated in this effort support improved mobility for all vehicles, including rovers and legged and airborne platforms for Lunar/planetary and small body exploration. RVS and AloftPNT can also provide accurate navigation for crewed and small uncrewed aerial systems that host sensors for collecting Earth science data in support of key NASA objectives. The mesh nature of Aloft's innovations enable the coordination of swarms of vehicles which can transform robotic exploration in all domains.

Potential Non-NASA Applications (Limit 400 characters):

Broader applications of Aloft radar vision system technologies include commercial robot mobility, assisted driving, and drone navigation. Scaled to larger platforms, RVS and AloftPNT allow airlines/aircraft to navigate effectively without the aid of GPS. The sensors developed in this effort are based on low-cost commercial technologies, allowing broad market adaptation.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S13.03-2143**

SUBTOPIC TITLE: Extreme Environments Technology

PROPOSAL TITLE: Wire-laser metal 3D printed bearings for extreme environments

Small Business Concern

Firm: **Multiscale Systems, Inc.**
Address: **49 Canterbury Street, Suite 500, Worcester, MA 01610**
Phone: **(855) 955-7900**

Principal Investigator:

Name: **Dr. Arthur Evans**
E-mail: **art@multiscalesystems.com**
Address: **49 Canterbury Street, Suite 500, MA 01610 - 1703**
Phone: **(855) 955-7900**

Business Official:

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Address: **49 Canterbury St, Suite 500, MA 01610 - 1703**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters):

Exploring outer planets, their subsurface oceans, and Venus is crucial for understanding the origins of life and planetary evolution in our solar system. The scientific opportunity presented by these missions is challenged by extreme environmental conditions ranging from cryogenic temperatures to corrosive atmospheres. Survivability and mechanical failure are major concerns for operating in these harsh conditions.

Bearings are necessary for mobility, drilling, and sample manipulation during normal mission operation. Multiscale Systems will use wire laser metal (WLM) to 3D print bearings in a multi-material alloy, providing a reliable and repeatable manufacturing solution to meet the demanding requirements of missions operating in extreme environments. This approach to design and manufacturing offers the benefits of lightweighting, design complexity, and the ability to create alloy composites with high ductility, controllable thermal expansion, and corrosion resistance.

Other solutions are limited by cost, manufacturing difficulty, unreliable performance, weight, and a high risk of failure. WLM 3D printing overcomes these difficulties in a variety of ways.

In Phase I, the team proposes to focus on design, initial prototyping, and initial testing to validate the approach. Phase II will seek to mature the technology by testing in controlled environments that simulate the operating conditions. Phase III commercialization will focus on manufacturing the components to customer specifications.

Potential NASA Applications (Limit 550 characters):

The next three decades of solar system exploration offer the opportunity for missions to Venus, Callisto, Enceladus, Europa, Titan, etc. Temperatures on the surface of Europa are cryogenic (-220 °C), and involve exposure to large dosages of ionizing radiation. Venus, on the other hand, has a corrosive atmosphere, high temperatures (~500 °C), and high pressures (~90 atm). High performance bearings for extreme environments will be required for all of these missions to succeed.

Potential Non-NASA Applications (Limit 400 characters):

A market opportunity for high performance bearings and related components exists in the renewable energy sector, where NASA has overlapping requirements with the high-temperature corrosive environments of enhanced geothermal systems. The geothermal heat pump market is a potential entry point for commercialization.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S13.03-2774**

SUBTOPIC TITLE: Extreme Environments Technology

PROPOSAL TITLE: High Energy Density Radiation Tolerant Capacitors for Cryogenic Temperature Applications

Small Business Concern

Firm: **Polycharge America, Inc.**
Address: **10960 North Stallard Place, Tucson, AZ 85737**
Phone: **(520) 575-8013**

Principal Investigator:

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Business Official:

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Phone: **(520) 575-8013**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 6
Technical Abstract (Limit 2000 characters):

Two of the largest and critical components in virtually all NASA Power Processing Units (PPUs) of spacecraft, probes and landers, are energy buffer and DC-link capacitors, used to minimize ripple current, voltage fluctuations and transient suppression. Current capacitor technologies have severe performance limitations at cryogenic temperatures, especially when combined with exposure to radiation. The proposed development will address the evaluation of these two capacitor designs, using a disruptive solid-state, polymer capacitor technology, developed for PPUs of electric vehicles. NanoLam™ capacitors, are produced using a nanolaminate composite, that has 1000s of high temperature polymer dielectric layers. The capacitors are self-healing, they can handle high continuous and pulsed currents, and the nanothick polymer dielectric has high breakdown strength, which results in superior energy density and specific energy. The capacitors are formed using 1-2Mrad of ionizing Beta radiation, and have high resistance to radiation exposure, as well as superior parametric stability with voltage and temperature in the range of -196^{o}C to +200^{o}C.

Potential NASA Applications (Limit 550 characters):

NanoLam™ capacitors can be used in a range of PPU circuit functions, as well as higher temperature and voltage applications. This includes PPUs for spacecraft, probes, and landers, powered by roll-out solar arrays tailored to 120V and 300V, and PPUs for Hull ion thruster propulsion, powered by solar arrays with an output of 300V-1000V. In addition to the projected performance at cryogenic temperatures, NanoLam capacitors have proven superiority in stability, energy density and specific energy, at higher temperature and voltage applications.

Potential Non-NASA Applications (Limit 400 characters):

Government applications for NanoLam™ capacitors include electric drives, aerospace, pulse power systems for directed energy weapons, and applications where capacitors are exposed to radiation. Commercial applications for DC-link capacitors include inverters for electric vehicles, wind turbines, utility scale photovoltaics, rail traction, UPS, motor drives, aerospace, and medical electronics.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S13.04-1022**
SUBTOPIC TITLE:	Contamination Control and Planetary Protection
PROPOSAL TITLE:	Low-surface Energy, Self-Sterilizing Smart Coating for Spacecraft Cleanliness

Small Business Concern

Firm: **SynMatter LLC**
Address: **16914 Deer Oak Lane, Orlando, FL 32828**
Phone: **(321) 368-3013**

Principal Investigator:

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Business Official:

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Phone: **(321) 368-3013**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

A key concern with space travel is that microorganisms can hitch a ride on spacecraft leading to biological contamination of other planetary bodies or the transport of pathogenic organisms to Earth during return missions. Contamination of spacecraft and associated hardware with inorganic, organic or biological material can damage sensitive electronics and hardware and potentially cause catastrophic events associated with space travel. To ensure cleanliness and protect planets from microorganisms, NASA has implemented extensive cleaning procedures and processes, such as clean rooms, UV light and other surface disinfection protocols, to ensure a contamination-free environment.

SynMatter proposes demonstrating the feasibility producing a self-cleaning & sterilizing low surface energy coating, which prevents adhesion of contaminants and reduces cleaning requirements, with inherent self-sterilization properties that prevent the adherence, growth and spread of microorganisms. This coating will be achieved through the creation of Smart Particles that impart multiple layers of protective mechanisms. The coating will be highly water and oil repellent which minimizes adherence of water- and oil-soluble compounds and microorganisms and produces a self-cleaning surface. The coating will have inherent antimicrobial properties, killing any biological organisms that do adhere to the surface. As a tertiary protection mechanism, the Smart Particles can deliver human safe biocides in response to the growth of microorganisms, ensuring that the surface remains free of living microbes.

This omniphobic, antimicrobial coating is applicable for many types of spacecraft within NASA's portfolio, be they satellites, rovers, space stations, or capsules for human space travel. They can provide continuous protection against adherence of inorganic, organic and biological contaminants giving the saying "Cleanliness is a virtue" a whole new meaning.

Potential NASA Applications (Limit 550 characters):

The main application for the low surface energy, self-cleaning & sterilizing coating is to improve cleanliness of spacecraft by preventing the adhesion of contamination and microorganism growth. This coating has use on most spacecraft, but particularly those that come in contact with other planetary bodies, such as upcoming lunar landers (Peregrine, Blue Ghost, Nova-C, etc.), or those that will be returning samples, such as upcoming JAXA's Martian Moons eXploration mission. ISS use would reduce microbial contamination and protect human health.

Potential Non-NASA Applications (Limit 400 characters):

There is a growing need for coatings that prevent the growth and spread of pathogens. Hospital acquired- infections require costly medical treatment and cause avoidable deaths. Contaminated food results in illness and food waste. Accelerated by COVID-19, there is also demand for antimicrobial surfaces in high traffic environments such as daycares, schools, aircraft, entertainment venues and more.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S13.05-1353**
SUBTOPIC TITLE:	In Situ Instruments and Instrument Components for Planetary Science
PROPOSAL TITLE:	Cs Atom Interferometer Laser

Small Business Concern

Firm: **Opto-Atomics Corp.**
Address: **1891 North Gaffey Street, Suite 223, San Pedro, CA 90731**
Phone: **(424) 477-5132**

Principal Investigator:

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Business Official:

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Phone: **(424) 477-5132**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Quantum sensing takes advantage of the quantum mechanical nature of matters (e.g., atoms and ions) to boost the sensitivity of various sensors critical in NASA and other government/commercial applications. A stable, high-power, narrow-linewidth laser source is an essential subsystem needed in various atom-based quantum sensing. In atom-based sensing, high-power laser beams can generally increase the number of atoms, enhancing a metrology system's signal-to-noise ratio (SNR). Although the principle of operation for atom interferometry (AI) applies identically for any atomic species, certain atomic species could be better suited for specific applications. However, although cesium is one of the most commonly used species in cold atom experiments performed in laboratory environments, field-deployable light-pulse atom interferometry with cesium is not often available in low SWaP (size, weight, and power) packaging due to the lack of a compact laser subsystem supporting the atom interferometry operation.

To address the need, Opto-Atomics Corp. (OAC) proposes to develop a Cs Atom Interferometry Laser (CSAIL) that can be adopted in NASA's space-borne atom-interferometers with cesium in inertial navigation and other applications. The proposed development addresses NASA's call (S13.05) for a laser subsystem enabling Raman-based light-pulse atom interferometer with Cs. In Phase I, OAC will design and assemble key system components of CSAIL, evaluate their

performance, and perform feasibility demonstrations. We will also conduct a preliminary design of the fully-packaged CSAIL system for future development.

Potential NASA Applications (Limit 550 characters):

With the development of various enabling technologies, significant performance leaps can be achieved to meet NASA's needs in inertial sensing, gravity sensing, timekeeping, magnetic field sensing, and RF/microwave sensing. CSAIL can be readily adopted in Cs-based atom interferometers for inertial navigation and planetary geodesy applications of NASA. CSAIL can also be modified to provide the D2 transition beam for various atom-based sensing platforms such as Rydberg atom-based RF/microwave sensors or magnetometers.

Potential Non-NASA Applications (Limit 400 characters):

Atom-based sensing has many potential applications for the military and other governmental sectors. CSAIL will significantly expedite the field deployment of these quantum devices with Cs by providing a robust, versatile light source that can be used in various quantum metrology/communication applications. All atom-based sensing techniques using Cs can benefit from SWaP reduction offered by CSAIL.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S13.05-1856**
SUBTOPIC TITLE:	In Situ Instruments and Instrument Components for Planetary Science
PROPOSAL TITLE:	CryoScint: An Extreme Environment Sensor Head for Elemental Compositional Analysis

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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Business Official:

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Phone: **(617) 668-6851**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

Radiation detectors are an invaluable tool for space applications that span planetary science, astrophysics, heliophysics, and dosimetry for human exploration. A common technology used for radiation detection is the scintillator, where the material generates a light flash with an intensity that is proportional to the energy deposited by the incident radiation. For planetary science, the elementary composition can be determined down to a couple meters below the surface by measuring the emitted gamma rays produced from nuclear decay, proton inelastic scattering, or neutron interactions. The ambient galactic cosmic rays or trapped charged particles in a magnetosphere will scatter with nuclei in the planetary body generating neutrons, which interact with isotopes producing specific gamma rays. As a test case, a mission to Europa presents numerous challenges due to the high radiation environment because of its orbit in relationship to the trapped radiation in Jupiter's magnetosphere as well as the extremely low temperature. Within this extreme environment, common scintillation materials will fail for numerous reasons. The light yields may be suppressed at the low temperatures, the material may darken due to radiation damage, or the response time of the light flash is too slow to handle the high event rates. There are some materials that function down to 70 K, yet the transient response is slow making it difficult to provide good gamma ray spectroscopy in a high radiation environment. New scintillation materials, which includes ceramics, provide promise for developing a nuclear instrument for planetary science that can function at low temperatures and high radiation environments. The goal of this project is to develop a high-performance scintillation material for deployment to the surface of Europa, where in the Phase 1 effort, candidate materials will be identified based on their low temperature performance.

Potential NASA Applications (Limit 550 characters):

- Gamma ray spectroscopy for planetary science and astrophysics.
- Instrument for mapping elemental constituents on planetary surfaces.
  Supports orbital missions, borehole probes, lander missions, and rover missions for planetary science.

Potential Non-NASA Applications (Limit 400 characters):

Advanced scintillation materials serve a number of applications:

- Nuclear and High-Energy Physics Experiments
- Nuclear Nonproliferation.
- Nuclear Material Accounting and Control.
- Non-destructive testing using neutron radiography.
- Medical imaging.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S13.05-1970**

SUBTOPIC TITLE: In Situ Instruments and Instrument Components for Planetary Science

PROPOSAL TITLE: Miniature TOF Mass Spectrometer with Enhanced Resolution

Small Business Concern

Firm: **Zeteo Tech, Inc.**
Address: **6935 Warfield Avenue, Sykesville, MD 21784**
Phone: **(410) 979-1190**

Principal Investigator:

Name: **Dr. Vadym Berkout**
E-mail: **vadym.berkout@zeteotech.com**
Address: **6935 Warfield Avenue, MD 21784 - 7454**
Phone: **(410) 530-8834**

Business Official:

Name: **Thomas McCreery**
E-mail: **tom.mccreery@zeteotech.com**
Address: **2790 S Mario Ranch Ln, AZ 85730 - 1547**
Phone: **(520) 664-4999**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

Zeteo Tech, Inc. proposes to design, develop and prototype a robust, small size, weight, and power (SWaP) TOF mass spectrometer with enhanced mass resolving power ($m/\Delta m \geq 25{,}000$, FWHM) and practically unlimited mass range, which will allow *in situ* detection of organic and biomolecules in complex mixtures. It is based on a novel design of a multi-reflection TOF using microfabrication techology. The mass analyzer operates at low static voltages (a few hundred volts). Using static voltages (without pulsing) simplifies the electronics and minimizes power consumption for the proposed miniature mass spectrometer.

In phase I we will complete a preliminary design of the miniature TOF mass analyzer with enhanced mass resolving power and prototype key elements of the design.

Potential NASA Applications (Limit 550 characters):

In addition to the primary application for *in situ* detection and unambiguous identification of amino acids, nucleobases and other prebiotic organic molecules in solid samples, the proposed technology may be used for: 1) identification of salts, and/or minerals at Mars, ocean worlds, and other bodies; 2) monitoring of chemical composition of gas samples, including atmospheric analysis.

Potential Non-NASA Applications (Limit 400 characters):

Proposed technology may be utilized in a wide range of government and industrial applications: 1) on-site determination of pollutants in environmental samples; 2) quick reliable identification of deadly substances in complex mixtures; 3) point-of-care diagnostics without time-consuming sample pretreatment.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S13.05-2543**

SUBTOPIC TITLE: In Situ Instruments and Instrument Components for Planetary Science

PROPOSAL TITLE: Quantum Sensor for D/H Ratio Measurement in Water in Outer Planets

Small Business Concern

Firm: **QuantCAD, LLC**
Address: **1165 Oakes Drive, Iowa City, IA 52245**
Phone: **(319) 594-2507**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

Compact chip-scale nano-NMR sensors to measure D/H ratio in water of outer planets based on atomistic defects in semiconductors will have orders of magnitude improved sensitivity compared to classical NMR instruments. Our sensors will be able to detect D/H ratio in reduced sample size as the magnetic fields generated by small samples are too small for traditional sensors to detect. Microscopic modeling of noise and nuclear dipole fields will_estimate spin and charge noise frequency-dependent spectra of the D/H ratio sensor with a given set of parameters including geometry, dimensions, surface termination composition, and temperature. Our computer-assisted design (CAD) software will be used in the optimization of the sensor for D/H ratio measurements of water by identifying configurations/designs and microwave (MW) interrogation protocols where the NMR signals from hydrogen and deuterium can be reliably measured from the underlying base noise and thus maximizing the sensitivity. We will design the optimal sensitivity of the sensor based on tradeoffs for isotopic purity, regularity of thickness of substrate material and defect occurrence. A Phase II plan will be constructed, identifying the issues related to device growth and fabrication, testing, and integration. Plans will be developed to mitigate issues and partners confirmed for the Phase II project.
Potential NASA Applications (Limit 550 characters):

Compact chip-scale nano-NMR sensors will have smaller size, weight and power consumption compared to traditional NMR-type sensors and could cover the growing need for robust sensors with small footprints. They would thus be very well suited for planetary exploration where the instrument size, power, and complexity restrictions are most severe. The orders of magnitude improved sensitivity compared to classical NMR instruments, would allow D/H ratio detection in very small samples, unpractical with other approaches.
Potential Non-NASA Applications (Limit 400 characters):

NMR have extensive applications in biotechnology, medicine, materials science and other industries. Examples include characterization of nanoparticles, molecular imaging, detection of biomarkers, quality control of nanomaterials and development of new materials. These will greatly benefit from an NMR-type quantum sensor due to its high sensitivity and spatial resolution down to a single ion.
Duration: **6**

PROPOSAL NUMBER:	23-1- **S13.07-2721**
SUBTOPIC TITLE:	Energy Storage for Extreme Environments
PROPOSAL TITLE:	Modular Radioisotopic Power Sources

Small Business Concern

Firm: **Direct Kinetic Solutions**
Address: **1009 Metate Place, El Paso, TX 79912**
Phone: **(915) 352-8555**

Principal Investigator:

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Address: **1009 Metate Pl, TX 79912 - 7550**
Phone: **(865) 712-2712**

Business Official:

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Phone: **(915) 352-8555**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 4
Technical Abstract (Limit 2000 characters):

Direct Kinetic Solutions (DKS) proposes the development of a modular radioisotopic power source (RPS) to enhance the current state of the art offering, which is a combination of chemical batteries and solar arrays in the small satellite market. These power sources contain and energy density that is orders of magnitude superior to the one offered by commercially available chemical batteries. The difference between these power sources and traditionally used RTGs is that our devices convert the energy directly when using beta emitting isotope, and leverage a phosphor when using alpha emitting ones, The RPS are compact (the cell can be as little as .5cm x .5cm), lightweight, and will fit into the side panel on the structure of a CubeSat. We expect the RPS devices can be used to power critical systems independently, or can be connected in multiples to become a significant power source for the main electric power system of the spacecraft. We believe that they can be used in other applications such as lunar expiration as they can generate power in extremely low temperatures, or be used as power alternatives for complex systems in deep space exploration.

Potential NASA Applications (Limit 550 characters):

DKS believes the main application for NASA will be on the development of small satellites. Once that application has been demonstrated, they can go into different equipment, such as rovers for lunar exploration, given their characteristics.

Potential Non-NASA Applications (Limit 400 characters):

The company expects the commercial application to be similar to NASA: an enhancement to the currently used battery and solar array system. Small satellites swarms have been increasing and this tendency is expected to continue. Space partners such as SpaceX and Blue Origin can benefit greatly form the technology.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S14.01-1428**

SUBTOPIC TITLE: Space Weather Research-to-Operations-to-Research (R2O2R) Technology Development and Commercial Applications

PROPOSAL TITLE: Mixed Reality Platform to Enhance Space Domain Awareness of Space Weather and Facilitate Data-Driven Decision-Making

Small Business Concern

Firm: **XR Solutions Inc**
Address: **2069 West 14th 1/2 Steet, Houston, TX 77008**
Phone: **(832) 279-7993**

Principal Investigator:

Name: **Mrs. Lori-Lee Elliott**
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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):

NASA needs tools that allow people to visualize and understand the complex space environment. Three dimensional augmented, mixed, and virtual reality (AR, MR and VR, or collectively extended reality - XR) provide a way to enhance space data understanding and improve the quality of space domain-related decision-making. Company proposes using a mixed reality medium to meet the objectives of this solicitation, with respect to making informed decisions concerning space weather by combining & displaying space weather-related data sources in one platform. Mixed reality blends the real world with digital assets contextually placed in an environment. It lends itself to a collaborative experience that can be shared with peers or "multiuser".

Dauntless XR proposes a mixed reality holodeck platform to collaboratively view space weather data on coronal mass ejections (CMEs) visualized in immersive 3D. Dubbed “Aura” the proposed solution enables users to integrate NASA data into their decision-making process and make

more informed decisions regarding space weather. We propose to accomplish this by taking data from a Unified Data Library API and visualizing the data as a realistic 3D artifact in the Aura holodeck as it becomes available, paired with relevant standards, best practices, and data interpretation tips. The proposed innovation is hardware agnostic across headsets, phones, and tablets to maximize accessibility.

The proposed innovation makes NASA space weather data easy to access, quick to understand, and seamless to integrate into a workflow, even as forecasts remain uncertain. Aura for space weather would provide value to a general audience to educate and foster further innovation and inquiry to those with space domain expertise who may or may not be traditional users of NASAs data. As a digitally native solution the proposed platform is able to use existing data sources, but also add new ones as they become available giving the solution longevity and agility to adapt.

Potential NASA Applications (Limit 550 characters):

The potential NASA application is a novel space weather application that combines multiple data sources and practices to support space operations, that can continuously be improved and updated over time. Ultimately XR data visualization modules could include: Space weather; Launch & early orbit phase checkout; and Satellite Impact/position. The proposed application will ingest data from select sources; however, the backend architecture will ingest data from a variety of sources and sensors to continually enhance space domain awareness.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications for the proposed Aura innovation is a cohesive space weather monitoring, prediction & mitigation application for use by defense customers, commercial space companies, companies impacted by space weather events such as airlines, energy companies, and insurance companies, as well as academic institutions, where end-user understanding of Sun-Earth physics varies.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S14.01-2104**
SUBTOPIC TITLE:	Space Weather Research-to-Operations-to-Research (R2O2R) Technology Development and Commercial Applications
PROPOSAL TITLE:	Rapid Integration of Disparate Data Assets for Space Weather Research and Operations

Small Business Concern

Firm: **Meroxa**
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Phone: **(415) 754-8830**

Principal Investigator:

Name: **DeVaris Brown**

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 7
Technical Abstract (Limit 2000 characters):

In Phase I, Meroxa proposes to demonstrate the technical feasibility of building accessible tooling and connectors (proof of concept) for NASA to move space weather data, regardless of format and location, to any destination in the format required and in real-time.

Potential NASA Applications (Limit 550 characters):

The current operational suite of space weather products and services can be found in various formats and in disparate environments. Current processes to extract these data insights are too cumbersome and take too long. Moving data quickly and in real-time will contribute to the development and advancement of forecasting capabilities through better information dissemination for NASA operations and research.

Potential Non-NASA Applications (Limit 400 characters):

Development of pipelines that integrate disparate data sources is costly, time intensive and often still requires significant manual processing. The innovations of the Meroxa Platform and Conduit can be used by any non-NASA organizations to quickly move data for better analyses.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S14.01-2686**

SUBTOPIC TITLE: Space Weather Research-to-Operations-to-Research (R2O2R) Technology Development and Commercial Applications

PROPOSAL TITLE: Improved Forecasting of Operational Solar and Geomagnetic Indices

Small Business Concern

Firm: **Space Environment Technologies, LLC**
Address: **1676 Palisades Drive, Pacific Palisades, CA 90272**
Phone: **(310) 573-4185**

Principal Investigator:

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E-mail: **smutschler@spacewx.com**
Address: **1676 Palisades Drive, CA 90272 - 2111**
Phone: **(937) 654-3982**

Business Official:

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Address: **1676 Palisades Drive, CA 90272 - 2111**
Phone: **(310) 573-4185**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 6
Technical Abstract (Limit 2000 characters):

Improved thermospheric density forecasts are a critical need identified by the Space Weather Operations, Research, and Mitigation (SWORM) Working Group, a Federal interagency coordinating body [National Space Weather Strategy and Action Plan, 2019]. This work will improve thermospheric density prediction by reducing forecast error up to 65% during large geomagnetic storms. We will validate two replacement forecast drivers used by operational models. Given the increased debris environment in Low Earth Orbit (LEO) there is strong interest by U.S. agencies, companies, and international organizations for managing hazards from debris collision. There are two areas in which we will improve forecast neutral thermosphere densities. First, we will validate an existing observation-based solar irradiance index, i.e., the S10 produced by National Solar Observatory (NSO) SIFT model, that can accurately extend operational forecasts out to 7 days. Second, we validate a combined solar wind Gated Recurrent Unit (GRU) networks using solar wind observations algorithm (from Hu) plus a solar feature data-driven, machine-learned (ML) algorithms (Logit) (from Swiger) that together create a forecast Disturbance storm time (Dst) geomagnetic index for short (hours) and long (days) time frames, respectively. The SEFT S10 index will improve 3-7 day predictions for the debris collision maneuver and reentry windows. The Hu+Swiger Dst forecast capability will help resolve the single largest problem in thermosphere density forecasting, i.e., large error in

densities during geomagnetic storms resulting from poorly forecast storm magnitude and timing by Anemomilos Dst. SET will validate SIFT S10 as well as the GRU and Logit Dst data outputs in Phase I by comparing them to existing SET S10 and SET Anemomilos Dst that are the operational baselines used for the past decade. This project will design a method to automatically feed our new Dst predictions to the CME Scoreboard in coordination with CCMC.

Potential NASA Applications (Limit 550 characters):

This proposal supports NASA's mission as defined by Grand Challenges for cutting-edge technological solutions that can i) solve important space-related problems; ii) radically improve existing capabilities; or iii) deliver new space capabilities. Under Challenge 1 (expand human presence in space), our work helps mitigate the hazards of space debris collision by providing innovations for updating the baseline thermospheric density forecasting in the USSF HASDM system used by NASA CARA.

Potential Non-NASA Applications (Limit 400 characters):

Four LEO growth cases that can use our solar and geomagnetic drivers for improving thermosphere density forecasts are i) civilian agency satellites, ii) commercial satellites, iii) defense applications, and iv) space traffic management. SET already has customers of USSF 18 SDS and has also sold forecasts to commercial aerospace firms in the U.S., Japan, Germany, and Brazil over the past decade.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S14.02-1131**

SUBTOPIC TITLE: In Situ Particles and Fields and Remote-Sensing Enabling Technologies for Heliophysics Instruments

PROPOSAL TITLE: Compact Rydberg atom-based LF transmitter

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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Address: **510 Earl Boulevard, OH 45342 - 6411**
Phone: **(937) 320-1877**

Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

Cornerstone Research Group Inc. (CRG) proposes to develop a low frequency transmitter for active sensing of ionospheric and magnetospheric plasma density structure. CRG will leverage its experience with the compact Rydberg-atom based VLF transmitter for submarine to air communication. Active sensing with injection of ELF/VLF (300Hz -30kHz) frequency band electromagnetic waves into the Earth's magnetosphere have played an important role in discovering and elucidating wave-particle interactions in near-Earth space. For example, Siple Station VLF injection experiments were very successful in producing observations of non-linear growth and triggering whistler mode waves. Today, however, electromagnetic sounding of ionospheric and magnetospheric plasma density structure at low frequencies relies on passive sensing, i.e., using either naturally occurring radiation or using transmitters of opportunity such as global navigation satellite system or ground-based transmissions. The reason for that lies in in the significant engineering challenges of efficiently radiating in the low frequency bands. Rydberg atom-based technology overcomes many of these challenges and makes it feasible to construct a compact VLF transmitter which could be installed on a space platform. During Phase I, CRG will demonstrate design of such a transmitter adhering to the SWAP constraints associated with the space applications.

Potential NASA Applications (Limit 550 characters):

- Low frequency transmitter for space platforms

Potential Non-NASA Applications (Limit 400 characters):

- VLF transmitter for underwater to surface communications
- Through-the-earth (TTE) communication for mining applications
- Geophysical surveying using low frequency electromagnetic waves

Duration: **6**

PROPOSAL NUMBER: 23-1- **S15.02-1255**

SUBTOPIC TITLE: In Situ Sample Preparation and Analysis for Biological and Physical Sciences in a

Microgravity Environment

PROPOSAL TITLE: Long Term Cell Culture Monitoring System

Small Business Concern

Firm: **Wainamics Inc.**
Address: **7026 Koll Center Parkway, Suite 225, Pleasanton, CA 94566**
Phone: **(925) 480-7622**

Principal Investigator:

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Business Official:

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Phone: **(925) 480-7622**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Microbiology research in space is important for understanding effects of microgravity and space ionizing radiation on biological organisms, which is critical for human space exploration. CubeSat missions, such as BioSentinel, SporeSat, O/OREOS, and life science experiments on the International Space Station (ISS) have included microfluidic cartridges for research of cell and organism growth and metabolism in space. These systems require sample loading and full system assembly on Earth, using highly specialized equipment and specially trained personnel, which can limit the pace of research advancement in space.

Our proposed Microfluidic Biospecimen Cartridge (MBC) system will allow loading, sealing of biological samples, automatic perfusion and monitoring of the specimen growth on the ISS or in a laboratory without the requirement of specially trained engineers or specialized equipment. Once closed, the unit is entirely self-contained, minimizing chance of contamination and enabling safe handling of a wide variety of biological specimens in a microgravity environment. The MBC will allow users to monitor growth under microgravity over long periods on the ISS, providing maximum flexibility for executing experiments. The species studied with this system can be cells,

such as bacteria, human cell lines, or algae, fungi, spores and even more complex biospecimens such as C. elegans worms.

The MBC will contain 16 wells that are interconnected with microfluidic channels. The channels deliver nutrients and remove waste from the wells. The biospecimens in each well are trapped by filter membranes at the top and bottom of the wells. This project will focus on design and prototype of a microfluidic cartridge that is compatible to standard large-scale manufacturing methods including injection molding, heat staking, and ultrasonic welding. Yeast cells will be used to demonstrate cell isolation within each well, and automated cell perfusion and growth in a complete enclosed system.

Potential NASA Applications (Limit 550 characters):

This MBC can be used on the ISS for microbiology experiments, advancing our understanding of space biology. Astronauts can prepare samples on the ISS without the need for special equipment, and all subsequent processes are automated in the MBC. The cartridge can also be used in CubeSat missions, offering simplified, consistent performance, while reducing development time and cost. As a standardized, low-cost system, the MBC also enables academic research laboratories and STEM students to design and perform space biology research experiments.

Potential Non-NASA Applications (Limit 400 characters):

The MBC has pharmaceutical, environmental, and educational applications. Therapies can be tested and validated quickly, as the MBC provides both sample storage and detection of the impact of therapies on cell vitality and growth. It can be used for environmental monitoring such as long-term water and soil testing, and can enhance research potential in low-budget laboratories and STEM classrooms.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S16.02-1610**

SUBTOPIC TITLE: Dynamic Power Conversion

PROPOSAL TITLE: Affordable In-Space Demonstration of Dynamic Radioisotope Power Conversion

Small Business Concern

Firm: **Ultra Safe Nuclear Corporation-Technologies**
Address: **2320 West Commodore Way, Unit 200, Seattle, WA 98199**
Phone: **(858) 342-4837**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 4
Technical Abstract (Limit 2000 characters):

USNC-Tech is proposing a modular radioisotope power system. This system would enable a low-cost flight demonstration of a high efficiency dynamic power system using a low-cost radioisotope and maintaining compatibility with the GPHS Pu-238 power source due to its modular design. Co-60 is routinely produced in 500 W scale quantities needed for a dynamic power system demonstration. While interfacing C0-60 is different than for the General Purpose Heat Source (GPHS) block, the proposed concept is (1) modular to accommodate either Pu-238 or Co-60, (2) still optimized for Pu-238, (3) uses currently developed hardware by the NASA DRPS programs, and (4) focuses on enabling a near term launch demonstration.

USNC-Tech has teamed with Sunpower, the developer of the Sunpower Robust Stirling Convertor (SRSC). USNC-Tech is bringing expertise with inexpensive radioisotope technology based on the medical radioisotope industry in the form of its EmberCore™ technology to combine the radioisotope with the SRSC in a configuration notionally like the Advanced Stirling Radioisotope Generator (ASRG) but modified to (1) be modular such that it can utilize alternative radioisotopes or GPHS blocks and (2) utilize heat pipes to distribute heat to convertors. USNC-Tech refers to the concept as the Modular Radioisotope Dynamic Generator (MRDG).

Modularity of the radioisotope will allow for use of a shorter-lived inexpensive isotopes such as 5.7-year Co-60 for lower cost missions, ease the supply chain requirements for Pu-238, yet leverage system commonality for Pu-238 to be used for long-life missions to the outer solar system, for example.
Potential NASA Applications (Limit 550 characters):

- Lunar surface landers & rovers in need of night survival or PSR operation.
- Deep space science missions of limited budget (Discovery, SIMPLEX, etc.).

Potential Non-NASA Applications (Limit 400 characters):

- Defense customers in need of spacecraft solutions that are agnostic to the Sun and are not burdened by the need to point photovoltaic panels.
- Defense customers looking for non-photovoltaic power sources to act as supplemental backup power to a primary photovoltaic system.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S16.02-1705**
SUBTOPIC TITLE:	Dynamic Power Conversion
PROPOSAL TITLE:	Robust Linear Motor Controller Proof-of-Principle Hardware Demonstration

Small Business Concern

Firm: **Converter Source, LLC**
Address: **16922 South Canaan Road, Athens, OH 45701**
Phone: **(740) 592-5166**

Principal Investigator:

Name: **James Huth**
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Address: **16922 South Canaan Road, OH 45701 - 9461**
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Business Official:

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Phone: **(646) 306-4824**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

Based upon our review of published NASA papers and reports, compared with other teams’Stirling machine controllers, our controller appears uniquely capable of precisely controlling piston motions (i.e., amplitude, mean position offset, frequency) and phase-synchronization with other machines. Our robust active controller implements a novel nonlinear control algorithm to maintain stable machine operation despite model parameter uncertainty and unmodeled dynamics. However, to date, we have only evaluated the performance of our controller as part of software simulations of Stirling machines. The virtual controller performance has been extensively studied through two NASA SBIR Phase I projects.

The next logical step in developing this controller is transitioning from present *virtual* model simulations to *real* processor hardware. The migration to hardware always introduces new and unexpected problems. Therefore, we propose validating our control algorithm using a simple linear motor on the lab benchtop. We will derive the motor test hardware from convertor alternator/ piston/ cylinder components from a past NASA SBIR Phase II project. The effort will include the selection of a physical processor board, deploying the control algorithm to the board, and initial controller integration with the power stage, sensors, and linear motor.

Lastly, we will subject the hardware system to a range of test scenarios and parameter sweeps to confirm the robustness of our controller to maintain desired piston motion. As a performance reference, we will update our virtual system model throughout the project. This hardware demonstration will test our performance predictions and help guide the future development of the standalone controller for use with other linear free-piston machines.
Potential NASA Applications (Limit 550 characters):

Our controller can support dynamic radioisotope power system (DRPS) Stirling convertors at any power level – offering reliable, efficient, and robust control of one or more convertors under off-nominal conditions. We could adapt the controller for NASA cryocooler applications to directly cool space sensors and reliquefy vapor for zero-boiloff fluid storage. The proposed controller could also be applied to linear gas compressor/ liquid pump or other linear actuator applications.
Potential Non-NASA Applications (Limit 400 characters):

Our controller could support convertors for terrestrial remote power applications requiring high reliability (e.g., navigation or communications equipment in off-grid areas). The controller could support cryocoolers for commercial CubeSat/ SmallSat or other missions requiring cooling multiple heat loads, possibly at different temperatures.
Duration: **6**

PROPOSAL NUMBER: 23-1- **S16.02-1929**

SUBTOPIC TITLE: Dynamic Power Conversion

PROPOSAL TITLE: Computational design of robust, compatible interconnect alloys for improved PbTe-based thermoelectric devices

Small Business Concern

Firm: **QuesTek Innovations, LLC**
Address: **1820 Ridge Avenue, Evanston, IL 60201**
Phone: **(847) 328-5800**

Principal Investigator:

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Business Official:

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Phone: **(847) 425-8226**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

Radioisotope power systems (RPSs) including thermoelectric systems are proven technologies for long-term power generation in distant, dark, and/or dusty environments where solar power is not viable. Despite significant advancements in thermoelectric (TE) material technology, modern TE systems rely on legacy TE technologies due to shortcomings in systems-integration and reliability of improved TE materials. Crucial TE material development challenges stem from the interface joining TE materials and the metallic interconnect (IC) material near the heater unit hot-end, which must be manufacturable, robust, and stable after decades of operation. In this program, QuesTek Innovations will leverage its Integrated Computational Materials Engineering (ICME) expertise and Materials by Design® technology to rapidly design and prototype a TE-IC junction combining a novel IC alloy design and a mechanically robust, highly efficient p-type PbTe material with improved power generation efficiency near radioisotope heater unit hot-end temperatures. Phase I involves thermodynamic database development and utilization of CALPHAD (CALculation of Phase Diagrams) methods to computationally design a junction between the PbTe material and a QuesTek-designed Co-based IC material with minimal experimental validation. Design will focus on thermodynamic interface stability and well-matched coefficients of thermal expansion between TE/IC materials to minimize thermal stress during fabrication and long-term operation. The database framework will be extended in Phase II work to design a similarly compatible IC-TE material junction for an improved n-type PbTe material, leading to further improved RPS efficiency. The longevity of a full device incorporating QuesTek's novel IC alloy and improved p- and n-type PbTe materials will be simulated using CALPHAD-based diffusion simulations to capture performance over multiple decades and experimentally verified through long-term device stability tests.

Potential NASA Applications (Limit 550 characters):

- Improved RPS components for improved power generation on unmanned scientific missions
- Exploration of deeper, darker space at the edges of our solar system
- Exploration of planetary moons and planetary surfaces
- Better opportunity to consider unmanned remote space stations
- Better opportunity to consider unmanned remote planet mineral mining

Potential Non-NASA Applications (Limit 400 characters):

- Improved RPS components for improved power generation to support commercial space endeavors
- Power to support unmanned mining operations
- Power to support equipment in commercial space stations and planetary bases

- Improved thermoelectric materials for renewable terrestrial energy harvesting

Duration: **6**

PROPOSAL NUMBER: 23-1- **S16.03-1803**

SUBTOPIC TITLE: Guidance, Navigation, and Control

PROPOSAL TITLE: Radiation Hardened ASIC for Control of Amplitude and Frequency Modulated Inertial Sensors

Small Business Concern

Firm: **Inertialwave, Inc.**
Address: **23868 Hawthorne Boulevard Suite 100, Torrance, CA 90505**
Phone: **(888) 628-7367**

Principal Investigator:

Name: **Mr. Anthony Challoner**
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Phone: **(888) 628-7367**

Business Official:

Name: **Peter Bond**
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Address: **23868 Hawthorne Blvd., Ste 100, CA 90505 - 8205**
Phone: **(310) 977-2988**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 6
Technical Abstract (Limit 2000 characters):

- A Universal Resonator Controller (URC) ASIC is proposed, primarily to measure inertial sensors. High performance, navigation-grade IMUs use discrete parts to sense accelerometers and gyroscopes. By using ASICs instead of COTS ICs IMU size and power consumption can be reduced. A major issue in both rad-hard and

terrestrial IMU markets is the lack of volume for high-performance systems when spread out across many players. It is not particularly feasible to develop a cutting-edge product with all the difficulties of an ASIC for a single specific sensor. Instead, the URC casts a wide net, allowing integrators to pick and choose which sensors to interface with. With only a handful of passives and support ICs, the proposed URC would be able to operate with most inertial sensors operating with resonant frequencies between 5kHz-150kHz. Nearly any resonating system may be controlled or sensed with this architecture due to its flexible digital programmable settings and selected external passives. A prototype with limited bandwidth and only amplitude modulation has been developed. Both voltage and current transduction modes are already available. Phase I efforts will be dedicated to improving and implementing targeted innovations. Due to the duration of work and award amount Phase I focuses on simulation and selected transistor-level designs. Radiation hardening methods will be simulated, ADC bandwidth improved, and frequency demodulation architectures designed. The existing ADC will be migrated to a rad-hard process and architecturally improved to guard against SETs. Phase II will then proceed with full chip design and migration efforts, culminating in the tapeout of a wide bandwidth, rad-hard URC ASIC with best in-class SWaP.

Potential NASA Applications (Limit 550 characters):

Rendevous, Proximity Operations, and Capture Maneuvering;

Formation Flying, Precison Pointing, Station Keeping, and Relative Navigation;

Affordable GNC for Expendable Vehicles;

Mars Sample & Return Missions (Mars Ascent Vehicle);

High Volume SmallSat Constellations;

Entry, Descent & Landing GNC;

Potential Non-NASA Applications (Limit 400 characters):

North Finding and Latitude Determination;

Down-Hole Navigation and Mapping for Geothermal and Oil;

Autonomous Vehicles and Drone Navigation/Stabilization;

Longer Duration Navigation for Munitions and GPS denied environments.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S16.03-1881**
SUBTOPIC TITLE:	Guidance, Navigation, and Control
PROPOSAL TITLE:	High Radiation Tolerant Star Tracker for Icy Ocean Worlds Exploration

Small Business Concern

Firm: **NewBridge Partners, Inc.**
Address: **2804 Baxley Hollow Court, Herndon, VA 20171**
Phone: **(703) 822-1159**

Principal Investigator:

Name: **John Anagnost**
E-mail: **JAnagnost@yournbpartners.com**
Address: **2804 Baxley Hollow Ct, VA 20171 - 2126**
Phone: **(310) 944-0894**

Business Official:

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Phone: **(703) 822-1159**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

NewBridge Partners, Inc. has developed an innovative, radiation-hard, very high-performance all-reflective optics star tracker deemed HRST (High Radiation Star Tracker). The instrument directly addresses the need for long-life performance in high radiation environments such as Jupiter where current conventional star trackers cannot readily meet the harsh radiation requirements. The design consists of a 3-mirror reflective triplet design form with an additional fold mirror. Additionally, with the inclusion of TRL8 on-board advanced processing algorithms it is readily possible to achieve better than 500 nrad of random star tracker error, rivaling the best performance available in the world today. The size, weight and power are in family with the other star trackers, resulting in an overall very high-performance GNC sensor with outstanding performance, capable of supporting NASA in operating in a high-radiation environment to study icy ocean worlds.

Potential NASA Applications (Limit 550 characters):

- Supports NASA spacecraft in earth observing orbits as well as satellites used for planetary exploration that require high radiation subsystems (MEO, Jovian, etc.)
- Provides 4X better performance over commercial star trackers with comparable SWaP for spacecraft requiring star trackers in any orbit
- Design form scalable to many other NASA EO/IR missions requiring good radiation performance

Potential Non-NASA Applications (Limit 400 characters):

The proposed star tracker can be used in potential commercial applications especially with the expanding interest in the cislunar arena. Star trackers are used on many space vehicles in support of attitude control, for earth-orbiting satellites as well as satellites dedicated to the study of planets, moons, asteroids, and comets beyond Earth orbit.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S16.03-1967**

SUBTOPIC TITLE: Guidance, Navigation, and Control

PROPOSAL TITLE: Precision Ion Nano Thruster

Small Business Concern

Firm: **Espace, Inc.**
Address: **30 Lynn Avenue, Hull, MA 02045**
Phone: **(781) 925-3893**

Principal Investigator:

Name: **Francois Martel**
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Address: **30 Lynn Avenue, MA 02045 - 2216**
Phone: **(781) 925-3893**

Business Official:

Name: **Francois Martel**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

We are proposing the development of a new miniaturized and low power stand-alone “nano-thruster” instrument, the Precision Ion Nano-Thruster (PINT) to perform very fine thrusting in support of precision attitude and pointing control on space platforms.

The miniature precision device development effort will be based on previous R&D results and experience, and proven technologies developed in collaborations between Espace Inc. and the MIT Space Propulsion Laboratory. The effort will focus on the miniaturization of the electronics and the high precision control of micro-fabricated ion-electrospray thrusters, leveraging the state of the art in the technologies, and optimizing the micro-thrusters for fine control and stability.

The ultimate objective of the PINT development will be rugged, industrially and economically manufactured, miniature stand-alone electric thrusters, providing precision controlled ion beams.

Potential NASA Applications (Limit 550 characters):

The applications of the PINT thrusters are in the area of very high precision control of space platforms, in attitude or trajectories. Advanced technologies such as laser telecommunications or fractionated interferometric instruments require stable and precise controls for which PINT will provide an economical and practical tool for fine adjustments and stabilization. PINT will have applications in NASA future astrophysics observatories and fractionated space system designs.

Potential Non-NASA Applications (Limit 400 characters):

The applications of the PINT thrusters are in the area of very high precision control of space platforms, in attitude or trajectories. Advanced technologies such as laser telecommunications require stable and precise controls. A commercial or governmental application is in fine stabilization and controls for small platforms using laser telecommunications.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S16.08-1927**

SUBTOPIC TITLE: Atomic Quantum Sensor and Clocks

PROPOSAL TITLE: Additively Manufacture Hyperfine Optomechanical Laser Discipline (AM-HOLD) Module

Small Business Concern

Firm: **Vapor Cell Technologies, LLC**
Address: **2060 Broadway, Suite 490, Boulder, CO 80302**
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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):

Atomic technologies such as atom interferometry, atomic clocks, atomic magnetometers, and Rydberg sensors have demonstrated exquisite stabilities and sensitivities. However, the high complexity, cost, and length development cycles have prevented these technologies from achieving their ultimate value. We propose to use additive manufacturing in combination with microfabricated components, micro optics, and low-noise electronics to rapidly build and assemble atomic devices for atom interferometry applications.

Success will be the offering of integrated atomic devices that can be used by NASA, academics, and commercial entities to build compact atomic sensors. This innovation will decrease the Size, Weight, Power, and Cost (SWaP-C) of atomic devices and produce a reliable, high-performance component for stabilizing atom interferometer systems. Atom interferometers are under heavy development using laser cooled atoms in free fall as ultra-precise inertial measurement objects. Enabling this technology can enable ultra-low-bandwidth rate measuring gyroscopes and accelerometers suitable for dead-reckoning deep in space. The NASA Cold Atom Lab (CAL) aboard the International Space Station has used atom interferometry for ultra-precise test of microgravity using absolutely accurate quantum sensing and is managed by the Jet Propulsion Laboratory under the BPS Divison of NASA's Science Mission Directorate.

While the underlying technology has been demonstrated, effort in making it manufacturable, repeatable, and reliable is now necessary so that a team of scientists and engineers are not required to operate such advanced devices. This work will enhance the ability for systems to be design, built, and characterized quickly. To develop next-generation atomic sensors, NASA needs reconfigurable, low-power, low-mass atomic devices compatible with off-the-shelf fiber optics and laser systems.

Potential NASA Applications (Limit 550 characters):

NASA missions require high accuracy and high sensitivity measurements and atom interferometers represent a cutting edge inertial measurement and navigation sensor. Potential NASA applications include: fundamental tests of gravity in space, the detection of gravitational waves using a laser ring interferometer geometry in space, precision tests of gravity during planetary flybys detecting sub-surface minerals and water, and navigating through space precisely and accurately using absolutely accurate inertial navigation.

Potential Non-NASA Applications (Limit 400 characters):

Compact atomic devices can solve medical, defense, and telecommunications applications if the cost can be brought down by over an order of magnitude. By utilizing technologies suitable to repeatable and mass-manufacture, this high-complexity technology can be applied to commercial problems where cost-sensitivity is very high and this work reduces some of the associated cost barriers.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S16.08-2009**

SUBTOPIC TITLE: Atomic Quantum Sensor and Clocks

PROPOSAL TITLE: Optical Frequency Synthesizer for Quantum Applications

Small Business Concern

Firm: **Vescent Photonics, Inc.**
Address: **14998 West 6th Avenue, Suite 700, Golden, CO 80401**
Phone: **(303) 296-6766**

Principal Investigator:

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Business Official:

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Phone: **(303) 296-6766**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Vescent Photonics, LLC (Vescent) proposes to develop a compact, low-power, environmentally robust optical fiber frequency comb (OFC) that operates in the visible spectrum (400-800 nm) and is constructed from telecommunications (telecom) components to enable next-generation space-deployed optical atomic clocks and Rydberg-atom based quantum sensors. The proposed system will meet the challenging performance requirements for state-of-the-art quantum sensors and clocks while maintaining a low size, weight, and power (SWaP) in a configurable platform that can be adapted to the diverse needs for several of the key space-deployed applications described in Focus Area S16.08. For example, optical atomic clocks can offer instabilities as low as 4.8x10-17 in a second, opening myriad possibilities for precision sensors addressing NASA's core interests including accurate positioning, navigation, and timing (PNT) onboard a spacecraft as well as the measurement of weak gravitational fields in near-zero gravity. Rydberg-atom based quantum sensors offer similarly dramatic improvements for electric field and microwave measurements. However, the most promising optical atomic clock platforms (e.g., Sr and Yb lattice clocks and Sr+ and Yb+ trapped ion clocks) and Rydberg-atom based sensor platforms can only operate reliably in laboratory environments, largely due to their reliance on the environmentally susceptible, high-SWaP infrastructure required to frequency stabilize multiple lasers across the visible and near-infrared spectral regions. OFCs are an ideal substitute that can significantly reduce both SWaP and complexity of the optical atomic clock or quantum sensor. However, there is a clear and critical gap in field-deployable, low-SWaP, visible OFCs. Our proposed solution exploits rugged nonlinear micro-optic modules in telecom-style packaging to synthesize arbitrary visible frequencies from Vescent's existing radiation-hardened, environmentally robust OFC.

Potential NASA Applications (Limit 550 characters):

This proposed visible frequency comb platform addresses NASA's research topic area S16.08 Atomic Quantum Sensors and Clocks – **Critical technology gaps** related to: (1) optical atomic clocks for measurements of gravitational field variations, time-variations of physical constants, detection of dark matter, etc. and (2) Rydberg atom quantum sensors for ultra-broadband, ultra-sensitive microwave receivers for earth observation sciences. The proposed technology is relevant to the following missions: DSAC, CLPS, ISS, and Artemis.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications that would benefit from a low-SWaP visible frequency comb include: optical atomic clocks for navigation in GPS-denied environments, time and frequency transfer, ultra-low phase noise microwave generation for 5G-and-beyond wireless communications and radar sensing, dual comb and precision spectroscopy, and geodetic sensing for earthquake monitoring and construction projects.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S16.08-2021**

SUBTOPIC TITLE: Atomic Quantum Sensor and Clocks

PROPOSAL TITLE: Visible light phase and amplitude modulators for quantum sensors and clocks

Small Business Concern

Firm: **ADVR, Inc.**
Address: **31948 Frontage Road, Bozeman, MT 59715**
Phone: **(406) 522-0388**

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):

This Phase I SBIR will lead to the development of key photonic components for use in high performance quantum sensors and clocks. AdvR proposes to develop very high performance phase and amplitude modulators for use at visible and ultra-violet wavelengths. The proposed innovation utilizes high performance, damage resistant optical waveguides with high speed traveling wave electrodes to provide integrated functionality. These components are expected to be used in a variety of NASA and non-NASA applications including cold atom and trapped ion systems for precision sensing, timing, and computing.

Potential NASA Applications (Limit 550 characters):

Quantum Computing

Quantum Communications

Quantum Networking

Ion Traps

Atomic Interferometry

Optical Clocks

Environmental Monitoring

Potential Non-NASA Applications (Limit 400 characters):

Random Number Generation

Secure Communications

Quantum Computing

Precision Spectroscopy

Environmental Monitoring

Duration: **6**

PROPOSAL NUMBER: 23-1- **S17.01-2144**

SUBTOPIC TITLE: Technologies for Large-Scale Numerical Simulation

PROPOSAL TITLE: CHEM-ML MODEL FOR NON-EQUILIBRIUM CHEMISTRY IN HYPERSONIC FLOWS

Small Business Concern

Firm: **Karagozian & Case, Inc.**
Address: **700 N Brand Boulevard Suite 700, Glendale, CA 91203**
Phone: **(818) 240-1919**

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):

The K&C team plans to propose efficient artificial intelligence (AI) and machine learning (ML) based surrogate models (CHEM-ML) for non-equilibrium chemistry in hypersonic flows which is critical in designing hypersonic vehicles for space exploration. The CHEM-ML model can be coupled with reactive Navier-Stokes equations or high fidelity CFD models such as FUN3D and DPLR. In addition, CHEM-ML will be able to support both simple and complex chemical mechanisms. A deep operator network (DeepONet) will be employed to model the chemical kinetics in hypersonic flows such as gas-species reactions and gas surface reactions depending on the velocity, altitude and the materials of the hypersonic vehicle. DeepONet is based on the universal approximation of nonlinear operators which is suggestive of the potential application of neural networks in learning nonlinear operators from data. DeepONet can learn the stiff temporal evolution of chemical species' mass fractions over a given duration during offline training, so that during a prospective simulation inference from the learned algorithm can evolve the thermo-chemical state at a rate comparable to the hydrodynamic time scale, but without sacrificing the fidelity of the chemical system's transition path. Note that K&C team has recent experience with DeepONet models for stiff chemical kinetics problems which were successfully used in reactive flow CFD simulations to speed up the calculation by over x1000 times. The K&C team is poised to develop a model for a variety of chemical reaction mechanisms despite the short period of performance for Phase I due to the extensive expertise and existing DeepONet tools already used by K&C.

Potential NASA Applications (Limit 550 characters):

Potential for NASA space missions in both Human Exploration and Operations Mission Directorate (HEOMD) and Science Mission Directorate (SMD) with an EDL segment. Missions depend on aerothermal CFD to define critical flight environments and would see significant, sustained reductions in cost and time-to-solution if an effective ML-based model is deployed. The scope has strong crosscutting benefits for tools used by ARMD to simulate airbreathing hypersonic vehicles, which have stringent accuracy requirements like those in aerothermodynamics.

Potential Non-NASA Applications (Limit 400 characters):

The CHEM-ML non-NASA market is extensive and covers Government, private sector, and academia from various scientific fields. The market size for the Phase II product includes all scientists and researchers working on reactive flows. The market includes a variety of applications such as: 1) weapon effects, 2) agent defeat, 3) modeling of hypersonic plumes, 4) propulsion, 5) combustion engines, etc.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S17.02-1070**

SUBTOPIC TITLE: Integrated Campaign and System Modeling

PROPOSAL TITLE: AISE: AI for Systems Engineering, a Digital Design Assistant

Small Business Concern

Firm: **Orbital Transports, Inc**
Address: **965 West Chicago Avenue, Chicago, IL 60642**
Phone: **(773) 218-6151**

Principal Investigator:

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Business Official:

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Address: **965 W Chicago Ave, IL 60642 - 5413**
Phone: **(773) 218-6151**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

To address NASA's need for advanced model-based systems engineering (MBSE) methods and tools that integrate digital engineering and science activities across the entirety of the mission and program life cycle, Orbital Transports proposes to develop AI for Systems Engineering (AISE), an innovative digital design assistant to provide semantic search and classification of systems design work products enabling reuse of systems models in new missions and contexts. Historically, knowledge about a system or its context would be siloed within a single mission or even a single project. AISE will make system models and institutional systems engineering knowledge broadly accessible across the organization for use with other missions and programs, greatly accelerating risk-informed and evidence-based decision making.

The proposed digital design assistant utilizes OpenAI's Generative Pre-Trained Transformer 3 (GPT-3) to identify and classify systems engineering models expressed in SysML v2 for retrieval from a repository of SysML v2 models using symmetric and asymmetric queries. Symmetric queries use an engineer's current work context to recommend similar models from the repository developed within the organization in different projects and contexts, reducing redundancy and errors, thus streamlining development by encouraging reuse of previously validated work products. Asymmetric queries enable NASA engineers to use naturalistic, free-form prompts to pursue effective lines of inquiry through the repository, easily finding relevant engineering designs and work products even when the exact target of search is not clearly known or well-formed.

The Phase I effort will validate methods for extracting and saving embeddings of SysML v2 work products, and for processing symmetric and asymmetric searches of a repository of systems models. The proposed effort will deliver a proof-of-concept demonstrating these methods to support efficient retrieval and usage of organization work products.

Potential NASA Applications (Limit 550 characters):

AISE will help NASA teams and projects achieve higher value collaboration across all programs, teams and stages of the NASA life cycle. This work will also support decision making within projects by facilitating access to information and evidence in designs and work products, accelerating evidence-based decision-making. Access to industry partner-generated designs and work products as part of the proposed innovation will enhance inter-agency and NASA/industry collaboration while promoting data-centric information exchange.

Potential Non-NASA Applications (Limit 400 characters):

Customers for AISE products include commercial groups and Government agencies deploying MBSE with significant needs: to make system models and institutional knowledge accessible across their organization; to identify models for normalization and reuse in ongoing design and future development; and to utilize previously validated models, reducing errors and streamlining development.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S17.04-1642**

SUBTOPIC TITLE: Application of Artificial Intelligence for Science Modeling and Instrumentation

PROPOSAL TITLE: DAPE: Data Assimilation and Model Parameterization for Earth Science

Small Business Concern

Firm: **EnviTrace LLC**
Address: **1048 Mansion Ridge Road, Santa Fe, NM 87501**
Phone: **(505) 310-4367**

Principal Investigator:

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Business Official:

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Phone: **(505) 310-4367**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters):

We will develop methods and a software framework for data assimilation and parameterization (DAPE) using Unsupervised and Physics-Informed Machine-Learning (UML and PIML). We will apply DAPE to parameterize processes represented by the Variable Infiltration Capacity (VIC) Hydrological Model. VIC is critical for simulating surface/subsurface water flow in several Earth System Models (ESMs).

DAPE will be capable of assimilating and merging discrete in-situ (e.g., weather/gage stations, monitoring wells) and continuous (e.g., satellite/airborne/geophysics images) datasets. DAPE will apply ML to generate high-resolution spatiotemporal mappings of the meteorologic, surface water, and groundwater parameters (e.g., precipitation, evapotranspiration, infiltration, surface runoff, soil moisture, temperature, and heat flux). The mappings will be applied to parameterize the surface water and groundwater flow in the VIC model. The parameterization will combine analyses of field measurements, remote data, and modeling outputs.

In the next project phases, we will apply DAPE to develop a PIML model representing all energy/mass balance processes simulated in VIC. We will also address VIC limitations related to lateral surface-water/groundwater flow. We will also explore alternative models (PRMS, Noah-LSM, Noah-MP). We will evaluate the impacts of input and conceptual model uncertainties on the predictive uncertainties. We will also analyze NOAA/NASA satellite images representing land surface water and energy dynamics. We will also explore how the ML analyses of these datasets will impact the characterization, parameterization, and prediction of Earth system processes, with an emphasis on floods and droughts. These analyses will account for anthropogenic activities and climatic changes. We will apply our work to update the Livneh dataset.

Potential NASA Applications (Limit 550 characters):

Applications are aligned with the NASA/NOAA projects aimed to characterize Earth science processes using remote sensing and in-situ measurements. Some of the projects are NASA/NOAA's Global Temperature/Climate initiative, Global Precipitation

Measurement (GPM) Mission, Joint Polar Satellite System (JPSS/JPSS-2), Geostationary Operational Environmental Satellite Program (GOES), International Satellite Cloud Climatology Project (ISCCP), Global Energy and Water Exchanges (GEWEX), and Aqua Earth-observing satellite mission.

Potential Non-NASA Applications (Limit 400 characters):

Or software will help industries develop smart and safe technologies related to water resources and support stakeholders to make scientifically-defensible decisions. Potential DAPE customers are also academia and research institutions. Target sectors include insurance, agriculture, water supply, food/energy production and other federal agencies including NOAA, DOE, EPA, and USDA.

Duration: **6**

PROPOSAL NUMBER:	23-1- **Z1.05-1735**
SUBTOPIC TITLE:	Lunar and Planetary Surface Power Management and Distribution
PROPOSAL TITLE:	Blue Laser Long Range Remote Beaming System

Small Business Concern

Firm: **NUBURU Inc.**
Address: **7442 Tucson Way, Suite 130, Centennial, CO 80112**
Phone: **(636) 578-1567**

Principal Investigator:

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Business Official:

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Address: **7442 Tucson Way, Suite 130, CO 80112 - 3999**
Phone: **(636) 578-1567**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters):

NUBURU is proposing a high power blue laser based power beaming system to provide up to 1kW of electrical power at a remote site, 1GPS bi-directional lasercom data link between terminals, and, because the laser is visible, unaided visual navigation from one site to the next. The system can be configured as a point-to-point system or a broadcast system depending on the needs of the mission. This approach to power distribution on either the lunar surface or other planets such as Mars eliminates the need to bring heavy equipment to these sites to install copper or aluminum wires. Given the cost of lifting a kg of weight to these worlds, it is clear that power beaming is an ideal solution.

Potential NASA Applications (Limit 550 characters):

NASA identified the weight of transporting copper or aluminum wires as a significant issue for distributing power on a lunar or planetary base to remote locations. The cost of lifting equipment to the moon is about $1.8M/kg (NASA spaceflight forum). Due to space's commercialization, these costs are lowering and attempts have reached lunar orbit, but none have successfully landed. The cost goes up at least 5x when placing a system on Mars. Thus, it's uneconomical to transport wire or even its raw materials. Power beaming is a realistic solution.

Potential Non-NASA Applications (Limit 400 characters):

The system will be deployable in minutes, restoring power to critical areas. Applications include temporary power to distressed areas damaged by war or natural disasters and power distribution at temporary remote depots, which allow the depots to be set up and removed rapidly. This capability should be of interest to DOD. FEMA may also be interested in the temporary power capability.

Duration: **6**

PROPOSAL NUMBER:	23-1- **Z1.05-2323**
SUBTOPIC TITLE:	Lunar and Planetary Surface Power Management and Distribution
PROPOSAL TITLE:	Radiation-Tolerant, High-Voltage Bidirectional DC-DC Converter PMIC

Small Business Concern

Firm: **Alphacore, Inc.**
Address: **304 South Rockford Drive, Tempe, AZ 85288**
Phone: **(480) 494-5618**

Principal Investigator:

Name: **Dr. Marek Turowski**
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Address: **304 South Rockford Drive, AZ 85288 - 3052**
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Business Official:

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Address: **304 South Rockford Drive, AZ 85288 - 3052**
Phone: **(520) 647-4445**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

In response to the NASA SBIR topic Z1.05-1 “Radiation-Tolerant, High-Voltage Converters for Lunar and Mars Missions”, Alphacore Inc. will develop a 1kW, 100-Vdc to 1,000-Vdc radiation-tolerant, bidirectional, high-voltage, high-gain, lightweight, high-efficiency, DC-DC converter based on a mixed-signal (analog/digital) **power management integrated circuit (PMIC)** driving external Wide Band Gap (WBG) gallium nitride (GaN) or silicon carbide (SiC) field effect transistors (FETs) and passive components (inductors, transformers, capacitors). Other important characteristics are wide temperature (-150 ºC to 150 ºC) operation, high power density (>2 kW/kg), and high efficiency (>96%). While WBG discrete FETs are to some degree radiation-tolerant, their control/drive integrated circuits (ICs) are not. Alphacore PMIC satisfies the need for a radiation-tolerant, high-voltage, high-gain, lightweight controller/driver of WBG power FETs.

The developed PMIC will have a reduced component count, enabling reduced failure modes, and smaller area of PCB (printed circuit board). It will include over-voltage protection, fault tolerance, load monitoring, as well as allow control and status monitoring by a remote power system controller. This PMIC includes all controller circuitry and drivers integrated in a single package and drives an external WBG-based power stage.
Potential NASA Applications (Limit 550 characters):

These PMICs will bring significant value to Lunar and Planetary Surface Power Management and Distribution as well as NASA Programs and Directorates, including Aeronautics, Human Exploration, Science, Space Technology, Artemis, and Gateway, among others. The PMIC will enable NASA Decadal Strategy for Planetary Science and Astrobiology 2023-2032 per following examples. Artemis Base Camp **power systems**. Mars **power system concepts**. Lucy and Psyche **solar arrays for power**. Radioactive decay **electric power**. Future **solar power generation and storage**.
Potential Non-NASA Applications (Limit 400 characters):

Target applications include high-voltage power switching and power conversion, grid power and battery chargers for electric cars. The rise in demand for telecommunications, autonomous and electric vehicles, and industrial robots is expected to be a significant driver to commercial market segments. Alphacore’s PMIC fulfills all those needs, with specifications that exceed its known competitors.
Duration: **6**

PROPOSAL NUMBER: 23-1- **Z1.05-2421**

SUBTOPIC TITLE: Lunar and Planetary Surface Power Management and Distribution

PROPOSAL TITLE: Lightweight ultra-strong flexible power cables from metallic nanoparticles and aramid nanofibers

Small Business Concern

Firm: **Amphionic, LLC**
Address: **875 North Lima Center Road, Dexter, MI 48130**
Phone: **(734) 660-9412**

Principal Investigator:

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Phone: **(765) 609-1308**

Business Official:

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Phone: **(734) 660-9412**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5
Technical Abstract (Limit 2000 characters):

This SBIR Phase I project will develop lightweight, high-strength, temperature-resilient copper-based cabling derived from a facile manufacturing process. In previous work, large volumetric fractions of gold, silver, and copper 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 includng carbon based nanomaterials (CNTs and graphene) and other metallic nanomaterials. 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 planar 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 previous demonstrations done with planar conductors to copper-ANF cylindrical and hollow wires that are relevant to planetary power-handling that require mass-efficient, environmentally-robust 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. Finally, we will design manufacturing tools to scale-up the production of the solids.

Potential NASA Applications (Limit 550 characters):

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 400 characters):

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: 23-1- **Z10.01-1090**

SUBTOPIC TITLE: Cryogenic Fluid Management

PROPOSAL TITLE: Flight-Weight Cryogenic Cam Butterfly Valve

Small Business Concern

Firm: **C-Suite Services, LLC**
Address: **114 Mulberry Drive, Metairie, LA 70005**
Phone: **(303) 594-4300**

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):

The main technical objectives are:

1. Modify the design of the CCV geometry and materials to be a C_V 100 flight-weight valve
2. Optimize the camshaft's impact on CCV disc motion to support bubble-tight sealing
3. Optimize the design of the flight-weight CCV to minimize mass and dimensions
4. Determine whether some or all of the parts of the modified CCV are candidates for additive manufacturing
5. Match the actuation and actuation mechanisms to the redesigned valve

Potential NASA Applications (Limit 550 characters):

The cryogenic flight-weight Cryogenic Cam Butterfly Valve will enable fluid management, including actuation, for cryogenic propellants (oxygen, hydrogen, and methane) for the Artemis Program. Proposer will evaluate whether some or all of the valve components are candidates for additive manufacturing, without compromising safety, reliability, durability, elasticity retention, and integrity throughout operating flow rates, pressures, and temperatures. Evaluations for cryogenic fluid management with this valve will be conducted at all NASA sites.

Potential Non-NASA Applications (Limit 400 characters):

The smaller size and valve performance features sought for this flight-weight valve closely mirror the sizes and features required for super-cooled liquid hydrogen and liquified natural gas production, storage, transfer, and distribution (truck, rail, barge, ship).

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z10.01-1304**

SUBTOPIC TITLE: Cryogenic Fluid Management

PROPOSAL TITLE: Lightweight, Low-Power Cryogenic Valve for Orbital Propellant Management

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:

Name: **Patrick Magari**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Orbital refueling of cryogenic propellants is a key enabling technology that will extend the usable life of spacecraft around Earth and facilitate the next generation of advanced exploration missions. Propellant management on orbit requires advanced propellant tanks, liquid acquisition devices, propellant transfer pumps, space-rated valves, and other subcomponents compatible with common propellants and designed for use at cryogenic temperatures. We propose to help meet this need by developing a space-rated valve for cryogenic propellants. Our valve uses a floating seal to provide low flow restriction without the bulky housing typically required of valves with large orifices. In Phase I, we will complete detailed design of the valve and actuator, fabricate a prototype valve, and leverage existing Creare facilities to test flow and leakage with liquid nitrogen. In Phase II, we will update our valve design using lessons learned, integrate it with our space-rated actuator, and conduct valve testing under relevant operating conditions. At the end of Phase II, we will have a complete valve assembly with demonstrated performance, ready for spaceflight qualification and mission use.
Potential NASA Applications (Limit 550 characters):

Our cryogenic valve is intended to operate in propellant depots located on orbit, as well as spacecraft designed to interface with these depots. We expect NASA will leverage our valve in both systems. Although designed for use in space, it is possible our valves will also become a part of ground-based cryogenic fuel production, storage, and transfer facilities supporting the SLS and other launch systems.
Potential Non-NASA Applications (Limit 400 characters):

Commercial aerospace companies are actively pursuing orbital propellant management systems to realize economic advantages of refueling on orbit. Our valve will be an attractive component for spacecraft and fuel depot subsystems, especially if they seek to share a common interface

with NASA systems. It may also be used in ground-based propellant management systems to support launch operations.
Duration: **6**

PROPOSAL NUMBER: 23-1- **Z10.04-1969**

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

PROPOSAL TITLE: Improved Design of the VASIMR Radio Frequency Transmission Line

Small Business Concern

Firm: **Ad Astra Rocket Company**
Address: **141 West Bay Area Boulevard, Webster, TX 77598**
Phone: **(281) 526-0518**

Principal Investigator:

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Address: **141 W. Bay Area Blvd., TX 77598 - 4111**
Phone: **(281) 526-0518**

Business Official:

Name: **Franklin Chang-Diaz**
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Address: **141 W. Bay Area Blvd., TX 77598 - 4111**
Phone: **(281) 526-0518**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 5
Technical Abstract (Limit 2000 characters):

The proposed Phase I work addresses the subtopic “High-Temperature, High-Voltage Electric Propulsion Harnesses Connectors and Cables” and aims to deliver an improved design of the VASIMR® “Rhino Horn,” the low impedance section of the engine’s 2nd stage RF transmission

line.
Lying deep in the rocket core assembly, this component carries the largest fraction of the RF power. The Rhino Horn must withstand kV-level reactive voltages and be actively cooled to remove hundreds of watts of Joule self-heat and additional heat conducted from its proximity to the rocket core.
Three generations of Rhino Horns have preceded the proposed design, each improving over the previous one. Generation-3 (Gen-3), the most recent operational design, enabled the VX-200SS™ VASIMR® prototype to demonstrate, in July of 2021, thermal steady state at 80 kW in an endurance test lasting 88 continuous hours. The fourth generation (Gen-4) Rhino Horn presented here, features innovations in thermal management, high-voltage insulation, integrated manufacturing and ease of assembly and installation.
In this proposal we aim to complete the Gen-4 Rhino Horn design to Critical Design and validate its assumptions in a sub-scale Rhino Horn experimental assembly to be built and tested in vacuum. Also, a numerical "twin" of the Gen-4 Rhino Horn will be developed, validated with the experimental results, and used to predict the thermal behavior of the Gen-4 Rhino Horn at power levels > 100 kW.
While the proposed work focuses on Rhino Horn improvements, the innovation is systemic and relevant to the low impedance RF line driving the first stage "ionizer" as well. That section has not exceeded thermal limits at the power levels explored thus far; however, being also a high current-carrying component, it is likely to do so at higher rocket power when the system demands more from the "ionizer". Like the Rhino Horn, the Helicon RF line must maintain insulator integrity to kilovolt potentials in a cramped space.

Potential NASA Applications (Limit 550 characters):

- Lunar resupply missions with high-power solar and nuclear electric propulsion (SEP/NEP)
- Fast interplanetary robotic science missions with high-power NEP
- Cislunar NASA in-space transportation with high-power SEP/NEP
- Planetary defense missions with high-power SEP/NEP
- Orbital debris mitigation (could also be non-NASA)
- Multi-MW-class human fast interplanetary missions with high-power NEP

Potential Non-NASA Applications (Limit 400 characters):

- Lunar resupply missions with high-power SEP/NEP
- In-space "mining" missions with high-power SEP/NEP
- Cislunar commercial in-space logistics with high-power SEP/NEP
- DoD cislunar robotic applications with high-power SEP/NEP
- Commercial mission extension, resupply, maintenance and repair vehicles with high-power SEP/NEP
- Reboost and orbit maintenance of large space stations in LEO with high-power SEP

Duration: **5**

PROPOSAL NUMBER: 23-1- **Z12.01-1216**

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

PROPOSAL TITLE: Processing and Extraction of Metal Oxide Slag on the Moon (PEMOS)

Small Business Concern

Firm: **Lunar Resources, Inc.**

Address: **6721 Portwest Drive, Houston, TX 77024**
Phone: **(646) 455-8382**

Principal Investigator:

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E-mail: **alex@lunarresources.space**
Address: **5000 Gulf Freeway, Exploration Research Park, Bldg 4, TX 77023 - 4636**
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Business Official:

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Address: **5000 Gulf Freeway, Exploration Research Park, Bldg 4, TX 77023 - 4634**
Phone: **(646) 455-8382**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

Lunar Resources proposes to NASA the Processing and Extraction of Metal Oxide Slag on the Moon (PEMOS) to extract rare earth elements, thorium and high temperature metal oxides on the Moon without any earth-based consumables. The global objective of PEMOS' Phase I project is to mature the PEMOS system to TRL 4 for the extraction of titanium, calcium, chromium, rare earth elements and thorium from regolith slag through experimentation and system design. In addition, an economic analysis will be developed whose objective is to determine if/when would the extraction of rare earth elements and thorium from lunar regolith be economical for use on Earth (i.e., to be extracted from the Moon and transported back from Earth).

Potential NASA Applications (Limit 550 characters):

Utilization of titanium, magnesium, calcium and chromium to directly support lunar surface infrastructure development including being used to produce structures, transmission lines, or alloyed to enable additive manufacturing.

Potential Non-NASA Applications (Limit 400 characters):

Utilization of rare earth elements and thorium for applications on Earth to alleviate America's dependence on adversary countries' supply of rare earth elements. As well, support commercial and US government efforts on in-space servicing, manufacturing, and repair.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z12.01-1502**

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

PROPOSAL TITLE: Extraction and Utilization of Water and Gases from Icy Lunar Regolith

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: 3
Technical Abstract (Limit 2000 characters):

NASA's in-situ resource utilization (ISRU) mission is to put in place a sustainable infrastructure that will allow human habitation on Moon with minimal support from earth. One particular resource available on the lunar permanently shadowed regions (PSRs) is the icy regolith which consists of icy water and volatile components (e.g., H_2S, NH_3, SO_2, C_2H_4, CO_2, CH_3OH, CH_4). Recovered water and volatile components from the icy regolith could be used to support human life on the moon. For instance, water could be used as life support and propellant; volatile gases can be used to manufacture polythiols polymer, sulfur can be used in concrete, composites, batteries, space sealant, etc. Faraday and the University of Kansas will demonstrate a high recovery scalable manufacturing platform for extraction of icy lunar regolith. In Phase I, Faraday and University of Kansas will develop a process to solubilize water and volatile gases from icy high-fidelity regolith simulant. Next, Faraday will utilize thermosensitive liquids to

demonstrate the separation of pure water and a desorption process to remove the absorbed gases from the liquid. Finally, we will demonstrate regeneration of the thermosensitive liquids and show a plan to utilize recovered products in a way that reduced the cost of landing consumables on the lunar surface. The results of this investigation will provide a basis for transition planning and an alpha-scale semi-continuous system design. Alignment of this technology for future NASA (Artemis) and commercial missions (Xelene) is critical for future integration and with the help of our team, we will assess system robustness metrics required for Phase IIE/III. In Phase II we will build the semi-continuous extraction system that can process 7kg/hr of icy lunar simulant and optimize the process parameters based on the input from NASA and our commercial partners.

Potential NASA Applications (Limit 550 characters):

The proposed technology would support longer-term activities and the eventual establishment of facilities on the lunar surface capable of supporting human missions while reducing the launch costs of excess materials. Water recovered through this technology could be used for human habitation. Recovered volatile gases could be utilized for manufacturing products such as polythiols polymer; coolant; metal halides stripped solvent; sulfur could be utilized in concrete, batteries, composites, photoelectrochemical cells and space sealants.

Potential Non-NASA Applications (Limit 400 characters):

The terrestrial market opportunity is in the domestic gas producing industries. For instance, Airgas, AirProducts, and Linde are large companies that produce industrial and specialty gases product. Natural gas-producing industries such as ExxonMobil, BP and Chevron could be potential customers for this technology for the selective removal of H2S and other impurities from natural gas.

Duration: **6**

PROPOSAL NUMBER:	23-1- **Z12.01-2307**
SUBTOPIC TITLE:	Extraction of Oxygen, Metal, and Water from Lunar Regolith
PROPOSAL TITLE:	Lunar Magnesium from Beneficiated Regolith

Small Business Concern

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

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

The proposed Lunar Magnesium from Beneficiated Regolith (LuMBR) system produces high-purity magnesium metal and oxygen byproduct from beneficiated lunar regolith. LuMBR targets electrostatic and magnetic separations to concentrate lunar minerals such as magnesium-containing minerals such as olivine and pyroxene to boost the magnesium oxide (MgO) content from less than 10 percent average concentration in lunar soils to as much as 40 to 50 percent MgO in individual mineral grains. Most of the balance of the beneficiated mineral content consists primarily of silicon oxides. The silicon oxides in the beneficiated feed are first reduced to silicon metal via carbothermal reduction. The resulting silicon metal then serves as the reductant for production of magnesium metal from MgO. The relatively high vapor pressure of magnesium metal at elevated temperatures (compared to other light metals such as aluminum and titanium) facilitates the recovery of nearly pure metal when condensed from vapors downstream of the silicothermic reduction reactor. LuMBR also generates high-quality fumed silicon oxide (SiO) that can be recovered during carbothermal reduction of beneficiated feed minerals.

Magnesium metal exhibits tensile strength similar to aluminum and is generally formulated with small amounts of other metals such as aluminum, zinc, manganese, silicon, copper, rare earths, and zirconium to achieve strength and corrosion properties required for Earth applications. Alloying requirements for lunar applications can be tailored to achieve properties required in reduced gravity and the presence of large temperature swings in vacuum. Similarly, alloying to minimize oxidation or corrosion for applications in habitats or other potential lunar environments can also be achieved based on current terrestrial utilization. Magnesium and its alloys have been successfully demonstrated in key components of lunar rover frames and wheels.
Potential NASA Applications (Limit 550 characters):

The primary application of Lunar Magnesium from Beneficiated Regolith is to support human space exploration by facilitating the production and fabrication of important structural metal components from in-situ resources. The technology is applicable to a permanent human presence in which local raw materials are leveraged to substantially reduce the dependence on Earth-supplied oxygen and metal.
Potential Non-NASA Applications (Limit 400 characters):

LuMBR have potential terrestrial application in renewable energy applications in which CO_2 collected and concentrated from industrial sources can be converted to solid carbon for sequestration or manufacture of graphite, graphene, and composite materials. The proposed work is also expected to provide insight into the potential for terrestrial production of magnesium from low-grade resources.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z13.05-1119**

SUBTOPIC TITLE: Components for Extreme Environments

PROPOSAL TITLE: Scalable Magnetically Geared Actuator for Future Missions in Dusty & Extremely Cold Environments

Small Business Concern

Firm: **FluxWorks LLC**
Address: **707 TEXAS AVENUE, SUITE E106, COLLEGE STATION, TX 77840**
Phone: **(817) 929-0377**

Principal Investigator:

Name: **Dr. Matthew Johnson**
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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):

Gearboxes are critical for reducing the mass of drivetrains but the lubrications that they require struggle with extremely cold and dusty environments. Magnetic gears (MGs) are a promising noncontact alternative that does not require lubrication; however, existing topologies either struggle to achieve high gear ratios (coaxial MGs) or suffer from reliability and efficiency limitations (cycloidal MGs). The proposed patented Flux Angle Mapping MG relies on an entirely new operating principle, which offers the potential to achieve the key performance parameter (KPP) goals listed below:

(A) Min. ambient temperature actuator operation in hard vacuum without supplementary heating (°C)

(B) Average total efficiency in a lunar permanently shadowed region (%)

(C) Magnetic actuator life in dust-free environment (Output Cycles)

The state-of-the-art and goals for these KPPs are given in Table I of the Technical Volume and are listed on the briefing chart.

The high-level technical objectives of this project are to research and evaluate FAM MGs. The deliverables are a final technical report including a transition and commercialization plan.

The first technical objective will be the use of parametric multi-physics simulation models to evaluate the suitability of FAM magnetic gears MGs for use in cold and dusty environments and to design a FAM MG technology demonstrator with the following specifications:

- >208 N·m slip torque
- >43:1 gear ratio
- >55 N·m/kg total mass torque density of the gearbox alone
- >2 rpm low-speed shaft speed
- >90% efficiency

The second technical objective will be the development and testing of a proof-of-concept magnetic gear prototype with the same specifications listed above. This prototype will demonstrate the feasibility of FAM magnetic gears and calibrate and validate the aforementioned simulation models.

The third objective is to develop a transition and commercialization plan, including a detailed plan to achieve TRL 6 in Phase II and TRL 9 by 2028.

Potential NASA Applications (Limit 550 characters):

The proposed technology is potentially applicable for rover wheels, solar arrays, gimbals, ISRU (drills, buckets, etc.), and robot arms for nearly all planetary exploration missions, including missions to the Lunar surface, Lunar Gateway, Mars, Europa, Titan. Moreover, this magnetic gearbox technology is also potentially useful for deep space applications, such as the James Webb telescope.

Potential Non-NASA Applications (Limit 400 characters):

The proposed technology is potentially useful for several applications outside of NASA, such as advanced air mobility flight control surface actuators and backlash free backdrivable high-precision robotics actuators.

Duration: **6**

PROPOSAL NUMBER:	23-1- **Z13.05-1830**
SUBTOPIC TITLE:	Components for Extreme Environments
PROPOSAL TITLE:	High Power Wireless Charging Systems for Extreme Environments

Small Business Concern

Firm: **Yank Technologies, Inc.**
Address: **19 Morris Avenue Building 128, Brooklyn, NY 11205**
Phone: **(845) 598-4648**

Principal Investigator:

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Business Official:

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Phone: **(845) 598-4648**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

In the NASA SBIR 2022 Phase I Solicitation documentation Z1.05 Lunar and Planetary Surface Power Management and Distribution, it stated that there was an interest in “near-field wireless power transfer in the 1 to 10kW range” for the subtopic Z13.02 Mechanisms for Extreme Environments. Furthermore, in the recent NASA SBIR 2023 Phase I Solicitation documentation, there continues to be a desire for Z13.05: Components for Extreme Environments (SBIR) for Mechanism for Extreme Environments. In this subtopic, mechanical systems will need to operate on the dusty surface of the Moon for months to years and endure regolith dust with little to no maintenance.

The purpose of this R&D effort is to develop a high-power wireless charging system that can operate in extreme environments from farms on Earth to lunar missions. The system will need to include redundancy functions for longer durability, be modular for further increased system lifespan, have a feedback system for dynamic receiver device movement, be physically sealed to prevent functional interference from regolith and other particles, and be thermally stable for harsh temperature extremities.

At the completion of the Phase I project, the wireless power system will be capable of outputting more than 5kWs to the receiver device with the antenna and electronic housings completely sealed from the environment with no fan cooling. It will be able to endure regolith simulants up to 1kg, power the receiver device while in movement, and will be verified that there are no single-point electrical failures in the transmitter system. Given the high switching costs associated with a system failure, the system will also include new modularity functionality so that if one component or PCB in the inverter is not functioning properly, there will be a second inverter electrically coupled to the antenna module that can automatically initiate itself as a backup so that no single-point failure can occur in the electronics.
Potential NASA Applications (Limit 550 characters):

The primary NASA applications for the wireless power system will be to implement the receiver devices in future NASA mobile robots and the transmitter device on the Moon so that there is a more robust and durable charging infrastructure for future lunar missions. By implementing a robust wireless power system, NASA mobile robots can be used for longer periods of time and have increased system durability.

Potential Non-NASA Applications (Limit 400 characters):

The agricultural sector today is heavily transitioning towards autonomous and electric vehicles to reduce labor costs and improve productivity. To fully leverage the benefits of autonomy, wireless charging infrastructure needs to be developed so that tractors can power themselves when the farmer is not present while enduring environmental conditions, such as dirt interfering with fan cooling.

Duration: **6**

PROPOSAL NUMBER:	23-1- **Z13.05-1875**
SUBTOPIC TITLE:	Components for Extreme Environments
PROPOSAL TITLE:	Dust tolerant dynamic seal material for extreme lunar atmosphere

Small Business Concern

Firm: **ATSP Innovations**
Address: **6762 Shadyvilla Lane, Building #3, Houston, TX 77055**
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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):

NASA is interested in long-term operation in the lunar environment, Mars and small bodies such as asteroids, comets, and Near-Earth Objects. Dust Tolerant Mechanisms and specifically the listed interest in sealing materials and techniques that can keep out regolith and operate in the extreme Moon/Mars environments are of high interest. The Moon is covered by large amounts of dust particles, called regolith, which could cause serious problems for tribological/bearing components on the Moon. Because the Moon has large temperature spans during day and night, from cryogenic temperatures of -173°C to upwards of 127°C, in addition to the abrasive studies, the effect of temperature should be taken into account to achieve a better understanding of their tribological performance in combination with abrasive dust. From the experience gained during the Apollo missions, significant lunar dust-related problems could occur. Therefore, NASA seeks technologies that are required to protect/tolerate the dust intrusion into rotary, linear, or static joints (e.g., bearings, landing gears, covers, etc.). The tribological study is largely dependent on experimental research that simulates outer space and relevant environments. The Lunar surface has vacuum added with cryogenic to high temperature condition. ATSP composite bulk material has demonstrated excellent wear resistant property in the presence of lunar dust simulant against 440C hardened bearing steel. The excellent data from previous Phase I and the tribological capability of ATSP combining we propose to find the best ATSP composite composition for the extreme lunar dusty environment. Thus, ATSP polymers can be a potential solution for aggressive dusty conditions as a sealing material. In Phase I, we will investigate the tribological and dynamic sealing performance of ATSP-based composites under various temperature conditions with abrasive dust.

Potential NASA Applications (Limit 550 characters):

ATSP composites can be potentially used in extreme temperature application in space, lunar or Mars dusty environment or even at vey cold conditions of Europa or Titan. ATSP composites can be used for bushing, bearing retainer, linear bearing, tilting pad bearing and seal applications, especially in cryogenic temperature of -220°C and high temperature conditions up to 300°C even is dusty environment. Titan Dragonfly mission and COLDarm projects can be possible application.

Potential Non-NASA Applications (Limit 400 characters):

Provide vacuum cryogenic and dust related tribological testing service for society, especially for NASA's Venus mission bearing design/verification. Supply high performance tribological ATSP composite for commercial bearing retainer, bushing, linear bearing, tilting pad bearing and seal applications.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z14.02-1795**

SUBTOPIC TITLE: Extraterrestrial Surface Construction

PROPOSAL TITLE: Basalt Brackets for Truss Structures

Small Business Concern

Firm: **Cislune Company**
Address: **301 North Almansor Street, Alhambra, CA 91801**
Phone: **(661) 390-1060**

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):

Cislune and PISCES propose a joint/node design using lunar regolith as a building material for truss-based structures. We aim to directly cast joint and bracket components from lunar regolith, which can be used to cast various structural elements like brackets, tools, anchors, small enclosures, tiles, and pavers. The proposed solution fulfills the desires of the subtopic Z14.02, and enables a number of desired deliverables articulated in the "Extraterrestrial Surface Construction: Assembly of Tall Truss-Based Power

Towers" scope. The proposed innovation is significant because it reduces the energy inputs and avoids issues associated with molten oxide electrolysis and refinement, and offers a method to generate structural elements for assembly and joining structural elements.

The technical objectives of this proposal are to analyze the efficacy of using cast regolith for truss joints, design applicable truss joints, and create a prototype cast regolith joint. The team will use both mare- and highland-like regolith to cast test samples for structural analysis, and then subject them to compressive, flexural, and tensile strength tests. Based on the results, the team will design truss joint elements optimized for cast regolith and compatible with available robotic hardware, and use computer modeling (FEA, CAD, topology optimization) to simulate their structural behavior. The proposed deliverables include a proposed cast regolith joint design that meets NASA's requirements for the power tower, a final report detailing the maturity of the technology, and a foundation for Phase II work to advance the system to TRL 5+ through benchtop prototyping and testing of the various nodes in the power tower, and constructing 5 meter sections of the power tower for structural analysis.

Potential NASA Applications (Limit 550 characters):

Cast basalt joints from ISRU feedstock are important for lunar exploration and development. These innovations directly map to NASA STMD's Strategic Framework thrusts of Live - ISRU, and Advanced Materials, Structures, and Construction. This technology will make lunar power less expensive to produce and therefore more abundant. Importantly, the underlying process and expertise needed to cast basalt joints is an enabling technology for an array of products that can be produced for a wide range of tasks (e.g brackets, containers, pipes, etc).

Potential Non-NASA Applications (Limit 400 characters):

Commercial infrastructure on the Moon and Mars need abundant power enabled by ISRU derived products like truss joint nodes. Cislune and PISCES FEA anchored to results from material testing will demonstrate a lower cost, reliable ISRU product which will enable lower cost development and utilization of the lunar surface.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z2.01-1167**

SUBTOPIC TITLE: Spacecraft Thermal Management

PROPOSAL TITLE: Additively Manufactured Ceramic Heat Pipes for Space Nuclear Reactors

Small Business Concern

Firm: **Advanced Cooling Technologies, Inc.**
Address: **1046 New Holland Avenue, Lancaster, PA 17601**
Phone: **(717) 205-0628**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

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

In this SBIR program, Advanced Cooling Technologies in collaboration USNC-Tech will develop an additively manufactured high-power ceramic thermal management system for space nuclear applications. The system will be highly reliable, passive, efficient, and lightweight. The use of ceramics will result in substantial mass and volume savings to the reactor and thermal management system.

Potential NASA Applications (Limit 550 characters):

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

Potential Non-NASA Applications (Limit 400 characters):

A passive ceramic-based thermal management system will result in significant improvements to the nuclear reactor design. In addition to space-based applications, the thermal management system is relevant to small modular and micro nuclear reactors. Additively manufactured ceramic-based thermal management systems will also benefit high-temperature applications such as hypersonic flight.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z2.02-1476**

SUBTOPIC TITLE: High-Performance Space Computing Technology

PROPOSAL TITLE: Dynamically Reconfigurable Scalable Array Processor for Low Power and High Performance DSP and AI/ML Processing In-Space

Small Business Concern

Firm: **xcelerium**
Address: **530 Technology Drive Suite # 100, Irvine, CA 92618**
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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):

Unlike GPUs, which are optimized for latency tolerant computations, DRSAP exploits memory locality systematically to achieve a power profile that is 50x lower than GP-GPUs. Unlike conventional SIMD processors DRSAP dynamically reconfigures to support systolic dataflows for matrix and FFT computations, which allows it to achieve 20x speedup over SIMD and vector processors. At the same time, DRSAP can offer ML computations for deep neural networks that is comparable to deep learning accelerators like NVDLA.

DRSAP achieves these performance breakthroughs with dynamic reconfiguration. DRSAP's internal datapath reconfigures 1 million times faster than FPGAs. While FPGAs offer great flexibility to realize any hardware structure by reconfiguring LUTs, DRSAP's reconfiguration is limited to computations and interconnections. This allows DRSAP datapaths to execute at much faster clock rates and offer die-sizes that are more than 100x smaller for the same computations than leading FPGAs.

DRSAP **is compliant with the RISC-V instruction set architecture (ISA), which provides a path for software portability, and access to a growing number of open-source tools and large and growing software ecosystem.**

Xcelerium's DRSAP, combining convenience and flexibility of general-purpose processors with cost and power advantages of custom hardware, offers new degrees of freedom to meet NASA future energy efficient compute needs. Xcelerium proposes to establish the performance and energy benefits of DRSAP technology for space applications during Phase I and to develop plans for a space-grade prototype (to be completed in Phase II).

Potential NASA Applications (Limit 550 characters):

The proposed solution will enable NASA to complete space-computation meeting conditions that is not currently possible with commercially available solutions. These include: space-compute applications, on-board autonomy, high-bandwidth processing applications, and digital signal processing.

Potential Non-NASA Applications (Limit 400 characters):

Xcelerium DRSAP has significant commercial applications, including automotive radar, RF sensing, 5G/6G and satellite communications, drones, robotics, and edge applications. The Edge semiconductor market size was estimated at $20B in 2021 and expected to grow to more than $65B by 2025.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z4.05-2497**

SUBTOPIC TITLE: Nondestructive Evaluation (NDE) Sensors, Modeling, and Analysis

PROPOSAL TITLE: In-space X-ray Analyzer

Small Business Concern

Firm: **Advanced Analyzer Labs, Inc.**
Address: **3982 Old Columbia Pike, Ellicott City, MD 21043**
Phone: **(301) 708-7759**

Principal Investigator:

Name: **Huapeng Huang**
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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):

To meet the NASA's needs for in-space inspection, Advanced Analyzer Labs, Inc. (AAL) proposes an innovative X-ray analyzer. This analyzer is designed to be portable, compact, low power, safe, light weight, flexible, and highly efficient for conducting the following None-destructive Evaluation (NDE) tests using X-ray Diffraction (XRD), X-ray Fluorescence (XRF), and X-ray imaging.

- *Inspection of additively manufactured parts in space.*
- *Detection of commonly known defects in materials.*
- *Analysis of regolith/drill core samples*

The key innovation of this X-ray analyzer is the utilization of a large, intensive collimating X-ray beam, with a diameter of up to 15mm, to facilitate flexible XRD, XRF, and X-ray imaging measurements. The parallel beam geometry of the analyzer enhances the reliability and efficiency of XRD and XRF measurements and improves the flexibility and efficiency of X-ray imaging.

The significant innovation of this analyzer is:

- *Highly efficient and reliable from using one compact X-ray source and parallel beam geometry.*
- *Simple and flexible configuration to implement multiple NDE X-ray functions.*
- *Safe due to the collimating beam is easy to constrain.*
- *Portable and flexible for in-situ and in-field tests of AM parts, and other components/samples.*

The compact size, lightweight, low power consumption, safety, flexibility, and multiple capabilities of the X-ray analyzer make it a highly desirable tool for NASA's in-space inspection needs.

Potential NASA Applications (Limit 550 characters):

NASA is seeking new None-destructive Evaluation (NDE) tools for astronauts to use in a habitat or in the space environment.

This proposed analyzer can be used for the following in-space NDE tests for the NASA applications:

- *Inspection of additively manufactured parts in space.*
- *Detection of commonly known defects in materials.*
- *Analysis of regolith/drill core samples*

through X-ray Diffraction (XRD), X-ray Fluorescence (XRF), and X-ray imaging.

Potential Non-NASA Applications (Limit 400 characters):

This X-ray analyzer technology with XRD, XRF and X-ray imaging brings a totally new Quality Assurance (QA) and Quality Control (QC) tool for a variety of industrious applications, which include the fast-growing Additive Manufacturing (AM) in the aerospace industry, the automotive industry, consumer products, healthcare, government and defense etc.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z4.07-2348**

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

PROPOSAL TITLE: Rapidly Configurable Mold and Cavity System

Small Business Concern

Firm: **Muse Engine Inc**
Address: **1224 Saint Andrew Street, New Orleans, LA 70130**
Phone: **(703) 501-2540**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters):

The ability to manufacture small to large batch productions on demand in low gravity environments is imperative for the expansion of low orbit manufacturing and lunar colonization. Injection molding is one of the most common manufacturing processes and is used to make large and small components. It is also used for developing both polymer and metal composites. Two benefits of injection molding systems are that they are self-contained and do not require gravity to work. The Rapidly Configurable Mold and Cavity System (RCMCS) differs from current injection molding processes by utilizing Muse Engine's patent pending rapidly configurable, reusable mold and cavity system. The RCMCS saves both tooling costs and time which reduces the threshold to get a product manufactured and can essentially turn traditional injection molding into an additive manufacturing process. The RCMCS consists of two reconfigurable cavities that are integrated and locked into a specialized mold used during a traditional injection molding process. Each plate consists of reconfiguring pins and a locking system. The core of the RCMCS lies in the technical development of the "pin art" children's toy into an industry tool that is highly reconfigurable and can be used to translate computer aided design (CAD) parts to a format ready for the manufacturing line in a matter of minutes. Muse Engine is proposing the development of a manually configurable RCMCS and its integration into existing injection molding systems. This system will demonstrate both the feasibility and commercialization of the proposed RCMCS.

Potential NASA Applications (Limit 550 characters):

The RCMCS offers flexible, rapid manufacturing of cast or injection molding components in low-gravity environments. Topic FA15/Z4.07: Advanced Materials and Manufacturing for In-Space Operations, is looking to identify technologies for the planned and sustained exploration of the Moon, and eventually Mars.

Potential Non-NASA Applications (Limit 400 characters):

Manufacturing represents a $5.1T market that spans all related verticals in the United States. Global contract manufacturing generates $6B annually and, by 2025, rapid prototyping services are estimated to be nearly a $1B market. The consumer, construction, aerospace, automotive, defense industries represent a $2B U.S. and $20B global market opportunity.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z5.06-1579**

SUBTOPIC TITLE: Servicing and Assembly Applications

PROPOSAL TITLE: Nautilus: GEO Survivability of Novel In-Space Docking Hardware & Capture Mechanism for High-Radiation Orbital Environments

Small Business Concern

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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):

Starfish Space envisions a future where autonomous robotic interaction in space is ubiquitous, enabling a thriving in-space community of scientific research, business, habitable platforms, exploration systems, and more. An underlying capability critical to enabling these missions is **a universally-compatible, non-destructive capture system for in-space docking** in all orbits**.** The ability to rendezvous and dock with unprepared spacecraft – those launched without pre-configured docking hardware – is vital to NASA's overall goals as it will enable space exploration and science missions to expand well beyond Low-Earth Orbit (LEO). **Such missions include** satellite servicing, satellite life extension, in-space logistics, assembly, manufacturing, and active debris remediation (ADR).

NASA seeks robotic systems for space exploration that operate in challenging environments and enable servicing and assembly applications. Successful use of robotic end-effectors are critical to accomplish robotic manipulation tasks for space vehicles while interacting with orbital assets and enabling in-space servicing, assembly, and manufacturing (ISAM) technology. A robust in-space capture capability is required to bring this future to life and is a key enabler of all RPOD missions. Without it, capture of unprepared surfaces and assembly of delicate structures in space is impossible. A universally-compatible capture mechanism will also open the door to new possibilities in servicing and assembly across all orbits.

The ability to do this depends on two key innovations. First, survivable systems able to withstand the space environment in GEO and beyond. Second, robotic capture mechanisms capable of

operating independent of prebuilt docking interfaces.

Potential NASA Applications (Limit 550 characters):

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

Potential Non-NASA Applications (Limit 400 characters):

Starfish has raised $20.75M from top VC's, won $5.1M in U.S. Space Force contracts and a $3M contract with NSIC, and is building relationships with major satellite operators, who are interested in Nautilus to enable commercial missions such as satellite life extension and defunct satellite removal.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z5.07-2077**

SUBTOPIC TITLE: Autonomous Robotic Manipulation, Utilization, and Maintenance

PROPOSAL TITLE: Miniature Lightweight, 3D Printable, Optical Dual Contact Force and Temperature Sensor for Dexterous End Effectors

Small Business Concern

Firm: **Intelligent Optical Systems, Inc.**
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Phone: **(424) 263-6313**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 4
Technical Abstract (Limit 2000 characters):

Dexterous robotic manipulation is an essential technology for establishing a permanent, sustainable space infrastructure (NASA's Moon-to-Mars objectives). Given the massive cost of having humans in space, sustained human presence and exploration throughout the solar system, ironically, requires capable non-human labor resources. Crew time is a highly limited resource and robotic operations are an efficient method for assembly and maintenance of in-space assets. Achieving the goal "practice on the Moon, demonstrate on Mars," will require robots to perform the vast majority of the labor.

To be effective, dexterous manipulation requires multi-sensory feedback. Current touch sensor technology relies on electronics, which places limits on material properties of an end effector and requires additional circuitry for temperature sensing. Through the proposed work, Intelligent Optical Systems, Inc. (IOS) will develop a novel end effector sensor technology that enables a single sensor to measure both contact force and temperature simultaneously using the same data stream. The sensitive component of the system is simply a polymer with a luminescent dye blended into it, opening the material space available to sensorized end effectors. The materials used for the sensitive component can be 3D printed, enabling direct integration into an end effector using standard multi-material 3D printing techniques.

Enabling technologies for general-purpose robots have applications across several NASA Mission Directorates including Space Technology, Exploration Systems, and Science. There is potential in any Mission Directorate where a task could be performed by a robot rather than a human in space.

At the conclusion of Phase I, IOS will have prototyped the optical dual contact force and temperature sensor and will deliver a full report on the R&D work, including full characterization of the individual sensors and the prototype dual sensor, as well as analysis of that characterization.

Potential NASA Applications (Limit 550 characters):

NASA must develop robotic systems to support sustainable operations in space. Given the extreme costs of having humans in space, the Moon-to-Mars objectives effectively require development of robots capable of performing human-like labor tasks off-planet.

Enabling technologies for general-purpose robots have applications across several NASA Mission Directorates including Space Technology, Exploration Systems, and Science. There is potential in any Mission Directorate where a task could be performed by a robot rather than a human in space.

Potential Non-NASA Applications (Limit 400 characters):

Industrial robots are designed for the target application. However, the general-purpose robot market is growing. Sensors that enable greater generalization of robot tasks will be critical for expanding robots from primarily repetitive tasks to robots with human-like labor utility, and with the advent of more and more powerful AI, we may be on the precipice of a robotic labor revolution.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z5.08-1126**

SUBTOPIC TITLE: Integrated Mission Planning and Execution for Autonomous Robotic Systems

PROPOSAL TITLE: P23-014 Co-design of Shared Tasking with human and Autonomous Robot teams (Co-STAR)

Small Business Concern

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

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

Space operations are undergoing a paradigm shift towards persistent assets in space, supported by coordinated, adjustable human-robot partnerships. Such partnerships require enabling technologies which can: support co-design of reference missions, partner robots and novel human-robot teaming paradigms to assist in integrated mission planning and execution. To address these challenges, SoarTech, along with partner SimDynamX, propose Co-STAR (Co-design of Shared Tasking with human and Autonomous Robot teams), an innovative approach to human-robot teaming to support development and testing of integrated human-autonomous robot team mission planning and execution for persistent operations in space. Our toolset will

include a cognitive autonomy architecture, alongside the task representation and concurrent analysis of robot capabilities within a reference space mission to facilitate the human-machine team. The effort will focus on a reference mission to validate the approach and supporting tools. Our approach is to augment and extend an existing flexible task representation, Hierarchical Task Network to support shared human-robot tasks and task allocation, augment and extend an existing SoarTech cognitive autonomy architecture to support seamless human-robot partnership, and develop a parametric capability analysis process, using an existing SDX high-fidelity simulation for collaborative space operations to assist in co-design of robot capabilities simultaneously with reference missions. The result is a toolset that allows for the exploration of the aspects of human-autonomous robot partnerships and, and the supporting iterative design of missions and capabilities in support of actual operations.

Potential NASA Applications (Limit 550 characters):

NASA is preparing for a future of persistent robots in space, supported by coordinated, mixed human-robot partnerships

Potential Non-NASA Applications (Limit 400 characters):

The proposed technology will be adaptable for DoD/AF logistical application, enabling the loadmaster and the autonomy to co-plan and execute the loading plan. As this technology matures, we will plan discussions with Air Mobility Command. Commercial applications are in the construction industry where autonomous vehicle are beginning to be used.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z7.04-1267**

SUBTOPIC TITLE: Landing Systems Technologies

PROPOSAL TITLE: Coupled Continuum-Rarefied-Granular Flow Modeling for Plume-Surface Interaction in Low-Pressure Environments

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

Detrimental environments from plume-surface interaction (PSI) during spacecraft propulsive landing include dust lofting, regolith particle ejecta stream obscuration, and debris transport that can threaten the lander and nearby assets. Design of mitigative strategies requires detailed understanding of the characteristics, behavior, and trajectories of ejected particles and surface erosion during the landing phase. For landings in low-pressure and rarefied conditions, evolving PSI physics traverse a complex mixed continuum-rarefied regime which defies analysis using existing state-of-the-art methods. Current PSI predictions have made great strides, but they fall short of simultaneously resolving the underlying continuum, granular, and rarefied flow physics required for accurate characterization of the landing environment. This SBIR will develop and deliver an innovative computational architecture for prediction of PSI in low-pressure and rarefied environments within the massively parallel Loci framework. Recent advances by CFD Research in coupling: (1) continuum and rarefied; (2) gas-granular and rarefied; and (3) continuum and gas-granular predictive methodologies will be leveraged and built upon to enable a coupled continuum-rarefied-granular modeling capability. This first-of-its-kind enabling technology will help improve understanding of PSI in low-pressure and rarefied propulsive landing environments including time-evolving cratering, erosion, and ejecta transport. Phase I will establish proof-of-concept and demonstrate three-way solver coupling for PSI at Lunar conditions including runtime adaptive algorithm selection based on locally evolving physics. In Phase II, the capabilities for detailed investigations into PSI at low-pressure conditions will be matured, and validations against NASA Physics Focused Ground Test (PFGT) data will be performed.

Potential NASA Applications (Limit 550 characters):

The proposed capability integrates multiple novel computational approaches into one unified simulation environment. This technology will be highly beneficial to NASA and its contractors for simulations of spacecraft propulsive landing on unprepared regolith and characterization of landing environments. Definition and mitigation of PSI-induced debris and visibility obstruction is crucial for robotic landers including Commercial Lunar Payload Services (CLPS) landers, for Human Landing System (HLS), and future robotic and human Mars landers.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications include support for landers and commercial partners developing lander systems. Terrestrial applications include sand/dust-related military and civilian applications such as rotorcraft sand/dust brownout and engine dust ingestion. Space applications include assessment of thruster plume-induced environments and contamination on commercial and military spacecraft.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z7.04-2593**

SUBTOPIC TITLE: Landing Systems Technologies

PROPOSAL TITLE: Floatinator: A Low Gravity Simulator to Study Plume-Surface Interactions

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 4
Technical Abstract (Limit 2000 characters):

Astrobotic proposes the development of “Floatinator,” a one-of-its-kind tunable lunar and planetary gravity simulator for terrestrial testing of plume-surface interactions (PSI) and cratering. In its initial lunar configuration, Floatinator will consist of a hot-fire test chamber capable of being dropped at a controlled acceleration of 5/6g, thereby providing a 1/6g gravity reference frame inside the chamber. Floatinator will be outfitted with a box of regolith simulant and integrated with Astrobotic's Dropinator dynamic test stand to test plume-surface interactions and deep cratering effects under the relevant gravitational conditions. By providing a relevant lunar gravity environment, Floatinator will control for and eliminate a major variable – namely, Earth gravity – that has limited the applicability of all ground-based lunar PSI and cratering testing to date. This novel test platform will enable the collection of valuable data about how lunar lander dust plumes will affect lander systems, onboard payloads, landing sites, and nearby

surface infrastructure on upcoming CLPS, Artemis, and commercial missions. Astrobotic further proposes to expand upon this proposed scope of work in Phase II, during which it intends to conduct hot-fire engine testing in this simulated gravity environment.

Potential NASA Applications (Limit 550 characters):

The proposed lunar/planetary gravity simulator would greatly enhance NASA's ability to test and model plume-surface interactions on the Moon and other celestial bodies. In particular, Floatinator's lunar gravity simulation capability can be used to simulate plume-surface interactions for Artemis and CLPS landings. Subsequent iterations of Floatinator will be calibrate their drops to approximate gravitational conditions on Mars, asteroids and dwarf planets (e.g., Ceres), and the moons of other planets in preparation for missions to those bodies.

Potential Non-NASA Applications (Limit 400 characters):

Floatinator will enable commercial lander providers, including Astrobotic, to more accurately simulate and model plume surface interactions and anticipate the effects of ejecta on their landers. It will also help university researchers study the behavior of regolith in its native gravitational conditions.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z7.04-2788**

SUBTOPIC TITLE: Landing Systems Technologies

PROPOSAL TITLE: Fiber-based Multi-resolution Imaging Tools And Algorithms For Ejecta Dynamics in Plume Surface Interactions

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

Vertical landing of a rocket vehicle on an irregular, unimproved surface has a number of challenges, including generation of a dust cloud that creates an observable event, erosion of the surface leading to a crater, rocket instability, damage to the vehicle, and optical occlusion. The proposed research program will focus on the development and demonstration of a high-speed (10-100 kHz) fiber-based imaging solution that can be used for evaluating PSI interactions at multiple resolutions (5–500 µm), with tomographic information of the plume envelope. This work will enable state-of-the-art measurements of particle sizes, distributions, and velocities for the PSI program for scaled tests at NASA facilities under near vacuum conditions. The new capability to quantify ejecta dynamics will fill the gaps in the current understanding of PSI for future landers, including the Moon and Mars. By selectively detecting various regions with varying resolution and angles, it will be possible to minimize interferences, optimize dynamic range, and obtain 2D–3D flowfield information throughout key regions of the landing area rocket plume. The proposed work will result in a robust instrument that can provide key information needed to validate numerical models and predict the potential challenges associated with unimproved landing sites.
Potential NASA Applications (Limit 550 characters):

The proposed work will pave the way for development of a full prototype instrument for testing under a range of plume surface interaction conditions at NASA facilities during the Phase II period and beyond. The prototype instrument will fill a critical gap in measurements of particle sizes, velocities, and flow structures impacting the safety and reliable operation of NASA launch and landing vehicles for terrestrial and planetary spacecraft.

Potential Non-NASA Applications (Limit 400 characters):

This research and product development will have applications in combustion, propulsion, engines, materials synthesis, energetics, and other reacting flow systems. The advanced measurement system also represents game-changing diagnostics capability that will play a significant role in advancing predictive modeling in a wide range of applications associated with multiphase flows.
Duration: **6**

PROPOSAL NUMBER: 23-1- **Z8.09-1067**

SUBTOPIC TITLE: Small Spacecraft Transfer Stage Development

PROPOSAL TITLE: Transfer Stage

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 6
Technical Abstract (Limit 2000 characters):

A new class of liquid oxygen and natural gas (LOX/LNG) rocket enables a high-performance Orbit Transfer Stage suitable for launch on Venture Class launch vehicles. The engine, called Mjölnir, is being developed by New Frontier Aerospace. Mjölnir uses a Full Flow Staged Combustion (FFSC) cycle in an innovative design enabling rapid Hohmann transfers between orbits. The use of LNG dramatically reduces cost and carbon emissions, with NEGATIVE greenhouse gas (GHG) emissions when sourced from the burgeoning renewable natural gas industry. The high thrust, light weight engine has a specific impulse higher than any of today's rocket engines other than hydrogen fueled rockets making it ideal for an Orbital Transfer Stage (OTS). Moreover, because the density of LNG is over 6X hydrogen the resulting OTS size is significantly smaller, with a much lower dry mass than a hydrogen fueled OTS. The engine can support OTS gross weights from 3,000 to 20,000 lbs while still supporting very fast Hohmann transfers between orbits. These are reasonable sizes that can be launched by a wide range of emerging commercial launch vehicles in the Venture Class.

Potential NASA Applications (Limit 550 characters):

The Mjölnir engine enables revolutionary applications, the obvious point solution is an expendable NASA OTS evolving to a lunar lander and reusability. From LEO a 3,000 lb gross OTS can deploy a 400 lb payload to GEO and over 200 lbs to any location in cislunar space, including Earth escape velocity. By launching directly into the transfer orbit and scaling the tankage to 20,000 lb gross weight, the same Mjölnir engine inserts over 10X greater payloads.

Potential Non-NASA Applications (Limit 400 characters):

There is strong interest in a 3,000 lb OTS enabling militarily responsive space domain awareness for all orbits, and also offering an exciting path to expanded commercial activities in low earth orbit. The Mjölnir engine will be availablefor OTS, lunar lander or related capabilities.

Duration: **6**

PROPOSAL NUMBER:	23-1- **Z8.09-1154**
SUBTOPIC TITLE:	Small Spacecraft Transfer Stage Development
PROPOSAL TITLE:	Solar Powered Rocket with Impulsive Thermal Engine (SPRITE)

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

The Solar Powered Rocket with Impulsive Thermal Engine (SPRITE) combines the high performance of a nuclear thermal rocket with the simplicity of solar thermal propulsion. The system operates by collecting solar power and storing energy in a high temperature phase change material. This allows the SPRITE to minimize solar collector area by gathering energy over a period of time and releasing it quickly for propulsion. The SPRITE uses an upgraded ThermaSat Plus engine design, complete with deployable solar collectors and hydrogen propellant.

The SPRITE is able to achieve high thrust propulsion with and Isp of ~830s while maintaining a total spacecraft wet mass below 200kg. It is capable of delivering 50kg of small satellite payload to the Moon from LEO. Once delivered, the spacecraft can be reclaimed or disposed of on the lunar surface.

Unlike nuclear thermal systems, there is no hazardous material on board the SPRITE and no long term nuclear drawbacks. Yet it is still able to achieve a comparable Isp and high thrust propulsion. Unlike other solar thermal concepts, the SPRITE has a very high thrust to weight and does not need to have collectors faced towards the Sun when firing. The end result is a versatile, reliable, and effective vehicle for transporting payloads to the Moon.

Potential NASA Applications (Limit 550 characters):

NASA can use the SPRITE to deliver supplies and equipment to the Lunar Gateway or to astronauts on the lunar surface. It can also be used to build infrastructure, such as lunar GPS systems. High thrust and high Isp propulsion provides many uses for 3rd stage rockets, allowing payloads to be placed in their desired location rapidly.

As the SPRITE is capable of recharging itself in the Sun, future designs can be used to explore other planets such as Venus, Mercury, or possibly even Mars.

Potential Non-NASA Applications (Limit 400 characters):

Private industry will be able to inexpensively place their small satellites in their desired location using the SPRITE, as the low launch mass and high performance propulsion will provide major improvements over current methods. The upcoming space industry will see decreases in costs which will make many opportunities more attractive.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z8.09-1533**

SUBTOPIC TITLE: Small Spacecraft Transfer Stage Development

PROPOSAL TITLE: The Argonaut: Water-Propelled Reusable High DeltaV Spacecraft Transfer Stage

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

Argo Space Corp. is developing the Argonaut, a highly reusable small spacecraft transfer vehicle with large amounts of deltaV that captures payloads on-orbit. The massive growth in small satellites and cislunar activity is driving an urgent need for affordable and reliable in-space transportation. The Argonaut offers affordable and dependable transportation through the introduction of true in-space reusability for propulsive in-space vehicles, from the choice of propellant to the docking mechanism.

The Argonaut is propelled by Argo's water-fed microwave electrothermal thruster (MET) and leverages existing common launch vehicle interfaces to simplify orbital docking and capture operations for client spacecraft. This MET enables use of readily storable water propellant with both a low thrust, high efficiency plasma mode and a low efficiency, higher thrust steam mode. By using water as propellant, the Argonaut increases the safety of transport, ground handling, and launch operations while also simplifying in-space propellant storage and management. Additionally, water propellant can be refueled through in-situ resource utilization (ISRU) on the lunar surface to support America's permanent human presence there. Initial Argonauts are designed to transport small spacecraft from CubeSats up to ESPA-class from low Earth orbit (LEO) to lunar orbits, but future iterations will scale in capability to transport payloads up to 10 metric tons.

Argonaut's unique mechanical spacecraft capture system requires no additional hardware installation on or pre-launch integration with client spacecraft. Launch vehicles with limited payload capacity to LEO need to maximize their useful payload delivered to orbit, and this new capability extends the reach of small launch vehicles and enables new mission architectures. The unique combination of our vehicle's reusability and efficiency is designed to make in-space transport abundant and affordable throughout cislunar space and beyond.

Potential NASA Applications (Limit 550 characters):

Argo's in-space transport vehicle is uniquely positioned to help NASA perform science and explore the solar system with small spacecraft, particularly in cislunar space. With Argonaut, NASA can dramatically increase access to destinations beyond LEO at much lower costs than previously available. By combing our reusable, high-deltaV vehicles and on-orbit payload pickup, NASA can utilize the full capability of small launch vehicles for science payloads and small spacecraft can use their propulsion for life extension rather than orbit raising.

Potential Non-NASA Applications (Limit 400 characters):

For non-NASA customers, Argo's solution primarily provides affordable, dependable transportation to high energy orbits from LEO. Additionally, our reusable, refuellable Argonaut is well suited to perform in-space servicing, de-orbit, and inspections. By leveraging reusability and sourcing propellant from the lunar surface, Argo will make in-space maneuver responsive and abundant for any purpose.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z8.09-1754**

SUBTOPIC TITLE: Small Spacecraft Transfer Stage Development

PROPOSAL TITLE: An Affordable, Hybrid-Electric Propulsion Architecture for Small Transfer Stages

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

QAM is pleased to present this proposal to demonstrate feasibility of an affordable O_2/CH_4 propulsion system architecture that is well suited for a small transfer stage that enables reliable ride share opportunities for cubesat development teams around the world. The uncomplicated multi-start architecture derives its affordability through a reliance upon the use of proven thruster technology and alternative fuel technology borrowed from the automotive industry. Namely, it uses a hybrid electric power cycle for both motive and electrical power, as well as low pressure (~500 psi) gas adsorption propellant tanks. As a result, the proposed architecture—called "HERA" (hybrid electric rocket assembly)—boasts high performance, (at least 340-sec delivered vacuum I_{sp}) and much better propellant fraction than scaling laws predict (generally speaking, stage dry mass and achievable propellant fraction are directly proportional).

Potential NASA Applications (Limit 550 characters):

Small transfer stage propulsion

Lunar and planetary lander ascent and descent propulsion

Potential Non-NASA Applications (Limit 400 characters):

Missile defense divert and attitude control systems

Payload bus propulsion

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z8.13-1530**

SUBTOPIC TITLE: Space Debris Prevention for Small Spacecraft

PROPOSAL TITLE: Coordinated Autonomous Debris Avoidance

Small Business Concern

Firm: **Stottler Henke Associates, Inc.**
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Phone: **(650) 931-2700**

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):

The relative accessibility of launching SmallSats into LEO offers an opportunity to both commercial and government organizations to provide high-quality services and conduct cutting-edge research at the cost of a large increase in the number of objects in LEO. More objects in LEO results in more conjunction alerts, which will eventually overwhelm human operators. We propose to develop a swarm coordination and control system called **C**oordinated **A**utonomous **D**ebris **A**voida**NCE** (CADANCE) which will run on every SmallSat in a swarm and enable the swarm to autonomously avoid debris and other satellites. Our proposed innovation builds on existing technology that Stottler Henke has developed, creating an architecture and set of software methods that will achieve the goal of reactive management over a swarm of SmallSats. The proposed innovations are specifically based on our Smart COordination of Unmanned Teams (SCOUT) command and control framework, originally developed for NASA (and demonstrated to NASA stakeholders **in flight on actual UVs**). Our solution will combine case-based reasoning, automated probability of collision computations, and trajectory optimization to create a system that can handle reactive control of heterogeneous teams of SmallSats. In Phase I, we will adapt SCOUT and integrate it with the collision computation and trajectory optimization components to develop an initial prototype system. We will prove the feasibility of the prototype in Phase I by testing it against an existing SmallSat simulation. We will also research the CADANCE integration requirements to understand the requirements for deploying it with the ultimate SmallSat actuation, sensing, communication, and other hardware and software systems.
Potential NASA Applications (Limit 550 characters):

Any NASA SmallSat or CubeSat swarm is a good candidate for deploying CADANCE. For example, NASA’s SunRISE SmallSats are a set of six small satellites that will work together to create a large space telescope that can use CADANCE to provide the capability to keep the SunRise satellites in formation, avoid mission disruptions, and reduce the likelihood of conjunctions. CADANCE can bring standardization and predictability to SmallSat collision avoidance.
Potential Non-NASA Applications (Limit 400 characters):

Non-NASA commercial applications for CADANCE include satellites that provide services like the Starlink internet constellation and science satellites like Planet Labs' fleet of 200 Earth-imaging satellites. CADANCE will provide the opportunity to increase the number of these commercial satellites while reducing the possibility of collisions, all without significant impact to mission goals.
Duration: **6**

PROPOSAL NUMBER:	23-1- **Z8.13-1547**
SUBTOPIC TITLE:	Space Debris Prevention for Small Spacecraft
PROPOSAL TITLE:	Lithium-Ion Battery Solid Rocket Motor for Deorbit Applications

Small Business Concern

Firm: **Cairn Engineering, LLC**
Address: **2016 Strathmore Street, Louisville, CO 80027**
Phone: **(608) 852-4106**

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):

Our proposed innovation is the Lithium-Ion Thruster (LIT) system, a multi-use device capable of both electrical energy storage and thrust generation using the same hardware. The LIT system is an ideal candidate for a NASA Phase I SBIR grant because proving its feasibility will introduce a new propulsion and battery technology that provides distinct advantages over all other deorbiting technologies. It will do this by creating a massless battery within the propulsion system, using the stored energy inside the battery to power the spacecraft during normal operations, and then converting that same energy into thrust when the mission is complete. This unique coupling of systems reduces the overall size, weight, and power draw of the propulsion and battery system while also increasing the energy storage available. This allows spacecraft designers to dedicate more resources to the payloads they need to accomplish their science, commercial, and defense

objectives while including a system to effectively deorbit spacecraft to reduce crowding and collision risk in low Earth orbit (LEO).

This novel technology improves on traditional propulsion systems in the following ways:
● Combining the battery and propulsion system into a single device creates massless hardware by using the same mass for two distinct purposes. Volume, power draw, and cost will also be reduced, allowing more resources to be dedicated to the spacecraft payloads.
● Electrical energy storage capacity of the spacecraft will be increased, reducing pressure on mission designers with tight power budgets.
● The thrust of a burn can be controlled by altering the charge state of the battery cell.
● System safety will be increased during high-risk activities, such as handling, transportation, or launch, by putting the batteries into a low energy state (effectively unfueling the system). The battery cells can then be charged to the appropriate level on orbit before a propulsive event.

Potential NASA Applications (Limit 550 characters):

The rise in small spacecraft launches and spacecraft swarms is contributing to congestion in low Earth orbit (LEO). If congestion is not managed, access to critical orbits in LEO could be lost due to the dangerous density of debris. To respond to this threat, US Orbital Debris Mitigation Standard Practices dictates the US shall limit the creation of new debris. The LIT system can be used on all LEO NASA missions that require low SWaP-C devices to provide deorbit abilities which will allow more resources to be dedicated to payloads.
Potential Non-NASA Applications (Limit 400 characters):

To comply with US Orbital Debris Mitigation Standard Practices, the LIT system can be used on commercial and defense missions that require low SWaP-C devices which will allow more resources to be dedicated to payloads.

Duration: **6**

PROPOSAL NUMBER:	23-1- **Z8.13-1679**
SUBTOPIC TITLE:	Space Debris Prevention for Small Spacecraft
PROPOSAL TITLE:	Gecko Articulated Debris Gripper and Deorbiter Enhanced Technology

Small Business Concern

Firm: **Orbotic Systems Inc.**
Address: **275 East Hillcrest Drive, Suite 160-139, Thousand Oaks, CA 91360**
Phone: **(805) 941-1028**

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):

The amount of debris in Earth orbit is increasing at an alarming rate. If this trend continues, a detrimental effect to the space environment will occur, impacting the future of space travel and space traffic management. While many solutions to this growing threat have been proposed over the years, very few are capable of removing debris at a fast enough rate to combat its growth. A vast majority of these proposed solutions cannot adapt to the wide variety of debris geometry and the cost is prohibitive on a large scale. We offer a unique solution using shape metal alloys, gecko grippers (Starfish), non-explosive thrusters, and our De-orbit Drag Device (D3). As more and more objects are sent into orbit each year, the need for a sustainable solution is becoming critical. The goal of this Gecko Articulated Debris Gripper and Deorbiter Enhanced Technology (GADGET) proposal is to offer an innovative design and feasibility study that provides a solution to the orbital debris issue. The combination of concepts described herein, utilizes the Starfish and D3 modules for altitudes up to 700 km. The addition of a "green" thruster will allow GADGET to operate at higher altitudes. A modular design enables GADGET to be assembled in a small, CubeSat configuration. The end result is an autonomous debris remover that is adaptable to a multitude of different altitudes and debris categories, is cost effective, power efficient, light weight, and reusable.

Potential NASA Applications (Limit 550 characters):

- Docking mechanism for dead spacecraft.
- Assist astronauts in an EVA
- Attach to space debris for removal
- Starfish gripper for use with on-orbit robots

Potential Non-NASA Applications (Limit 400 characters):

- On-orbit manufacturing and assembly
- On-orbit drone delivery
- Agriculture - picking (Starfish Module)
- Military – spy device grabber
- All NASA applications

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z8.13-2038**

SUBTOPIC TITLE: Space Debris Prevention for Small Spacecraft

PROPOSAL TITLE: Additively Manufactured Hybrid Propulsion System for Smallsat Deorbit

Small Business Concern

Firm: **HyBird Space Systems 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):

Hybird Space Systems (Hybird) is developing a retrobraking propulsion system, named RT-5X, whose initial application is focused on deorbit of spacecraft in LEO. RT-5X combines the “smart” advantages of liquid propulsion (throttleability, restartablility, low impulse bit) with the operational simplicity of solid propulsion (high reliability, low-cost design, storability) in an entirely “green” propellant package. RT-5X offers advantages over the current active and passive deorbit systems, addresses the key pain points of satellite deorbit customers, and incorporates:

1. Ultra-low costs to minimize the financial impact to mission developers

2. Reliable, safe de-orbit transfer through controlled thrust

3. Flexibility across constellation and spacecraft bus sizes

4. Highest in-class propulsive performance

5. Hazard avoidance maneuvering in addition to end-of-life servicing

RT-5X is a green, non-toxic, high-performance, deorbit propulsion system consisting of a 5-lbf hybrid rocket engine (including valves and plumbing), a propellant tank, and flying leads for system control. RT-5X integrates with smallsats prior to launch and then performs a controlled, deorbit burn at mission termination. The system includes ΔV margin for additional on-orbit hazard avoidance maneuvers. At the core of RT-5X technical and cost innovation is a 5-lbf hybrid rocket engine. The proposed RT-5X system incorporates a self-pressurizing propellant tank by using Nytrox as an oxidizer. Nytrox is created by bubbling GOX under pressure into N_2O until the solution reaches saturation. Oxygen in the ullage dilutes N_2O vapor and increases the required decomposition energy barrier by several orders of magnitude. Thus, risks associated with inadvertent thermal or catalytic N_2O decomposition are virtually eliminated. Because Nytrox is self-pressurizing, the need for an additional volumetrically inefficient oxidizer pressurization system is eliminated.

Potential NASA Applications (Limit 550 characters):

RT-5X offers a low-cost preventative debris solution that also provides controlled reentry, all characteristics that are well aligned with NASA’s priorities for Debris Remediation. Long term, there is an opportunity to **recycle** satellite components to use as propellant on RT-5X by using spacecraft structural mass as solid rocket fuel feed stock.

Potential Non-NASA Applications (Limit 400 characters):

RT-5X offers controlled, deorbit capabilities for small satellite developers and users while minimizing integration, financial, and operational complexities to their missions.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z8.13-2523**

SUBTOPIC TITLE: Space Debris Prevention for Small Spacecraft

PROPOSAL TITLE: Autonomous Space Traffic Management Technologies for Small Spacecraft Swarms and Constellations

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):

Syrnatec proposes a novel robust solution for the “Onboard Devices for Deorbit and/or Disposal of Single Spacecraft” via the development of a hardware-based energy harvesting and controller module for electrodynamic-tether (EDT) systems. Recently, passive EDTs have successfully demonstrated deorbit of small spacecraft (e.g., Millennium Space System’s *Dragracer* mission in 2021). Our proposed module will enable these passive EDT de-orbit systems to perform controlled deorbit/disposal as well as to harvest the energy generated during deorbit for mission-enabling and -enhancing objectives. The module will leverage Syrnatec’s radiation-tolerant, high-voltage, high-power MOSFETs for tether current switching and control and in the harvesting of electrical energy from the EDT. Our system will enable EDT control throughout the disposal process, protecting against collisions and interferences with both active and inactive spacecraft and debris. The module could be included as part of a dedicated de-orbit system or it could be an integral component of a debris tug deorbit system, enabling multiple debris objects to be de-orbited.

Potential NASA Applications (Limit 550 characters):

NASA APPLICATIONS

The target applications/ mission identified for NASA programs include: Artemis, Mars Mission, Human Space flight, Jovian Moon, Saturn Satellite Subsystem

- Lunar and planetary surface power distribution.
- Feed systems development for the NASA Kilo power project.

Potential Non-NASA Applications (Limit 400 characters):

NON-NASA APPLICATIONS
- European Space Agency (ESA)
- Indian Space Research Organization (ISRO)
- Military; Surveillance service
- International Space Station
- Earth-observation satellites for Surface, Environment, and Weather
- SmallSat swarms and constellations of commercial companies: SpaceX, OneWeb, Theia Space, Boeing, Amazon Kuiper, Inmarsat

Duration: **6**

PROPOSAL NUMBER: 23-1- **A1.02-1571**

SUBTOPIC TITLE: Quiet Performance - Airframe Noise

PROPOSAL TITLE: Advanced Measurement Technology for Airframe Noise Source Identification

Small Business Concern

Firm: **Interdisciplinary Consulting Corporation**
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Phone: **(352) 283-8110**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

The Interdisciplinary Consulting Corporation (IC2), in partnership with AVEC, Inc., proposes to develop advanced phased-array and dynamic pressure sensing instrumentation and processing capabilities for airframe noise source identification. High channel-count, high-density, low cost-per-channel microphone arrays, and ultra-small, ultra-smooth sensing surface, low-cost, instrumentation-grade, model-embedded dynamic pressure sensors, both using microelectromechanical systems (MEMS) piezoelectric sensors with backside contacts and advanced packaging technology, will be combined with advanced array processing capabilities to create innovative airframe noise source identification capabilities. The goals of this research include: (1) developing high-fidelity phased arrays, with flexible mounting options including surface mounting, to avoid encumbrances typical when through-wall installations are required

with existing commercial instrumentation products; (2) developing dynamic pressure sensors that can be embedded in model-scale parts, such as landing gear components, flaps, and slats, with ultra-smooth surface outcomes such that the instrumentation itself does not impact the fluctuating pressures that are being measured; and (3) developing advanced phased-array processing algorithms that combine propagating acoustic signals received at the array with localized fluctuating pressure signals measured at the model surfaces to directly correlate noise source generating regions with propagating acoustics.

Potential NASA Applications (Limit 550 characters):

The proposed instrumentation technology has the potential to be usable in multiple NASA facilities as well as implemented across government-owned, industry and academic institution test facilities. Potential NASA applications include use in the 14x22-Foot Subsonic Tunnel, National Transonic Facility, and Basic Aerodynamic Research Tunnel at Langley, the 7x10 and 40x80-Foot tunnels at Ames, and the 9x15 tunnel and Aeroacoustc Propulsion Facility at Glenn.

Potential Non-NASA Applications (Limit 400 characters):

Other government agencies (e.g., DOD, DARPA) and industry manufacturers (e.g., Boeing, Lockheed, GE) have similar needs to NASA. Specifically, researchers and test engineers are limited in their ability to collect high-fidelity aeroacoustic measurements in wind tunnel testing due to sensor packaging limitations and cost.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A1.04-2594**

SUBTOPIC TITLE: Electrified Aircraft Propulsion

PROPOSAL TITLE: Superconducting stator that enables much lower weight 1 MW - 4 MW motors

Small Business Concern

Firm: **Solid Material Solutions, LLC**
Address: **55 Middlesex Street, Suite 205, North Chelmsford, MA 01863**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Future fuel-efficient hybrid aircraft require high temperature superconducting (HTS) electric motors in order to achieve power densities well above 10 kW/kg while operating at temperatures above 20 K and locally up to 30K. However, the AC modes of stator coils makes it impossible to use available HTS tapes due to their large AC losses, requiring instead fine HTS wires made with the Bi2212 material and with advanced loss reducing features.

This Phase I program will now establish the feasibility of a low loss HTS-2212 based full-scale stator coil design that provides commercial-level operating currents, current densities, and losses suitable for developing much higher power density electric plane motors. It will build on our recent breakthrough development of low-loss HTS-2212 wire and cable.

A design analysis and survey of high-power density superconducting electric plane motor initiatives will be completed to establish a first proof-of-concept design and winding specifications for a 1 MW class high power density motor. A specific version of our standard low loss cable design will be selected, and its current, current density and loss levels determined relative to the requirements of the 1 MW generic motor type. Additional essential features like insulation, as well as mechanical resistance of the coil build to Lorentz and body forces will be established.

The tooling and procedures for winding this type of coil will be developed and qualified followed by the winding of a demo pancake saddle coil. After reaction it will be tested for current, current density and field generating capacity. Finally, it will be shipped to NASA. These developments will set the stage for developing in Phase II, of a fully functional,1 MW class HTS-2212 stator coil suitable motor development initiatives, with custom variations derived from the generic design that will be produced and provided for their evaluations and inclusion in those initiatives.

Potential NASA Applications (Limit 550 characters):

- Magnetic energy storage systems that require rapid magnet discharge and recharging

- Actuators

- Low loss AC and fast ramp power cables

- Specialty lighter weight, much higher power density motors and generators, for example for cryogenic liquid pumps

- Specialty AC and fast ramp instrument magnets

Potential Non-NASA Applications (Limit 400 characters):

- High power density electric plane motors

- Lighter-weight, lower cost, easier to site, and more efficient wind generators

- Magnetic energy storage systems

- Medical instruments such as proton therapy scanner magnet systems

- Fusion reactor magnets, specifically the central solenoid of Tokamak designs

- High efficiency, compact and lighter-weight specialty transformers

Duration: **6**

PROPOSAL NUMBER:	23-1- **A1.05-1513**
SUBTOPIC TITLE:	Computational Tools and Methods
PROPOSAL TITLE:	Dynamic Adaptive Mesh Refinement for Wall Modeled LES of Complex Configurations

Small Business Concern

Firm:	**Scientific Simulations, 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: 5
Technical Abstract (Limit 2000 characters):

The objective of this proposal is the development and demonstration of a dynamic adaptive mesh refinement (AMR) capability for wall modeled large eddy simulations (WMLES) of complex configurations using arbitrary grid types including unstructured grids with hybrid element types. Our approach consists of linking legacy CFD codes to an octree mesh subdivision library, which is highly scalable and can handle all element types including tetrahedra, prisms, pyramids and hexahedra. Through the definition and implementation of a suitable API, our approach will enable dynamic AMR at scale on HPC systems with no internal changes to existing CFD codes.

Although many WMLES applications can be considered as statistically steady or quasi-steady problems for which an optimized final static grid can be constructed either manually or through repeated application of AMR, the development of a fully dynamic AMR capability offers several advantages. Firstly, an efficient dynamic AMR capability enables more frequent mesh refinement passes during the simulation phase, opening up new possibilities in the use of refinement criteria, while at the same time retaining all the capabilities of quasi-steady AMR approaches. At the same time, the tightly coupled nature of the dynamic AMR library will provide a more streamlined and simpler to use workflow which can be run seamlessly on large scale HPC architectures including heterogeneous GPU hardware. Finally, we anticipate that truly dynamic AMR capabilities will be required for grand challenge problems and certification by analysis, which involve multiple time scales such as dynamic maneuvers and/or relative body motion, in addition to the unsteady nature of scale resolved turbulence eddies.

Potential NASA Applications (Limit 550 characters):

Various programs and projects of NASA missions use CFD for advanced aircraft concepts, launch vehicle design,and planetary entry vehicles. Either the developed dynamic AMR capability may be used with our CFD solvers for NASA mission objectives, or the developed API may be used to couple NASA CFD codes with a dynamic AMR capability. The tightly coupled dynamic AMR capability targets directly proposed Grand Challenge problems and Certification by Analysis, the development of which remain long term priorities within NASA.

Potential Non-NASA Applications (Limit 400 characters):

WMLES represents the next level of fidelity that will be key for the realization of accurate simulations at the edge of the flight or operational envelope and necessary for realizing the vision of Certification by Analysis. There is a strong need for commercially viable and reliable WMLES among commercial, military and space air vehicle and propulsion OEMs and associated sub-contractors.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A1.08-1931**

SUBTOPIC TITLE: Aeronautics Ground Test and Measurement Technologies: Sensors and Diagnostic Systems for High-Speed Flows

PROPOSAL TITLE: High-Temperature, MHz-Bandwidth, Miniaturized Heat-Flux Sensors for High-Speed Flows

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):

The Interdisciplinary Consulting Corporation (IC2) proposes to develop high-temperature, high-bandwidth, miniaturized heat flux sensors that are applicable in a variety of environmental conditions such as those encountered in high-speed ground- and flight-test facilities. The proposed sensing system addresses a critically unmet measurement need in NASA's technology portfolio, specifically the ability to make quantitative, time-resolved, mean and fluctuating heat-flux measurements with sufficient dynamic range, bandwidth, and spatial resolution in high-temperature, high-speed flows using a robust, miniature sensor to facilitate installation in scale models and high-speed ground- and flight-test facilities. The sensor system will enable single-point measurement of heat flux for characterization of complex boundary layer flows in ground-test facilities over a wide range of temperatures, with a target maximum continuous operating temperature >1000 K (727 °C). The proposed heat-flux sensor consists of a microfabricated thin-film thermopile on top of a support substrate with a thin protective coating and backside electrical connections. This design represents a robust, flush-mounted, miniature, heat-flux sensing system that possesses improved sensor survivability, reduced humidity sensitivity, and less bulky, fragile packaging than existing solutions. The flow disturbance for this sensor is minimal because of the flush-mount design and small footprint. Optimized sensor electronics will also help improve the sensitivity, dynamic range, and bandwidth of the sensor.

Potential NASA Applications (Limit 550 characters):

Potential applications for the system include use within NASA's supersonic and hypersonic ground-test facilities such as the 20-inch Mach 6 Air Tunnel, 31-inch Mach 10 Air Tunnel, and the 8-Foot High Temperature Tunnel (8-ft HTT) at NASA Langley Research Center (LaRC) as well as other high-speed facilities at NASA's Glenn and Ames Research Centers.

Potential Non-NASA Applications (Limit 400 characters):

This technology is also applicable to DOD high-speed test facilities, e.g., Tunnel A/B/C at AEDC and Tunnel 9 at AEDC White Oak, as well as commercial defense contractors working in the guided missile and space vehicle manufacturing (e.g., Boeing Defense, Lockheed Martin, Raytheon).

Duration: **6**

PROPOSAL NUMBER:	23-1- **A1.09-2514**
SUBTOPIC TITLE:	Zero-Emissions Technologies for Aircraft
PROPOSAL TITLE:	Rotating Detonation X-Combustor (RDXC) Turbine Integration Program

Small Business Concern

Firm: **CPEC Technologies**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters):

The Rotating Detonation X-Combustor - Turbine Integration Program (PDXC-TIP) will develop a novel pressure gain combustor that is integrated with a turbine and engine configuration. The x-combustor is designed to improve turbine efficiency by attenuating effects of the detonation. The RDXC/turbine pair is integrated into a gas turbine architecture to support zero emission technologies for aircraft. The overall engine design supports electric-hybrid aircraft architectures with integrated electrical generators and motors.

The pressure gain combustion will boost the efficiency of a hydrogen-fueled gas turbine and offset potential installation costs of hydrogen. The use of hydrogen eliminates any carbon-based combustion products. The very short combustion time reduces the creation of NOx products.

Current TRL = 1: Basic Principles observed and reported

Example paper: Nordeen, C. A., Schwer, D., Corrigan, A. T., and Cetegen, B., "Radial Effects on Rotating Detonation Engine Swirl," AIAA Propulsion and Energy 2015 Forum, American Institute of Aeronautics and Astronautics, AIAA 2015-3781, 2015. https://doi.org/10.2514/6.2015-3781

TRL Progression 2&3: Technology concept formulated and analytical critical function demonstration via this proposal "NASA Phase I SBIR 2023 subtopic A1.09 application: “Rotating Detonation X-Combustor (RDXC) Turbine Integration Program”. RDXC 1-D Analytic Model correlated with 3-D CFD simulation with detailed geometry, operability and performance maps.

TRL Progression 4&5: Breadboard validation in a laboratory environment and then validation in a relevant environment via Phase 2 of this program. NASA Phase II SBIR 2023 subtopic A1.09 application: (1) DXC/Turbine Test Rig demonstrates shock and swirl attenuation and turbine efficiency gain or equivalent constant pressure efficiency, (2) RDXC Engine Test Rig demonstrates complete engine cycle efficiency.

Potential NASA Applications (Limit 550 characters):

A flight-weight subscale engine will support subscale H2 zero emissions and integrated aircraft studies of hybrid aircraft (SUSAN) and drone-scale autonomous aircraft.

The RDXC can be adapted to rocket engines with conventional nozzles and a variety of fuels.

Potential Non-NASA Applications (Limit 400 characters):

A production subscale RDXC supports H2 fueled drone-scale autonomous aircraft.

Microturbine power generation would benefit substantially from the increased cycle

The full scale RDXC support H2 fueled transport aircraft i.e. SUSAN.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A1.10-2715**

SUBTOPIC TITLE: Structural Sensors for Health Monitoring of Hypersonic Vehicles

PROPOSAL TITLE: Advanced High Temperature Sensors for Hypersonic Vehicles

Small Business Concern

Firm: **Acree Technologies Incorporated**
Address: **1037 SHARY CIRCLE STE E, Concord, CA 94518**
Phone: **(925) 798-5770**

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):

Hypersonic flight is currently an extremely important research area that represents a disruptive technology with the potential to revolutionize modern aviation, military defense, and space exploration. Advancements in high-speed vehicle development are possible if insights can be gained, analyzed, and used to create new technologies. New insights will require advancements of current measurement techniques as well as novel forms and integration techniques to fill existing technological gaps. The purpose of this project is to develop high temperature sensors on Ceramic Matrix Composite (CMC) components that can survive and operate in the extreme environmental conditions of hypersonic flight including high temperature, vibration and acoustic environments to address these gaps. Acree's proposed thin film sensors are fabricated either directly on CMC components (direct write) or on thin ceramic substrates that can be affixed to CMC components and thermal protection system (TPS) of hypersonic vehicles, allowing versatility in their use. The development of these advanced sensors will allow for vehicle Structural Health Monitoring (SHM) and advances in hypersonic aircraft research and design. The long-term goal for this technology is an operational, reusable hypersonic aircraft.

Potential NASA Applications (Limit 550 characters):

The advanced sensors developed in this project will be used for the development, design and deployment of hypersonic aircraft. They will be used for vehicle Structural Health Monitoring (SHM) in extreme hypersonic environments.

Potential Non-NASA Applications (Limit 400 characters):

The advanced high temperature sensor technology developed in this project can be used in virtually any aircraft or land-based combustion turbines for structural health monitoring.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A2.02-1469**

SUBTOPIC TITLE: Enabling Aircraft Autonomy

PROPOSAL TITLE: Certification and Safety of In-Flight Multi-Objective Decision Making Algorithm Techniques

Small Business Concern

Firm: **Systems Technology, Inc.**
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Phone: **(310) 679-2281**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

The Advanced Air Mobility (AAM) marketplace has seen rapid growth in recent years with hundreds of possible designs at varied stages of development. Many manufacturers are approaching the design problem under the presumption that each of their vehicles will include a pilot onboard. According to an AP News article from February 2023, the government estimates a shortage of ~30k airline pilots by 2032. Autonomous operation of these vehicles could help mitigate/eliminate the piloted need but only a small subset of designers is considering this as their entry point. The necessary autonomous technologies are currently not mature enough to meet this challenge and will be met with intense regulatory scrutiny. Without the ability to take in information from multiple sources and distill that to an actionable response, these vehicles will be limited in their operation scope. Alternatively, without a clear path to certify these new capabilities, the realization of an autonomous UAS/AAM system and its potential benefits will languish. As such, a team led by Systems Technology Inc. (STI), propose to address this problem through the development of Certification and Safety of In-Flight Multi-Objective Decision Making Algorithm Techniques (CERTIFICATE). CERTIFICATE will establish a robust certification approach and companion software-based toolset for multi-objective decision making (MODM) autonomous technologies and demonstrate this process with novel envelope protection (EP) schemes based upon neural control certificates and correct-by-construction software paradigms. Phase I will establish the system requirements and demonstrate the CERTIFICATE process using these novel techniques. At the conclusion of the Phase II program, a prototype of the CERTIFICATE software will have been developed and validated for supporting the certification of MODM systems. In addition, two MODM EP methods will have been advanced towards addressing increasingly complex and robust mission scenarios.

Potential NASA Applications (Limit 550 characters):

The CERTIFICATE toolbox directly supports the goals of the NASA Revolutionary Vertical Lift Technology Project. Here, CERTIFICATE directly supports the goal to “develop and validate tools, technologies and concepts to overcome key barriers for vertical lift vehicles.” Furthermore, CERTIFICATE will provide a means to support the NASA AAM National Campaign, which will provide “…vehicle manufacturers and operators, as well as prospective airspace service providers, insights into the evolving regulatory and operational environment.”

Potential Non-NASA Applications (Limit 400 characters):

A study by Frost & Sullivan sees the UAM marketplace “expanding with a compound annual growth rate of about 46% to more than 430,000 units in operation by 2040.” There is a need for the new methods in CERTIFICATE to support the design, analysis, and certification of these vehicles. STI has relationships with a number of these companies from which an emerging customer base will be established.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A3.01-1447**

SUBTOPIC TITLE: Advanced Air Traffic Management for Traditional Aviation Operations

PROPOSAL TITLE: Explainable Artificial Intelligence (XAI) for Air Traffic Management

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: 2
End: 3
Technical Abstract (Limit 2000 characters):

Machine Learning (ML) and Artificial Intelligence (AI) have matured to the point where they are being used throughout many modern applications. Explainable AI (XAI) – AI in which humans can understand the decisions or predictions made by the AI system – is becoming critical for many applications, including Air Traffic Management (ATM). In contrast, ML-enabled and AI-enabled systems too often resemble “black boxes” that mysteriously convert incoming data into predicted outcomes. At best, such “black box” systems can be explained by *inferred explanations* where the input/output relationships are analyzed and generalized. Even the designers of such systems cannot explain why the AI or ML system arrived at a specific decision. Outcomes of such “intelligent systems” should resonate with the decision makers’ own expertise, understanding, and intuitions (tacit knowledge). This effort sspecifically merges deep generative models, optimal transport theory along with AI Intent Inference Learning (IIL) to create a *vocabulary* for XAI that can be used to explain ATM-domain situations.
Potential NASA Applications (Limit 550 characters):

Supporting NASA's Airspace Operations and Safety Program (ASOP), this technology can be implemented to form a real-time monitoring of system safety, or in terms of analyzing historical data, for data mining, test and evaluation of machine learning an AI systems integrated into ATM, and controller training.

Potential Non-NASA Applications (Limit 400 characters):

XAI has a wide range of applications where ML and AI are used to provide decision support to process control, manufacturing, airline operational control, and military defense (decision support and training).

Duration: **6**

PROPOSAL NUMBER: 23-1- **A3.02-1640**

SUBTOPIC TITLE: Advanced Air Traffic Management for Nontraditional Airspace Operations

PROPOSAL TITLE: Fleet and Flight Operations Integration and Optimization in a Mixed-Advanced Air Mobility Environment

Small Business Concern

Firm: **Aerial Vantage, Inc.**
Address: **470 L'Enfant Plaza, Suite 7112, 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: 2
End: 6
Technical Abstract (Limit 2000 characters):

We propose an innovation for a data-driven Artificial Intelligence/Machine Learning (AI/ML) model for uncrewed aviation fleet and flight operations optimization (UA-FFOpt) that will be trained with real-world data from an active flight program in the State of Michigan and at a partner cattle ranch in Florida. UA-FFOpt will leverage our existing Intellectual Property (IP), AVIATE, and NCR. AVIATE’s capabilities for optimized mission planning and NCR’s access to real-time weather and airspace constraints accelerate UA-FFOpt’s path to operation. Our model will incorporate aircraft capabilities across the fleet, airspace operational ‘rules of the sky’ for integration into airspace classes, and dynamic re-planning based on real-time events such as

traffic encounters, varying weather conditions, and community and geographic constraints. UA-FFOpt will be developed to be transferrable to other fleet operations applications for other use cases, including larger uncrewed aircraft, destined for the AAM ecosystem. By its nature as an AI/ML-based approach, it will be extensible to incorporate additional ecosystem (e.g., Class B, C, and D airspace) and operational variables beyond our primary use case with additional data and training.

Potential NASA Applications (Limit 550 characters):

- Optimization scheme for broad mission, equipment, weather, and airspace constraints in AAM fleet operations.
- Requirements and methods for UAS Traffic Management/AAM operator fleet optimization using 1<m:N operations.
- Integration of operational and data requirements into fleet planning for transition between UTM and traditional airspace.

Potential Non-NASA Applications (Limit 400 characters):

- Extensible model for multi-variable uncrewed aircraft (UA) operational fleet optimization.
- Framework for scalability of team (1<m:N aircraft) collaborations with autonomous aircraft.
- Scalable fleet management concept for complex operations

Duration: **6**

PROPOSAL NUMBER: 23-1- **A3.03-2133**

SUBTOPIC TITLE: Future Aviation Systems Safety

PROPOSAL TITLE: Polaris Aero's VOCUS Safety Intelligence Platform

Small Business Concern

Firm: **Polaris Aero LLC**
Address: **34522 North Scottsdale Road, C120, Scottsdale, AZ 85266**
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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):

Polaris Aero is proposing research to revolutionize aviation Safety Management. Polaris Aero is proposing the modification of their proactive aviation Safety Management System (SMS) to a predictive SMS using Artificial intelligence and Machine Learning (AI/ML). The key to aviation safety is not just capturing data to find trends but to understand what the data represents, how they relate to each other and provide actionable insights to mitigate risks. Providing the right information and risk mitigation measure before an incident occurs will save time, resources, and lives. Modifying Polaris' VOCUS Safety Intelligence Platform with AI/ML will provide faster, more reliable actionable insights based on the large amounts of data generated by the aviation community. VOCUS centers around the Safety Management System which pushes and pulls data to applications used by pilots, schedulers, and maintainers for daily activities. An AI/ML enhanced VOCUS platform will find safety trends, relationships, and mitigation measures faster and more accurately than relying on just safety officers. AI generated mitigation measures can automatically be presented back to the pilots and maintainers through VOCUS applications used for daily tasks.

Potential NASA Applications (Limit 550 characters):

The potential NASA application will integrate Polaris Aero's modified VOCUS Safety Intelligence Platform with NASA's In-Time Aviation Safety Management System. The modified VOCUS platform will use AI/ML to increase the speed and accuracy of safety monitoring, risk assessments and provide tailored risk mitigation recommendations throughout the aviation community. The final product will ensure safety information is provided to the right people, at the right time, in the right amount to make better decisions.

Potential Non-NASA Applications (Limit 400 characters):

Potential non-NASA applications include commercial, Federal government and Department of Defense VOCUS Safety Management System users. Users of Polaris Aero's VOCUS platform will benefit from increases speed and accuracy in predicting and mitigating aviation risks.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A3.05-2280**

SUBTOPIC TITLE: Advanced Air Mobility (AAM) Integration

PROPOSAL TITLE: BABEL: V2V Standards Testbed for Enabling Advanced Air Mobility

Small Business Concern

Firm: **Unmanned Experts, Inc.**
Address: **720 South Colorado Boulevard, Penthouse North, Denver, CO 80246**
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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):

The proposed Phase I is expected to produce the design specifications for an Advanced Air Mobility (AAM) Vehicle-to-Vehicle (V2V) testbed. The technical effort will involve the following Lines of Development:

V2V Testbed Design: A scalable design for a V2V testbed of communication and computational nodes. Each node will be equipped with a Software-Defined Radio (SDR), configured for transmit power, frequency, and bandwidth. The nodes will organize themselves into a Vehicular Ad-Hoc Network (VANET) with ground and air nodes. The ground nodes might be at fixed locations to support operations in a corridor. When a vehicle is flying in the corridor, its airborne node connects to one of the ground nodes dynamically based on its current location. The R&D work involves identifying suitable SDRs that meet the requirements of the V2V testbed and an embedded computer with sufficient computational power to implement the V2V protocols.

Collaboration with IEEE and RTCA: The program aims to engage with the V2V standard development process, and the team will meet with IEEE and RTCA on a regular basis (once in a month) to learn the progress of V2V standardization, while sharing the progress of the V2V testbed design. This collaboration allows the proposing team to design the testbed that can support the V2V standard.

Engaging with the NASA AAM National Campaign (NC) Series: The objective of this effort is to engage with the ongoing NC. The team will continue leading the North Texas (NTX) Cohort and pursue the NC project as it develops into NC2 and beyond. This engagement will allow the team to conduct tabletop exercises for testing various use case scenarios. Our previous experiences in X3, X4, and X4+ proved that these sprints are very valuable before conducting live tests.

Working with the AAM Ecosystem: The objective of this effort is to continue engaging with the AAM Ecosystem Airspace Working Group. This will allow the team to seek input/feedback from the AAM stakeholders.

Potential NASA Applications (Limit 550 characters):

The proposing team are SAA partners in NASA's AAM National Campaign (NC) program since its inception in Nov 2018. The team has successfully completed X3, X4, and X4+, including leading a live flight demo as part of NC1.

The proposed V2V testbed reference design will help aggregate ideas across AAM stakeholders, including NASA entities engaged in AAM/UAM (e.g., ARMD, ATM-X, IASP, DRF), to identify technologies, procedures, best practices, and guidelines needed for successful implementation of V2V comms for strategic and tactical deconfliction.

Potential Non-NASA Applications (Limit 400 characters):

Networked collaborative aircraft use within the civ/mil sector provide viable commercialization options for Phase II-derived products, such as an IEEE standard-compliant V2V comms package. Use cases and markets for V2V include civil AAM, agriculture, public safety, and DoD networked collaborative autonomy programs. The outcomes can also inform the FAA in their V2V rule making process.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H3.10-1592**

SUBTOPIC TITLE: Microbial Monitoring of Spacecraft Environments: Automated Sample Preparation for Sequencing-Based Monitoring

PROPOSAL TITLE: AutoEASE: Automated Extraction of DNA for Sequencing Evaluation

Small Business Concern

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

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

NASA's plans to return to the moon and ultimately send astronauts to Mars requires unique technologies that can safeguard both the health and wellbeing of the crew during long-duration missions. One major threat to health and safety is the presence of microbial contaminants. Current methods for microbial monitoring in space are predominantly culture based, which requires returning samples to Earth for analysis. This causes an inherent delay in acquiring results and creates a bias towards culturable organisms. Recent advancements in microbial monitoring capabilities have been made onboard the International Space Station (ISS) using molecular sequencing technologies, and this allows for real-time analysis of microbial contaminants. However, these methods are highly manual and require a large amount of active crew time to complete. With the many tasks required of an astronaut crew, consistent use of such methods for frequent monitoring is not feasible. Therefore, there is a need for an automated, streamlined process to monitor microbial growth in real-time.

To address this need, Luna Labs USA, LLC will develop the AutoEASE platform to enable automated preparation of DNA for nanopore sequencing. Our approach is centered around the use of a dissolvable swab previously developed at Luna Labs (NanoSwab) for effective capture and release of microbe samples. These samples can then be automatically processed using a microfluidic device designed to isolate, purify, and prepare DNA. Additionally, this system would be designed with the ability to process multiple samples and be compatible with polymerase chain reaction (PCR) testing. Overall, this technology will be designed as a drop-in solution to existing technologies validated on the ISS, while removing previous hurdles including low biomass environmental conditions, sample preparation time, and active crew effort.

Potential NASA Applications (Limit 550 characters):

Automated sample processing for DNA sequencing

Real-time microbial monitoring

Potential Non-NASA Applications (Limit 400 characters):

Biological sample preparation in low resource settings

Surveillance and rapid diagnosis of microorganisms

Routine sampling for monitoring disease outbreak/spread and potentially hazardous environmental conditions
Duration: **6**

PROPOSAL NUMBER: 23-1- **H4.08-1596**

SUBTOPIC TITLE: Anti-Fog Solutions for Spacesuit Helmet

PROPOSAL TITLE: Durable Antifogging Coatings for Spacesuit Helmets

Small Business Concern

Firm: **Luna Labs USA, LLC**
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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):

Maintaining a high level of visibility through the helmet of NASA Extravehicular Mobility Unit (EMU) is very difficult under inclement operational conditions. The interior of the helmet bubble will fog up in a high humidity / cold environment with high work rate breathing for extravehicular activity (EVA) that can last up to 8 hours. Currently used wipe on antifog solutions has problem with i) durability, requiring reapplication for every EVA, ii) can potentially get in the astronaut's eye, impairing their vision, and iii) bottles of solution are a consumable that need to be continuously restocked. Luna has developed an inexpensive, transparent coating that will maintain optical and antifogging properties for the lifetime of the equipment.

Potential NASA Applications (Limit 550 characters):

The durable antifogging coating will ensure the maintenance of visibility on NASA EVA helmets. The coatings are very durable to survive the lifetime of the equipment.

Potential Non-NASA Applications (Limit 400 characters):

Beyond the immediate NASA application, this coating system is directly applicable to military goggles, lenses, face shields, optical sensors, automotive windshields, SCUBA masks and numerous other applications.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H5.01-1351**

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

PROPOSAL TITLE: Sunflake Extra Linear

Small Business Concern

Firm: **Gendell Associates DBA Folditure**
Address: **1031 Bloomfield Street, Hoboken, NJ 07030**
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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):

The solicitation request is for a structural and mechanical innovation, with a deliverable of an elevated Lunar Surface Solar Array design capable of delivering 50kW of power.

We propose modifying and integrating Folditure's proprietary Pyramid Hinge Array design, with novel linear extension mechanisms, as a solution for a large scale re-deployable Lunar Surface Solar Array Structure - **Sunflake Extra Linear Array (Sunflake XL).**

Combined with a modified UCTT base, the design would deliver a disruptively compact, robust structure for Lunar Solar Power Generation. The design is scalable, modular, and can be integrated for transport/deployment with a lunar rover.

In contrast, traditional designs require heavy structural support, and complex locking mechanisms. These are weak points prone to failure, that add substantial weight and volume, pack inefficiently, and are mostly not retractable.

In Phase I we propose to fully develop a working mechanical design for the array 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 II.

Potential NASA Applications (Limit 550 characters):

The Sunflake XL could be used on any Human Lander, or future Lunar Outpost. It could be modified for other Planetary missions, and can also be deployed on Orbit Stations or Satellites.

Sunflake XL is designed for multiple actuations. It can also be easily modified for spring-loaded single actuation. Because of its light mass, and proven Pyramid Hinge reliability, it could prove effective on mid to large scale satellite missions.

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

Potential Non-NASA Applications (Limit 400 characters):

A modified Sunflake XL array, could be used in a variety of terrestrial applications.

It would make an extremely compact and portable design. A stand-alone system could be deployed, programmed to track sun angles, and retract remotely.

We are exploring DOD and other applications for remotely re-deployable pop-up PV power generation, suitable for challenging terrain.

Duration: **6**

PROPOSAL NUMBER:	23-1- **H5.05-2105**
SUBTOPIC TITLE:	Inflatable Softgoods for Next Generation Habitation Systems
PROPOSAL TITLE:	Multi-Modal SHM of Inflatable Habitats via Embedded Fiber Optics Sensing

Small Business Concern

Firm: **Luna Innovations, Inc.**
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Phone: **(540) 769-8400**

Principal Investigator:

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Phone: **(434) 972-9950**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

Luna is proposing to add new distributed acoustic sensing capabilities to embedded fiber optic sensors that have been proven to sense creep in inflatable structures. The team will apply Artificial Intelligence (AI) / Machine Learning (ML) algorithms to the strain and acoustic signals to automatically localize impacts and leaks, sense creep in the restraint layer materials, and detect anomalies in real-time. Phase I will focus on applying distributed acoustic sensing (DAS) to webbing materials to prove the feasibility of this new sensing modality. Strain profile data and acoustic data from the fiber optic sensors will serve as input to prototype AI/ML algorithms that will extract features for tracking and modeling creep trends, damage, and remaining life. Tensile testing of flight-representative webbing with embedded fiber optics and sensor egress designs will prove the ruggedness and quantify strength knockdown factor that is critical for acceptance in future flight vehicles. Folding and packing studies will be performed to further assess feasibility of the sensors for launch and deployment. Designs for space hardened sensors, modules, cables, and ruggedized interrogator will be identified for implementation in Phase II. The Phase I will culminate with a demonstration of impact and leak detection and localization using data from an instrumented Vectran inflatable test article. Phase II will deliver prototype software and hardware for further evaluation by NASA and/or industry partners. Phase III will transition the sensing and AI/ML technology to space stations and habitat modules.

Potential NASA Applications (Limit 550 characters):

NASA’s Commercial LEO Destinations program is aiding industry development of commercial space stations. Inflatable habitats will likely be an important component to these structures, as well as surface and transit habitats for missions to Mars. Inflatable habitat structural health monitoring of the structural restraint layer will be enabled by embedded fiber optic sensors and AI/ML automatic impact, leak, and structural anomaly detection.

Potential Non-NASA Applications (Limit 400 characters):

Distributed fiber optic sensing is a growing market. Fiber optic sensors provide a rich dataset that will benefit from AI and ML processing of large batches of data to identify off-nominal conditions. The results of this development will directly translate to the commercial market and will be compatible with Luna's existing product lines.

Duration: **6**

PROPOSAL NUMBER:	23-1- **H6.23-1128**
SUBTOPIC TITLE:	Spacecraft Autonomous Agent Cognitive Architectures for Human Exploration
PROPOSAL TITLE:	P23-016 Autonomous Virtual Agent for Interactive Explanation (AVA-Ex)

Small Business Concern

Firm: **Soar Technology, Inc.**
Address: **3600 Green Court, Suite 600, Ann Arbor, MI 48105**
Phone: **(407) 437-4334**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

Due to delays in communication during deep space missions, astronauts will need to solve more problems without connection to ground teams. To reduce overburdening, the astronauts will leverage new decision aids including procedure generation tools. New virtual assistants are needed that can explain decision aid outputs, reducing ambiguity, increasing task performance, and helping to calibrate astronaut trust. Virtual assistants implemented using cognitive agents can model and reason about problems and interact like humans do, enabling them to act as an onboard teammate and deliver relevant information in ways that crew members can easily understand. However, to serve the needs of astronauts, these agents must be 1) adept at providing coherent, interactive explanations, 2) able to tailor these explanations for different crew roles and 3) able to leverage different multi-modal output channels, as the situation demands. To address these requirements, we propose Virtual Agent for Interactive Explanation (AVA-Ex), a research effort to design and assess the feasibility of building a cognitive-architecture-based interactive explanation agent. AVA-Ex will support human deep-space exploration by demonstrating that such an agent can improve end user task performance and trust when conducting system diagnostics procedures with dynamically generated procedures. We will leverage Soar Tech's 25 years of experience developing and applying cognitive architectures, the Principal Investigator's 15 years of experience developing cognitive architecture based virtual agents, and SoarTech's recent work developing cognitive architecture-based explanation agents. We will also leverage our SME Dr. Greg Chamitoff's deep understanding of NASA space mission operations. Phase 1 will result in a design and feasibility analysis with a simple demonstration; Phase 2 will result in a working prototype, followed by a demonstration in a representative environment.

Potential NASA Applications (Limit 550 characters):

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

Potential Non-NASA Applications (Limit 400 characters):

AI explanation assistants for system operation, maintenance, repair, and troubleshooting in general aviation and any complex systems environment, including manufacturing, power generation, and medical systems.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H8.01-1945**

SUBTOPIC TITLE: Low-Earth Orbit Platform and Microgravity Utilization for Terrestrial Applications

PROPOSAL TITLE: On-Orbit Solution Recycling Methods to Improve Scale of Layer-by-Layer Artificial Retina Manufacturing

Small Business Concern

Firm: **LambdaVision, Inc.**
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Phone: (860) 679-2558

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):

LambdaVision has developed a protein-based artificial retina to restore vision to the millions of people blinded by retinal degenerative diseases, including retinitis pigmentosa and age-related macular degeneration. The artificial retina thin films are manufactured using a layer-by-layer (LBL) assembly technique, in which alternating layers of the light-activated protein, bacteriorhodopsin, and a polycation binder are deposited onto an ion-permeable film. Because uniform orientation and layer homogeneity of the multilayered implant is critical for achieving activity and long-term performance, LambdaVision is leveraging the unique properties of microgravity that allow for more ordered and consistent three-dimensional assembly of the protein and polymer layers. The microgravity manufacturing paradigms have the potential to improve the quality of the films, reduce intralayer defects, and, as a result, enhance the stability and performance of the artificial retinas for future preclinical and clinical trials. In collaboration with Space Tango, LambdaVision has completed a series of proof-of-principle microgravity experiments that have established a foundation for producing artificial retinas using a low-Earth orbit (LEO) platform. This effort led to the optimization of the CubeLab architecture, though further steps are required to improve the scale of artificial retina manufacturing for commercial production. This Phase I SBIR work plan includes a series of experiments and hardware development used to purify, sterilize, and analyze LBL layering solutions for recycling to improve scale, reduce up-mass raw materials, and reduce waste. The completed tasks will add new on-orbit tools to the established LBL manufacturing paradigm, and solution recycling techniques will ensure that artificial retina production can be achieved at an increased scale on the ISS or future commercial LEO destination.
Potential NASA Applications (Limit 550 characters):

The outcomes of the proposed Phase I SBIR experiments will help to optimize the use of raw materials in LEO and will yield critical hardware components that will aid in the successful commercialization and scale required for artificial retina production. Moreover, the purification, sterilization, and analytical techniques established in this research will provide new tools for integrating biomaterials as components for in-space production applications.

Potential Non-NASA Applications (Limit 400 characters):

This research establishes the capabilities required to support LEO commercialization of protein-based artificial retinas. An enhanced LBL assembly process in microgravity can improve thin film manufacturing for many biomedical applications. Strategies to improve scale, control raw material consumption, and improve unit economics will also inspire new research and commercial product development.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H9.01-2071**

SUBTOPIC TITLE: Long-Range Optical Telecommunications

PROPOSAL TITLE: Platform Isolation and Control

Small Business Concern

Firm: **Controlled Dynamics Inc.**
Address: **18141 Beach Boulevard, Suite 170, Huntington Beach, CA 92648**
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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):

CDI has developed a free-floating isolation and pointing technology that addresses a critical need for free-space optical communications. This research develops a new inertial sensor to replace an obsolete sensor and provide improved robustness and performance, while staying within the size/mass/power and operational environment constraints for space terminals.

Packaged into 2-axis strut assemblies, the design is modular to accommodate a wide range of space terminal geometries. Using inertial sensors and non-contact actuators, the design provides 6-DOF isolation with high-bandwidth active stabilization to attenuate a broad range of both on-platform and host-spacecraft disturbances. By developing new inertial sensors tolerant to the deep-space environment, CDI’s isolation and pointing technology will be sufficiently robust and reliable to support all NASA mission classes in the future.

Phase I will establish the feasibility of the inertial sensor design through architecture development, simulation, and proof-of-concept prototype demonstration. Phase II will develop and qualify the inertial sensor and then integrate it into an updated design for the 2-axis strut assembly. Four prototype strut assemblies will be delivered in Phase II, complete with design updates from lessons learned on the Psyche DSOC technology demonstration mission.

Potential NASA Applications (Limit 550 characters):

Planetary mission communication using optical relays back to Earth. Deep-space exploration. The design is scalable to a wide range of deep-space missions; from small solar-system probes, to human Moon and Mars missions. Primary Technology Taxonomy: TX 05.1 Optical Communications.

Potential Non-NASA Applications (Limit 400 characters):

Commercial Moon and Mars missions that require high bandwidth communications back to Earth. Free-space optical communication in Earth orbit for satellite-to-satellite communication and communication from orbit to ground.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H9.03-2014**

SUBTOPIC TITLE: Flight Dynamics and Navigation Technologies

PROPOSAL TITLE: Improved Autonomous Navigation Through Optimal Sensor Outliers

Small Business Concern

Firm: **XAnalytix Systems**
Address: **9424 Pinyon Court, Clarence Center, NY 14032**
Phone: **(716) 741-6395**

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):

One of the greatest challenges associated with pose estimation using cameras or sensors such as LIDAR is removal of sensor outliers. Outliers exist for numerous reasons, such as incorrectly associated feature points, extraneous data points, etc. Without proper removal of outliners, an incorrect pose estimate may result, which can lead to difficulty in achieving mission goals for autonomous operations. A common approach to remove outlines is the Random Sample Consensus (RANSAC) algorithm, which is an iterative and non-deterministic algorithm. RANSAC may not be optimal, especially if an incorrect model is used, thus leading to outliers that may pass the RANSAC test but may degrade the pose estimate.

The XAnalytix Systems team has developed an optimal closed-form approach to replace the RANSAC algorithm. It is optimal in that it is based on using the statistical properties of the sensor error in its derivation. The heart of the solution is based on an optimally derived pose estimation solution from a Total Least Squares (TLS) approach. A byproduct of the TLS solution is the error-covariance of the sensor residuals. The error-covariance is the key to remove outliers. Because the error-covariance is optimal, it is believed that using it will result in a more robust approach to remove outliers than the standard RANSAC algorithm and its variants. The proposed effort will focus on studying the effectiveness of the newly derived closed-form error-covariance in a new RANSAC-type algorithm, called the Statistical Optimal RANSAC (SO-RANSAC) algorithm.

It is expected that at the completion of Phase I the optimal nature of the SO-RANSAC algorithm, compared to traditional RANDAC-type algorithms, will be verified through simulation testing within a realistic test environment. This initial testing and hardware configuration will be used to expedite prototyping and system tests to be conducted during Phase II.
Potential NASA Applications (Limit 550 characters):

NASA has flown several formation flying missions, such A-Train and Cluster. Also, applications involving proximity operations are of great interest to NASA, as well as safe, precision landing on small bodies. The proposed technology further advances current navigation applications related to all these applications since it provides a robust solution for noncooperative objects. The application is based on rigorously derived error definitions, so that physically correct uncertainty bounds are provided for feature outlier mitigation.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications, especially DoD ones, are heavily focusing on anti-jamming communication and navigation systems, such as GPS-less navigation. The proposed technology can significantly advance these focus areas because it is self-contained and decreases the susceptibility to outside attacks.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H9.08-2613**

SUBTOPIC TITLE: Lunar 3GPP Technologies

PROPOSAL TITLE: Wireless Channel Simulation and Coverage Analysis for Lunar Environments

Small Business Concern

Firm: **REMCOM, INC.**
Address: **315 S ALLEN STREET, SUITE 416, STATE COLLEGE, PA 16801**
Phone: **(814) 861-1299**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

In this Phase I proposal, Remcom proposes a complete, end-to-end modeling and simulation solution for predicting wireless propagation and network coverage for lunar scenarios. Our solution builds on mature, existing capabilities previously developed for the wireless industry and the U.S. government, specifically enhanced to include 4G and 5G technologies. Under this effort, we will perform research and development to incorporate key extensions to properly model lunar terrain, position assets on or above its surface, and handle several key conditions unique to the lunar environment, such as the surface materials, the presence of dust, and unique terrain features. The proposed capabilities provide sufficient precision to support analysis reliant on detailed phase and delay information, including applications such as MIMO, Doppler estimation, and precise Position, Navigation, and Timing (PNT). The study will also include link-level analysis which accords with 3GPP specifications to determine potential impacts to communication from Doppler due to fast-moving vehicles or satellites, latency due to high-altitude or long-range links, and delay spread caused by high-multipath environments, such as propagation within craters. At the conclusion of Phase I, we will have a preliminary simulation capability within a mature product, and proofs-of-concept for several proposed enhancements to further improve its capabilities for lunar channel simulation.

Potential NASA Applications (Limit 550 characters):

The ultimate outcome of this SBIR will be an enhanced version of the Wireless InSite simulation product, incorporating new data and algorithms for handling lunar materials, the unique terrain, and the impact of multipath, Doppler, and latency to communications. Given the challenges of lunar channel modeling and measurement, this will provide a valuable predictive tool for understanding the channel, planning placement of 4G/5G towers and relays, and estimating device-to-device connectivity for systems unable to otherwise connect to the network.

Potential Non-NASA Applications (Limit 400 characters):

Two of the major innovations are also very relevant for the broader wireless industry, including enhancements for longer-range propagation over terrain (has applications for rural coverage and satellite links), as well as the ability to incorporate the effects of Doppler, fading, and delay spread on the communication link, which will also be very valuable for dense urban and indoor simulations.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H10.01-2182**

SUBTOPIC TITLE: Advanced Propulsion Systems Ground Test Technology

PROPOSAL TITLE: Intelligent Fiber Optic Sensor Suite for Advanced Propulsion Ground Testing

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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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

IFOS proposes to develop a test rig sensor suite to measure pressures/acoustics, static and dynamic strains and temperatures for advanced propulsion systems such as that used for NASA's Space Launch System (SLS) and SpaceX's Starship IFOS will leverage off its experience in the turbine engine industry and harsh environment sensors. The system incorporates multiplexed optical fiber sensors adapted to measuring temperature, dynamic pressure/acoustics, static and dynamic strain at high sampling rates. Compared to existing ground testing technology, the system has greatly simplified design, reduced size, and expanded sensing capability in terms of number of sensing points, multi-functionality and overall precision. Phase I will demonstrate feasibility and Phase II will develop and deliver an engineering prototype for transitioning to NASA's test rigs. The proposed test rig sensor suite will assist rigorous ground testing to. It will faciltate minimization of test program time, cost, and risk including mitigate propulsion system risks inherent in spaceflight as well as meet existing environmental and safety regulations.

Potential NASA Applications (Limit 550 characters):

This technology also has the potential to provide solutions to NASA's challenges in developing better propulsion systems, lighter weight, higher performance structural materials, higher performance instrumentation, improved measurement capability, and enhanced platform safety over extended operational lifetimes. The technology will readily extend to any NASA vehicle application where Structural Health Monitoring (SHM) is desired, including extra-planetary exploration, robotic missions, and human space operations.

Potential Non-NASA Applications (Limit 400 characters):

The proposed work will significantly benefit the commercial space launch industry through development of advanced fiber optic sensor based ground test systems that enhance chemical and advanced propulsion technology development and certification. Example applications include enhancing safe launching of rockets such SpaceX's Falcon 9 and Starship, and Rocket Lab's Electron and Neutron rockets.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H10.02-1926**

SUBTOPIC TITLE: Autonomous Operations Technologies for Ground and Launch Systems

PROPOSAL TITLE: GUARDIAN: Grounding visual data with actions for task verification

Small Business Concern

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

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

To support NASA missions that expand to the Moon, Mars and deeper into space, robots must be capable of increased levels of autonomous operation, such that they can provide effective support on ground and launch activities where human presence is either not viable, such as in hazardous environments, or in remote locations where human interaction is expected to be through remote, limited supervision. In this proposal, we focus on improving the state estimation capabilities of a robot system, such that during the execution of a long-horizon task, the robot agent will be capable of: (1) Descriptively assess its current state, by grounding visual data into predicates; and (2) Use this discrete representation to execute robot plans

with closed-loop monitoring, where the visual feedback state is compared to the expected planned state,
and if an anomaly is detected, the system is notified so appropriate action is taken.

To provide robotic systems with the ability to ground visual feedback into symbolic states for long horizon
robot planning to support sustained operation in space, TRACLabs proposes to develop GUARDIAN,
a framework that allows a robot system to analyze RGB images, and infer predicates that describe
its state, enabling it to perform close-loop task verification. GUARDIAN will be a system that bridges
visual feedback information and transforms it into a symbolic state that will allow a robot to plan complex,
multi-step tasks. For this, GUARDIAN will be implemented as a representation network that receives as
input an image, and - after being trained in synthetic data labeled with efficient, weak supervision - outputs
a set of predicates that describe the current state of the system, which can then be compared with the
expected state, and thus anomalous situations can be timely detected.

Potential NASA Applications (Limit 550 characters):

A number of near-term NASA missions could benefit from the advances developed during this project.
Some of the applications may include IVR caretakers such as the Astrobee robot in the ISS, or more
dexterous robots in deep space uncrewed spacecrafts. This work is also applicable to lunar surface robots for activities such as sample retrieval. Future missions could leverage the technology delivered by this project in more advanced applications involving robot manipulation, such as Commercial Lunar Payload Services (CLPS) and Mars sample return.

Potential Non-NASA Applications (Limit 400 characters):

The technology developed in this project is applicable to any application involving robot task execution with continuous failure detection. As such, commercial applications including the automotive and aerospace sectors can be served with the increased robustness provided by this technology.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H12.05-2295**

SUBTOPIC TITLE: Autonomous Medical Operations

PROPOSAL TITLE: Space Medicine GPT

Small Business Concern

Firm: **Tietronix Software, 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):

During exploration missions, human crewmembers will be away from Earth for extended periods of time. As the distance from Earth increases, real-time communication with flight surgeons and expert medical consultants located in Mission Control will no longer be possible. The response to medical problems that might arise on exploration missions must be crew-based rather than ground-based. Instead of having expert medical consultation available via communications links to Mission Control, such expertise will need to reside on the spacecraft. This paradigm shift has been labeled as Earth Independent Medical Operations or EIMO. The ideal solution to this problem is to create a tool that replaces the ground-based medical expertise that is currently available to crews in low earth orbit and locates it onboard. This tool must possess the same information base as a consultant on the ground, be immediately responsive, function without internet, and be capable of communicating with the crew via keyboard, text or voice. The crew must be able to interact with this client in exactly the same way that they would interact with a flight surgeon in Mission Control.

We propose that building a Large Language Model (LLM) GPT (Generative Pre-Trained Transformer) Knowledge Base, trained with information from large medical databases, including additional information derived from space medicine libraries, may be an innovative, and feasible tool for spaceflight Clinical Decision Support. We plan to select an earth-based medical knowledge base and augment it with all relevant medical information provided by our space medicine expert consultant, Dr. David Hilmers. Thus, our intelligent medical agent will not only have the benefit of thousands, if not millions of human datasets informing clinical decision support, it will also have a more extensive advisory capability by utilizing true spaceflight medical risk references and procedural guidance.

Potential NASA Applications (Limit 550 characters):

S-Med GPT could be used for medical capability on Gateway missions.
S-Med GPT could be used for Artemis missions autonomous medical capability.
S-Med GPT could be used for Mars mission autonomous medical capability.

Potential Non-NASA Applications (Limit 400 characters):

S-Med GPT will be of interest to DoD and specific military branches for combat medics uses.
S-Med GPT could be used in Telemedicine applications where a live doctor is not immediately available.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S11.01-1336**
SUBTOPIC TITLE:	Lidar Remote-Sensing Technologies
PROPOSAL TITLE:	In-Space Assembled Booms for Deployable Lidar Instruments

Small Business Concern

Firm: **MMA Design, 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):

In support of deployable lidar membrane optic systems requiring maximal deployed tension, the proposed Phase I effort seeks to advance the state of closed cross-section deployable booms. The proposed Assembled Tubular Masts (ATMs) provide closed-cross section performance while eliminating problems associated with permanently bonding shell halves to form closed cross-section booms. At the time of this proposal, MMA predicts it can achieve at least twice (2x) the tension on the deployed optic membrane MMA's Lidar system all within the same stowed volume if booms are changed from an open section slit tube to a closed, ATM cross-section. Beyond Lidar instruments, the fundamental ATM technology developed in this Phase I effort is also directly applicable to any deployable space structure that seeks to maximize deployed system stiffness, while minimizing stowed volume and mass. The ATM technology may be applied to future NASA missions requiring deployed solar arrays, deployable antenna systems, or other space deployable structures both in Earth orbit, interplanetary, or for lunar or Mars surface operations.

Potential NASA Applications (Limit 550 characters):

Compact, light weight deployable structures can support an extremely broad range of NASA interests including: Deployable Membrane Optical Lens for LIDAR missions, photon sieve, deployable drag sail de-orbit systems for large satellites and rocket stages, deployable sunshades, large aperture deployable antennas, Large lightweight solar arrays, and lunar/planetary/space in-situ construction.

Potential Non-NASA Applications (Limit 400 characters):

The technology is absolutely dual-use for non-NASA applications. Compact, light weight deployable structures can support an extremely broad range of non-NASA applications including, deployable drag sail de-orbit systems for large satellites and rocket stages, deployable sunshades, large aperture deployable antennas, Large lightweight solar arrays, and space on-orbit assembly construction.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S11.02-1215**
SUBTOPIC TITLE:	Technologies for Active Microwave Remote Sensing
PROPOSAL TITLE:	Optimized frequency-stabilization subsystem for a compact Rydberg laser package

Small Business Concern

Firm: **Rydberg Technologies LLC**
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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):

A primary critical hardware need that is common to all atomic quantum sensors – including atomic clocks, inertial sensors, gravimeters, and electromagnetic sensors – is laser and laser-frequency-stabilization subsystems for the specific manipulation of atoms and readout in the quantum sensor that is in a portable form factor and operational in real-world and harsh environments on sea, land, air, and space. Technical challenges remain to maintaining high frequency stability, frequency control, with lower SWaP form factors required for laser and frequency-stabilization subsystems while operating in real-world and harsh environments.

In this effort Rydberg technologies will evaluate architectures for optimal atomic frequency-stabilization of a frequency-agile 510-nm coupler laser that uses electromagnetically induced transparency (EIT) signal from a modulated alkali gas cell to both (1) frequency-stabilize the coupler laser to <100 kHz (10 kHz goal) during signal reception operation and (2) provide frequency-agility with wavelength tuning over nanometers to access Rydberg levels and S-band and K-band RF transitions. In this effort to realize QRR-ready multi-color tunable Rydberg laser packages, we will exploit the fact that atom-based vapor-cell saturation and Rydberg-EIT spectroscopies offer stabilization approaches that provide mechanical and thermal robustness, as well as compactness. These are critical features that cannot be met with SOTA ultra-stable cavity references. The proposed atomic Rydberg-EIT laser lock seamlessly dovetails with the QRR sensors and hybrid electrode-integrated vapor-cell detectors because both types of cells are similar and use the same atomic transitions, ensuring laser frequency locks that are drift-free and free of laser-frequency-shifting schemes that are complex and/or not sufficiently agile.

Potential NASA Applications (Limit 550 characters):

The proposed work supports the advancement of JPL's Quantum Rydberg Radar (QRR) effort. QRR based on Rydberg atom sensing is poised to advance capabilities in remote sensing for Earth and space-based science missions in Surface Topography and Vegetation (STV). The work here will address needs in high-spatial and temporal resolution identified in the 2017-2027 Earth Science Decadal Survey.

Potential Non-NASA Applications (Limit 400 characters):

The stabilized laser subsystems developed in this effort will have impact on the many applications for Rydberg atomic sensing systems. The markets impacted include RF test and metrology, communication applications from long-wavelength to the growing 5G/6G markets, and millimeter and THz imaging applications.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S11.03-2161**

SUBTOPIC TITLE: Technologies for Passive Microwave Remote Sensing

PROPOSAL TITLE: High-Efficiency Terahertz Source

Small Business Concern

Firm: **LongWave Photonics, 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):

LongWave Photonics and the Massachusetts Institute of Technology are proposing the development of high operating temperature terahertz frequency Quantum Cascade Laser for the detection of H2O and OH volatiles on the lunar surface. The improvement in operating temperature to > 250 K allows for increased wall plug efficiency through the use of cryocoolers which operate with improved Carnot efficiency at these temperatures. This allows reducing the size weight and power of the QCL source for use in a lunar instrument. In the proposed work, new quantum well structures will be engineered to increase gain at high temperature. High operating temperatures QCLs will be fabricated into Distributed Feedback Devices to assess the feasibility of frequency control and the impact on maximum operating temperature.

Potential NASA Applications (Limit 550 characters):

This project aims to support the NASA/GSFC Early Career Initiative (ECI) in the development of the Terahertz Heterodyne Spectrometer for In Situ Resource Utilization (THSiRU). The project is targeted at NASA's requirement for locating and identifying the availability of water and critical volatiles in the Moon's polar and equatorial regions for future *in situ* resource use and extraction, during the period between Commercial Lunar Payload Services (CLPS) to sustainable human presence (2024-2028).

Potential Non-NASA Applications (Limit 400 characters):

This technology potential use in a lower cost gas spectroscopy system for trace gas detection. Additional potential uses include measurement of field strength and plasma density for magnetically confined fusion.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S11.04-2555**

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

PROPOSAL TITLE: COMPACT MULTI-SPECTRAL INFRARED CAMERA WITH 4-MEGAPIXEL FOCAL PLANE ARRAY WITH INTEGRATED SPECTRAL FILTERS

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

QmagiQ proposes to develop and deliver a small, lightweight, low-power 4-MEGAPIXEL (2Kx2K) multi-spectral infrared camera covering a broad spectral band from 1-14 microns. A key feature is a broadband high-quantum-efficiency strained layer superlattice focal plane array (High-QE SLS FPA) with spectral filters deposited directly on the FPA – a design that allows the camera to be very compact and reliable. The spectroscopic information provided by the filters will be useful in detecting and identifying a variety of targets at distance.

The proposed camera will greatly improve ground resolution due to the high pixel count and small pixel pitch, allow more chemical analysis due to broader spectral coverage, and be smaller, lighter, and more reliable than the current state of the art which uses a 1-megapixel FPA with 3-12 micron spectral coverage and discrete attached filters.

In addition to detecting, tracking and chemically analyzing fires, a drone/airplane equipped with such a camera can be used to detect and analyze industrial gas leaks and pollution with high ground resolution.

Potential NASA Applications (Limit 550 characters):

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

Potential Non-NASA Applications (Limit 400 characters):

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: 23-1- **S11.05-1484**

SUBTOPIC TITLE: Suborbital Instruments and Sensor Systems for Earth Science Measurements

PROPOSAL TITLE: In Situ Depolarization, Attenuation, and Scattering Sensor

Small Business Concern

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

Principal Investigator:

Name: **Dr. Marc SeGall**
E-mail: **notify@intellisenseinc.com**
Address: **21041 S. Western Avenue, CA 90501 - 1727**
Phone: **(310) 320-1827**

Business Official:

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

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 4
Technical Abstract (Limit 2000 characters):

NASA is seeking a sensor that provides in situ measurements of ocean particulate backscatter, depolarization, beam attenuation, and diffuse attenuation coefficients relevant for combined ocean-atmosphere active remote sensing. To address this need, Intellisense Systems, Inc. (Intellisense) proposes to develop an In Situ Depolarization, Attenuation, and Scattering (IDEAS) sensor. IDEAS is submersible to >300 m and innovatively incorporates a beam attenuation and depolarization sensing subsystem and a backscattering sensing subsystem in a single unit, along with a depth sensor. The first subsystem innovatively measures the inherent losses and depolarization for linearly and circularly polarized beams as a function of depth and uses this data to calculate the diffuse attenuation coefficients based on a user-defined light field. The second subsystem determines the scattering for angles >170 deg with an angular resolution of

<1 deg and innovatively calculates the full scattering matrix using polarization-sensitive detectors. IDEAS operates at wavelengths ranging from 355 nm to 1064 nm and is designed for unattended operation. In Phase I, Intellisense will develop a system that measures beam attenuation, depolarization, and backscattering by particulates at multiple wavelengths in a laboratory environment and calculates the diffuse attenuation coefficients, thus clearing the way for Phase II. In Phase II, Intellisense will develop a prototype that is ocean-submersible to 300 m or deeper and that will provide in situ measurements of ocean particulate backscatter, depolarization, beam attenuation, and diffuse attenuation coefficients relevant for combined ocean-atmosphere active remote sensing at 355, 473, 486, 532, and 1064 nm. The backscattering sensing subsystem will provide measurements from 170 deg to 180 deg scattering angles with an angular resolution of <1 deg. Intellisense will deliver the prototype to NASA, including all necessary hardware and software.

Potential NASA Applications (Limit 550 characters):

IDEAS directly meets NASA's needs for quality field instruments that support NASA's Earth science objectives in current and future research programs such as the PACE, SBG, NAAMES, and EXPORTS missions. IDEAS will enable an accurate determination of the optical signature of aquatic environments and allow for precise determination of biogeochemical parameters such as chlorophyll or particulate organic carbon concentration. This allows NASA's satellite-based sensors to be properly calibrated.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications for IDEAS include measuring the concentration of water pollutants such as microplastics for water safety testing and oceanic characterization in support of underwater optical communications systems.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S12.01-1797**
SUBTOPIC TITLE:	Exoplanet Detection and Characterization Technologies
PROPOSAL TITLE:	Surface Finish Improvement in MEMS Deformable Mirrors for High Contrast Imaging

Small Business Concern

Firm: **Boston Micromachines Corporation**
Address: **30 Spinelli Place, Suite 103, Cambridge, MA 02138**
Phone: **(617) 868-4178**

Principal Investigator:

Name: **Steven Cornelissen**
E-mail: **sac@bostonmicromachines.com**
Address: **30 Spinelli Place, MA 02138 - 1070**
Phone: **(617) 868-4178**

Business Official:

Name:	**Paul Bierden**
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Address:	**30 Spinelli Place, MA 02138 - 1070**
Phone:	**(617) 868-4178**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5
Technical Abstract (Limit 2000 characters):

This proposal aims to make fundamental progress in one of NASA's core objectives: to explore Earth-like exo-planets using space-based Coronagraphs. One NASA-identified technology gap is the need for compact, ultraprecise, multi-thousand actuator deformable mirrors (DMs). Boston Micromachines Corporation is a leading producer of such DMs, which have been used in space-based applications and NASA Coronagraph test beds. However, their surface quality is currently limited to by topographic print-through on and stresses in the mirror surface. BMC proposes to develop a modified manufacturing process to improve the surface quality building on recent advancement in other programs. The new process will lead to production of DMs with surface figure errors measuring 1nm-rms. Such DMs are needed for all space-based coronagraphs that have been proposed for future NASA missions such as the Habitable World Observatory.

Potential NASA Applications (Limit 550 characters):

Deformable mirrors that can enable 1x10-10 contrast in NASA Coronagraph test beds and are candidates for use in space-based Coronagraphs used to search for Earth-like exo-planets. Planned NASA space-based observatories such Habitable World Observatory require the control provided by the proposed DMs. These devices will fill a critical technology gap in NASA's vision for high-contrast imaging and spectroscopy instruments.

Potential Non-NASA Applications (Limit 400 characters):

High-resolution, ultra-smooth MEMS deformable mirrors have non-NASA applications. They can improve the performance of terrestrial telescopes such as TMT and E-ELT. They can also be used as high-resolution wavefront correctors in laser communication, microscopy, and imaging.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S12.02-1519**
SUBTOPIC TITLE:	Precision Deployable Optical Structures and Metrology
PROPOSAL TITLE:	High-volumetric-efficiency inflatable-rigidizable booms for secondary support structures

Small Business Concern

Firm: **Helios Applied Science Inc.**
Address: **1 Westinghouse plaza Suite D157, Hyde Park, MA 02136**
Phone: **(781) 974-8841**

Principal Investigator:

Name: **Alfram Bright**
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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):

Our proposed inflatable-rigidizable composite boom is an ideal application for secondary support structures for space telescope sunshades. The deployable boom combines the high volumetric compaction ratio of a pure fabric inflatable with the strength, stiffness and thermal stability of a high performance fused quartz glass fiber composite.
Its compact deployment system is self contained and does not require solar or electrical energy to drive the rigidization process. The resulting boom structure is long lasting, dielectrically transparent and will not suffer catastrophic damage from micrometeoroids.

Potential NASA Applications (Limit 550 characters):

Satellite solar arrays, long instrumentation booms, solar sails, habitation volumes, phased array antennas, atmospheric reentry vehicles, kinetic energy absorption structures.

Potential Non-NASA Applications (Limit 400 characters):

Commercial satellite solar arrays, commercial satellite antennas. Piping, large conduit, rescue hoists, supports for softwalled shelters.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S12.03-1413**
SUBTOPIC TITLE:	Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical to Mid/Far-Infrared Telescopes
PROPOSAL TITLE:	Sub-nanometer CMM for Mirror Surface Metrology

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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Phone: **(585) 265-0160**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

In this work, we propose the development of a Sub-Nanometer Coordinate Measuring Machine (SNCMM) to complement the Nanometric Probe and complete the surface metrology solution. The SNCMM will enable larger, lower cost, and higher quality freeform and aspheric optics, and have performance that far surpasses areal interferometry as the primary means of feedback to optical fabrication and requirements verification.

The SNCMM will have the capability to measure the prescription and mid- and low-order surface errors for meter-class segments for large astronomical telescopes. Accurate metrology of the

prescription (i.e., radius of curvature, conic constant, and off-axis distances) will speed the fabrication, hence reducing costs, of primary mirror segments, because SNCMM metrology will have greater dynamic range than current CMM technology, allowing SNCMM to be used “deeper” into the fabrication process (i.e., from rough machining and grinding of blanks though the fine stages of optical polishing) before transitioning to an interferometric test, if that is even required for the final stages of polishing and verification.

All SNCMM sub-systems save one - the test-piece positioning sub-system - have been substantially de-risked on previous SBIR projects. The proposed project entails the design, construction, and testing of a high-stability test-piece positioner that is believed to be capable of holding a test-piece within the SNCMM with surface position stability better than a few tens of picometers through the duration of a surface measurement.

Potential NASA Applications (Limit 550 characters):

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

• Origins Space Telescope (OST) and the Habitable Worlds Observatory, which may use freeform optics.

• Lynx, Advanced X-ray Imaging Satellite (AXIS), and other X-ray telescopes.

• Large telescope mirrors, such as those for the Habitable Worlds Observatory and OST, requiring sub-nanometer metrology.
Potential Non-NASA Applications (Limit 400 characters):

The proposed metrology probe would benefit many applications, including:

- Metrology of high-precision optical components for commercial products such as those used in lithographic steppers.
- Metrology of X-ray and neutron mirrors (Department of Energy).

Duration: **6**

PROPOSAL NUMBER: 23-1- **S12.06-2123**

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

PROPOSAL TITLE: Additive manufacturing of robust, nonplanar electrical interconnects

Small Business Concern

Firm: **Optomec Design Co**
Address: **3911 Singer Boulevard NorthEast, ALBUQUERQUE, NM 87109**
Phone: **(505) 761-8250**

Principal Investigator:

Name: **Michael Renn**

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Address: **13170B Central Avenue Southeast, Suite 310, NM 87123 - 5588**
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Business Official:

Name: **David Ramahi**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

Optomec's proposed innovation is a direct-write additive manufacturing process, creating 25um electrical interconnects that can accommodate 3D steps and are terminated in a wire bond pad. These printed interconnects will minimize packaging space by replacing traditional wire bonds with conformal fan-out electrodes. This additive manufacturing proposal "is a science enabling technology for the next strategic-class of astrophysics missions," as stated in scope description of solicitation S12.06. Improving the packaging for large-format multishutter arrays is a goal relevant to several NASA missions, including the Large UV/Optical/IR Surveyor (LUVOIR) and the Habitable Exoplanet Observatory (HabEx) missions.

Optomec's innovation uses metal nanoparticle suspensions or "inks" to create pad and trace patterns, and these patterns are functionalized by sintering the metal nanoparticles at low temperatures or with a laser to make electrically conductive conformal interconnects. The Aerosol Jet® technology creates a high velocity stream of tightly collimated droplets, which means that liquid inks can easily be jetted in precise patterns. Tilting the jetting head relative to the flat substrate gives direct vision of both horizontal surfaces and vertical sidewalls, enabling interconnect printing over steps up to 1.5mm high and beyond. The tight collimation of the Aerosol Jet stream also means that Optomec can create very fine features, 25um size and smaller.

This Phase 1 NASA project will deliver test analysis and samples focusing on two important performance metrics for these printed interconnects: electrical isolation and wire bond reliability. Overspray of ink droplets outside the central printed lines can cause electrical shorting, and this will be measured and controlled. Finally, we will test the strength and reliability of bonds made to conformal printed pads.

Potential NASA Applications (Limit 550 characters):

The printed interconnect innovation is directly relevant to several NASA programs. It will reduce space requirements and improve packaging reliability for next-generation microshutter arrays, such as those needed for the Large UV/Optical/IR Surveyor (LUVOIR), the Habitable Exoplanet Observatory (HabEx), and the Cosmic Evolution Through UV Spectroscopy (CETUS) missions. It has the potential to reduce the size and weight of electronic assemblies used in a wide range of other projects.

Potential Non-NASA Applications (Limit 400 characters):

Conformal 3D printed interconnects have a wide variety of potential commercial applications. Two immediate markets for this innovation are in RF packaging, where it can improve RF transmission efficiency at very high frequencies used by defense and aerospace agencies, and in reducing size and increasing packing density in micro-LED applications.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S13.01-1619**

SUBTOPIC TITLE: Robotic Mobility, Manipulation and Sampling

PROPOSAL TITLE: Low-Gravity Robotic Arm System (L-GRAS)

Small Business Concern

Firm: **Motiv Space Systems, Inc.**
Address: **350 North Halstead Street, Pasadena, CA 91107**
Phone: **(626) 737-5988**

Principal Investigator:

Name: **Jesse Wigfield**
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Business Official:

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Phone: **(626) 389-5785**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters):

Motiv Space Systems (Motiv) presents the Low-Gravity Robotic Arm System (L-GRAS) to address the growing need for extremely lightweight robotics for low-gravity environments. With both NASA and commercial entities targeting operations in low-gravity environments such as the Moon there is a robotics capability gap for low-gravity robotic arms that can scale for different use cases and vehicles. This need extends not only for the Moon but also environments like Enceladus where the gravity is 1% of Earth's. In addition to operating in such an environment there is a priority to minimize mass for many of these missions. In particular, the rotorcraft missions envisioned for planetary bodies such as Mars, made feasible by the success of the Ingenuity helicopter, require ultra-lightweight systems. Because every mission is different the L-GRAS system is designed to be modular and scalable to afford the varied use cases, dexterity, and reach needs of a variety of missions. Any commercial solution for low-gravity arms must be technologically feasible and affordable. Additionally, for the design to be commercially viable, potential solutions must be scalable and tolerant of various kinematic solutions. L-GRAS can be scaled for rovers, rotorcraft, or landers. The focus of this proposed research is a solution based on well-established principles in motion control, robotics, and electrostatic adhesion but tailored to take advantage of the low-gravity planetary environments. Additionally, for sample handling or transfer, the choice of the electrostatic adhesion gripper can be designed to both handle a wide variety of specimens and impart no detrimental magnetic field into the sample. L-GRAS is comprised of a small robotic arm with distributed drive electronics and a customizable electrostatic adhesion gripper powered by a high voltage DC-DC converter. This robotic system will enable a low cost, versatile, scalable approach to enable low-gravity environment exploration.

Potential NASA Applications (Limit 550 characters):

NASA applications include rovers, rotorcraft, and landers destined for low-gravity environments. Though not the target application, L-GRAS could be used on small orbital applications such as those found on the International Space Station.

Potential Non-NASA Applications (Limit 400 characters):

Commercial companies developing small scale rovers for the Moon could make use of the robotic system. This also extends to CLPS lander providers that could use the scalable robotic arm for sample acquisition and/or transfer.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S13.03-2430**

SUBTOPIC TITLE: Extreme Environments Technology

PROPOSAL TITLE: Ultra-Thin Ceramic Film Based Passive Electronics

Small Business Concern

Firm: **Applied Thin Films Inc**
Address: **8261 Elmwood Avenue, Skokie, IL 60077**
Phone: **(847) 807-4077**

Principal Investigator:

Name: **Dr. Gary Etheridge**

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Business Official:

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Address: **8261 Elmwood Ave, IL 60077 -**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

This Phase I investigation is focused on demonstration of both capacitors and inductors based on an innovative micron-scale thick high temperature stable dielectric film (Cerablak® UTF) deposited on suitable metal substrates to form MIM capacitors or coating on metal wire to form inductors on an insulating core material. Cerablak® UTF is a transparent ultra-thin film with excellent dielectric characteristics made of aluminophosphate oxide material derived from a patented chemical precursor system. Cerablak® UTF h as excellent adhesion to most metal substrates and also serves as a highly effective diffusion barrier to protect the metal substrate from harsh environments. Previous studies, including recent GEER testing, has confirmed the robust stability and protective nature of Cerablak® UTF films. Phase I effort will include fabrication of suitable prototype specimens of both capacitors and inductors with the objective to downselect suitable MIM designs and identify metal wire based on laboratory scale prolonged high temperature exposure conditions. Suitable specimens will be delivered to NASA for GEER and other testing.

Potential NASA Applications (Limit 550 characters):

Passive circuit components that can survive in harsh space environments are of critical need to NASA. Power storage via use of stable MIM capacitors is also a critical need for NASA in many of their explorations, including Venus, Mars, and the like.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications include vehicle engine health monitoring systems for aerospace markets.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S13.04-2102**

SUBTOPIC TITLE: Contamination Control and Planetary Protection

PROPOSAL TITLE: Microorganisms Genome Enrichment and Amplification Sequencing (MGEAS)

Small Business Concern

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

Principal Investigator:

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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: 1
End: 4
Technical Abstract (Limit 2000 characters):

Recent evidence shows that the Space Assembly Facility (SAF) of Jet Propulsion Laboratory environments, such as floors and hardware surfaces, could harbor various microorganisms, and a comprehensive metagenomics framework to characterize organisms relevant to planetary protection is needed. Sequencing-based approaches, especially whole genome non-targeted metagenomics techniques, are preferred ways of microbial detection for planetary protection due to its fast turnaround time and ability to detect a broader spectrum of viable organisms. Current practices for microbe detection in low biomass samples generally do not fit well with NASA needs, due to high requirements in DNA concentration, small sample processing volumes, variability, and high predictive errors. In this project, we will tackle the problems through three modules (1) A sampling or filtration unit that process larger volumes of input solutions, (2) DNA preparations, enrichment, and amplifications followed by NGS sequencing, (3) Bioinformatics pipeline optimizations for error handling, assembly, and annotations, as well as integration with culture-based data for better risk modeling. The core technological contribution would be to validate or compare the use of two recent library preparation techniques 2bRAD-M and TruePrime MDA methods for microbiome diversity estimates. The technology is superior to 16S rRNA in the ability to detect a broader scope of microbes including virus, archaea, bacteria and fungi and other eukaryotes. This would be the first use of these technologies in JPL low biomass

samples. The resulting microbe taxa estimates can guide risk-assessment modeling parameterization of planetary protection practices.

Potential NASA Applications (Limit 550 characters):

Potential NASA applications include the detection of microorganisms before and after spacecraft missions to reduce or mitigate the possibility of inadvertent false positives, forward/backward contamination and to ensure the safety and soundness of spaceflight missions. Furthermore, increasing our ability for microbial detection in low biomass samples is also critical to crew safety in long-duration space habitation and the sustained operation of life support systems on space flights, stations, and surface habitats.

Potential Non-NASA Applications (Limit 400 characters):

Microbiome market is growing in the biotech industry and is expected to reach $1.3B in 5yrs. The growth is due to increasing research in microbiome science, the rising of microbiome-related diseases and the demand for personalized medicine. This technology could improve areas particularly relevant to low biomass microbiome studies. e.g neonatal disease diagnosis, deep ocean microbe communities.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S13.05-1769**
SUBTOPIC TITLE:	In Situ Instruments and Instrument Components for Planetary Science
PROPOSAL TITLE:	Lunar Lidar Technology for Artemis Human Habitation

Small Business Concern

Firm: **Fibertek, Inc.**
Address: **13605 Dulles Technology Drive, Herndon, VA 20171**
Phone: **(703) 471-7671**

Principal Investigator:

Name: **Dr. Zachary Lapin**
E-mail: **zlapin@fibertek.com**
Address: **13605 Dulles Technology Drive, VA 20171 - 4603**
Phone: **(703) 471-7671**

Business Official:

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E-mail: **tperinis@fibertek.com**
Address: **13605 Dulles Technology Drive, VA 20171 - 4603**

Phone: **(703) 471-7671**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

This SBIR will develop an in situ Lunar lidar for the Artemis missions that can be incorporated into a rover, astronaut-mounted backpack, NASA’s Lunar Terrain Vehicle (LTV) or other vehicles for planetary exploration within the solar system. The lidar developed in this SBIR will enable NASA to quantitatively map Lunar terrain with unprecedented, cm-scale, spatial resolution as well as provide real-time quantitative position and navigation information on the Lunar surface. This information is multi-use, serving both daily needs for Lunar habitation as well as scientific needs such as mapping challenging permanently shadowed regions (PSRs).

The current state-of-the-art for in situ Lunar and planetary mapping and navigation are passive stereo vision cameras such as the Navcams on the Perseverance Mars Rover. Such technology cannot inherently provide quantitative 3D mapping or image into dark/shadowed regions. The proposed lidar will create novel in situ mapping and navigation capabilities.

The in situ lidar to be developed under this SBIR will be robust to the extreme lunar environment and therefore have additional NASA applications for exploration of other planets, such as Mars, and the larger moons in the solar system. In situ lidar can provide a wealth of otherwise inaccessible terrain mapping data that can address NASA’s science objectives that cannot be achieved with passive optical instruments.

In situ lidar can provide high-resolution information for:

- Terrain mapping at cmscales
- Target ranging at >100 m
- Realtime position and navigation information in GPS-denied environments
- Realtime obstacle detection and hazard avoidance

Active imaging to probe dark regions, such as Lunar PSRs

Potential NASA Applications (Limit 550 characters):

The Primary application is to support NASA Artemis mission

- Provide cm-scale resolution mapping of the Lunar terrain.
- Provide real-time position and navigation information.
- Enable the imaging and mapping of Lunar PSRs.

Additional applications include in situ exploration of planetary bodies.

Potential Non-NASA Applications (Limit 400 characters):

- Provide an environmentally hardened Lidar for extreme environments.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S13.07-1991**

SUBTOPIC TITLE: Energy Storage for Extreme Environments

PROPOSAL TITLE: Thermally Resistant Gel Polymer Electrolyte for Lunar Applications

Small Business Concern

Firm: **AUDIANCE**
Address: **2000 South County Trail, East Greenwich, RI 02818**
Phone: **(401) 644-5686**

Principal Investigator:

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Address: **2000 South County Trail, RI 02818 - 1530**
Phone: **(401) 644-5686**

Business Official:

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Phone: **(781) 424-6612**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

It is important to consider lithium-ion battery limitations particularly regarding temperature range, to ensure safe and successful mission outcomes. We have developed a gel polymer electrolyte

that meets stringent requirements of high safety, stability, and non-flammability for implantable medical devices and plan to further develop this electrolyte for use in cells operating in extreme environments (-230 to 120˚C) and high voltages (>4.2 V). Our results show negligible loss in capacity over 4500 cycles, no damage to cell reversibility after extended periods of time at 0˚C operation, and no emission or flames during overcharge and external short circuit tests within LFP|LTO cells that contain our safe and stable electrolyte. By carefully selecting additives, we aim to overcome common performance issues and enable operation in extreme environments. We will combine this with a high-voltage cathode and graphite anode to achieve exceptional temperature stability, safe operation, and optimal performance in extreme environments.

Potential NASA Applications (Limit 550 characters):

The proposed technology would apply to any industry or technology that requires a battery and operates in an extreme environment including but not limited to spacecraft used for planetary exploration, such as rovers and landers, remote sensing and data collection equipment, satellites, spacecraft power systems, and portable devices for astronauts.

Potential Non-NASA Applications (Limit 400 characters):

The proposed innovation, a battery capable of safely operating within extreme environments, would be applicable to Non-NASA industries such as electric vehicles, portable soldier devices utilized in military operations, and unmanned underwater vehicles, such as ROVs and AUVs.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S14.01-1662**

SUBTOPIC TITLE: Space Weather Research-to-Operations-to-Research (R2O2R) Technology Development and Commercial Applications

PROPOSAL TITLE: Low-latitude Scintillation Nowcasting and Forecasting

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: 4
Technical Abstract (Limit 2000 characters):

The NASA SBIR subtopic, S14.01 Space Weather R2O2R, discusses key risks associated with space weather effects, including risks posed to spacecraft, crew, telecommunications, satellite systems, and position, navigation, and timing services. The Heliophysics Division is seeking innovative approaches to better understand, monitor, predict and mitigate space weather impacts. Area 1 of the subtopic description expresses a need for solutions that enable the characterization and prediction of ionospheric variability, including improved forecasting of ionospheric scintillation. Area 3 of the subtopic description explains BASA's desire for innovative data assimilation and integration tools for the operational space-weather community. **Orion's ISIP.AI tool will address both of these critical needs by improving low latitude scintillation nowcasting and forecasting with an innovative machine-learning approach.**

Ionospheric scintillation is the rapid fluctuations in phase (σφ) and amplitude (S4) experienced by radio signals (up to 2 GHz) propagating through ionospheric irregularities. While scintillation severity varies, in the most severe case scintillation can make it impossible for a GNSS receiver to calculate a position. Currently, there are no reliable tools to forecast or nowcast ionospheric scintillation for a given communication link. ISIP.AI will be a first-of-its-kind tool that can improve the reliability of ground-to-space communication links by nowcasting and forecasting low-latitude scintillation. This capability can ultimately help NASA mitigate risks associated with mission-ending scintillation disruptions.
Potential NASA Applications (Limit 550 characters):

Without reliable models for nowcasting or forecasting, the SWORM Working Group, Artemis missions, and other Exploration Systems Development Mission Directorate programs lack the necessary data to provide operational products for the occurrence of ionospheric irregularities and resulting scintillation. These gaps in reliable scintillation data increase risks of communication disruptions during daily NASA operations such as communicating with the ISS. ISIP.AI's innovative approach can help NASA mitigate these risks.
Potential Non-NASA Applications (Limit 400 characters):

The DoD is budgeting $2.5 billion for PTS satellites and a ground system called PTES. Other agencies such as NOAA will also be interested in ISIP.AI's scintillations nowcasts and forecasts. Additionally, private space companies would be interested in scintillation forecasts to adjust their downlink schedules to avoid missed communications.
Duration: **6**

PROPOSAL NUMBER: 23-1- **S14.02-1663**

SUBTOPIC TITLE: In Situ Particles and Fields and Remote-Sensing Enabling Technologies for Heliophysics Instruments

PROPOSAL TITLE: ReflecTEC

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:

Name: **Joe Hughes**
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Phone: **(303) 993-8039**

Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

The ionosphere is a dynamic and enigmatic region of Earth’s atmosphere that can absorb, bend, reflect, and distort radio frequency (RF) waves. To guard against deleterious effects that this environment might have on vital systems, measurements are routinely taken and used to predict and mitigate the ionosphere’s effect on RF signals. However, there exists gaps of data over the open ocean where instruments cannot be fielded. ReflecTEC is a space-borne instrument that will fill this measurement gap by providing measurements of the vertical Total Electron Content (TEC) over the open ocean. Additionally, this TEC data will be ~1,000 times more accurate than existing data from GNSS signals of opportunity. ReflecTEC is a revolutionary space instrument that will transform the oceans from data-starved to data-rich regions.

Potential NASA Applications (Limit 550 characters):

The ReflecTEC instrument can provide high quality data from any orbital platform. As such it could be a singular payload on a cubesat through a NASA program such as a H-FORT, LCAS, or the soon-to-be-released TechFlights. It could also be a hosted payload on a larger satellite mission such as NASA GDC. Once operational, we plan to sell the data back to NASA through their CSDA program.

Potential Non-NASA Applications (Limit 400 characters):

A detailed 5 step commercialization plan is detailed in the proposal. We expect to transition away from NASA funding at the third or fourth stage where we would provide Data as a Service (DaaS). ReflecTEC can be useful for specifying the ionosphere in real time. We would sell this data to NOAA through their CWDP program as well as the Air Force and Space Force through their CWDP programs.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S15.02-1206**

SUBTOPIC TITLE: In Situ Sample Preparation and Analysis for Biological and Physical Sciences in a Microgravity Environment

PROPOSAL TITLE: Array Based Exhaled Breath Analyzer

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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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

NASA's Biological and Physical Sciences (BPS) Division uses the spaceflight environment to study the interaction of spaceflight stressors with human physiological systems. Experiments on such platforms examine how plants, microbes, and animals adjust or adapt to living in space, and allow to examine processes of metabolism, growth, stress response, physiology, and development. Most experiments, however, require preserving, storing, and returning the samples to Earth, where detailed analyses are conducted. Consequently, the pace of scientific discovery has been sluggish due to the inability to quickly conduct the iterative process of research that includes the ability to either synthesize or adjust sample composition on-orbit based on real time diagnostic measurements. For animal model-based research, in-situ compact devices for measuring and transmitting data regarding cells, proteins, and metabolites in various specimen types, including blood, saliva, urine, and other body fluids is highly desired. Analysis of exhaled breath is especially attractive as it can be obtained from animals noninvasively and may hold important clues about mammalian physiology. Lynntech has previously developed array-based chemical sensors for the detection of toxic industrial materials, groundwater contaminants, chemical warfare agent surrogates, and volatile organic compounds (VOCs), for assessment of seafood freshness and human VOC signature identification. In addition, Lynntech has conducted extensive research to evaluate potential analytical devices that can be used for the fast, inexpensive, reliable detection of VOC biomarkers in exhaled breath. By adapting engineering advances carried out in Lynntech's array-based chemical sensor, microgravity-compatible, on-board exhaled breath analyzer will be developed. In the Phase I, Lynntech will demonstrate the feasibility of the proposed approach with a breadboard system. An automated prototype will be delivered to NASA during Phase II.

Potential NASA Applications (Limit 550 characters):

Direct NASA applications of the array-based, microgravity-compatible, on-board exhaled breath analyzer (ABBA) include the in situ exhaled breath analysis for animal model to better understand impacts of spaceflight stressors on the overall health of astronauts. The attributes of the non-invasive and non-intrusive sample collection and the near-real-time analysis will save time and effort conducting experiments on board and allow to quickly conduct iterative process of research.

Potential Non-NASA Applications (Limit 400 characters):

Successful development of the technology will have a high commercial applicability to a wide range of industries where require the detection of VOCs, e.g., the Gas and Chemical Industries and Regulatory Agencies, environmental remediation, food, beverage, and perfume industries, agronomic industries, medical industry, and homeland security.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S16.01-1286**
SUBTOPIC TITLE:	Photovoltaic Power Generation and Conversion
PROPOSAL TITLE:	Eye Safe IR Power Beaming to GaSb PV Modules at Remote EV Charging Station

Small Business Concern

Firm: **JX Crystals**
Address: **1085 12th Avenue NorthWest #D7, Issaquah, WA 98027**
Phone: **(425) 392-5237**

Principal Investigator:

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Business Official:

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Phone: **(425) 392-5237**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 6
Technical Abstract (Limit 2000 characters):

We propose to develop and demonstrate a compact high efficiency power beaming system that couples a 1.5-micron laser source to a high quantum efficiency, low cost, GaSb-based infrared photovoltaics receiver for agile power distribution from the edge of a moon crater to a charging station. This could serve as a first step toward eye safe power dense wireless energy transfer. With the use of concentrator lenses the efficiency of the system will be higher and the weight will be lower.

Potential NASA Applications (Limit 550 characters):

A power transfer system using an infrared laser to send power in permanently shadow regions on the lunar surface.

A solar power satellite equipped with an infrared laser could beam energy down to lunar bases during lunar nights.

Spacecraft to spacecraft power beaming.

Lasers are also used for sending data. A future application could be to merge this technology with laser communication to send both power and data.

Potential Non-NASA Applications (Limit 400 characters):

The military could use the power transfer system to beam power to a squadron of troops to power their gear.

Power can be beamed to areas on Earth where laying 100's of miles of cable isn't feasible.

Temporary bases for military or research purposes could have power beamed to them during the lifetime of the base.

Power beaming to drones to sustain longer flight.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S16.03-1975**

SUBTOPIC TITLE: Guidance, Navigation, and Control

PROPOSAL TITLE: Precision Scanning Star Tracker for Spin Stabilized Spacecraft

Small Business Concern

Firm: **CrossTrac Engineering,Inc.**
Address: **2730 Saint Giles Lane, Mountain View, CA 94040**
Phone: **(408) 898-0376**

Principal Investigator:

Name: **John Hanson**
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Business Official:

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Phone: **(408) 898-0376**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters):

Recent advances in the design of microsatellites have led to renewed interest in the missions that can be flown with small spacecraft and small payloads. The CubeSat platform has prompted the development of attitude determination hardware typical of larger, more sophisticated, three axis stabilized spacecraft, including miniature gyroscopes and star cameras. The Precision Star Scanner is a new class of attitude sensor, designed to support

precision spin-stabilized CubeSat and smallsat missions by providing arcminute attitude accuracy in a size compatible with a CubeSat, in fact occupying less than half of a 1U CubeSat module. The scientific and technological advances necessary to make this instrument possible are in place. Robust catalogs of guide stars is available through several all-sky surveys performed at various wavelengths. Solid state detectors and their related support electronics have been flown on a variety of missions. The concept of using guide stars to determine the attitude of a spinning vehicle has been demonstrated using flight data. The PSS fills the need created by the CubeSat platform for accurate attitude determination on a spin stabilized platform provided in a small package and fills the need expressed by NASA for accurate attitude determination hardware compatible with Earth observing spinning CubeSats.

Potential NASA Applications (Limit 550 characters):

The PSS will provide an arcminute level attitude reference for spin-stabilized spacecraft with a design targeting Earth observing CubeSat class spacecraft. However, this attitude sensor will be useful to any spin-stabilize spacecraft requiring arcminute level attitude determination accuracy enabling new missions by providing arcminute level point accuracies for spacecraft supporting key NASA missions such as: Earth mapping and observing missions; solar and astronomical observatories; and space weather missions.

Potential Non-NASA Applications (Limit 400 characters):

The PSS will find users outside of NASA in the smallsat and CubeSat communities in general, but more specifically. There are several obvious DoD applications for precision spin stabilized spacecraft, including electronic intelligence, space weather observations, rapid responsive space communications satellites and earth observing spacecraft.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S16.07-1568**

SUBTOPIC TITLE: Cryogenic Systems for Sensors and Detectors

PROPOSAL TITLE: Low Temperature, Low Capacity Cryocooler Technology

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):

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, Origins Space Telescope, and the Superconducting Gravity Gradiometer. Cooling loads for these missions are 50 to 300 mW at temperatures of 4 to 10 K, with additional loads at higher temperatures for cooling shields and other subsystems. Due to low jitter requirements, a cryocooler with very low vibration is needed for many missions. Turbo-Brayton cryocoolers have space heritage and are ideal for these missions due to negligible vibration emittance and high efficiency at low temperatures. Technologies have been demonstrated or are under development for refrigeration loads in the range of 200 mW to 500 mW at 4 to 10 K, respectively. Many future missions have lower refrigeration requirements and require commensurably lower input power. Further miniaturization is needed for the cold turbine to provide high cryocooler efficiency and low input power when loads are reduced to 50 to 150 mW. On the proposed program, Creare plans to advance recent developments in gas bearings and miniature permanent magnet alternators to a smaller turbine capacity than attempted to date. On the Phase I project, we will perform analyses and fabrication trials to demonstrate feasibility of a turbine optimized for 50 to 150 mW at 4 to 10 K. On the Phase II project, we will build and demonstrate the turbine in a cryocooler.

Potential NASA Applications (Limit 550 characters):

The successful completion of this program will result in an extremely efficient, low temperature, low capacity 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 the Lynx, Origins Space Telescope, and the Superconducting Gravity Gradiometer.

Potential Non-NASA Applications (Limit 400 characters):

The military market is for cooling multi-spectral and hyperspectral imaging systems on space-based observation, surveillance, and missile defense systems and low temperature superconducting electronics. Commercial applications include cooling for communication satellites; superconducting instruments, digital filters, and magnets; low temperature gas-separation systems; hypercomputers; and SQUIDs.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S16.08-2115**

SUBTOPIC TITLE: Atomic Quantum Sensor and Clocks

PROPOSAL TITLE: Miniature Laser System for Cs Atom Interferometer

Small Business Concern

Firm: **OEwaves, Inc.**
Address: **465 North Halstead Street, Suite #140, Pasadena, CA 91107**
Phone: **(626) 351-4200**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters):

OEwaves Inc. offers to develop and demonstrate a compact diode laser system producing the wavelengths for operation of Cs based atomic sensor including Cs atomic interferometers. The system will include **852 nm and 894 nm lasers** including modulation functions typically required for the operation of quantum sensors. The system will feature the properties required for long duration space applications. The system will be based on semiconductor lasers locked to monolithic microcavities using the self-injection locking technique. *This technique results in a complete suppression of mode hops in the laser during its operational lifetime. The microcavity will not only stabilize the frequency of the laser but will also be used to measure and stabilize the power of the laser. The microcavity provides a modulatable laser that features exceptionally low residual amplitude modulation, allowing a robust lock as well as offset lock to the atomic transition of interest. The proof of principle validation of the technique has been demonstrated by earlier efforts at OEwaves*.

At the end of Phase II, our goal is to deliver a prototype that achieves better than 10^{-11}/g acceleration sensitivity, and the required frequency stability (defined by the customer; varies

depending on the laser use). A unique feature of crystalline WGM resonators pioneered by OEwaves is their high optical transparency leading to quality factors that routinely exceed 10^9. This will add to simplification in locking lasers to the modes of the resonator.

Potential NASA Applications (Limit 550 characters):

The laser development addresses the emerging Quantum Technologies market, which is expected to grow globally at a high double digit CAGR of from 2021 to 2030 to reach $3,518.3 million by 2030. A significant value of the laser development effort in this project is that it is based on an architecture not limited to lasers at Cs wavelengths but can apply to any wavelength lasers. The packaged laser will dramatically enhance the performance of a wide range of NASA as well as DOD systems.

Potential Non-NASA Applications (Limit 400 characters):

This OEwaves technology can be used for atomic ion and neutral transitions covering the near-UV to the near-IR, the lasers are useful for quantum computing applications such as machine/deep learning, simulation and data modeling, optimization of traffic, financial analysis, cyber security. Other markets are atomic clocks, spectroscopy, inertial navigation systems (INS), and optical communication.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S17.01-2521**

SUBTOPIC TITLE: Technologies for Large-Scale Numerical Simulation

PROPOSAL TITLE: Surrogation of High-Fidelity Simulation Software

Small Business Concern

Firm: **Anyar, Inc.**
Address: **2113 Lewis Turner Boulevard Suite 104, Fort Walton Beach, FL 32547**
Phone: **(850) 226-8511**

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):

The proposed innovation is a mesh-based graph neural network (GNN) framework for training high-fidelity surrogate models. The models are highly accurate and increase computational efficiency approximately 1-2 orders of magnitude faster than the software which generated the data. This would allow use of previously generated simulations to alleviate High-Performance Computing (HPC) resources, minimize the time-to-solution for engineering and science workflows, and increase the collaboration of various initiatives by providing a leaner alternative to simulations.

The mesh-based GNN, or simply MeshGraphNetwork (MGN), is based on a pioneering publication from Google's DeepMind project shown to accurately predict the dynamics of a wide range of physical systems, including those found within computational fluid dynamics (CFD). MGNs are a novel class of GNNs that directly operate on irregular meshes with arbitrary connectivity which have difficulty scaling on hardware accelerators. Due to the neural network basis of the MGNs components, it is suitable for acceleration on hardware commonly present in HPCs.

Potential NASA Applications (Limit 550 characters):

Machine learning solutions that model the continuous fields of a CFD scenario, or other system dynamics, solved by a simulation code such as FUN3D or Cart3D, will be invaluable to NASA as computing demands are projected to increase year over year for many types of high-fidelity simulations. These simulations are essential for all aspects of a technical workflow such as design, development, and testing. Our proposal is a general solution that can leverage existing tools and ultimately increase the operational compute capacity of an HPC system.

Potential Non-NASA Applications (Limit 400 characters):

This proposal expands Anyar's ongoing research for the DoD related to Physics-Informed Neural Networks (PINN). Our DoD customers believe our MeshGraphNet library will fundamentally alter the speed of their penetration mechanics solutions for hydrodynamics problems. This proposal is a natural extension and expansion of our existing MGN library into fluid dynamics.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S17.02-1729**
SUBTOPIC TITLE:	Integrated Campaign and System Modeling
PROPOSAL TITLE:	Collaborative Multidimensional Trade Space Analysis Capability

Small Business Concern

Firm: **System Strategy, Inc.**
Address: **5698 Sussex Court, Troy, MI 48098**
Phone: **(313) 806-3929**

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):

The Collaborative Tradespace Capability (CTC) prototype proposed by the SSI team is designed to address critical areas of interest to NASA, such as improving model interoperability, managing varying levels of fidelity/uncertainty, and rapidly and iteratively operating across a distributed collaborative environment to characterize and select optimum candidates. The goal of the Phase I project is to build a proof of concept prototype that can generate models of complex system behavior with improved confidence levels. The SSI team will accomplish this by using and integrating recent advancements in Digital Engineering, incorporating workflow automation, and extending the capabilities of the Whole System Trades Analysis Tool (WSTAT) by incorporating new methods of uncertainty reduction.

The CTC prototype aims to be a 10x+ game changer in rapidly navigating architecture trades, requirements development and flow down, and design optimization. By leveraging new and advanced systems modeling tools and methods, the CTC will enable NASA to more efficiently explore multidimensional tradespaces and make informed decisions about complex systems. The CTC prototype will also enable distributed collaboration, allowing teams to work together more effectively and iteratively. Ultimately, the CTC prototype has the potential to significantly improve NASA's ability to design and develop complex systems, leading to more efficient and effective missions.

Potential NASA Applications (Limit 550 characters):

The proposed Collaborative Multidimensional Trade Space Analysis Capability is a Digital Engineering (DE) capability enabling NASA to gain deeper insights into the value of system concepts and identify which technologies are essential to achieve system-level objectives. It uses authoritative models over a highly distributed collaborative DE Ecosystem, making it suitable for any NASA development, acquisition, or upgrade project where design options exist, iteration is necessary, uncertainty is high, and a large design space must be understood.
Potential Non-NASA Applications (Limit 400 characters):

Selecting the best system architecture among competing candidates with confidence is one of an organization's most valuable capabilities. CTC will provide the ability to rapidly iterate, configure, assess and selects designs with higher confidence and market value. SSI is highly confident in bringing on current commercial clients from across sectors as partners for a Phase II effort and beyond.
Duration: **6**

PROPOSAL NUMBER: 23-1- **S17.03-2054**

SUBTOPIC TITLE: Fault Management Technologies

PROPOSAL TITLE: Fault Analysis and Resilience for SpaceCraft Autonomous Protection Enhancement (FARSCAPE)

Small Business Concern

Firm: **Charles River Analytics, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters):

NASA relies heavily on the computational systems of spacecraft to perform missions in the harsh environment of space. Failures due to faults may interfere with mission-critical events, jeopardizing mission success and potentially resulting in the loss of expensive equipment and scientific data. To ensure mission success, space platforms must be equipped with onboard capabilities to autonomously detect, analyze, and mitigate faults using in-the-loop mechanisms and algorithms. When system-wide faults occur that cannot be mitigated purely in software, the software-based fault management algorithms must detect these and initiate failover to existing hardware-based recovery mechanisms if available on the platform.

To address fault management for space platforms, Charles River Analytics is pleased to propose the Fault Analysis and Resilience for SpaceCraft Autonomous Protection Enhancement (FARSCAPE) system, which will automatically monitor, detect, diagnose, and mitigate faults in space platforms to realize greater system autonomy. FARSCAPE adds software-based autonomous fault management capabilities to space systems to (1) monitor system-level, middleware, and application-level mission-critical component execution; (2) apply an ensemble of machine learning (ML) techniques to accurately detect known and unknown faults; (3) compute mitigation plans when faults arise; and (4) execute mitigations to fight through faults and minimize data loss and damage caused by system failures. The proposed FARSCAPE effort is at the intersection of several of our team’s longstanding interests, namely fault management and resilient systems design. Our approach is founded on our extensive domain expertise, as well as current and past research at Charles River Analytics in resilient OS design, ML, anomaly detection, system monitoring, and fault resilience.
Potential NASA Applications (Limit 550 characters):

We expect the full-scope FARSCAPE system to benefit users of spaceborne systems needing protection from failures due to faults, especially in remote environments with limited communications. Specifically, FARSCAPE will provide a fault monitoring and mitigation framework to ensure that autonomous space systems can continually operate on long-duration missions with minimal data and equipment loss. The innovations developed under FARSCAPE will enable operators to ensure that space systems can successfully and reliably complete mission objectives.
Potential Non-NASA Applications (Limit 400 characters):

We see a commercially viable market licensing FARSCAPE as a system extension (e.g., with Hewlett Packard) to protect commercial space platforms, industrial control systems, and internet of things (IoT) devices from unexpected faults. FARSCAPE applies to cyberdefense and contributes commercially attractive technical improvements to our secure and resilient system extensions (SRSE) technology.
Duration: **6**

PROPOSAL NUMBER: 23-1- **S17.04-2237**

SUBTOPIC TITLE: Application of Artificial Intelligence for Science Modeling and Instrumentation

PROPOSAL TITLE: Toward a Framework for Earth System Digital Twins with Machine-Learned Parameterizations

Small Business Concern

Firm: **Bayesics, LLC**
Address: **12747 Hillmeade Station Drive, Bowie, MD 20720**
Phone: **(202) 492-3408**

Principal Investigator:

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Business Official:

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Phone: **(202) 492-3408**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

We propose **a framework leveraging machine learning to enable the development of Earth System Digital Twins (ESDTs)** through a machine-learned (ML) stochastic bin microphysics (SBM) emulator. To achieve the fast observational feedback required by an ESDT, we plan to first implement a conditional variational auto-encoder/decoder (cVAE/D) model as a radar observation parameter (ROP) mapper that maps the high-dimensional hydrometeor size spectra produced by the physics-based SBM model to a manifold of much-reduced dimensionality, from which the original ROP mapper input can be accurately recovered efficiently when needed. The encoder of the cVAE/D projects the physics-based SBM outcomes, including the hydrometeor species and their size spectra, to a compressed manifold of much lower dimensionality than that of the original SBM model outcomes. Radar observation parameters (ROPs) for simulating radar signals will be part of the compressed manifold as prescribe variables. The corresponding decoder can invert the projection and reproduce the SBM model outcome. ROPs from the ROP mapper enable efficient radar observable calculations for feedback to the SBM emulator and, in turn, the host dynamic cloud-resolving model (CRM).

More crucially, we will train a neural network (NN) as an *SBM emulator,* based on the Long Short-Term Memory (LSTM) model, to mimic the functioning of the physics-based SBM model through the manifold variables obtained from the ROP mapper for time-series prediction. We plan to use high temporal resolution (i.e., time steps of 1 or 2 minutes) physics-based SBM model outcomes within CRM simulations to train the LSTM SBM emulator. Our goal is to incorporate the SBM emulator into the CRM as a computationally efficient alternative to the expensive physics-based SBM model in Phase II of this proposed project if the feasibility of this approach is verified in Phase I.

Potential NASA Applications (Limit 550 characters):

NASA has considerable efforts involving weather and climate modeling for research and climate prediction, which would directly benefit. Researchers of weather products usually apply them in operational contexts, such as mission and field campaign planning and execution, which have demanding real-, near-real-, or in-time requirements. Our proposed ML-based microphysics emulation would support improved rapid responses in these regimes by allowing (real-time) observation feedback to be brought to bear that is currently infeasible or impractical.

Potential Non-NASA Applications (Limit 400 characters):

The global weather forecasting market was about $2.2 billion/year in 2021, projected to reach almost $4 billion/year by 2030. Our natural client base is the plethora of weather and climate analysis firms serving application areas, including planning, monitoring, and analysis supporting agriculture, fisheries, disaster planning/response, insurance, energy, and transportation, among others.

Duration: **6**

PROPOSAL NUMBER:	23-1- **Z1.05-2475**
SUBTOPIC TITLE:	Lunar and Planetary Surface Power Management and Distribution
PROPOSAL TITLE:	Rad-Hard Extreme Temperature Bidirectional Converter

Small Business Concern

Firm: **Mainstream Engineering Corporation**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters):

The vision of NASA's Artemis program is to lead humanity forward in the exploration of the Moon which will prepare us for the exploration of Mars. Paramount to the success of this program is the ability to provide reliable electric power throughout the lunar day and night. The terrestrial grid is primarily composed of AC systems to accommodate legacy grid infrastructure. However, DC microgrids are of primary interest to NASA because of the reduced transmission line and voltage level conversion losses, as well as the reduced complexity of interfacing with DC generation and storage elements such as photovoltaic (PV) panels and battery energy storage systems (ESS). Due to the extreme Lunar and Martian environments, typical terrestrial DC-DC converters often fail due to high energy single event upset radiation effects and extreme temperatures. To address these deficiencies, Mainstream proposes to develop a modular bidirectional isolated DC-DC converter to interface between low voltage sources and loads and the DC microgrid.

To achieve this goal, Mainstream will first develop an electro-thermal simulation model of the converter and perform a trade study of available proven radiation-tolerant and temperature rated semiconductor options to maximize the efficiency and specific power of the inverter. Next, Mainstream will prepare detailed schematics for and design the power stage and control card PCBs. Mainstream will develop embedded firmware to control the converter and perform detailed hardware-in-the-loop simulations to validate the control architecture. Finally, Mainstream will detail the requirements for the thermal management system and develop a high-fidelity thermal model of the system.

Potential NASA Applications (Limit 550 characters):

Mainstream's proposed converter is directly aligned with the Artemis Plan, NASA's Lunar Exploration Program, and with NASA's Global Exploration Roadmap. Providing reliable electric power in the extreme environments of the moon and Mars is essential for establishing long term exploration to support communication, space exploration vehicles, rovers, and ground-based habitation outposts. Specific NASA programs that could benefit include Advanced Exploration Systems (AES), Human Exploration and Operations (HEO), Gateway, and Artemis.

Potential Non-NASA Applications (Limit 400 characters):

Mainstream develops power converters, including variable-frequency motor drives, active rectifiers, and isolated DC-DC converters, for demanding applications where commercial products are not suitable. Examples include bidirectional multiport DC-DC converters for spacecraft electric power systems and bidirectional battery isolator units and battery inverters for electric vehicle systems.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z7.03-2364**

SUBTOPIC TITLE: Entry and Descent System Technologies

PROPOSAL TITLE: Additive Insulative Layer for Thermal Protection System

Small Business Concern

Firm: **Bally Ribbon Mills**
Address: **23 North 7th Street, Bally, PA 19503**
Phone: **(610) 845-2211**

Principal Investigator:

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E-mail: **joegeiger@ballyribbon.com**
Address: **1301 Montgomery ave, apt 1-1, PA 19096 - 1035**
Phone: **(610) 845-2211**

Business Official:

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Address: **23 North 7th Street, PA 19503 - 1904**
Phone: **(610) 845-8221**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 4
Technical Abstract (Limit 2000 characters):

The Heatshield for Extreme Entry Environmental Technology (HEEET) project started as a solution to the difficult entry temperatures and conditions. Its design is robust for the extreme environments that it needs to survive. HEEET Thermal Protection Systems (TPS) is fabricated with two different layers. The first is a dense carbon layer that is meant to be thermally ablative (forebody) and the second is a phenolic less dense weave that acts as an insulation layer. These heavy applications were developed for the Adaptable Deployable Entry Placement Technology (ADEPT) program. Recently NASA Ames Research Center (ARC) is exploring other options using this system to produce robust materials that can be scaled to environmental conditions for Mars and low earth orbit (LEO) and other planetary entry. This hybrid manufacturing solution that will utilize the tight weave of the carbon layer and the low fiber volume of the phenolic thermal insulation. The application will use the weaving process established by Bally Ribbon Mills (BRM) and needle punched layer that will be developed with BRM engineering and Thomas Jefferson University (formerly Philadelphia University / Philadelphia Textile) engineering and lab equipment. The BRM team will develop a TPS that can have thermal layers added after the weaving process using needle punching techniques.

Potential NASA Applications (Limit 550 characters):

The proposed technology for aeroshell manufacturing offers an innovative perspective on re-entry vehicles system, including the principles of design for manufacturability as key points to reduce mass, delivery time and costs of the final product. The deployable aeroshell concept will prove itself as a viable thermal protection system (TPS) for entry, descent and landing of future exploration class payload missions such as Mars.
Potential Non-NASA Applications (Limit 400 characters):

The proposed development of a nonwoven and HEEET hybrid material concept will pave the way for future development of specific materials for quickly adaptable entry, decent and landing systems with specific need thermal protection systems. This modifiable system will be essential in reducing cost and manufacturing time of thermal protection systems that do not need to withstand extreme conditions.
Duration: **6**

PROPOSAL NUMBER: 23-1- **Z7.04-2623**

SUBTOPIC TITLE: Landing Systems Technologies

PROPOSAL TITLE: Combined High-Speed, Thermal, and Event Camera Imaging Sensor for Plume-Surface Interactions

Small Business Concern

Firm: **Astrobotic Technology, Inc.**
Address: **1016 North Lincoln Avenue, Pittsburgh, PA 15233**
Phone: **(412) 682-3282**

Principal Investigator:

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Phone: **(818) 270-5688**

Business Official:

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Phone: **(412) 682-3282**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 4
Technical Abstract (Limit 2000 characters):

The Plume-Surface Interaction Combined Hot-fire Imaging Camera (PSICHIC) is a novel imaging sensor that will advance the state of plume-surface interaction (PSI) observation by combining the capabilities of a high-speed camera, a thermal camera, and an event camera into a single, compact system designed to be used in stereo. PSICHIC leverages advances in camera technology to study and measure plume surface interaction PSI effects for planetary landings, initially in a terrestrial test setting and ultimately as a payload aboard lunar landers. Developed with a focus on studying lunar PSI effects, PSICHIC could also be useful for observing and modeling PSI and cratering effects for rocket-powered landings on Earth and Mars as well as for observing and imaging hot-fire rocket engine tests. PSICHIC will provide valuable new data from terrestrial hot-fire testing (and eventually from lunar landings), including data not readily observed by the human eye or high-speed cameras, that will advance the state of the art of PSI modeling and simulation. The PSICHIC system can be readily paired with existing Astrobotic PSI test infrastructure to provide a wealth of new optical and thermal data concerning ejecta physics and the behavior of regolith during lunar and planetary landings.

Potential NASA Applications (Limit 550 characters):

PSICHIC would greatly enhance NASA's ability to observe and collect data from terrestrial PSI tests and use that data to model plume-surface interactions on the Moon and other celestial bodies. In particular, PSICHIC's event camera and infrared camera components will enable researchers to observe and measure optical and thermal data not readily visible to the human eye or high-speed cameras. This new PSI data and the models that result therefrom will be a tremendous asset to the Artemis and CLPS programs as well as future Mars lander missions.

Potential Non-NASA Applications (Limit 400 characters):

PSICHIC will also enable commercial lander providers, including Astrobotic and other CLPS providers, to more accurately study and model plume surface interactions and anticipate the effects of ejecta on their landers. It will also aid university and commercial researchers in developing a more comprehensive understanding of regolith particle physics and thermal transfer.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z10.04-1939**

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

PROPOSAL TITLE: Novel Grids and Coatings for High-Power Ion Thrusters

Small Business Concern

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

Principal Investigator:

Name: **Bernard Vancil**
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Phone: **(503) 628-0703**

Business Official:

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Phone: **(503) 628-0703**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4

Technical Abstract (Limit 2000 characters):

A novel screen-accelerator grid pair is offered for ion thrusters for electric space propulsion. They will be flat and highly tensioned and fastened to ceramic frames. The frames provide extreme rigidity. The tensioning of the masks virtually eliminates relative movement of grid apertures, even at high vibration levels and large temperature excursions. This technology was proven in the manufacture of millions of high-resolution color cathode ray tube displays in the last century. In addition, graphitic coatings are offered up to 0.020-inch thickness known for their resistance to sputtering erosion of the grids. These coatings have ingredients which overcome the problems encountered in previous efforts to use carbon in ion thruster grids. In Phase I, a tensioned, flat grid pair will be constructed, coated, tested, and delivered.

Potential NASA Applications (Limit 550 characters):

NASA Deep Space probes

Manned missions to the moon and Mars

Nuclear electric missions to outer planets

Potential Non-NASA Applications (Limit 400 characters):

Orbit-raising of heavy geosynchronous satellites and subsequent station-keeping and attitude control

Small satellite propulsion for LEO

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z12.01-2563**

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

PROPOSAL TITLE: Multi-stage Oxygen and Regolith Resource Extractor

Small Business Concern

Firm: **Blueshift, LLC**
Address: **575 Burbank Street, Unit G, Broomfield, CO 80020**
Phone: **(850) 445-3431**

Principal Investigator:

Name: **Alan Carter**
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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):

Blueshift LLC d/b/a Outward Technologies proposes to develop a Multi-stage Oxygen and Regolith Resource Extractor (MORRE) for the production of high purity silicon, aluminum, titanium, magnesium, and other metals. The underlying method utilizes novel process and temperature control systems to extend terrestrial vacuum metallurgical extraction processes used since the 1940's to lunar regolith feedstocks not typically associated with vacuum metallurgy. MORRE requires limited to no process consumables while yielding multiple high purity products. The process takes advantage of the lunar environment and utilizes demonstrated terrestrial industrial processes to reduce technical risk.

Development of the MORRE concept will increase humanity's presence in space by leveraging the readily available ultra-high vacuum on the Moon to unlock the abundant resources found within lunar regolith. Additionally, the MORRE system will not only enable the production of high purity materials on the lunar surface but can also be implemented for space-based vacuum metallurgical processes that are currently not economically viable in terrestrial industries.

The objective of the Phase I project is to raise the technology readiness level of the MORRE system from TRL3 to TRL4 by performing bread board validation for the MORRE system in a

relevant vacuum environment. A prototype able to process no less than 50g of lunar highlands simulant will be constructed and tested in Phase I. Thermodynamic models representative of the Phase I prototype and full-scale system will then be developed and studied to help identify the optimum operating conditions for the MORRE reactor.

Potential NASA Applications (Limit 550 characters):

The primary application within NASA's technology roadmap is TX07.1: In-Situ Resource Utilization, under SBIR FY2023 subtopic Z12.01 Extraction of Oxygen, Metal, and Water from Lunar Regolith. The MORRE system can be incorporated into several future manned and unmanned NASA missions to the lunar surface. The system would allow extraction of pure silicon and metals from in situ resources to enable sustained lunar operations while supporting the nascent cislunar economy by yielding a nearly limitless supply of high purity refined products.

Potential Non-NASA Applications (Limit 400 characters):

The MORRE system will benefit governments and companies operating on the surface of the Moon by enabling sustained lunar surface operations by providing a ready source of high purity silicon and metals. Access to the ultra-high vacuum on the Moon will further lead to extractive processes that are not economical on Earth to enable space-based production of resources for terrestrial markets.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z13.04-1296**

SUBTOPIC TITLE: Lunar Dust Filtration and Monitoring

PROPOSAL TITLE: Low Maintenance Lunar Dust Filtration

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: 4

Technical Abstract (Limit 2000 characters):

Creare proposes an Autonomous Habitat Filtration System (AHFS) that uses an electrostatic precipitator and autonomous regeneration system to effectively remove dust from habitable environments in long-duration space missions. Currently, HEPA style filters are a bulky consumable that have a large pressure drop across the filter that increases over time from particle loading. Human Lunar and Mars missions will generate a lot of dust from EVAs and need to be low maintenance. The AHFS has low pressure drop so it uses a compact and efficient blower. The proposed AHFS is also highly efficient in all particles of interest including collecting ultrafine (<100 nm) particles. In Phase I, we will prove the feasibility of the AHFS by building a breadboard unit, demonstrating operation in proof-of-concept tests, and producing a design for a Phase II system. In the Phase II, we will build the full AHFS and measure its performance under conditions that simulate habitable environments using simulated lunar dust.

Potential NASA Applications (Limit 550 characters):

Controlling dust in habitable environments for long-duration space missions to the Moon and Mars is critical. Creare's AHFS can improve the performance over HEPA style filters while requiring low maintenance and no consumables during the mission duration.

Potential Non-NASA Applications (Limit 400 characters):

Commercial space companies that are developing manned spacecraft can use Creare's AHFS to gain the same performance benefits as NASA. We are also developing versions of this technology for atmospheric research applications including for both long-duration balloon missions and shorter UAV flights.

Duration: **6**

PROPOSAL NUMBER:	23-1- **A3.03-2428**
SUBTOPIC TITLE:	Future Aviation Systems Safety
PROPOSAL TITLE:	Safety Assessment of a Machine Learning-Based Runway Detector

Small Business Concern

Firm: **Xwing, Inc.**
Address: **292 Ivy Street, Suite A, San Francisco, CA 94102**
Phone: **(415) 375-3366**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters):

Xwing proposes to develop a black-box verification framework to facilitate the certification of safety-critical machine learning subsystems. Xwing, a leader in the development of autonomous flight technology, is investigating the safety assessment of machine learning models. Machine learning has demonstrated impressive results in sensing tasks relevant to autonomous flight. One such example is improving the safety and performance of runway detection in camera images. However machine learning cannot be substantiated following the standard DO-178 framework for software. Xwing thus proposes to investigate how to implement IASMS for the safety assessment of machine learning based subsystems. By leveraging an in-house simulator and runway detector, Xwing will investigate efficient sampling methods to estimate the probability of failure of the subsystem. The proposal focuses on three of the IASMS pillars: assessing the safety of the current model, mitigating the failures modes exhibited through the framework, and assuring a revised model for certification. The framework will be validated with flight test data and used to produce example certification artifacts.

Potential NASA Applications (Limit 550 characters):

- **Pathfinding for Airspace with Autonomous Vehicles (PAAV)**: directly addresses the auto-land challenge of the PAAV by performing the safety assessment
- **Advanced Air Mobility (AAM)**: the economics of AAM truly unlock through autonomy, and the certification of machine learning algorithms is a key milestone
    - **High Density Vertiplex (HDV)**: the safety assessment of autonomous landing on HDV landing pads could be performed through this proposal
- **System-Wide Safety (SWS)**: general modernization of aircraft technologies, including through machine learning

Potential Non-NASA Applications (Limit 400 characters):

In general, the autonomous flight industry is looking for suggestions of generic certification methodologies for machine learning models. Such a proposal would benefit the whole autonomous flight industry and has the potential to unlock a plethora of new applications.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A3.05-2162**

SUBTOPIC TITLE: Advanced Air Mobility (AAM) Integration

PROPOSAL TITLE: Weather Integrated Network Design Software

Small Business Concern

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

Principal Investigator:

Name: **Mr. Jeremy Frank**
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Business Official:

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Phone: **(310) 320-1827**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters):

NASA is supporting the Advanced Air Mobility (AAM) concept for safe, sustainable, affordable, and accessible aviation (e.g., passenger transport and cargo transport) both locally and intraregionally. However, operations occur is a dynamic environment in which conditions vary rapidly, both spatially and temporally. Therefore, a reliable network of cost-effective weather sensors is required to meet regulatory and safety constraints. To address this need, Intellisense Systems, Inc. (Intellisense) proposes to develop a new Weather Integrated Network Design Software (WINDS) system that automatically designs scalable, robust, and tailored weather sensing networks to support AAM operations in the most cost-effective method possible. The web-based tool includes an integrated, constantly updated database of all available sensing technologies and sensors, including their applicability to the ASTM tiered standards with

everything from commercial aviation-grade sensors, low-cost integrated weather sensors, and data provided by non-traditional means and imagery including cameras and satellite. WINDS then leverages an integrated mapping and topography tool to analyze system performance over the user-defined operational area and mission requirements. WINDS's network synthesis automatically generates a slate of weather networks meeting the target with clear illustrations of tradeoffs between various configurations including cost. The pathfinding-based network synthesis algorithm navigates an underlying safety risk model that links weather network capability to UAS safety in specific airspaces. WINDS system outputs tailored system designs that refine cost, core functionality (including features such as communications requirements), and performance to provide the most cost-effective solution possible to the AAM customer. During Phase I feasibility will be demonstrated through catalog development and algorithm demonstration in preparation for full system deployment in Phase II.

Potential NASA Applications (Limit 550 characters):

The WINDS system has direct applicability to NASA research, specifically to the NASA Aeronautics Research Mission Directorate (ARMD) Advanced Air Mobility (AAM) mission to accelerate applications of passenger transport, aerial work, and cargo transport. Among the three pillars of the AAM ecosystem (vehicle, airspace, and community), weather is a critical component and the WINDS technology addresses this critical need by deploying reliable, robust weather networks that meet regulatory and mission requirements at the lowest cost possible.

Potential Non-NASA Applications (Limit 400 characters):

Advanced Air Mobility (AAM) will revolutionize transportation and delivery. An enormous impact is expected on the commercial aerospace industry and regulated by the FAA. Safe operation of all aircraft including new electric and hybrid aircraft (e.g., Joby Aviation, Wisk Aero) requires monitoring of the weather, and the WINDS system is an essential planning tool to address this need.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H3.10-2121**

SUBTOPIC TITLE: Microbial Monitoring of Spacecraft Environments: Automated Sample Preparation for Sequencing-Based Monitoring

PROPOSAL TITLE: Soft Cleaning of Wire-Immobilized Genetic Material

Small Business Concern

Firm: **nou Systems, Inc.**
Address: **7047 Madison Pike, Suite 305, Huntsville, AL 35806**
Phone: **(256) 327-9012**

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):

To automate the sample prep for MinION sequencing, we propose a paradigm shift in the inherently liquid-based, multi-step protocol. The traditionally labor-intense process will occur within disposable microfluidic “cards” which have an unexpected feature. Each card will contain separate reaction wells where single operations will occur (e.g. lysis, fragmentation, amplification). However, these chambers will all remain physically isolated from one another, having no active fluidic interconnects between them. The target DNA will undergo each successive modification step – moving from reaction well to reaction well – simply by going through the intervening walls. This technique, which we call Soft Cleaning of Wire-Immobilized Genetic material (SCWI-G), constitutes a *mechanical* method of isolating and purifying nucleic acids.

Potential NASA Applications (Limit 550 characters):

The ISS has a respectable portfolio of biological testing equipment. Two of these instruments include flight-hardened versions of the Cepheid SmartCycler and the Oxford Nanopore MinION. These represents the cutting edge of genetic testing technology. The prevailing challenge has been the multistep nature of the sample preparation protocols. We have solved this problem for qRT-PCR reactions in the SmartCycler, and we now propose to adapt this TRL8 method to the more challenging task of sample prep for MinION sequencing of microbial DNA.

Potential Non-NASA Applications (Limit 400 characters):

The biotech targeted market is a 4.7 billion market with an established CAGR of 11.4%. Primary commercialization strategy is by licensing the technology to our BioGX technology transitioning partners and supporting future technology refinements and modifications pending feedback from end users and field tests.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H4.08-2210**

SUBTOPIC TITLE: Anti-Fog Solutions for Spacesuit Helmet

PROPOSAL TITLE: Non-coating laser-nanostructured superhydrophobic transparent polycarbonate for anti-fog spacesuit helmets

Small Business Concern

Firm: **AlchLight, Inc.**
Address: **10-3 Selden Street, Rochester, NY 14605**
Phone: **(585) 355-1725**

Principal Investigator:

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Business Official:

Name: **Chunlei Guo**
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Phone: **(585) 355-1725**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

In this project, AlchLight introduces a far superior approach to produce high-performance anti-fog transparent superhydrophobic polycarbonate for spacesuit helmets using our pioneered femtosecond pulsed laser surface patterning technology. Without relying on chemical coating, our laser patterning permanently alters the intrinsic wetting property of polycarbonate without compromising its transparency. In this Phase I, AlchLight's goal is to produce a superhydrophobic polycarbonate surface with a contact angle greater than 150^{o}, a sliding angle smaller than 10^{o}, and a transmittance greater than 70% over the visible wavelengths. We will perform a range of tests to demonstrate the applicability of the superhydrophobic polycarbonate in a spacesuit helmet environment through the steam cycle, adhesion, and cleaning tests. Five treated flat samples at a size of 1 inch × 1 inch will be delivered to NASA for further testing.

AlchLight has a robust customer base and an outstanding technology transition track record, currently standing at a 100% success rate beyond SBIR Phase II. Particularly, AlchLight is a

technological leader in developing non-coating based superhydrophobic polymers and glass. Currently, AlchLight is helping a number of key industrial customers in creating anti-fog and anti-icing polymer covers for protecting the sensors and detectors of self-driven vehicles. Our unparallel technological know-how and extensive industrial involvement in solving this very issue of creating superhydrophobic transparent glass and polymers will guarantee AlchLight's success in this NASA project.

Potential NASA Applications (Limit 550 characters):

Our highly transparent anti-fog superhydrophobic surfaces can be used for visors of various types of helmets and face shields, covers for sensors and detectors, covers for NASA's cameras, telescopes, and crucial equipment, and covers for solar panels on spacecrafts.

Potential Non-NASA Applications (Limit 400 characters):

In the auto industry, covers sensors and detectors for self-driving vehicles. In the medical industry, endoscopes and surgical face shields. In sports, ski goggles, face protection, and diving equipment. In commercial electronics, camera lenses, and electronic displays. For scientific equipment, lens, microscopes, and telescopes.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H5.01-1868**

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

PROPOSAL TITLE: Shape Memory Actuated Retraction and Deployment (SMARD)

Small Business Concern

Firm: **Dynovas, Inc.**
Address: **12250 Iavelli Way, Poway, CA 92064**
Phone: **(508) 717-7494**

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):

Dynovas' Shape Memory Actuated Retractable and Deployable (SMARD) booms provide the Vertical Solar Array Technology (VSAT) program and Dynovas' own Motorless Array Deployment (MAD) energy and Motorless Expandable Solar (MESA) arrays a high-load, motorless option to deploy and retract solar arrays in the 40-60 kW class. SMARD integrates Nitinol shape memory alloy with a bistable composite boom(s) to deliver lifting/lowering forces > 330 N (the estimated weight of a 50 kW solar array). The Nitinol shape memory alloy can impart 172 Mpa during its shape change at a tunable transition temperature ranging from -180-300 °C. The shape change can be activated by resistive heating requiring only ~ 1 Watt. The conformal packaging of the SMARD actuators delivers the 50 kW solar array with packaging and weight efficiencies up to 60 kW/m^3 and 180 W/kg.

In comparison to other smart material actuators – such as Macro Fiber Composite (MFC) ceramic piezoelectric actuators being investigated by Dynovas for 1-10 kW solar array – the shape memory alloy Nitinol delivers 20+ times the strain and force. The increased force/strain will increase the survivability of SMARD and allow it to be applied to higher curvature geometries such as lenticular and triangular bi-stable composite booms. Relative to motors, Nitinol eliminates the potential to bind in the presence of dust/temperature changes, at 12% the volume and 20% the mass. Lastly, SMARD provides a bolt-on capability to a successful 10 kW array from VSAT that could expand the array's capacity to 50 kW. VSAT will address many of the challenges associated with the 10 m stand-off, positioning, sun tracking, leveling, etc. If possible, it is ideal to re-use that technology instead of redesigning an entire 50 kW array. As such, the SMARD technology provides a direct drop in for the deploying boom OR can be attached to the ends of the deploying booms to extend out rigid transverse booms that allow additional wings of the array system to deploy.

Potential NASA Applications (Limit 550 characters):

This SBIR augments the VSAT program (10 kW arrays) by developing avenues towards enhancing the VSAT technologies (set for TRL 6 in 2024 and a return to the moon in 2027) to 50 kW as early as 2030. Other NASA uses of SMARD include: lunar landers, rovers, non-vertical or surface conforming arrays, deep space/Mars arrays, orbital arrays, sun shields, reflectors, solar sail batons, antenna, and lunar pop-up habitation structures.

Potential Non-NASA Applications (Limit 400 characters):

In addition to commercial applications identical to those of NASA (e.g., arrays), SMARD can be applied to heat engines, valves, as a replacement to solenoid actuators, antenna structures, hinges, solar powered electric vehicles, power substations, refueling stations, orbiting debris removal, and communications towers. The scalability of SMARD makes it applicable from a backpack to a tower.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H5.05-2110**

SUBTOPIC TITLE: Inflatable Softgoods for Next Generation Habitation Systems

PROPOSAL TITLE: Method for Accelerated Creep Testing For Softgoods Utilizing Dynamic Mechanical Perturbation and Advanced Fourier Techniques

Small Business Concern

Firm: **X-wave Innovations, Inc.**
Address: **555 Quince Orchard Road, Suite 510, Gaithersburg, MD 20878**
Phone: **(301) 200-8368**

Principal Investigator:

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Business Official:

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Phone: **(301) 200-8368**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters):

One of the primary concerns when incorporating inflatable softgoods into habitation structures is the potential for structural material failure due to creep, which is the deformation that occurs under sustained loading. However, conducting real-time creep testing at the component and subscale levels can take an extensive amount of time, ranging from months to years. Therefore, there is a need to develop new test methods that can reduce the time required for long-duration creep testing of webbing and cordage materials, thus helping to expedite the overall development process of softgoods structures. For this SBIR program, NASA is interested in the development of an accelerated creep testing method for soft materials such as webbing and cordages. To address this critical need, X-wave Innovations, Inc. (XII) proposes to develop an accelerated creep testing method using dynamic stressing condititions and analysis, and

unsupervised learning methods. The key innovations in the proposed method are utilizing dynamic stressing conditions and advanced modified Fourier transform techniques to characterize creep and viscoelastic behavior and provide a better understanding of the material properties in relatively short time scales without altering the innate material behavior with external factors such as temperature and corrosives. The methodology will be developed by rigorous analytical developments and tested with prototype hardware additions to existing tensile testing devices. In addition, we will also develop software to apply the method to the experimental data for extracting viscoelastic and creep information.

Potential NASA Applications (Limit 550 characters):

Soft materials are used in many space and habitation applications. An accurate, reliable, and fast method of creep testing for soft materials will have many applications under NASA operations. Our proposed method has great potential for the characterization of soft materials used in habitat and inflatable structures. In addition, such a characterization method could prove useful in other applications such as; spacesuit development, robotics, parachutes, and fiber optics.

Potential Non-NASA Applications (Limit 400 characters):

Soft materials are utilized in almost any industry; therefore, the proposed method would be greatly valuable for many applications where soft materials are utilized under loads and are expected to have a long operation life. Therefore, the proposed technique could benefit biomedical, aerospace, automobile, sports equipment, and robotic industries where soft materials are commonly utilized.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z2.01-2742**

SUBTOPIC TITLE: Spacecraft Thermal Management

PROPOSAL TITLE: Robust Two-Phase Cooling Technology for Megawatt Space-Based Systems

Small Business Concern

Firm: **TTH Research, Inc.**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

Loop Heat Pipe (LHP) has been the leading two-phase heat transport technology for space-based thermal control subsystems (TCS) for more than 20 years. LHPs are capillary-pumped devices having no mechanical moving parts to wear out or break down. Due to the excellent phase-change heat transfer efficiency, for the most part, two-phase loops are lightweight and more compact than the single-phase counterparts. Hence, it has become popular among the thermal engineers for the operational reliability, robustness, long life, and more importantly, requiring no maintenance. Nevertheless, after more than two decades in service, the thermal requirements – imposed on the TCS by the ever-increasing demand for the payload power – are finally outpacing the LHP capability. Sintered metal powder wicks of today's technology generate a maximum capillary pumping head of about 5psid with Ammonia as the working fluid. Nominal room-temperature Ammonia LHPs have heat transport capacities of approximately 5kW-m, which is sufficient for most space-based TCS at the present. However, the NASA Artemis program – in which an astronaut lunar base camp is planned – shall require the heat management in excess of hundreds (if not thousands) of kilo-Watts over long distances. In addition, the lunar human base includes many heat-dissipating equipment situated at far-apart locations. The heat collection would be a serious challenge for a single-evaporator LHP for it has only one heat collection site with a limited external surface to interface the heat source. Hence, more capable heat transport technologies (with multiple evaporators and condensers) need to be developed and flight qualified quickly to achieve the Technology Readiness Level (TRL) of 7-8 for the LHP replacement in 10-20 years.

Potential NASA Applications (Limit 550 characters):

The proposed cooling technology employs a magnetic levitation impeller pump to provide fluid circulation in a hermetically-sealed closed loop. It has only one moving part - the impeller. Hence it is highly reliable and durable for manned or unmanned space nissions.
Potential applications are the thermal control systems (TCS) for spacecraft or to support the planned human habitation on the Moon or Mars. Specifically, megawatt cooling technologies shall be needed for spaced-based high energy propulsion, conversion and storage.

Potential Non-NASA Applications (Limit 400 characters):

The proposed technology is perhaps ultimately necessary for the development of all-electric platforms that the U.S. Department of Defense advocates for the near future from aircraft, ships/submarines, railguns. The heat dissipation for these systems may reach several megawatts.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z2.02-1495**

SUBTOPIC TITLE: High-Performance Space Computing Technology

PROPOSAL TITLE: Real-Time Hardware Configurable Coprocessors

Small Business Concern

Firm: **Resilient Computing**
Address: **269 Terrance Loop, Bozeman, MT 59718**
Phone: **(406) 451-8138**

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):

This project proposes a coprocessor companion to future radiation-hardened processors that can boost performance using commercial Field Programmable Gate Arrays (FPGA). This project will investigate the feasibility of using dynamically reconfigurable coprocessing circuitry within a proven fault-tolerant architecture known as RadPC. The RadPC architecture has been matured through NASA-funded flight demonstrations at Montana State University culminating with a lunar mission in 2024. RadPC was licensed to Resilient Computing in 2020 to bring it to market as a viable aerospace solution. Through prior NASA SBIR funding, RadPC has been adapted and matured into a form that uses the emerging RISC-V CPU, implements fault-recovery procedures abstracted from the developer, and supports inclusion of coprocessors within the fault-tolerant architecture. In this project, we will study how the coprocessor circuitry can be dynamically

configured using the partial reconfiguration (PR) capability of modern FPGAs. This approach enables more efficient use of FPGA resources by implementing signal processing algorithms as a sequence of tasks accomplished with different processing blocks that are swapped in and out while holding the interim results in the fast storage registers of the coprocessor. By swapping the processing blocks using PR, the hardware resources needed on the FPGA is reduced because not all the steps of the algorithm are implemented simultaneously. This leads to faster computation by reducing delays on the FPGA and less power consumption due to using less circuitry at any given time. This project will investigate whether the latency of swapping the PR blocks outweighs the speed up in computation and if this approach is feasible for the types of signal processing algorithms needed for future space missions.

Potential NASA Applications (Limit 550 characters):

- Accelerating computationally intense algorithms such as real-time science data processing, autonomy, and navigation using coprocessors.
- Boosting performance of rad-hard processors with higher performance, commercial-based companion technology.

Potential Non-NASA Applications (Limit 400 characters):

- Small satellites needing increased performance, but at a price-point below current rad-hard computers.
- Earth image processing (climate monitoring, disaster mitigation, agriculture).
- Communication networks.
- Critical Infrastructure Protection (CIP): electrical grid, transportation systems, water treatment plants.

Duration: **6**

PROPOSAL NUMBER:	23-1- **Z4.05-2659**
SUBTOPIC TITLE:	Nondestructive Evaluation (NDE) Sensors, Modeling, and Analysis
PROPOSAL TITLE:	Time-Synchronized X-Ray Compton Tomography

Small Business Concern

Firm: **Albireo Technologies LLC**
Address: **18870 Kilfinan Street, Northridge, CA 91326**
Phone: **(310) 849-6993**

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):

To address the NASA need for robust, high-fidelity, quantitative, there-dimensional (3D) nondestructive evaluation (NDE) of ablative materials and other spacecraft structures, Albireo Technologies LLC (ATC) proposes to develop a new Time-Synchronized X-Ray Compton Tomography (TESERACT). TESERACT technology is a powerful extension of the Compton imaging tomography (CIT) NDE technique, which is now used for the quality control of the Orion heat shield at Kennedy Space Center (KSC). By providing an innovative approach for data acquisition and signal processing, TESERACT offers robust rejection of multiple potential signal artifacts, enabling high-fidelity three-dimensional (3D) density profiling of spacecraft components, with high-contrast, clear images even in components with substantial thickness, such as thermal protection structures (TPS). Furthermore, TESERACT will offer simplified and more user-friendly operation, with faster scan rate and improved image resolution. In Phase I, ATC will demonstrate the feasibility of the TESERACT technology by developing the required data processing algorithms, as well as fabricating and testing a prototype system, with a projected technology readiness level (TRL)-4. In Phase II, ATC plans to develop a complete TRL-6 TESERACT system capable of automatic operation and demonstrate its NDE capabilities to NASA by testing it on relevant spacecraft materials and structures. At the end of Phase II, the TESERACT system will be delivered to NASA for further evaluation.

Potential NASA Applications (Limit 550 characters):

TESERACT technology can be applied to NDE of composites, metals, and other lightweight spacecraft materials resulting in high-fidelity, quantitative scan data suitable for accurate 3D component reconstruction, with significantly reduced signal artifacts, as well as faster and more user-friendly performance. TESERACT will increase the effectiveness of on-ground material development and quality control tasks for space exploration missions. TESERACT can also provide an effective solution for in-space NDE applications, for example on the ISS.
Potential Non-NASA Applications (Limit 400 characters):

Military and commercial applications of the TESERACT technology will include the NDE of composite aerospace multilayer structures composed of any combinations of lightweight conductors and insulators (metals, composites, ceramics, etc.). Additionally, TESERACT has significant applications in the oil and gas industries, such as detecting corrosion in pipelines through layers of thermal insulation.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z4.07-1455**

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

PROPOSAL TITLE: In-Situ Casting of Standard Structural Elements on the Moon (ICSE)

Small Business Concern

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

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

Lunar Resources proposes to NASA's SBIR program the In-Situ Casting of Standard Structural Elements on the Moon (ICSE) program to mature a process to cast standard lunar extracted ISRU metal structural elements on the Moon without earth-based consumables. The goal of the effort is to develop the capability of casting in-situ produced metals into truss elements to produce trusses with varying widths, lengths, and thicknesses. The focus of the effort is to mature the equipment and production process to efficiently produce truss elements without any consumables from Earth. Furthermore, the equipment and process will be matured for casting of other metals, such as iron, to produce other structural element geometries.

Potential NASA Applications (Limit 550 characters):

The proposed maturation of ICSE technology program leverages NASA's current ISRU investments to cast metals into structural truss elements without any Earth based consumables to enable low-cost structures to be reliably built in-situ on the Moon. Direct applications include in-situ lunar tall towers, landing pads, pressurized habitats and other lunar facilities.

Potential Non-NASA Applications (Limit 400 characters):

ICSE will enable the production of in-situ casted truss elements for in-space manufacturing, satellite servicing, and utilization by commercial industry to build structures in space and on the Moon.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z5.06-2460**

SUBTOPIC TITLE: Servicing and Assembly Applications

PROPOSAL TITLE: Xenon Refueling Demonstration for On-Orbit Servicing Applications using Efficient High-Pressure-Ratio Compressor

Small Business Concern

Firm: **Flight Works, Inc.**
Address: **17905 Sky Park Circle, Suite F, Irvine, CA 92614**
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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):

Flight works is proposing to demonstrate efficient Xenon Transfer for On-Orbit Servicing applications. The proposed effort utilizes a high-pressure ratio compressor to transfer xenon at greater than 10 kg/hr and can achieve a 94% utilization of supply tank Xenon mass (300 psia to 3000 psia) at a max power of less than 200 W. The transfer is done through a multi-stage compression scheme with inter-stage heat exchangers to optimize the work done on the fluid and reduce waste heat.

A Phase I demonstration of Xenon transfer is made possible by leveraging an existing compressor design developed by Flight Works work under another Phase I SBIR that determined the optimal compression staging scheme for Xenon and sized an on-orbit compressor for the targeted flow rate. This proposed effort's use of government furnished equipment (GFE) Xenon will allow Xenon testing which otherwise would take up a major portion of a SBIR project's budget. Testing with Xenon will allow verification of critical compressor behaviors that are impacted by the fluid properties that affect internal efficiencies (leaks/friction) and life (wear). The current plan had been based on testing an EDU compressor with CO2 as a low-cost substitute, but it will not be able to fully simulate Xenon. For example, CO2 has a different compressibility effect and so the pressure split across stages changes and heat release will be different. Another example is that parts will wear differently in Xenon vs. CO2 due to fluid differences (viscosity and density) but also due to the different chemical environment of the two fluids changing the surface material oxides that greatly drive material tribological interactions.

This effort will allow rapid maturation of required Xenon transfer technologies and plan for Phase II to continue risk reduction testing for high cycle/highly reliable use in a microgravity environment.
Potential NASA Applications (Limit 550 characters):

The compressor is designed for the NASA Lunar Orbital Platform-Gateway and can be used on any spacecraft using Xenon or other fluids such as helium, krypton, oxygen, methane, etc. Because it is highly scalable and designed to move inert gasses, refrigeration and thermal management tasks are likely candidates. These include electronics or optics cooling, and recompression systems. Scavenging gasses for processing in habitats or sampling missions, or even deflating structures for relocation or re-entry, are other potential applications.
Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications include Xenon (and other propellant or gasses such as helium or krypton) on-orbit refueling of DoD and commercial spacecraft. The scalability and versatility of the system in compressing gases makes it an attractive candidate for numerous fluid systems.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z5.07-2713**

SUBTOPIC TITLE: Autonomous Robotic Manipulation, Utilization, and Maintenance

PROPOSAL TITLE: A Framework for Failure Management and Recovery for Remote Autonomous Task Planning and Execution

Small Business Concern

Firm:	**PickNik, Inc.**
Address:	**4730 Walnut Street, Suite 106, Boulder, CO 80301**
Phone:	**(720) 513-2221**

Principal Investigator:

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Business Official:

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Phone:	**(413) 841-9404**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters):

Advanced robotic systems capable of near-human level autonomy will be required for NASA to maintain critical, human-rated spaceflight hardware in cislunar space and beyond. Occasionally, these systems may experience task planning failures, or detectable faults while executing a planned procedure to accomplish a necessary task such as transferring cargo or engaging levers. In order for a ground operator to effectively diagnose, mitigate, and respond to these failures, the system must provide comprehensive tooling that allows a remote user to asynchronously analyze the situation, identify solutions, and manually adjust the task specification to command the in situ robot to recover and ultimately complete the objective.

We propose a novel system for fault detection and reporting that will augment a remote operator’s ability to diagnose and resolve failures from an in situ robot during real-time task planning and execution. For this effort, PickNik will develop software tools that enable a robotic system to report exacting details into the nature of a reported failure, as well as user interfaces that allow a remote operator to asynchronously assist in recovering the system to complete the desired task. We will demonstrate these features on previously developed, NASA relevant autonomous tasks for pressing buttons, opening hatches, and transferring cargo. The developed features will be made available in MoveIt Studio, PickNik's flagship product for supervised

autonomy.

Potential NASA Applications (Limit 550 characters):

The proposed work balances autonomous capabilities with added human assistance with a framework for failure management and recovery designed for remote command and control of robots. In addition to supporting robotic needs of NASA's Artemis program, the technology will provide useful functionality to the other autonomous robotic efforts at NASA; including the Dexterous Robotics Lab and Robonaut, the SPHERES, and Astrobee projects, the OSAM servicing missions, and other future NASA enterprises that require remote robot systems.

Potential Non-NASA Applications (Limit 400 characters):

A robust fault management and recovery system would provide significant benefits to our users in other sectors. The platform is currently being evaluated by commercial providers in the commercial space flight industry for on-orbit manufacturing, the defense industry for bomb disposal systems, and industrial manufacturing for intelligent CNC machine tending.

Duration: **6**

PROPOSAL NUMBER:	23-1- **Z5.08-2056**
SUBTOPIC TITLE:	Integrated Mission Planning and Execution for Autonomous Robotic Systems
PROPOSAL TITLE:	Person Aware Liaison (PAL)

Small Business Concern

Firm: **Charles River Analytics, 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):

Collaborative human–robot teaming behaviors use the complementary strengths of humans and robots and are at their most successful when the human trusts in their robot companion. However, despite contemporary approaches to make robots more transparent in their behaviors and safer in their operation, humans still do not trust robots the same way they do a human partner.

The inability of current systems to observe all communications from their partner, draw usable inference from the contextual clues of the interaction, and respond in a courteous manner may prohibit humans from placing full trust in their robot collaborators.

To that end, we propose Person Aware Liaison (PAL) as an intermediary interface between the human and the robot as they complete a collaborative task. PAL generates multimodal observations (speech, gestures, and where the human's gaze lingers) during the execution of the task and fuses the information into a singular natural language transcription of events. This transcript is queried by a Generative Pre-trained Transformer (GPT) architecture, a state-of-the-art text-based inference model to understand the human's intent. Finally, PAL acts upon the extrapolated intent by developing safe, dexterous motion plans for an articulated robot arm and executing them in a courteous manner that avoids interrupting the human user while they are focused on completing task subgoals.

PAL is task agnostic and can use modular task knowledge to quickly adapt to new applications. We will demonstrate the capabilities of PAL both in simulation and in a physical setting using a collaborative welding task.

Potential NASA Applications (Limit 550 characters):

The innovations proposed under PAL will support NASA's strategic goals toward the development of autonomous systems, specifically with a focus toward Behavior and Intent Prediction (TX 10.3.2) and Motion Planning (TX 10.2.3). Additionally, the expected increase in robots in human spaces planned under ARTEMIS has highlighted a need for systems that "develop integrated human and robotic systems with inter-relationships" for Lunar and Martian missions (Moon to Mars Objectives, 2022, TH-9 and TH-10).

Potential Non-NASA Applications (Limit 400 characters):

Improving the trust between human and robot collaborators has demonstrable improvements to both efficiency and morale. These benefits are of imminent interest to industries such as manufacturing and assembly, which are expected to see an increase in the adoption of collaborative robots within the next decade.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z7.01-1510**

SUBTOPIC TITLE: Entry, Descent, and Landing Flight Sensors and Ground-Testing Technologies

PROPOSAL TITLE: LAser Navigation, Detection, and steering, LANDs

Small Business Concern

Firm: **Exciting technology LLC**
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Phone: **(937) 344-3921**

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):

Exciting Technology is developing revolutionary optical beam steering technology that will make NASA lidars more capable, smaller, lighter, and cheaper. This technology can steer relatively large beams to wide angles without bulky hardware. Today's optical beam steering technology for large apertures and wide angles is restricted to classic gimbals, which are expensive and bulky, or possibly Risley prisms, which can also be heavy with low optical quality. For precision landing and hazard detection, as well many other applications, such as terrain mapping, NASA needs capable, but affordable and compact, optical beam steering technology.

Dr. Paul McManamon has been developing optical beam steering technology for > 4 decades. Since he founded Exciting Technology in 2008 the company has focused on furthering optical beam steering technology and has filed more than 20 patents. Many of the beam steering technologies we have developed can now be assembled after overcoming engineering challenges associated with implementing these new, revolutionary beam steering technologies. Exciting Technology LLC is working on both novel near-term mechanical steering technology, and longer term, full non-mechanical, optical beam steering technology. Our hybrid novel optical

beam steering can be developed to provide ±25° optical beam steering in about 25msec mechanically, coupled with ~ ±0.1° in < 10 μsec non-mechanical beam steering with μrad accuracy.

In this Phase I, the proposed innovation is a wide-angle mechanical steering device that can be demonstrated in the near-term, coupled with a non-mechanical steering device to improve speeds and accuracy. Exciting Technology plans to investigate the operation of both the mechanical and non-mechanical systems in space.

Potential NASA Applications (Limit 550 characters):

Exciting Technology is developing revolutionary optical beam steering technology to make NASA lidars more capable, smaller, lighter, and cheaper. We can steer large beams to wide angles without bulky hardware. Today's optical beam steering technology for large apertures and wide angles is restricted to classic gimbals, which are expensive and bulky, or possibly Risley prisms, which can also be heavy with low optical quality. For precision landing and hazard detection NASA needs capable, but affordable and compact, beam steering technology.

Potential Non-NASA Applications (Limit 400 characters):

DOD and ISR applications can also use this technology.This technology will be much smaller and point more precise than gimballed lidars. This technology can be scaled to large apertures, up to 50 -100 cm in diameter.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z8.09-2819**

SUBTOPIC TITLE: Small Spacecraft Transfer Stage Development

PROPOSAL TITLE: Orbiter: An Orbital Transfer Stage for Small Spacecraft

Small Business Concern

Firm: **Launcher, Inc**
Address: **12624 Daphne Avenue, Hawthorne, CA 90250**
Phone: **(310) 923-3611**

Principal Investigator:

Name: **Max Haot**
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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):

Launcher proposes a NASA SBIR Phase I study to investigate the feasibility of using our commercial Orbital Transfer Vehicle (OTV), Orbiter, for delivering SmallSats to cislunar orbits and beyond enabling the rapid, low-cost development of exploration, science, and technology demonstration missions.

This effort will evaluate and determine optimal mission CONOPs and technical solutions for Orbiter to achieve a broad range of current and future orbital SmallSat deployment scenarios **- in orbits more widely dispersed in LEO as well as inclusive of other orbital regimes such as MEO, GEO, Cislunar and beyond** while minimizing changes to the baseline dual-use (government and commercial) product design. The products of the Phase I study will result in a proof-of-concept/conceptual design. In doing so, the team will identify the enhanced system performance requirements as well as the cost and schedule estimates to properly plan a demonstration of initial capability on orbit in a subsequent Phase II award.

Potential NASA Applications (Limit 550 characters):

Orbiter aims to leverage its multi-use platform as a scalable solution to enable small satellite transfer and sustained operations support in cislunar orbits and beyond. As a customizable platform capable of providing scalable propulsion (delta-v), power, data, and communication services**,** Orbiter allows small satellites to exceed inherent constraints facilitating the rapid development and deployment of exploration, scientific, and extraction missions.

Potential Non-NASA Applications (Limit 400 characters):

The Lunar surface is a rich source of in-situ resources to enabling planetary and asteroid missions. It provides raw materials such as magnesium, aluminum, silicon, titanium, and iron which can be used to construct infrastructure. Water and oxygen compounds can be used for life support and can be converted into propellant.

Duration: **6**

PROPOSAL NUMBER:	23-1- **Z8.13-1189**
SUBTOPIC TITLE:	Space Debris Prevention for Small Spacecraft
PROPOSAL TITLE:	Satellite Collision and Risk Assessment using Machine learning (SCRAM)

Small Business Concern

Firm: **Advanced Space, 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):

In response to the 2023 NASA SBIR solicitation subtopic Z8.13, “Space Debris Prevention for Small Spacecraft”, Advanced Space, LLC proposes to develop Machine Learning (ML) techniques to reduce and subsequently remove the “human-in-the-loop” bottleneck exhibited by the Collision Avoidance (COLA) Concept of Operations (ConOps). The proposed solution is named **SCRAM** or **S**atellite **C**ollision and **R**isk **A**ssessment using **M**achine learning. **SCRAM** features a trade study of Recurrent and Transformer Neural Networks (NNs) to develop autonomous risk analysis for spacecraft collision avoidance. These new ML applications in astrodynamics provide early predictions of future collision risk trends and validation of collision avoidance maneuvers. The autonomous conjunction assessment highlights specific information for early collision risk prediction, while the dynamic space debris catalog builds on historical Conjunction Data Messages (CDMs) to incorporate uncertainty in real time. ML models can be inferenced orders of magnitude faster than traditional methods, significantly reducing both the computational and human hours required to perform collision avoidance operations. By identifying conjunction events early and automating the validation of collision avoidance maneuvers, the strain on COLA operators is reduced. **SCRAM** will be developed with the goal of future implementation into current COLA ConOps for space agencies such as the NASA Conjunction Assessment Risk Analysis (CARA) team. The framework created by the innovation has similar applications for mega-constellations and private SDA providers.
Potential NASA Applications (Limit 550 characters):

There is direct applicability to enhance NASA’s Conjunction Assessment and Risk Analysis (CARA) operations with incorporation into the CARA ConOps. This technology screens trajectories, resulting in fewer CDMs flagged for further monitoring in operations and less human-in-the-loop effort for operators. Overall, resources that are no longer tied to monitoring conjunction are freed up to be used on other debris mitigation efforts to benefit NASA's goal of debris prevention and mitigation.

Potential Non-NASA Applications (Limit 400 characters):

Commercially, **SCRAM** will be used by operators of mega-constellations such as OneWeb, SpaceX, and Amazon to generate less collision risk. For national security, **SCRAM** will reduce overhead expenses and be used for space domain awareness of adversarial satellites. Lastly, **SCRAM** will be applied to data curation and data validation of state estimates for space objects within a catalog.

Duration: **6**

PROPOSAL NUMBER:	23-1- **Z10.01-2454**
SUBTOPIC TITLE:	Cryogenic Fluid Management
PROPOSAL TITLE:	Composite Cryogenic Hydrogen Insulated Lightweight Lined Storage (C-CHILL)

Small Business Concern

Firm: **Dynovas, Inc.**
Address: **12250 Iavelli Way, Poway, CA 92064**
Phone: **(508) 717-7494**

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):

Dynovas' Composite Cryogenic Hydrogen Insulated Lightweight Lined (C-CHILL) storage system provides a novel solution that specifically addresses NASA's call for development of liquid hydrogen compatible composite tanks for reusable systems such as spacecraft, surface systems, and hydrogen aircraft for long-duration storage of liquid hydrogen. The solution was developed based on previous technologies that have been proven for cryogenic storage, and advances on the state of the art to achieve long-duration cryogenic fluid storage. Dynovas' C-CHILL is scalable for a wide range of applications spanning aircraft, spacecraft, landers, rovers, launch vehicles, and refueling tanks.

Dynovas' proposed C-CHILL tank design leverages proven cryogenic hydrogen storage technologies and processes, and incorporates additional improvements to achieve a mass-efficient structural design for long duration storage with improved lifecycle capability. These include:

1. Thin Ply Composite Materials – Toughened thin-ply composite materials that allow an increased number of cross laminates in the composite overwrap, greatly reducing microcracking
2. Vacuum Jacketed Insulation – Vacuum insulated layer including composite honeycomb core and MLI between the inner and outer tanks, acting as a structural member and thermal barrier
3. Trapped Polymer Liner – Polymer liner designed for use at cryogenic temperatures, retained within the composite laminate greatly reducing hydrogen permeation through the tank walls
4. Nanomaterial Integration – Integration of thin-walled carbon nanotubes within the matrix during winding to increase micro-crack resistance, by increasing strength and toughness

Using these technologies together, Dynovas' C-CHILL will advance cryogenic hydrogen storage solutions to achieve long-duration storage with improved life-cycle capability, accounting for use cases requiring >5,000 pressure cycles at cryogenic temperatures (20K), and >10,000 thermal cycles between 20K and 300K.
Potential NASA Applications (Limit 550 characters):

The C-CHILL system supports near term NASA initiatives for lunar exploration and habitation such as the Artemis Lunar Landings and Commercial Lunar Payload Services (CLPS), and enables a sustainable presence on the moon through long-duration reusable storage systems which can be applied to reusable lunar landers and in-situ resource utilization (ISRU) for storage of extracted resources and refueling of landers. The C-CHILL system can also be applied to longer-term NASA initiatives such as Mars exploration and habitation.

Potential Non-NASA Applications (Limit 400 characters):

The NASA lunar specific missions also have parallel commercial and DoD applications to which the C-CHILL system applies. In addition to NASA Lunar and Mars exploration initiatives, other applications exist such as: UAV and commercial aircraft, commercial launch vehicles and lunar exploration, orbit transfer vehicles, and other in-space propulsion.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z10.03-2502**

SUBTOPIC TITLE: Space Nuclear Propulsion

PROPOSAL TITLE: High-Emissivity CVD Dendritic Rhenium Coatings for NEP Radiator Panels

Small Business Concern

Firm: **Ultramet**
Address: **12173 Montague Street, Pacoima, CA 91331**
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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):

Nuclear-electric propulsion (NEP) provides a means of significantly reducing mission durations for space exploration. NEP is able to provide substantially greater propulsion efficiency over chemical propulsion systems. The advantage of NEP is that it requires little propellant, is not reliant on solar proximity/orientation, and can provide thrust for extended periods of time. Further, NEP can be combined with chemical propulsion to provide high specific impulse (I_{sp})/low-thrust and low-I_{sp}/high-thrust propulsion respectively, depending on mission and spacecraft requirements. One of the largest obstacles to overcome for more efficient space travel is the total vehicle mass. NEP development is dependent on the development of several key technology areas, one of which is the primary heat rejection subsystem, which requires a highly emissive radiator. In a NEP vehicle, the radiator will account for a significant portion of the total vehicle mass. Improved radiator panels are needed, allowing for either a reduction in the overall vehicle mass as the panel size is reduced, or a more powerful propulsion system as waste heat is more effectively managed. The current state-of-the-art space radiator material system uses carbon/carbon (C/C) composite panels that are built around or bonded to titanium alloy heat pipes. To increase the emissivity of the radiator with minimal effect on the overall weight, Ultramet proposes to apply a thin high-emissivity coating to the C/C panels. In this project, Ultramet will use chemical vapor deposition (CVD) to deposit a thin, highly emissive dendritic rhenium coating on carbon and titanium substrates to demonstrate feasibility. The

emissivity and ion bombardment survivability of the dendritic coating applied to carbon and titanium substrates will be characterized through testing.
Potential NASA Applications (Limit 550 characters):

Enabling human Earth-to-Mars round trip mission durations of less than 750 days is a key goal for NASA. Nuclear power provides the means of achieving this goal, but operating a nuclear reactor in space require the reactor to be smaller and more compact than ground-based systems. Waste heat must be rejected into space through radiators. The proposed radiator panels will provide a lightweight, high-efficiency, high thermal conductivity advancement in heat removal for cislunar, Mars, and outer solar system missions, both crewed and robotic.
Potential Non-NASA Applications (Limit 400 characters):

The proposed technology will be ideal for existing and new electric propulsion systems used for spacecraft station-keeping and attitude control of commercial and military spacecraft. Terrestrial applications include plasma processing for a wide range of product manufacturing and services, pulsed power devices, and material characterization facilities utilizing high electron currents.
Duration: **6**

PROPOSAL NUMBER: 23-1- **Z13.05-2221**

SUBTOPIC TITLE: Components for Extreme Environments

PROPOSAL TITLE: Regolith Immune Linear Actuator Family

Small Business Concern

Firm: **Apech Labs LLC**
Address: **1576 Sweet Home Road Suite # 210, Buffalo, NY 14228**
Phone: **(716) 559-1500**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Apech Labs is offering NASA a Regolith Immune Linear Actuator Family (RILAF). Lunar dust is extremely abrasive and contains particulate sizes that range from tens of nanometers to multiple microns. In addition, it exhibits magnetic and electrostatic adhesion. To date, viable solutions have only been identified for rotary joints. The solution achieves full immunity to the lunar environment using an all-metallic impermeable corrugated flexure to protect moving interfaces, metallic static seals, hard wearing materials, limited or no lubrication, and an all-metallic permeable membrane to allow evacuation of internal atmosphere. With no integral elastomerics or other life-limited items, the product family will enable long term linear actuation on the Moon. The product family is fully extensible to different strokes and output forces to encompass all sorts of mission needs. The RILAF actuator is expected to find usage in lunar vehicles, as well as construction, mining, cargo conveyance, and general utility actuation.

Potential NASA Applications (Limit 550 characters):

This actuation technology can aid NASA Commercial Lunar Payload Services contracts, as well as Artemis V to enable lunar surface missions including construction (habitats), mining (digging), and cargo transport. The metallic sliding surface tech can aid deployable structures that require post-deployment motion (e.g. doors), active mechanisms, and potential lunar nuclear reactor control. This tech can also be extended to increase reliability of TVC systems use in lunar landers.

Potential Non-NASA Applications (Limit 400 characters):

The sealing technology can be applied in the clean equipment, medical and downhole markets where static and reciprocating linear seals are common in fluid control devices. While most seals in this market are plastic, Apech Labs sees a market for elastomer-free seals, which allows for sealing equipment at high temperatures or pH environments.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z14.02-1840**

SUBTOPIC TITLE: Extraterrestrial Surface Construction

PROPOSAL TITLE: Brickbot Induction Furnace-Nozzle 2.0 Technology Demonstration for Lunar Landing/Launch Pad Construction

Small Business Concern

Firm: **Astroport Space Technologies, Inc.**
Address: **110 East Houston Street, 7th Floor, San Antonio, TX 78205**
Phone: **(210) 404-2981**

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):

Brickbot is intended as a risk reduction technology demonstrator of a robotic deployed induction furnace with an integrated brick molding nozzle, which will store lunar regolith, melt it, and deposit a brick while molten. Subsequent bricks when poured next to the initial brick will be melded together from residual heat. . This eliminates the need for grout or binders between the bricks. This prevents exhaust gases from intruding underneath the bricks and displacing them. The molding nozzle has independently actuated sides which allow the bricks to be deposited next to a previous brick and by lifting the nozzle wall of the joining side, allow molten regolith to flow around and meld itself to the previous brick. Each brick has a release draft angle with an undercut, it is this undercut which allows the interlocking of the bricks, which are shaped as a lobed rounded hexagonal.

The proposed Induction Furnace-Nozzle 2.0 builds on results of our STTR 2021 Phase 1 Induction Furnace-Nozzle prototype 1.0, for development of a method of making in-situ lunar landing pad bricks.

Potential NASA Applications (Limit 550 characters):

Lunar and Martian landing pads, roads are the primary proposed application. Any planar surface such as foundations or dust mitigation zones. However any paving application is possible. Different nozzles could be interchangeable with the furnace and that leads to different uses of the bricks.

Potential Non-NASA Applications (Limit 400 characters):

The proposed use of this furnace is to melt high silica containing dust and deposit it in a useful application. However, continued advancement of this technology would allow melting materials to be used for mineral extraction, gas extraction, and other commercial mining applications. Especially in the rare earth mining processes which necessitate extreme heat.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A1.02-2524**

SUBTOPIC TITLE: Quiet Performance - Airframe Noise

PROPOSAL TITLE: Phased Array Processing for AAM Noise Flight Tests

Small Business Concern

Firm: **OPTINAV, Inc.**
Address: **10914 Northeast, Bellevue, WA 98004**
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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: 7
Technical Abstract (Limit 2000 characters):

In noise testing Advanced Aircraft Mobility vehicles, sound spheres represent directivity patterns. The current standard measurement approach is to fly or hover the vehicle over an array of microphones and project the microphone spectra onto the sphere. The quality of the results is

limited by the finite number of microphones, uncontrolled acoustic propagation effects related to weather, and background noise.

The proposed innovation models the complex acoustic source and radiation as a linear algebra problem and the latest techniques from signal processing are applied to produce much higher-quality results than the current state of the art. The results substantially improve the spatial fidelity of the radiation model. The influences of weather and aircraft source motion are tamed. A knob within the linear algebra offers the ability to neatly reject background noise, potentially permitting tests in suburban areas instead of remote desert locations.

The work plan extends the software to get the most out of the method in simulations and plans a flight test for Phase II. The flight test will leverage a wireless microphone system developed by a subcontractor to this project under an earlier NASA SBIR.

The subtopic for this proposed innovation is “A1.02: Quiet Performance - Airframe Noise (SBIR).” The specific bullet point is “Noise Analysis and Characterization”:

"Innovative source identification techniques for airframe (e.g., landing gear and high-lift systems) noise sources, including turbulence details related to flow-induced noise typical of separated flow regions, vortices, shear layers, etc. However, noise sources attributed solely to the engines are excluded from this call."

The term “airframe noise” does not exclude AAM noise work this year because the noise is not confined to engines and the NASA researchers who are working intensely with measurements of this type are mostly at LaRC, the lead Center for the call.

Potential NASA Applications (Limit 550 characters):

Measurements of the noise of AAM/UAM noise in support of the NASA Advanced Air Mobility Project and the AAM National Campaign. The microphone setup described in NASA's high-profile paper "Acoustic Flight Test of the Joby Aviation Advanced Air Mobility Prototype Vehicle" has been copied and explicitly modeled for simulation in the proposal. Also, the method would apply to US Army testing using NASA's Mobile Acoustics Facility.

Potential Non-NASA Applications (Limit 400 characters):

Noise tests of hundreds of air taxies and similar vehicles under development by dozens of companies. Mission planning tests for military applications in addition to those directly supported by NASA.

Duration: **6**

PROPOSAL NUMBER:	23-1- **A1.04-1608**
SUBTOPIC TITLE:	Electrified Aircraft Propulsion
PROPOSAL TITLE:	Brushless Doubly Fed Motor for Electric Aircraft Propulsion

Small Business Concern

Firm: **Balcones Technologies, LLC**

Address: **104 Alabaster Caverns Drive, Georgetown, TX 78628**
Phone: **(512) 699-5828**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 2
Technical Abstract (Limit 2000 characters):

Balcones Technologies, LLC, teamed with the University of Texas Center for Electromechanics, proposes to develop a second-generation electric aircraft propulsor Brushless Doubly Fed Motor (BDFM). This effort builds build on our team's previous BDFM STTR Phase I and Phase II efforts and two small subsequent Phase III efforts. The previous efforts yielded the following:

- Identification of a propulsor BDFM configuration within an Electrified Aircraft Propulsion (EAP) power grid that eliminates approximately 80% of required propulsor power electronics (PE) compared to traditional permanent magnet and induction motors. This reduces overall mass for the motor-PE system by approximately 40% and also improves efficiency.
- Advanced BDFM analysis, design, and controls capabilities, fully documented, and supported by MATLAB scripts and a library of more than 120 journal articles.
- First generation propulsor BDFM and test rig to support development of BDFM analysis, design, and controls technology. After testing, the first generation BDFM was updated with an improved stator and an experimental rotor.
- Identification and preliminary investigation into an emerging, non-traditional BDFM rotor, subsequently supported by 2020-2022 journal articles that document successful design and testing of one variant of the non-traditional rotor. The non-traditional rotor features of most potential significance to the EAP application include increased torque, increased rotor RPM capability, increased power density, improved efficiency, higher RPM capabilities.

The primary objective for our team's proposed Phase I effort *plus* the potential follow-on Phase II effort is to design, fabricate, and test a pseudo-optimized Second Generation propulsor BDFM at a meaningful scale. If feasible within SBIR funding, the result would be one BDFM stator and up

to two different rotor units – one traditional rotor and one emerging non-traditional rotor – to enable performance comparisons.
Potential NASA Applications (Limit 550 characters):

NASA High Voltage Hybrid Electric Propulsion (HVHEP) Program, Distributed propulsor systems, NASA flight demonstration programs evolving from HVHEP

Potential Non-NASA Applications (Limit 400 characters):

Small scale wind energy , small scale commercial and military microgrid power systems (500 KW or less), small single and twin engine commercial aircraft (private jets), energy infrastructure entities, green energy groups and environmentally sensitive electric machines

Duration: **6**

PROPOSAL NUMBER: 23-1- **A1.04-1799**

SUBTOPIC TITLE: Electrified Aircraft Propulsion

PROPOSAL TITLE: Multi-Level Converter Multiplier Effect in Propulsion System Performance

Small Business Concern

Firm: **LaunchPoint Electric Propulsion Solutions, Inc.**
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Phone: **(805) 683-9659**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

This project on multi-level converters is a collaboration between LaunchPoint EPS Inc. and Prof. Pilawa-Podgurski's lab at UC Berkeley. Multi-level converters enable increased power density of the converter itself, and, by producing higher quality power signals, they enable dramatic improvements in EMI filter power density and also improvements in motor power density. In a compelling example of a DC-to-AC converter from Prof. Kolar's group at ETH, moving from 2 to 3 levels reduced EMI filter weight by an astounding 89% of the converter weight. We call this system-level effect the Multi-Level Multiplier (MLM) effect and define the MLM quantitatively in the project as a measure of propulsion system improvements made possible with a multi-level converter. The innovations in this project are 1) use of the MLM to think about, choose, and optimize converters as components of propulsion systems, and 2) augment our MAAP® software design tool such that full propulsion systems incorporating flying capacitor multi-level (FCML) converters can be optimized. The resulting power-density advances are critical and significant to our existing customer projects and future megawatt-level projects.

Our technical objective in Phase I is to demonstrate, by analysis, that FCLM converters indeed yield transformative MLMs. The objective will be attained by designing two propulsion systems comprised of combined EMI filter/converter/motor systems. One design will be based on an updated version of our standard 2-level converter models, and the other design will be based on 3-copies of our 10-level FCML converter rated at 13.46 kW, 26.7 kW/kg, 98.6% efficient to form a 3-phase motor drive.

Potential NASA Applications (Limit 550 characters):

Electrical power conversion systems have critical and broad applications in NASA aircraft and space programs. Power density is essential to all NASA systems and there is a growing recognition that electromagnetic interference (EMI) is a challenge in electric aircraft and in systems hosting sensitive sensor payloads. Specific NASA applications include the High-Efficiency Megawatt Motor (HEMM) project, the Turbine Electrified Energy Management (TEEM) project, and NASA research on hybrid electric aircraft.

Potential Non-NASA Applications (Limit 400 characters):

LaunchPoint EPS is experiencing concrete market traction for high-power-density converters in eVTOL, UAM, and broader aerospace markets. The latter is expanding to include all airborne power conversion needs: jet engine starter/generators, auxiliary power units and other turbogenerators, drone hybrid power, cooling systems that require lightweight pumps, and electromagnetic actuation.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A1.06-2140**

SUBTOPIC TITLE: Electric Vertical Take-Off and Landing (eVTOL) Vehicle Technologies for Weather-Tolerant Operations

PROPOSAL TITLE: Erosion Tolerant Passive Anti-icing Materials for UAM Rotor Blades

Small Business Concern

Firm: **Innovative Dynamics, Inc.**
Address: **2560 North Triphammer Road, Ithaca, NY 14850**
Phone: **(607) 257-0533**

Principal Investigator:

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Business Official:

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Phone: **(607) 257-0533**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

"Weather-Tolerant Capability" is considered essential in the expanding urban air mobility vehicle industry. Erosion effects of rain, dust, and sand on vehicle surfaces, especially the rotor surfaces, have a considerable effect on operational and maintenance costs. Another crucial environmental condition that heavily impacts flight safety is ice accretion. This proposal addresses a novel erosion shield system incorporating passive ice-protective technology that can be applied directly to helicopter blades for cost-effective reparability of blades.

The Phase I effort will focus on the design and test of an SMA based erosion tape prototype with natural durability qualities as well as the ability to change phase (strain) for anti-icing properties. Its unique nature of high stress output rate and low power requirements is a promising material to meet the need for energy savings required for electric vertical take-off and landing vehicles. The SMA material is made to perform a thermally activated shape change action that is analogous to a conventional thermal expansion except that it is enhanced to the levels needed to deice. Instead of the thermal input being applied via conventional technology, it can be supplied passively from latent heat transfer energy due to the formation of the ice itself to transform the SMA and mechanically debond the ice.

During Phase II, we will work with NASA and commercial suppliers to define installation and configuration requirements necessary to develop a to-scale SMA based deicing system. Final

SMA erosion tape configurations will be tested and validated in natural icing and erosion flight conditions.

Potential NASA Applications (Limit 550 characters):

NASA seeks technologies to meet future needs of the aviation community for safe and environmentally sustainable air transportation. The passive SMA tape would fulfill a critical technology gap for power limited electric vehicles to enable flight in instrument meteorological conditions. The proposed erosion tolerant tape can be applied to NASA unmanned air vehicles, Lunar and Planetary ground exploration vehicles, and Mars exploration rotorcraft where dust and sand erosion is a major safety concern.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications would be focused on developing large volumes of highly durable SMA tape materials for application to package delivery drones, automobiles, Boats as well as a wide range of commercial/home repair applications where specialty tapes are in high demand. This large consumer market is estimated to be over $100million in annual sales.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A1.08-1827**

SUBTOPIC TITLE: Aeronautics Ground Test and Measurement Technologies: Sensors and Diagnostic Systems for High-Speed Flows

PROPOSAL TITLE: In-Situ Gas Diagnostics for High-Speed Flows

Small Business Concern

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

Principal Investigator:

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Phone: **(310) 756-0520**

Business Official:

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Phone: **(310) 756-0520**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

We will develop new sensor technology for high-speed, spatially resolved gas information by utilizing new detector technology, prior hyperspectral imaging techniques, and recent development of laser absorption sensors. The effort will result in the ability to obtain 2D-spatial, spectral, and temporal information in a concept we have dubbed, four-dimensional tunable laser absorption spectroscopy (4D-TLAS). In Phase I of this project, we will develop a breadboard 4D-TLAS system, and the effort will culminate with an optimized Phase II prototype design for use inside NASA test facilities.
Potential NASA Applications (Limit 550 characters):

The in-situ sensor will directly support NASA ground test facilities, which play a crucial role in aircraft and spacecraft development cycle.
Potential Non-NASA Applications (Limit 400 characters):

There are a wide range of applications for such technology from environmental monitoring (e.g., imaging leaks, smokestack emissions), process control (e.g., inhomogeneous flue gas, combustion processes), and hypersonics (e.g., flow-field characterization, test diagnostics) that will also be pursued with the resulting technology.
Duration: **6**

PROPOSAL NUMBER: 23-1- **A1.09-2246**

SUBTOPIC TITLE: Zero-Emissions Technologies for Aircraft

PROPOSAL TITLE: Propellers with Integrated Thermal Management for Electrified Aircraft

Small Business Concern

Firm: **Micro Cooling Concepts, Inc.**
Address: **7522 Slater Avenue, #122, Huntington Beach, CA 92647**
Phone: **(714) 847-9945**

Principal Investigator:

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Business Official:

Name: **David Underwood**
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Phone: **(714) 227-9025**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

Electrified aircraft offer advantages in operating cost & maintenance, energy economy, noise, and emissions, and with the increased heat dissipation demands due to modern avionics, thermal management is more critical than ever. Fuel has been the traditional heat sink for aircraft, but its heat sink capacity has been stressed by increased heat dissipation loads. For electrified aircraft, this heat sink may not exist, or may not be accessible where waste heat is generated. Therefore, alternate heat sink concepts using ambient air have been considered, including liquid cooling on the outer mold line (OML) or via heat exchangers with ducted air. Direct OML cooling is preferred, as it does not add drag, but OML cooling complicates the thermal sizing, since its performance is dependent on location, speed, altitude, and angle-of-attack. This is tractable, but the biggest issue lies with the mismatch between heat load and cooling performance. Thus, it would be desirable to augment the heat dissipation capacity at takeoff. One means of accomplishing this is to make use of the propellers on the aircraft, which are adjacent to a major heat source: the electric motors. Their distribution also provides cooling access at multiple points on the aircraft, reducing the need to transport waste heat or cooling fluids. Micro Cooling Concepts has a history in creating ultra-thin high-performance heat transfer structures and will leverage this experience to develop propeller-integrated cooling concepts that are constructed of aluminum or titanium and would either wrap around an existing blade or are developed as an integral part of the propeller. The program will consist of integrated cooling design studies, cooling loop interface development, and prototype thermal test article fabrication. This effort supports the NASA goal of reducing the mass and increasing the efficiency of heat acquisition and rejection components and advancing technologies for more electric aircraft.

Potential NASA Applications (Limit 550 characters):

Technology applicable to any NASA program where heat exchangers are required, and where weight has a significant impact on system performance. Examples include:

- Advanced Air Transportation Technology (AATT)
- Transformational Tools and Technologies (TTT)
- Electric Powertrain Flight Demonstration (EPFD)
- Revolutionary Vertical Lift Technology (RVLT)
- Convergent Aeronautics Solutions (CAS)
- Integrated Aviation Systems Program (IASP)
- Ultra-Efficient Commercial Vehicles
- Transition to Low-Carbon Propulsion

Potential Non-NASA Applications (Limit 400 characters):

Lightweight, compact, conformal heat exchangers have uses across a wide range of applications. Impact cannot be overstated as applicability to military and commercial sectors is vast.

- Energy / Transportation / Space

Duration: **6**

PROPOSAL NUMBER: 23-1- **A1.10-2380**

SUBTOPIC TITLE: Structural Sensors for Health Monitoring of Hypersonic Vehicles

PROPOSAL TITLE: An Ultra High-Temperature Inertial Sensor for Structural Health Monitoring of Hypersonic Vehicles

Small Business Concern

Firm: **Sporian Microsystems, Inc.**
Address: **515 Courtney Way, Suite B, Lafayette, CO 80026**
Phone: **(303) 516-9075**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

The U.S. hypersonic ground- and flight-test communities require advanced Instrumentation systems that can inform a vehicle structural health monitoring (SHM) system operating in extreme hypersonic environments, with the long-term goal of deployment on an operational hypersonic aircraft allowing maintenance requirements and life predictions to be based on the

vehicle's/system's actual flight history and improved vehicle/system reliability. A specific extreme environment instrumentation need, with application to both airframe and propulsion systems, is inertial vibration measurements at high temperatures and high acoustic levels. An ideal such sensor would not only operate at extreme temperatures, but also be very small/lightweight, easy to integrate, and include intelligent sensor functions such as internal data processing, temperature compensation, output in engineering units, internal health test, and supporting digital bus communications.

Sporian Microsystems has significant prior experience in the development of ultra-high-temperature sensors for aerospace propulsion and ground power energy generation applications. The long-term objective of the proposed effort is to heavily leverage this prior work and translate it to realize an ultra-high temperature (>1000°C/1830°F) inertial vibration sensor that can be integrated with hypersonic vehicle structures and ground test/flight systems for SHM.

Phase I effort will include: 1) working with NASA and industry stakeholders to define system requirements am foster transition; 2) evaluating revised hardware/electronics architectures and designs; and 3) proof of principle testing and demonstration using benchtop-scale prototype hardware. If successful, Sporian will be well positioned for the Phase II efforts focused on full system prototyping and relevant environment testing/demonstration to satisfy NASA's technical readiness level expectations.
Potential NASA Applications (Limit 550 characters):

The proposed technology addresses a need identified by NASA For a ultra-high temperature vibration sensor that can be integrated with hypersonic vehicle structures and ground test/flight systems for SHM. Such a capability would also have application to high-speed flight test demonstrators as well as ground test facilities, and broad utility across virtually all propulsion system s including liquid and solid rocket propulsion, chemical and non-chemical propulsion, boost stage, and in-space propulsion.
Potential Non-NASA Applications (Limit 400 characters):

Commercial beneficiaries would be those interested SRM, PHM, and system performance metrics at ultra-high temperatures, including propulsion (aerospace, marine, rail and locomotive), ground transportation, energy generation (nuclear, concentrating solar power, supercritical CO2, ground turbines), oil and gas, Department of Defense, government and academic laboratories.
Duration: **6**

PROPOSAL NUMBER: 23-1- **A2.01-1414**

SUBTOPIC TITLE: Flight Test and Measurement Technologies

PROPOSAL TITLE: A Transformative Approach to Flight Test for Autonomous Vehicles

Small Business Concern

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

Principal Investigator:

Name: **Mr. Marco Lotterio**

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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):

There are well established processes to conduct developmental and certification flight test of conventional Parts 23 and 25 fixed wing aircraft and Parts 27 and 29 rotorcraft. Further, organizations such as NASA and the Department of Defense also have well established processes to conduct developmental test and evaluation (DT&E) and operational test and evaluation (OT&E) of prototype and experimental aircraft. The classical sequence of the two processes features test pilots that are actively engaged in the flight test assessments. For the Advanced Air Mobility (AAM) marketplace that will feature vehicle designs with increasing automation to full autonomous operations, new flight test technologies are needed to execute flight test maneuvers safely and repeatedly when a human pilot is no longer in-the-loop. Further, new test technologies can facilitate extraction of data/information relevant in aircraft development from non-classical developmental type maneuvers. The expected high relevance of Mission Task Elements (MTEs) in the emerging AAM certification process offers and requires the opportunity to merge developmental and operational test concepts and practices from first flight to certification. Building upon the flight test capabilities established in the X-KIT suite of tools by S-PLANE Automation (S-PLANE), the team of Systems Technology, Inc. (STI) and S-PLANE propose the Aircraft Standardized Source for Integrated System Testing (ASSIST) that will embed with X-KIT to facilitate the flight test process from initial parameter and system identification to envelope expansion to mission suitability and certification testing using MTEs. This system will leverage STI and S-PLANE technology in the creation of ASSIST to facilitate the acquisition of critical information for aircraft development from refined flight test practices including the execution of MTEs.

Potential NASA Applications (Limit 550 characters):

ASSIST applies to the ARMD FDC that “operates, sustains and enhances the specific flight research and test capabilities…needed to achieve technical goals in ARMD’s Strategic Plan, other NASA mission directorate activities and national strategic needs.” Further, it applies to the AAM National Campaign that “…bring together aircraft manufacturers and airspace service providers to identify maturity levels for vehicle performance, safety assurance, airspace interoperability, etc., and to develop and demonstrate integrated solutions for civil use.”

Potential Non-NASA Applications (Limit 400 characters):

ASSIST and X-KIT together provide a complete flight test suite to the AAM market including passenger aircraft operated autonomously in what JP Morgan recently called the $1 trillion electric flying vehicle market. This flight test technology can also be introduced to military markets such as the AFWERX Agility Prime program that is seeking introduction of electric flight vehicles into the USAF.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A3.01-1462**

SUBTOPIC TITLE: Advanced Air Traffic Management for Traditional Aviation Operations

PROPOSAL TITLE: Accuracy Adjusted Airport Terminal Area Wind Profile Data for Flight and Flow Planning Optimization Applications

Small Business Concern

Firm: **AvMet Applications**
Address: **1800 Alexander Bell Drive, Reston, VA 20191**
Phone: **(571) 335-7079**

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):

Unanticipated adverse path-based wind shear can significantly affect airspeed resulting in non-optimal arrival flows into an airport or possibly result in a loss of separation known as wind compression. Stronger than expected tailwinds result in more aircraft entering airspace than expected or manageable – which results in sector saturation, holding, and reverting to Miles-In-

Trail (MIT). Whereas stronger than expected headwinds results in fewer aircraft entering the airspace than expected, introduces unrecoverable delay and underutilizes airport capacity. Without accurate, clear, and operationally relevant prediction of accurate wind profiles in the terminal and arrival airspace, significant impacts may occur or, at a minimum, non-optimal operations may develop as air traffic operators are caught by surprise by the unexpected wind profiles impacting arrival flows.

This proposal provides an accuracy-adjusted wind profile data set focusing on the terminal airspace and arrival area which is based on in-situ observation, upper-level wind forecasts, machine learning, and artificial intelligence that can be used for wind compression alerts and arrival flow planning. Using machine learning and artificial intelligence, this research uses all available airborne aircraft flight paths to calculate the wind profile throughout the ascent and descent into an airport's airspace to improve the wind forecast. This unique approach using passive participation by aircraft (i.e., no aircraft wind measurement equipment or communication of winds required) will help to create a more accurate and high-resolution wind profile for the atmosphere near the airport and along the approach paths which can be used for flow optimization and mitigation of other impacts to aviation due to winds.

Potential NASA Applications (Limit 550 characters):

This effort will provide NASA with an application and methodology for autonomously providing improved accuracy wind profiles that can be applied for flight path optimization. The innovation supports NASA's mission to provide advanced automated support for air navigation service providers and aircraft operators, increase safety, and reduce air-travel times and delays. The core application of this work furthers NASA's goals to deliver capacity, throughput, and efficiency gains by improving the accuracy of terminal/arrival corridor wind forecasts.

Potential Non-NASA Applications (Limit 400 characters):

Applications outside NASA include the FAA and NAS users, who have the need for improved wind profile information for ATM applications and improved airport efficiency. This innovation will offer the ability to increase situational awareness of weather changes that may impact trajectories, alert of changed weather impacts for approach and departure reroute strategies and provide safer operations.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A3.02-1707**

SUBTOPIC TITLE: Advanced Air Traffic Management for Nontraditional Airspace Operations

PROPOSAL TITLE: Traffic Pattern Integration for Autonomous Vehicles

Small Business Concern

Firm: **ATAC**
Address: **2770 De La Cruz Boulevard, Santa Clara, CA 95050**
Phone: **(408) 736-2822**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3

Technical Abstract (Limit 2000 characters):

ATAC proposes “Traffic Pattern Integration for Autonomous Vehicles,” in response to Subtopic A3.02. Our proposal fulfills the goals of Subtopic A3.02 by creating a cyber-resilient, service-based architecture that can be used to integrate autonomous vehicles with legacy users around small towered and non-towered airports. A significant challenge for an autonomous vehicle flying into a small airport is the lack of defined landing procedures. Most small airports do not have GPS procedures and instead rely on general rules for organizing traffic into a landing pattern around the airport; this is the case at both towered and nontowered airports. Our Traffic Pattern Intent Prediction (TPIP) tool overcomes this challenge by learning the traffic patterns at small airports and using them to predict aircraft intent in the traffic pattern around small airports. TPIP accomplishes this using an innovative approach that predicts the future intent of aircraft entering the traffic pattern using probability models trained on historical data. TPIP will help autonomous vehicles plan their route into an airport, avoid unsafe situations, and increase operational efficiency. The information provided by TPIP allows autonomous vehicles to strategically adjust their routes into crowded airspace in order to minimize the need for tactical maneuvers. It also provides dynamic route planning for landing trajectories that conform with local traffic patterns and avoid conflicts with other aircraft. This proposal fulfills the goals of Subtopic A3.02 by creating a service-based architecture that can be used to integrate autonomous vehicles with legacy users. Our solution will help safely scale autonomous operations while maintaining a safe and usable environment for legacy airspace users. At the end of Phase 1 we will create a proof-of-concept demonstration to show our ability to execute on these goals, as well as assess the accuracy of our model to ensure that the predictions are reliable.

Potential NASA Applications (Limit 550 characters):

The SWS Program obtains novel, probabilistic-based GA and AAM traffic risk assessment algorithms. NASA’s ATM-X Pathfinding for Airspace with Autonomous Vehicles (PAAV) subproject will be enhanced through the integration of our TPIP algorithms into UAS, UAM, and autonomous cargo separation assurance algorithms based on NASA’s Autoresolver technology. Finally, TPIP can be leveraged by future HITL simulations that leverage NASA’s ATM-X Testbed platform.

Potential Non-NASA Applications (Limit 400 characters):

A direct application for the proposed technology is as a DST to be used at nontowered, small manned, and remote tower facilities for projecting safety risks and demand/capacity overloads for any combination of traditional GA traffic, UAS, UAM, and autonomous cargo traffic. Our technology could be used by air traffic services, future USSs and PSUs, or UAS/UAM/autonomous air cargo operators.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H6.22-2297**

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

PROPOSAL TITLE: Radiation Hardened Programmable Deep Neural Processor in 22nm FDSOI CMOS process

Small Business Concern

Firm: **Alphacore, Inc.**
Address: **304 South Rockford Drive, Tempe, AZ 85288**
Phone: **(480) 494-5618**

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):

The need for Extreme Radiation Hard Neuromorphic Hardware is overwhelming for NASA, other government agencies and private industry. Neuromorphic computing is recognized by the electronics industry and aerospace industry as a promising tool for enabling high-performance computing and ultra-low power consumption to achieve what clients need. Satellites, Rovers and other key assets impose limits on size, weight and power consumption, as well as the need for radiation-tolerance. We propose to radiation harden a programmable in-memory compute neural network processor for deep neural networks by circuit, microarchitectural and architectural means. This processing paradigm has the potential to provide a full stack solution in the fields of in-situ cognition and autonomous decision making in extreme environments while bridging the gap between commercial state-of-the-art and the research efforts in the fields of neuromorphic space computing. Our solution can provide 10s of TOPS/W in inference performance when fully developed with comprehensive radiation assurance. Alphacore's proposed library includes blocks designed in 22nm FDSOI process which have gone through multiple development cycles. These will be suitable to function under high radiation and wide temperatures of planets, asteroids and comets in deep space. With Alphacore's solution, designers can develop technologies that are lightweight, highly efficient and can deliver advanced capabilities for next-generation missions, all without the need for heavy protective housing to ensure functionality in deep space.

Potential NASA Applications (Limit 550 characters):

Alphacore's cost-effective and energy efficient, rad-hard neuromorphic processor solution will enhance future missions for lunar, Martian and other deep space missions in applications such of in-situ cognition and autonomous decision making in entry, descent and landing type critical phases in presence of solar flares as well as radiation environments of outer planets.

Potential Non-NASA Applications (Limit 400 characters):

Neuromorphic computing is recognized by the electronics industry and aerospace industry as a promising tool for enabling high-performance computing and ultra-low power consumption to achieve autonomy and machine cognition. Satellites, Rovers, Rockets and other key assets require radiation-hardness for processors in critical deep space critical missions.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H6.22-2655**

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

PROPOSAL TITLE: Non-Volatile Optical Memory for Zero Power Neuromorphic Computation from GenXComm, Inc.

Small Business Concern

Firm: **GenXComm**
Address: **10000 Metric Boulevard, Suite #200, Austin, TX 78758**
Phone: **(512) 554-7601**

Principal Investigator:

Name: **Dr. Taran Huffman**
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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):

Long term space missions can greatly benefit from neuromorphic processors enabling in-situ learning in the extreme environments in space. Photonic Tensor Cores provide extremely energy efficient and robust hardware for the computations required for neuromorphic processing. However, current technologies require the significant expenditure of energy, through resistive heaters or current injection diodes, to maintain the state of the neural network for inference. Here we describe a photonic accelerator technology that utilizes the learning from FLASH memory devices to enable non-volatile, 0 energy state retention for neuromorphic processors, enabling the possibility of reaching incredible inference efficiency of 1 femto-joule per operation – a 3 order of magnitude improvement over todays GPUs.

Potential NASA Applications (Limit 550 characters):

Photonic computation, as implemented in optical neural networks, offers the promise to deploy neuromorphic processing with extreme speed and power efficiency. These attributes unlock opportunities for pushing computation/machine learning into smaller systems and spacecraft at the operational edge. On-board Image processing for small craft and real-time imagery inference for autonomous landing are attractive possibilities. Other applications include telescope motion control, terrain classification, medical monitoring and adaptive flight control.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA Applications span an even wider gamut, but follow a similar theme: equipping resource constrained platforms with computation. The following list of applications are attractive and large:

- Commercial space (e.g. Cubesat operators like Planet Labs)
- UAVs operated in military and commercial settings;
- Autonomous (i.e. self-driving) car market;
- Industrial robotics that rely on computer vision;

Duration: **6**

PROPOSAL NUMBER: 23-1- **H8.01-2342**

SUBTOPIC TITLE: Low-Earth Orbit Platform and Microgravity Utilization for Terrestrial Applications

PROPOSAL TITLE: Feasibility study for an automated Machine Learning analytics platform for better process control of artificial retina in-space manufacturing

Small Business Concern

Firm: **LambdaVision, Inc.**
Address: **400 Farmington Avenue, Farmington, CT 06032**
Phone: **(860) 679-2558**

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):

LambdaVision is developing an artificial retina to restore vision to the millions of people blinded by retinal degenerative diseases. The artificial retina is manufactured using a layer-by-layer (LBL) assembly technique, which results in an artificial retina thin film that contains hundreds of oriented layers of the light-activated protein, bacteriorhodopsin. The LBL process is subject to the effects of gravity, which leads to inefficient and homogenous layering. As such, the artificial retina is example of a drug product that may benefit from production in low earth orbit (LEO). Through Space Tango's CubeLab™ system and seven research flights to the ISS, LambdaVision has established proof-of-concept for artificial retina manufacturing in LEO. This **Phase I SBIR** proposal will build on results obtained from our microgravity work and

parallel terrestrial efforts to establish an informed data driven process via machine learning in order to efficiently and effectively leverage each experiment conducted in microgravity.

LambdaVision will partner with Dr. Ioana Cozmuta and her team at G-SPACE to use artificial intelligence (AI) and machine learning (ML) tools to systematically de-risk the key parameters required to achieve a viable microgravity product. Through G-SPACE's proprietary platform that uses data science, ML, and software automation tools, we will evaluate artificial retina thin films generated under various conditions to help establish real time quality and process control during the manufacturing process. These data will help to reduce the current trial and error approaches in LBL manufacturing and remove uncertainty from the experiments by using proprietary algorithms established via decades of microgravity research. By standardizing the experiments and achieving the process controls for experimentation we will maximize the data collected, reduce costs, and accelerate the timeline to commercialization.

Potential NASA Applications (Limit 550 characters):

This proposal establishes the capabilities required to support LEO commercialization of protein-based artificial retinas for patients with end-stage retinal degenerative diseases. The work outlined in this proposal allows for real-time process control and optimization of artificial retina manufacturing in microgravity. Moreover, improved process control for in-space production applications will support a new sector in the Space economy and allow for better prediction of how materials and processes will behave in a microgravity environment.

Potential Non-NASA Applications (Limit 400 characters):

An enhanced layer-by-layer manufacturing process can improve the homogeneity, orientation, and stability of multilayered thin films for broad applications, including retinal implants, photovoltaic cells, chemical sensors, drug delivery systems, and tissue engineering. Development of real-time processing controls will better streamline production processes for greater precision and efficiency.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H9.01-2410**

SUBTOPIC TITLE: Long-Range Optical Telecommunications

PROPOSAL TITLE: Grism Pointing Mechanism for Precision Laser Pointing in Space

Small Business Concern

Firm: **NewBridge Partners, Inc.**
Address: **2804 Baxley Hollow Court, Herndon, VA 20171**
Phone: **(703) 822-1159**

Principal Investigator:

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Address: **2804 Baxley Hollow Ct, VA 20171 - 2126**
Phone: **(310) 944-0894**

Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 4
Technical Abstract (Limit 2000 characters):

NewBridge Partners, Inc. has developed an innovative, compact, laser communications pointing mechanism for precise optical beam control. This pointing approach eliminates the need for fast steering mirrors and dual purposes a grating Risley prism to perform both the coarse pointing and the stabilization functions, thereby reducing complexity in the pointing system. The grating Risley enables good boresight performance of the transmit and receive beams compared to a conventional Risley prism pair. Our grating pointing mechanism has a very high bandwidth of ~200 Hz, rivaling the best steering mirrors in lasercomm systems today. It simultaneously has very low jitter of approximately 200 nanoradians, making it an outstanding mechanism for jitter control and large-angle steering. This extremely compact design is readily space qualifiable with the use of high TRL components. It reduces the line-of-sight pointing complexity compared with conventional laser communications gimbals. The pointing mechanism is modular, generally agnostic of the lasercomm details and, therefore, could interface with all the major lasercomm suppliers.

Potential NASA Applications (Limit 550 characters):

The Grism Pointing Mechanism supports NASA's space-based laser communications for interplanetary ranges by providing precision pointing. It reduces the size, weight, and power of current laser communication pointing devices while providing outstanding performance at low cost. These features enable use on conventional spacecraft as well as small, low-cost spacecraft that desire the use of laser communications.

Potential Non-NASA Applications (Limit 400 characters):

With the expanding business of laser communication in space, there are multiple opportunities for the proposed Grism Pointing Mechanism due to its small size, weight, and power. The improved mission capability, design simplicity, and inherent manufacturability are well-suited for these very large constellations employing small, low-cost satellites.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H10.01-2385**

SUBTOPIC TITLE: Advanced Propulsion Systems Ground Test Technology

PROPOSAL TITLE: Capacitance Based Combined Single and Two Phase Mass Flow Meter for Cryogenic Hydrogen

Small Business Concern

Firm: **Tech4Imaging, LLC**
Address: **4171 Fairfax Drive, Columbus, OH 43220**
Phone: **(614) 214-2655**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters):

Tech4Imaging (T4I) proposes to develop a Capacitance Based Combined Single and Two Phase Mass Flow Meter for Cryogenic fuel with an accuracy of 2% full scale from 0 to 100% liquid volume fraction. This flow meter can be scaled to different pipe diameters to measure flow rates between 0.1 lbm/s to 500 lbm/s depending on the fluid density. This flow meter will be applicable to most cryogenic two phase flows including nitrogen, hydrogen, oxygen, methane, and natural gas. This proposal will focus on the application of 2-phase nitrogen as an analog for other fluids due to price and accessibility, although much of the development for one cryogen is applicable to the others.

Combined 2-Phase cryogenic mass flow meter tool benefits:

1. Improve chill down performance
2. Quantify fuel system performance
3. Pinpoint process parameters for review, resulting in substantial savings
4. Minimal PPE required
5. Minimized boil off from device
6. Minimized cost
7. Lightweight and low power for flight integration

Potential NASA Applications (Limit 550 characters):

Members of NASA are also keenly interested in the successful development of this product for use in aerospace applications. This techology can minimize NASA test program time, cost, and risk.

Potential Non-NASA Applications (Limit 400 characters):

Leaders of innovation in the hydrogen industry have been consulted heavily during the development of the technology towards cryogen applications thus far. LTA research, Sierra Lobo Inc and Moran Innovation (Letter of Support provided) were all consulted during development to date and are potential users of the technology once developed.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H10.02-1580**

SUBTOPIC TITLE: Autonomous Operations Technologies for Ground and Launch Systems

PROPOSAL TITLE: Infrared Smart Cameras for Cryogenic Systems Monitoring

Small Business Concern

Firm: **Sensatek Propulsion Technology, Inc**
Address: **1 Aerospace Blvd, Daytona Beach, FL 32114**
Phone: **(850) 321-5993**

Principal Investigator:

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Phone: **(850) 348-0689**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters):

Ground operations involving rocket launches inevitably involve cryogenic storage, transport and loading as part of the launch procedure. These large systems operate at extremely high temperature differentials compared to the environment, usually measured in hundreds of degrees. Many of the issues associated with the cryogenic systems are detectable with temperature sensors, but instrumenting the large areas and lengths associated with cryogenic tubing and tanks with discrete sensors in order to catch anomalies would be quite difficult. Infrared cameras are a good option, as they have the capability to survey large areas. Unfortunately, most infrared camera systems are quite expensive and require expensive power and data lines to be run to each of them. Typical installation costs regularly exceed $20,000 per camera. More importantly for the establishment of Autonomous Operations, interpreting still or video infrared imagery is very time consuming and requires trained humans in the loop. This project looks to alleviate these issues by developing and deploying a novel Autonomous Operations Technology (AOT) that is extremely well suited for automatically monitoring cryogenic installations. Sensatek will develop and deploy low cost, wireless infrared cameras that have smart algorithms integrated in the camera to automatically detect, plot, and help infer anomalous or negatively-trending situations. These camera nodes will be designed to operate with high durability and safety outdoors in the presence of cryogenic and explosive gases.

Potential NASA Applications (Limit 550 characters):

The following NASA programs of record could benefit from the application of Sensatek AI-powered low-mass infrared camera systems:

Rocket Propulsion Testing Program; X-plane program; Artemis program; Space Launch System (SLS) program; Lunar Gateway Program; Commercial Crew and the International Space Station; Advanced Air Vehicles Program; Transformative Aeronautics Concepts Program; Sustainable Flight National Partnership; Hybrid Thermally Efficient Core (HyTEC) program; Scalable Traffic Management for Emergency Response Operations (STEReO)

Potential Non-NASA Applications (Limit 400 characters):

Power Generation Gas Turbine Engines; Power Generation Gas Turbine Lube Oil Pumps; Power Generation Wind Turbine Gearboxes Power Generation Electrical Distribution Panels, Transformers, and Power Lines; Oil and Gas Compressors; Oil and Gas Drilling Rigs; HVAC Compressors; Large Chiller Compressors

Duration: **6**

PROPOSAL 23-1- **H12.05-1021**

NUMBER:

SUBTOPIC TITLE: Autonomous Medical Operations

PROPOSAL TITLE: An Integrated Clinical Ensemble (ICE) for Autonomous Critical Care in Deep Space

Small Business Concern

Firm: **Nahlia Inc**
Address: **95 1st Street, Suite 240, Los Altos, CA 94022**
Phone: **(310) 936-6237**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 6
Technical Abstract (Limit 2000 characters):

The highly dynamic nature of Critical illness on deep space missions will require Astronaut crews to provide completely autonomous, Earth independent, Medical care. Critical care in an ideal well staffed and equipped Intensive Care Unit (ICU) hospital environment on Earth requires teams of expert caregivers function as highly coordinated teams with immediate access to telemedicine and evacuation. Critical care in space will be delivered with extremely limited resources, by a team of non-expert caregivers led by a single crew medical officer, in a small confined space. An Integrated Clinical Ensemble (ICE) that functions as a hearing, seeing, and speaking crew member will assist crews with intensive management of these complex patients when combined with the clinical reasoning ability of an Autonomous Medical Response Agent (AMRA)

AMRA is a multi-criteria feedback control Bayesian clinical decision support tool developed for NASA. AMRA's Bayesian graphs calculate post-test likelihood of possible disease states, clinical outcomes, and mission outcomes (Medical-101). Levels of expertise, inventory, and crew preferences personalize guidance, allow calculation of Equivalent system mass resource costs (Medical-201 and medical system trade space analysis (Medical-301). AMRA's outcome graphs estimate the current and future multi-system state health from diagnostic and treatment data to provide an estimated risk prognosis. AMRA sends all data back to mission control and will reduce mission resource costs (Medical-701).

The primary objective of this Phase I is to build upon AMRA to establish the feasibility of an explainable, Integrated Clinical Ensemble (ICE) that incorporates multiple streams of input to integrate Bayesian prognostic causal network, and is therefore able to explain and coordinate the simultaneous collaborative delivery of Critical Care with multiple human crew mates both on Earth and in Space as an integrated exploration medical system (Medical-501)

Potential NASA Applications (Limit 550 characters):

An Integrated Clinical Ensemble (ICE) combines multimodal sensor inputs (physiological, vision, speech, environmental, vehicle signals) with Bayesian causal and critical care intervention graphs to schedule and guide NASA Astronauts to provide immediate, autonomous, resource constrained critical care in an Earth Independent manner while on deep space missions. This core capability will enable NASA to pursue it's agenda of long duration human exploration to deep space destinations.

Potential Non-NASA Applications (Limit 400 characters):

Military: Remote autonomous critical care is essential for warfighters in peer, or near-peer combat where casualties are expected to be far greater than current military health capacity.

Civilian: Critical care is in increasing demand. Tele-ICU is currently a $7.3 billion industry, an Integrated Clinical Ensemble (ICE) will increase capacity to provide evidence based critical care globally.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S14.01-2650**

SUBTOPIC TITLE: Space Weather Research-to-Operations-to-Research (R2O2R) Technology Development and Commercial Applications

PROPOSAL TITLE: Spacecraft Anomaly Resolution Knowledgebase (SPARK)

Small Business Concern

Firm: **NextGen Federal Systems, LLC**
Address: **1399 Stewartstown Road, Suite 350, Morgantown, WV 26505**
Phone: **(304) 413-0208**

Principal Investigator:

Name: **Alexander Engell**
E-mail: **aengell@nextgenfed.com**
Address: **235 High Street, Suite 220, WV 26505 - 5446**
Phone: **(978) 621-5880**

Business Official:

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Address: **4031 Colonel Glenn Hwy, OH 45431 - 2700**
Phone: **(513) 392-1228**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5

Technical Abstract (Limit 2000 characters):

NextGen proposes the novel **Spacecraft Anomaly Resolution Knowledgebase** (SPARK) secure and centralized anomaly database and space environment anomaly analysis tool. SPARK extends the relevant Space Radiation Intelligence System (SPRINTS; Engell et al., 2017) framework to offer highly reactive user dashboards capable of visualizing 35+ years of space weather time-series and associated event (e.g., solar flare or inputted anomaly) data at 1-minute resolutions in seconds. SPARK has powerful time series data annotation tools for users to add to space weather or anomaly event information with associated APIs for database input and retrieval. Users securely input satellite diagnostic information – either events or time-series that can be used in additional analysis. Users can choose to share their anomalies or use them in their own secure SPARK deployment with other shared anomalies.

Potential NASA Applications (Limit 550 characters):

SPARK is aligned to fulfill NASA engineering needs regarding spacecraft anomaly databases related to space environments. Used by NASA engineering and space weather teams, SPARK will be able to support human spaceflight missions to the Moon and Mars as well as support NASA satellite operations. It will provide a scalable anomaly and fused space weather environment database with relevant workflows to support anomaly resolution and understanding.

Potential Non-NASA Applications (Limit 400 characters):

DoD, NOAA, and communities like the Coordination Group for Meteorological Satellites (CGMS) require anomaly databasing to support anomaly resolution. Spacecraft insurers often require anomaly reports for insured spacecraft. SPARK will support these organizations and further grow the SPARK anomaly database and anomaly resolution knowledge.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S14.02-1550**

SUBTOPIC TITLE: In Situ Particles and Fields and Remote-Sensing Enabling Technologies for Heliophysics Instruments

PROPOSAL TITLE: Small TEnuous Plasma Heliophysics Electric field Instrument (STEPHEI)

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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E-mail: **scott.thaller@orionspace.com**
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Phone: **(612) 845-1954**

Business Official:

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Phone: **(303) 993-8039**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters):

Much of the outstanding physics yet to be learned about the coupling of the magnetosphere-ionosphere (M-I) system resides in the small- and mesoscale structures of the aurora, field aligned currents, plasma convective motions, and wave activity. Untangling these spatial and temporal structures with in situ measurements will require a constellation of spacecraft. For cost-effectiveness, such a constellation would consist of CubeSats. To study M-I coupling, one of the essential measurements these CubeSat will need to make is of the DC electric field. The electric field plays a crucial role in M-I coupling from driving convective drifts in the magnetosphere and ionosphere, Joule heating, Poynting flux, waves, and auroral particle precipitation. The environment on the magnetospheric side of these processes is the tenuous plasmas of the earthward plasma sheet, plasma sheet boundary layer, ring current, and auroral zone. In such environments, the sunlit electric field sensors are surrounded by high plasma sheath impedance which causes large errors on the measurement. To reduce the sheath impedance, a bias current is driven from the spacecraft to the sensors. This current is large relative to the plasma thermal

current to CubeSat's small surface area, causing the CubeSat to charge to large potentials, contaminating the measurement. By effectively increasing the spacecraft surface area of a CubeSat, enough thermal plasma current can be collected to offset the effect of the bias current. STEPHEI, the Small TEnuous Plasma Heliophysics Electric field Instrument, is an electric field double probe for CubeSats in tenuous plasmas with a deployable electron collector that will prevent the spacecraft charging. The electron collector consists of a metallized polymer sheath deployed along either the sensor booms or on its own boom. STEPHEI will allow the measurements to be made that are needed to address fundamental problems in M-I coupling.

Potential NASA Applications (Limit 550 characters):

DC electric field measurements have been very valuable in space physics investigations. The science return on Heliphysics missions have been enhanced by electric field measurements. The electric field is used in such investigation to explain particle transport and energization, wave properties, Poynting flux, auroral dynamics, magnetic reconnection, and other processes. STEPHEI technology thus has NASA application by enabling further investigation of suck processes.

Potential Non-NASA Applications (Limit 400 characters):

Constellations of CubeSats with STEPHEI technology could be used to make multi-point electric field measurements for use in a space weather observatory. Such electric fields map into the ionosphere and directly drive currents and plasma drifts. These processes include those giving rise to GNSS scintillations and thus have application for forecasting PNT conditions.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S15.02-2265**

SUBTOPIC TITLE: In Situ Sample Preparation and Analysis for Biological and Physical Sciences in a Microgravity Environment

PROPOSAL TITLE: Fluidic Solutions for In Situ Sample Preparation in Microgravity

Small Business Concern

Firm: **IRPI, LLC**
Address: **27501 SouthWest 95th Avenue Suite 930, Wilsonville, OR 97070**
Phone: **(503) 974-6655**

Principal Investigator:

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Address: **27501 SW 95th Ave Ste 930, OR 97070 - 5705**
Phone: **(503) 200-4011**

Business Official:

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Phone: **(503) 545-2501**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters):

Whether in industry, at home, or in the lab, most fluids handing operations and equipment would fail immediately when directly employed in the microgravity environments of orbiting or coast spacecraft. This is due to the innate assumption of gravity in nearly everything we do, make, and think. Thus, special engineering considerations must be made to account for the large length scale inertial-visco-capillary fluid phenomena that occurs when the role of gravity is greatly diminished.

The fundamental and applied challenges governing such 'capillary fluidics' phenomena are significant and exposure to low-g environments is low. The technical fluid mechanics challenges are real, especially for multiphase microgravity flow of complex fluids in complex geometries with unknown initial conditions in an uncontrolled perturbation environment, with stringent requirements for spaceflight: compact, lightweight, low power, low crew activity, low resource utilization, minimal consumables, and program pressure for miniaturization and automation.

In this proposal we first highlight a variety of capillary fluidics challenges faced by NASA relating to sample preparation that are likely to find solutions considering the new state-of-the-art. We then focus on solutions that are cross-cutting to in situ sample preparation and analysis for Biological and Physical Sciences research in microgravity environments. We pursue a survey of the broader aerospace community to find a measure of consensus regarding high-value miniaturizable automatable sample preparation unit operations. We will then design and demonstrate at least one broadly applicable prototype solution addressing the stakeholder requirements. Our Phase II effort aims to provide broad solutions to miniaturized, automated and other in situ sample preparation challenges—for the NASA Biological and Physical Sciences as well as NASA's Life Support Communities for research, development, and exploration.

Potential NASA Applications (Limit 550 characters):

Our technology delivers devices and processes to conduct safe and efficient capillary fluidics in situ sample preparation operations for NASA BPS, NASA Life Support, space commercial biopharmaceutical industry, and other communities. Spacecraft target environments include microgravity, moon, and mars. We expect to report the successful performance of product-level hardware with performance data to NASA for mission integration. Our contributions will have cross-cutting applications to other troubling fluidics challenges aboard spacecraft.

Potential Non-NASA Applications (Limit 400 characters):

Commercial spaceflight operators can benefit from all our technology relating to liquid management in space. On Earth our technology is expected to enhance certain liquid/gas/particle separations, improve low-dose metering, rogue bubble and droplet passive separations, as well as have specialty applications for micro-to-milli-scale reacting liquid flows.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S16.01-2276**

SUBTOPIC TITLE: Photovoltaic Power Generation and Conversion

PROPOSAL TITLE: Optimal Radiation Tolerant High Intensity High Temperature Photovoltaics

Small Business Concern

Firm: **Structured Materials Industries, Inc.**
Address: **201 Circle Drive North, Suite 102/103, Piscataway, NJ 08854**
Phone: **(732) 302-9274**

Principal Investigator:

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Phone: **(732) 302-9274**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters):

In this SBIR Phase 1 project, we propose the development of a photovoltaic (PV) cell offering both high-intensity high temperature (HIHT) and low-intensity high temperature (LIHT) using silicon carbide (SiC) grown by MOCVD. The HIHT PV cells and blanket technologies will be used for near Sun missions and the LIHT will be used in missions such as Venus surface operation. We will use our proprietary technology building on two NASA patents to grow the cubic SiC (3C-SiC) based PV cell structure. In Phase I, we will demonstrate a single junction PV cell. Cubic 3C-SiC is considered a perfect material for high-temperature PV operation because

of its thermal stability and because its band gap decreases from ~2.7eV at room temperature to ~2.2eV as the temperature increases to ~770°C. Additionally, 3C-SiC theoretically offers a room temperature efficiency as high as 45-60% with boron interband; vs ~30% for a standard cell. In Phase I, we will first focus on demonstrating a baseline refining its growth, PV processing and characterization will span from room temperature to 500°C operation. Further, we will also demonstrate the nascent boron doping formation of an interband structure that we will optimize for each of HIHT and LIHT operations. Phase III will focus on providing mission implementation cells. We will leverage our growth expertise to further optimize the growth of 3C-SiC for this project's requirements. The Phase II project goal is to show the boron effect compared to a standard cell and to achieve efficiencies >30% at 450°C.

Potential NASA Applications (Limit 550 characters):

The High-Intensity High-Temperature PV cells and blanket technologies will be used for near Sub/Mercury missions and the Low-Intensity High-Temperature will be used for Venus's surface missions.

Potential Non-NASA Applications (Limit 400 characters):

The commercial applications of this technology will be in High-temperature Photovoltaics used in hybrid PV thermoelectric solar cells. It is noteworthy to mention that DOE's Solar Energy Technology Office (SETO) has recently announced $100 Million research effort to develop concentrating solar power.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S16.02-1352**

SUBTOPIC TITLE: Dynamic Power Conversion

PROPOSAL TITLE: Electronic Controller for Sunpower Stirling Power Convertor

Small Business Concern

Firm: **Wecoso, INC**
Address: **17682 Gothard Street, Suite 2021, Huntington Beach, CA 92647**
Phone: **(714) 222-0424**

Principal Investigator:

Name: **Carl Kirkconnell**
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Business Official:

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Phone: **(714) 587-4628**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

West Coast Solutions (WCS) and Sunpower, Inc. propose the development of a space-rated electronic controller for the Sunpower Robust Stirling Convertor (SRSC) in response to Topic S16.02 Dynamic and Solid-State Power Conversion. This controller will be called the Stirling Convertor Space Controller (SCSC). The effort will be led by WCS, who brings a proven track record developing and delivering space-rated controllers for Stirling cryocoolers, and many other space-flight applications. WCS has teamed with Sunpower, the industry leader in the design and build of highly efficient and reliable space-rated Stirling convertors. The strong WCS-Sunpower Team will close the gap on bringing Stirling convertor technology to space launch maturity with the development of this enabling SCSC technology.

A significant impediment to deploying the SRSC in space is the lack of a ***radiation hard, space-rated electronic controller***. WCS addresses this impediment in Phase I with the development of a flight-design controller circuit, fully compatible with the intended radiation environments. The starting point for the design is the Sunpower “Kilopower” Stirling convertor controller, a lab-based design which was developed under NASA’s Game Changing Development Program under the Space Technology Mission Directorate (STMD), which has been shown to effectively control the SRSC prototype. With the support of Sunpower, WCS will convert the Kilopower Stirling Convertor Controller to a space-rated design targeting > 300 krad (Si) total ionizing dose (TID) hardness at the module level.

Potential NASA Applications (Limit 550 characters):

There are many regions of space where solar power is not an option and there exists a need for long term operation of a spacecraft, lander, or rover for exploration. Radioisotope Power Systems (RPS) offer the technical advantage of a small size and long life, and the proposed SRSC-based solution is the most efficient, practical power convertor available for RPS. The proposed development of a matching flight controller will enable RPS-based missions to Mars, Venus, Jupiter, Europa, Saturn, Titan, Uranus, Neptune, the moon, asteroids and comets.

Potential Non-NASA Applications (Limit 400 characters):

WCS anticipates commercial applications for essentially the identical technology to emerge gioven the increasing private interest in moon, asteroid, and other planetary exploration missions.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S16.03-2187**

SUBTOPIC TITLE: Guidance, Navigation, and Control

PROPOSAL TITLE: Ultra-Low Noise Inertial Sensor Operating at Exceptional Point

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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Address: **4425 Fortran Drive, CA 95134 - 2300**
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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):

IFOS proposes an innovative approach to demonstrate enhanced inertial sensing with ultra-low-noise performance. In conventional ring laser gyros, precision increases with cavity size and measurement time. However, by exploiting Exceptional Points (EP) in coupled resonators, an enhanced gyro sensitivity can be achieved without having to increase size or measurement time, thereby extending the time for standalone spacecraft navigation. This new performance-enhancing principle therefore offers the promise, for the first time, of a chip-scale gyroscope photonic integrated circuit (PIC) platform with precision inertial navigation potential with all the benefits of integration, resulting in a monolithic sensor that is robust and resistant to shock. In Phase I, IFOS and Stanford University will analyze expected performance and limitations of a laser gyroscope that operates at an EP. In Phase II, we will design, fabricate, and characterize an EP gyro to produce a prototype of a chip-scale gyroscope with inertial navigation noise and drift performance. IFOS is working with aerospace primes for accerlated infusion. Beyond spacecraft GNC, the increased precision of the EP-enhanced gyro also opens new science possibilities such as measurements of fundamental physical constants, improving the sensitivity-bandwidth product for gravity wave detection, and tests of general relativity.The IFOS innovation

is applicable to commercial aerospace and maritime navigation, intelligent transportation, medical robotics, and subsurface energy prospecting.

Potential NASA Applications (Limit 550 characters):

NASA applications include CubeSats/SmallSats, ISS payloads, and flagship missions. Beyond spacecraft GNC, the increased precision of the EP-enhanced gyro also opens new science possibilities such as measurements of fundamental physical constants, improving the sensitivity-bandwidth product for gravity wave detection, and tests of general relativity.

Potential Non-NASA Applications (Limit 400 characters):

The IFOS innovation is applicable to commercial aerospace and maritime navigation, intelligent transportation, medical robotics, and subsurface energy prospecting.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S16.07-1860**
SUBTOPIC TITLE:	Cryogenic Systems for Sensors and Detectors
PROPOSAL TITLE:	Miniature 2-Stage 20K Cryocooler

Small Business Concern

Firm: **Wecoso, INC**
Address: **17682 Gothard Street, Suite 2021, Huntington Beach, CA 92647**
Phone: **(714) 222-0424**

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):

West Coast Solutions (WCS) and the Georgia Institute of Technology (GT) propose development of a Miniature 2-Stage Hybrid (M2H) Cryocooler in response to Topic S16.07, Cryogenic Systems for Sensors and Detectors. 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 low impedance regenerator designs in combination with efficient linear motors operating at high frequency relative to other 20K systems. Based on initial modeling results, the WCS M2H Cryocooler will weigh less than 1.75 kg while simultaneously providing a minimum of 100 milliwatts of net refrigeration at 20K and 2 Watts of refrigeration at 100K. The projected input power is ~40 WAC while operating in a 300K heat rejection environment, which translates to 13.8% of Carnot efficiency. Operation with this level of efficiency at a temperature as low as 20K is unique in the realm of linear cryocoolers, and to our knowledge there are no comparable coolers available or even in development.

Potential NASA Applications (Limit 550 characters):

The proposed effort is in response to NASA's stated need for a compact, high efficiency, low vibration cryocooler capable of providing two stages of cooling at 20 K (detector) and 80 to 120 K (local oscillator / optics) for high resolution spectrometers. With the cold tip achieving temperatures as low as 20K, benefitting detector technology also well enveloped the most commonly used HgCdTe LWIR detectors as well as other longwave detector technology, such as the quantum well infrared photodetector (QWIP).

Potential Non-NASA Applications (Limit 400 characters):

The most probably near term non-NASA applications would be for the Department of Defense (DoD) using similar detector technology for their specific missions, such as Intelligence, Surveillance, and Reconnaissance (ISR) from space, as well as potentially Ballistic Missile Defense (BMD).

Duration: **6**

PROPOSAL NUMBER: 23-1- **S16.08-1120**

SUBTOPIC TITLE: Atomic Quantum Sensor and Clocks

PROPOSAL TITLE: Spectroscopy-grade lasers and PICs operating around 689 nm

Small Business Concern

Firm: **Nexus Photonics, LLC**

Address: **6500 Hollister Avenue, Suite 140 , Goleta, CA 93117**
Phone: **(805) 895-4733**

Principal Investigator:

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E-mail: **komljenovic@nexusphotonics.com**
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Business Official:

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Phone: **(805) 895-4733**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters):

We propose to expand Nexus proprietary heterogeneous SiN based platform to include spectroscopy-grade lasers and PICs operating around Sr relevant wavelength in a wafer-scale process.

Potential NASA Applications (Limit 550 characters):

Advanced heterogeneous integration enables maximum improvement in size, weight, and power (SWaP) and cost reduction while improving the performance of science instruments, subsystems, and components utilizing visible optical sources. PIC technologies are particularly critical for enabling small spacecraft platforms, rovers, and wearable/handheld technology for astronauts as complex photonic functionality can be integrated into a chip.

Potential Non-NASA Applications (Limit 400 characters):

The proposed platform is applicable to multiple market verticals including augmented reality/virtual reality, healthcare, and sensing enabling us to leverage all these markets to push for commercialization while supporting NASA programmatic needs

Duration: **6**

PROPOSAL 23-1- **S17.01-2320**

NUMBER:

SUBTOPIC TITLE: Technologies for Large-Scale Numerical Simulation

PROPOSAL TITLE: Rapid Data Analytics Platform using Machine Learning

Small Business Concern

Firm: **RNET Technologies, Inc.**
Address: **5335 Far Hills Avenue, Dayton, OH 45429**
Phone: **(937) 433-2886**

Principal Investigator:

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Business Official:

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Phone: **(937) 433-2886**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters):

NASA's collection of observational and experimental data has undergone a revolutionary change in recent years. The ever-expanding breadth and fidelity of these scientific datasets have allowed NASA scientists to tackle real-world physical problems in unprecedented ways. While the high-fidelity data generated at NASA is a valuable resource for research and scientific exploration, it also presents a number of challenges, the most significant of which is the sheer volume and complexity of the data, which includes information from sources such as satellites, telescopes, spacecraft, and numerical simulations.

In this proposal, we introduce a cutting-edge data analytics platform that uses a novel dimensional reduction algorithm to promote optimal use of NASA's growing collection of scientific data. Preliminary results show that when applied to a 2.2TB turbulent flow dataset our platform's novel algorithms yield a 60-1000x reduction in download and storage costs and a 10-

1000x reduction in computational costs, depending on the desired accuracy in the solution.

Potential NASA Applications (Limit 550 characters):

NASA generates vast amounts of data through its missions, and it needs advanced analytics tools and techniques to manage and analyze this data. Some NASA missions and applications requiring extensive analytics of scientific data include the Mars Curiosity mission, the NASA Solar Dynamics Observatory and the Webb Space Telescope (58GB/day), and the numerous earth science and climate modeling missions. The huge amount of CFD simulation data generated at NASA is also a prime candidate for optimized data analytics using our platform.

Potential Non-NASA Applications (Limit 400 characters):

The target data for this platform is simulation data extracted from high fidelity numerical simulations and scientific data extracted from high profile experiments. Some of the many sectors developing such data include finance, transport, energy. automotive, and healthcare. Example companies and organizations include Lockheed, SNL and AFRL.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S17.02-1005**

SUBTOPIC TITLE: Integrated Campaign and System Modeling

PROPOSAL TITLE: Materials Modeling Hub: Interoperable and Collaborative Multi-Scale Modeling Ecosystem for Data Analysis, Visualization, and Management

Small Business Concern

Firm: **Materials Data Management, Inc.**
Address: **3202 North Meridian Street, Indianapolis, IN 46208**
Phone: **(317) 708-4969**

Principal Investigator:

Name: **Mr. Thomas Searles**
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Address: **3202 N Meridian St., IN 46208 - 4646**
Phone: **(317) 708-4969**

Business Official:

Name: **Mr. Peter Searles**
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Address: **3202 N Meridian St., IN 46208 - 4646**

Phone: **(317) 489-9094**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters):

Materials Modeling Hub (MMH) software integrates modeling, product design, manufacturing, and usage cycle into a digital ecosystem to accelerate, simplify, and strengthen ideation through implementation. When combined with a viable materials information management strategy, modeling techniques can replicate and predict experimental outcomes and material performance with growing accuracy. In industries where production costs are high and performance is critical, benefits of modeling can be seen over the entire product lifecycle, advising design and processing preproduction to significantly reduce development cost and time-to-market. The value of modeling is irrefutable, and researchers continue to produce an influx of new modeling algorithms. However, challenges in standardizing usage, understanding limitations, and managing data hinder use. While some large organizations have designed tools to meet limited and highly specialized needs, the complex nature of modeling deters many organizations altogether. With a void in commercial software that can automate and simplify modeling and data storage processes, few organizations fully leverage modeling technology.

MMH has been designed to fill this void. At the close of Phase 1, prototype software, refined through external testing and collaboration, will offer an adaptive, interoperable, traceable, and scalable solution that not only supports both physics and AI-based models through basic plug-in-play functionality, but also their integration to offer a multiscale solution. Here, experimental and virtual data can be seamlessly and dynamically used to improve modeling fidelity and afford AI deep learning. MMH forwards NASA goals of addressing interoperability challenges and improving the accessibility of data and analysis tools to drive collaboration and advance modeling technologies. As a result, MMH will directly augment research within NASA's Materials and Structures Division and significantly further NASA's 2040 Vision.

Potential NASA Applications (Limit 550 characters):

MMH Modeling software will support NASA-developed MAC/GMC and Machine Learning Surrogate models to directly augment broad materials research, in particular within NASA's Materials and Structures Division. Further, MMH's database integration leverages NASA's past and ongoing efforts within the Material Data Management Consortium and at Glenn Research Center, where a database schema to support modeling data is under development. Employing this schema within the MMH will allow immediate and significant NASA impact and further their 2040 Vision

Potential Non-NASA Applications (Limit 400 characters):

MMH standardizes, automates, and integrates modeling analysis and data management, simplifying the complex processes that inhibit widespread industry adoption. By streamlining modeling implementation, organizations at all scales can improve development costs, productivity, traceability, time-to-market, and more. Until now, few have fully leveraged these tools, but MMH makes innovation accessible.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z1.05-1674**

SUBTOPIC TITLE: Lunar and Planetary Surface Power Management and Distribution

PROPOSAL TITLE: Low Mass, High Voltage Cables for Long Distance Lunar Power Distribution

Small Business Concern

Firm: **Astrobotic Technology, Inc.**
Address: **1016 North Lincoln Avenue, Pittsburgh, PA 15233**
Phone: **(412) 682-3282**

Principal Investigator:

Name: **Evan Williams**
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Address: **1016 North Lincoln Avenue, PA 15233 - 2132**
Phone: **(412) 682-3282**

Business Official:

Name: **Mike Provenzano**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 6
Technical Abstract (Limit 2000 characters):

One of the greatest challenges with large scale power systems is the ability to transmit power over long distances while minimizing inefficiencies and loss. Just as it is on Earth, the most effective method of long-distance lunar power transfer will involve installation of cables for high voltage power transfer. However, unlike Earth, lunar cable installation systems will face extreme environments filled with harsh, abrasive dust, and must be optimized for robotic deployment. There is no existing solution for this capability gap to date. Consequently, Astrobotic proposes to develop a novel lightweight and high voltage cable along with a dust tolerant cable deployment system to enable the installation of long-distance power transmission lines on the lunar surface. These subsystems are comprised of 10kVDC and 10kW cabling that can span up to 4 km as

well as a reel that can be mounted to diverse spacecraft such as landers, large rovers, and Vertical Solar Array Towers.

Astrobotic, as a developer of VSAT has a vested interest in developing scalable power infrastructure on the Moon's surface to support the future electrical needs of habitats, ISRU plants, rovers and vehicles, and other critical Artemis technologies. Therefore, the proposed cable and reel system will be designed with dust tolerant components and prioritize a robust, scalable architecture capable of interfacing with a wide range of surface technologies, and deployment from a multitude of spacecraft.

Potential NASA Applications (Limit 550 characters):

Power distribution and management is one of the three core facets highlighted in Technology Taxonomy area 3 and specifically states that high-voltage power distribution technologies are sought to advance missions for the coming decades. Low mass, high voltage cables are the ideal power distribution solution to support a global power grid infrastructure on the Moon. Multiple VSAT and fission surface power nodes could be interconnected with long distance cabling solutions to provide continuous power across the poles of the Moon.

Potential Non-NASA Applications (Limit 400 characters):

The cable and reel proposed here are critical enabling technologies of Astrobotic's lunar power grid, LunaGrid, which will allow companies like Astrobotic to offer lunar "Power as a Service." Astrobotic will use this power for its own landers and rovers and sell it to other lunar lander and rover providers within the Commercial Lunar Payload Services (CLPS) program, a $300M annual market.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z2.01-2398**

SUBTOPIC TITLE: Spacecraft Thermal Management

PROPOSAL TITLE: High Temperature Oscillating Heat Pipe Transport System

Small Business Concern

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

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters):

High temperature heat acquisition and transport is a critical technology gap inhibiting full implementation of nuclear energy propulsion (NEP) and power sources for NASA inter-planetary and Lunar Surface missions. Nuclear energy thermal management requires acquisition and transport of 4-10MW of power at 1200-1400K; the target axial heat flux is 1.0MW/m^2. Furthermore, NASA requires candidate technologies to transport heat 5-10 meters with a temperature drop below 150K. ThermAvant Technologies (TAT) proposes to develop an Oscillating Heat Pipe (OHP)-based structurally integrated long distance high-temperature heat acquisition and transport device to meet this crucial need. TAT will conduct an extensive performance and validation test program to quantify OHP manufacturing and operating metrics, and quantify advances over the current state of the art (SOTA). The OHP is an emerging innovative thermal management device which has proven to be size, weight and power consumption and cost (SWaP-C) competitive for a number of heat flux acquisition and transport aerospace applications.

In view of SBIR Phase 1 program and resource constraints, TAT will develop proof of concept hardware fabricated from Inconel tubing - charged with sodium, potassium, or a sodium/potassium eutectic mixture to demonstrate and quantify OHP technology capabilities, see Figure 1. We expect to achieve the following analytical and performance innovations:

- Acquire and transport heat at 1300K a distance of 3 meters *(>10X further than current SOTA OHP)*
- Demonstrate axial heat flux greater than 1MW/m^2, with target temperature drop less than 150K
- Extend and validate limits of operation to long transport configurations
- Experimentally validate OHP performance map in Q vs. T operational space
- Assess candidate OHP designs for Phase II hardware
- Recommend Phase 2 OHP based high-temperature heat acquisition and transport design

Potential NASA Applications (Limit 550 characters):

NASA requires significant improvements over the state-of-the-art high temperature heat acquisition and transport to meet its ambitious Inter-planetary and Lunar Science portfolio. NASA requirements are up to acquire up to 10 MW of heat (heat flux up to 1MW/m^2) at 1200K to 1400K and transport the heat over 5 meters with temperature drop no greater than 150K. The most significant near to mid- term mission infusion points are:

- Nuclear Electric Propulsion (NEP)
- Lunar Surface Nuclear Power Systems
- Planetary Exploration Missions

Potential Non-NASA Applications (Limit 400 characters):

Acquisition, spreading, transport and rejection of high flux high temperature heat are significant thermal issues facing government and commercial applications.

- Nuclear power thermal management to meet high efficiency and clean energy needs
- High Temperature Electronics and Power Electronics
- Management of incident high energy at arbitrary locations (high heat flux strikes)

Duration: **6**

PROPOSAL NUMBER:	23-1- **H9.03-1069**
SUBTOPIC TITLE:	Flight Dynamics and Navigation Technologies
PROPOSAL TITLE:	Contingency Analysis for Low-thrust Missions (CALM)

Small Business Concern

Firm: **Advanced Space, 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):

In response to the 2023 NASA SBIR solicitation subtopic H9.03, “Flight Dynamics and Navigation Technologies”, Advanced Space, LLC proposes to develop a mission design and planning tool that uses operational algorithms to mitigate the impact of anomalies and missed thrust events for low-thrust and dynamically sensitive missions. The software tool is an extension of the Virtual Swarm Method (VSM) for low-thrust trajectory optimization to maximize the missed-thrust recovery margin. The tool will be used to generate a multitude of spacecraft trajectories simultaneously to determine the worst-case scenarios to account for margins in the mission design. The results will provide trajectories, thrust arcs from failure modes, inform mass and propellant margins, and contribute to mission risk analysis. The proposed solution will be especially useful to future crewed Artemis missions to reduce mission risk more comprehensively. The proposed solution is named CALM or Contingency Analysis for Low-thrust Missions.

Typical low-thrust spacecraft trajectory optimization consists of defining a nominal solution that obeys known constraints and minimizes the spacecraft propellant mass used. A major deficiency with these traditional methods is that it is difficult to incorporate missed thrust events, spacecraft failure modes, or other mission-specific anomalies in the mission planning phase. Experienced engineers use intuition and guesswork to manually arrive at solutions that are robust to failure modes, but this ad-hoc approach typically comes at the expense of the time it takes for trajectory optimization. There is no industry standard to account for anomalous activities or failure modes for low-thrust and dynamically sensitive missions. CALM aims to address this specific deficiency in the mission planning process.

Potential NASA Applications (Limit 550 characters):

Applications with NASA include interplanetary and deep-space science missions to enable low-thrust trajectory optimization at the mission planning stage. This also includes future low-cost missions to the Moon using Ballistic Lunar Transfers (BLTs) where fuel budgeting is paramount. Additionally, as Electric Propulsion gains market adoption for civil missions, highly efficient data collection is necessary to maximize mission lifespan and reduce mission risk.

Potential Non-NASA Applications (Limit 400 characters):

This technology can be extended to the commercial satellite markets for coordinated constellations in high-Earth orbits and beyond to help the mission planning stage. Specifically, the team will target Missions of Opportunity (MOOs) with the external support of the technology. Additional benefits to non-NASA missions include the USGS Landsat, NSF satellites, and NOAA satellites.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H9.08-2262**

SUBTOPIC TITLE: Lunar 3GPP Technologies

PROPOSAL TITLE: 5G-MOSAIC: 5G Mission-Critical Sidelink for Autonomous and Interoperable Communications in Lunar Networks

Small Business Concern

Firm: **EpiSys Science, Inc.**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 6
Technical Abstract (Limit 2000 characters):

NASA's lunar missions require innovative technologies to support increasing data volumes and performance enhancements of communication systems. 5G technology can provide the required support, but mission-critical and suit-to-suit communication necessitates the use of 5G Sidelink (SL). EpiSci and the Worcester Polytechnic Institute propose 5G-MOSAIC, a 5G Mission-Critical Sidelink for Autonomous and Interoperable Communications in lunar networks. 5G-MOSAIC aims to enable high-reliability and low-latency communication among mission-critical and autonomous applications in the lunar environment. It includes an infrastructure-less mode with multi-hop capabilities, as well as a multi-protocol solution to enhance communication capabilities.

5G-MOSAIC will be developed by implementing and integrating 5G SL features into OAI to produce 5GEM-SL, an OAI-based 5G emulation testbed with full SL features. Next, 5GEM-SL will be customized for lunar environments, missions, and applications. This includes a development of a lunar channel model for 5GEM-SL. The resulting testbed, 5GEM-SL-LN, will be demonstrated for representative lunar missions under various mobility scenarios and traffic loading conditions. The tool will include document with roadmap toward hardware prototype implementation for Phase II. Finally, we will design and demonstrate an AI-based 5G planning and predictive analytics tool called 5G-ANATOMY, capable of automating mission planning including 5G SL parameter configuration and resource optimization for a wide range of lunar missions. This tool utilizes AI to predict the LN performance or mission quality based on scenario configuration parameters including HW/SW parameters. Through 5G-ANATOMY, LN mission designers can quickly determine key system parameters required for a particular lunar task as well as identify necessary edge computing components to achieve desired performance. The resulting 5G-MOSAIC will be available as open source to foster collaboration.

Potential NASA Applications (Limit 550 characters):

5G-MOSAIC technologies, when fully developed and demonstrated, will offer commercially viable, cost-effective 5G SL solutions to meet the specific requirements of mission-critical communication scenarios, such as those encountered in lunar environments where connectivity can be limited or intermittent for future space missions, such as Artemis. Also, they will substantially reduce the operational complexity for mission engineers by automating various tasks of planning, scheduling and managing 5G communication resources across multiple assets.

Potential Non-NASA Applications (Limit 400 characters):

Space-based broadband internet services demand terrestrial-grade service quality despite many spacecraft participating in data forwarding through emerging 5G technologies. We expect 5G-MOSAIC to further advance such systems by seamlessly allowing the addition of new 5G SL communication assets on the moon with significantly reduced planning. DoD will also greatly benefit for tactical applications.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S12.01-1848**
SUBTOPIC TITLE:	Exoplanet Detection and Characterization Technologies
PROPOSAL TITLE:	Next Gen Components for Exoplanet Detection and Characterization Technologies

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 6
Technical Abstract (Limit 2000 characters):

Diffraction control masks known as apodizers are key components required for high contrast imaging and Exoplanet observations. The SBIR firm has taken ultradark carbon nanotube (CNT) coatings from a laboratory curiosity to an enabling technology for stray light control by applying the CNT to apodizers. Delivered prototype components have achieved 1.8E-9 monochromatic contrast in the JPL test bed. The development of apodizer mirrors has required new processes that survive high temperatures and caustic gases including a) low surface figure substrates b) high efficiency reflective coatings c) dark precise CNT growth. Challenges remain, since the ultimate goal is to achieve broad band contrast of 10E-10 for exoplanet coronagraphy envisioned in flagship missions such as LUVOIR. Small flaws in the coating of the apodizers will eventually impact coronagraphy. Current CNT formulations achieve about 0.3% hemispherical reflectance (HR) higher than the 0.1% HR goal. Key goals are to develop a high efficiency reflective coating with minimal inclusions compatible with our substrate and CNT growth process. Secondly, we will decrease the nanotube HR from 0.3% to 0.1% and demonstrate near ideal pseudo-grayscale patterning of nanotubes. Characterization of the apodizers has been performed by measuring witness samples for specular reflection (SR), HR of nanotubes and surface figure. Enhanced characterization will be performed by measuring HR of reflective coatings, SR of the CNT and direct characterization of surface figure. The last two of these are problematic due to the low reflectance of CNTs and the challenge of acquiring figure of apodizers with high density CNT patterning. The final objective is to design methods for enhanced characterization for Phase II and implement a near angle SR capability in Phase I. Phase II will include a characterization capability using high resolution phase mapping to characterize optical density and phase inhomogeneity apodizers.

Potential NASA Applications (Limit 550 characters):

Patterned CNT apodizers are enabling technology for high contrast imaging such as required for Exoplanet observations. The technology is also applicable for use on telescopes used in duplex such as Laser Interferometer Space Antenna (LISA), which requires extreme isolation between the transmit laser and the dim received beam. Deep space laser communications will use telescopes in duplex and have to deal with the same type of isolation of the received beam which can be millions of times dimmer than the transmit beam.

Potential Non-NASA Applications (Limit 400 characters):

Apodizers can be used in optical systems operating in high contrast environments such as experienced by autonomous driving systems and military imaging systems. CNT can mitigate stray light in nearly any type of optical instruments. Patterned CNT are being evaluated for use in art and fashion and may be used for high-end watch faces and jewelry.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S12.01-2589**

SUBTOPIC TITLE: Exoplanet Detection and Characterization Technologies

PROPOSAL TITLE: Ultra-high resolution integrated arrayed waveguide spectrometer with reusable delay lines for exoplanet detection

Small Business Concern

Firm: **New Integration Photonics**
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Phone: **(301) 367-9297**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 5
Technical Abstract (Limit 2000 characters):

New Integration Photonics, Inc., is proposing to develop an ultra-high resolving power (R>150,000) spectrometer based on arrayed waveguide gratings (AWGs) on a Si_3N_4/SiO_2 photonic integrated chip (PIC). The spectrometer implements a reusable delay line (RDL), replacing the large number of waveguides in the traditional AWG, which significantly reduces the size and increases the stability of the chip. This high-resolution integrated spectrometer can be used in the detection of exoplanets based on the Precision Radial Velocity (PRV) method. The proposed photonic chip has three unique advantages to significantly improve the performance of the traditional spectrometer and increases the feasibility of chip fabrication. 1.By reducing the number of waveguides to just one, and coupling the power from single waveguide to achieve the correct power and phase distributions, the new technique eliminates the need for making large AWGs and the associated step of actively compensating the phase error. The footprint of the spectrometer can be potentially reduced by a factor of more than 100. 2. A parabolic taper will be implemented instead of a linear taper before the free propagation region (FPR) to reducing the

cross-coupling, and thus the phase distribution error. 3. The photonic chip will be directly coupled to a 1-D CCD array in Phase II. To achieve this, a three-stigmatic-points compensation approach is proposed for the RDL-AWG design to realize a flat focal-plane at the output of the free propagating region. It also improves the accuracy and the uniformity of the RDL-AWG and compensates for the aberration.

Potential NASA Applications (Limit 550 characters):

A successful completion of Phases I and II would allow the Company to claim to have realized a high resolving power integrated spectrometer. This will lead to a very compact instrument that can potentially be used in many NASA related projects. This can include sensors, lidar, laser ranging, medical and health applications. The Company will pursue opportunities with NASA for infusion in future NASA missions (including exoplanet detection).

Potential Non-NASA Applications (Limit 400 characters):

Currently, the biggest market for on-chip spectrometers is academic labs. On-chip spectrometers may also find important applications for on-field geological measurement for mining or oil & gas. On-chip spectrometers might also find some interesting applications in pharmaceutics, food & beverages, agriculture, environment testing, medical point-of-care, consumer, and etc.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S12.03-1867**

SUBTOPIC TITLE: Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical to Mid/Far-Infrared Telescopes

PROPOSAL TITLE: Elastic Emission Machining of Substrates for EUV, Optical, and Infrared Optics

Small Business Concern

Firm: **OptiPro Systems, LLC**
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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):

Diffraction limited, low cost, and low weight mirror systems are required to enable and enhance telescopes for missions of all sizes, from CubeSats to Flagship missions. These missions also vary in their operating wavelengths from ultraviolet to far-infrared. With this wide range of sizes and operating wavelengths, a solution that is applicable to any size and material is necessary, capable of the following performance goals:

1. Mid-spatial frequency errors (6 – 60 cycles per aperture (CPA)) <5nm RMS
2. High-spatial frequency errors (>60 CPA) <1.5 nm RMS
3. Micro-roughness <0.5nm RMS

A methodology that OptiPro has recently employed can achieve these tolerances and is scalable for any size of optic: Elastic Emission Machining. EEM is a chemical polishing method, which causes low-energy collisions to occur between particulates and a substrate. These collisions cause chemical reactions whereby the particles become chemically to the surface atoms. The fluid, in which the particles are immersed, is accelerated to flow, and produces a sheering force on the bound particle, which pulls it – and its attached substrate atom – from the substrate, producing an atomic-level machining operation. This process does not damage the atomic lattice structure, allowing for no sub-surface damage. With the material being removed from the surface by the particulate, a Beilby layer is not allowed to form over the optical surface. This technology has been demonstrated on Silicon, and during this Phase I we will demonstrate the process on Ultra Low Expansion glass (Corning Incorporated) and Zerodur (Schott AG).

The other aspect of this project which OptiPro will demonstrate is the mitigation of mirror support print through on light-weighted mirrors. Support print through is a problem with light-weighted mirrors where the support structures are apparent in the mirror surface, due to a few factors which we believe EEM could solve, with its highly stable removal rates and low force for polishing.

Potential NASA Applications (Limit 550 characters):

With the capability to manufacture ULE and Zerodur optical components to the diffraction limit, NASA will be able to ensure that their telescopes, CubeSats, and Flagship missions have highest opportunity for success, enabling and enhancing future systems. OptiPro's Elastic Emission Machining Platform, with the success of this proposed SBIR project, will be capable of manufacturing any light-weighted optical component, made of Silicon, ULE or Zerodur, to the diffraction limit of their operating wavelength.

Potential Non-NASA Applications (Limit 400 characters):

EEM has proven its capabilities on diffraction limited Silicon polished for use in the Department of Energy's Synchrotron and Linear X-ray accelerators, which also use Zerodur and ULE in their beamline systems. Extreme Ultraviolet Lithography systems also use Zerodur and ULE in their systems and with the ever-growing need for microchips, more efficient and accurate optics are needed.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S12.03-1871**

SUBTOPIC TITLE: Advanced Optical Systems and Fabrication/Testing/Control Technologies for Extended-Ultraviolet/Optical to Mid/Far-Infrared Telescopes

PROPOSAL TITLE: Ultrahigh Precision CTE Measurements

Small Business Concern

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Poor CTE homogeneity can impact the performance of a telescope in at least two ways. First, if the CTE and/or the homogeneity of the CTE of a mirror blank exceeds known design parameters, then the resulting mirror will simply be unusable. Knowing the CTE and/or the homogeneity of the CTE of a mirror blank can therefore be used as a screening tool such that CTE-poor blanks are not machined and polished into mirrors only to be discarded after discovering the finished mirror does not perform well over temperature. Secondly, since a mirror may be manufactured at one temperature, say 300K, and operated at or undergo temperature swings during operation. While corrective measures exist, they still are a function of the mirror substrate's CTE homogeneity. This is why it is extremely important to discover these

inconsistencies and defects early in the manufacturing process. In this proposal, we will outline our system to non-destructively test a 100mm sample of low CTE material, with the intention of scaling it up to much larger sample sizes to accommodate the need to test 4m diameter blanks prior to machining

Potential NASA Applications (Limit 550 characters):

Ability to non-destructively screen low CTE mirror blanks for defects

- scalable to include extremely large test-pieces
- expected accuracy ranges of the parts per billion level
- resulting in significant cost reduction in labor and materials

This scalable non-contact metrology process is intended for use on telescope mirrors for the HabEx and UVOIR missions. Furthermore, the CTE measurement system will eliminate the uncertainty that a mirror will not suffer from CTE-related issues when in use.

Potential Non-NASA Applications (Limit 400 characters):

- Ability for manufacturers to non-destructively test low CTE materials for defects prior to manufacturing. They may also choose to market the products as "individually tested".
- Consumers of low CTE materials may want to test them prior to processing, saving the time and cost of manufacturing a defective piece of raw material.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S12.06-2656**
SUBTOPIC TITLE:	Detector Technologies for Ultraviolet (UV), X-Ray, and Gamma-Ray Instruments
PROPOSAL TITLE:	Defect-controlled AlGaN APDs for UV photon counting and space exploration

Small Business Concern

Firm: **Adroit Materials**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 6
Technical Abstract (Limit 2000 characters):

The proposed work aims to demonstrate significant improvement in AlGaN-based detectors and detector arrays by employing single crystal AlN substrates, which practically eliminates leakage induced by screw dislocations. By employing defect controlled APDs on single crystal AlN, we aim to demonstrate sensitivity over the whole UVC range (120 - 275 nm) while being solar and visible blind. We will provide APDs and their arrays of varying pixel resolution and pixel size capable of Geiger mode operation and photon counting. The detectors will be capable of elevated temperature operation allowing for extreme environment operations in places such as Venus. In addition, we also aim to demonstrate low dark currents at high linear gains by point defect control. We aim to demonstrate AlGaN-based photon counters with low dark counts and sensitivity only in the UVC range (< 275 nm) with solar and visible spectrum rejection, quantum efficiency exceeding 70%, high multiplication gain exceeding E6, and low dark current. During Phase I we will demonstrate Geiger mode operation and photon counting with >TRL 3. In a possible Phase II, we will extend our efforts and will have achieved TRL 6.

Potential NASA Applications (Limit 550 characters):

Development of solar blind UV APDs will enable various technologies that advance space exploration and observation. Venus exploration missions such as VERITAS and DAVINCI require spectrophotometers in the UV spectral range that are capable of withstanding the extreme environment of the planet. AlGaN based photodetectors would enable long-term operation with higher reliability in a hot and corrosive environment while exhibiting lower voltages, lower volume and lower weight and excellent solar spectrum rejection.

Potential Non-NASA Applications (Limit 400 characters):

A potential commercial application of the developed photon counters is bio-chem detection systems based on compact Raman spectroscopy. Real-time, on-site, ultra-sensitive detection of harmful bio and chemical agents requires a solar blind UV photon counter. Raman spectroscopy in the proposed 240-260 nm range is needed to avoid potential fluorescence of specimen.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S13.01-1823**

SUBTOPIC TITLE: Robotic Mobility, Manipulation and Sampling

PROPOSAL TITLE: Bulk Metallic Glass Planetary Gearboxes for Cryogenic, Unlubricated Spacecraft Applications

Small Business Concern

Firm: **Amorphology, Inc**
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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):

In this Phase I SBIR program, Amorphology proposes to develop, characterize and test an unlubricated (and also dry lubricated) two-stage planetary gearbox (22 mm, two-stage, 19:1 reduction ratio) fabricated using bulk metallic glass (BMG) planet gears, pinon gears, and sun gear. The gearbox will be characterized without liquid lubrication compared to a steel and plastic version and then life-tested at -50C under a variety of torques, speeds and operating conditions. Amorphology currently develops BMG gear technology for various applications, where unlubricated operations, low-cost manufacturing through injection-molding technology, and high-precision gears offer new actuator capabilities in the aerospace industry, the medical device industry, the food service industry, and various robotic applications.

Potential NASA Applications (Limit 550 characters):

Potential NASA applications include any mission identified in NASA's newly released Planetary Decadal Survey, for example, those to comets, asteroids, Enceladus, Titan, Mars and Earth’s moon where there is a combination of cryogenic temperature, high-vacuum conditions, dust, and extreme environmental conditions that require the development of new technology for mobility, manipulation, and sampling.

Potential Non-NASA Applications (Limit 400 characters):

Potential non-NASA applications include any precision gearing application that could benefit from not requiring lubrication/grease, for example, certain applications for robotics, medical devices, food manufacturing/service, drones/UAVs, aerospace, and automotive.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S13.03-2542**

SUBTOPIC TITLE: Extreme Environments Technology

PROPOSAL TITLE: Radiation-Hardened Wide-Temperature Mixed-Signal Library in a 22nm FDSOI CMOS Process

Small Business Concern

Firm: **Alphacore, 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):

The solicitation topic S13.03 indicates NASA's need to develop technologies for producing space systems that can operate without environmental protection housings in the extreme environments of NASA missions. Key performance parameters of interest are survivability and operation under the following conditions: 1) Very low temperature environments (e.g., temperatures as low as -180 °C, for several NASA missions); 2) Combination of low temperature and radiation environments (e.g., surface conditions at Europa of -180 °C with very high radiation).

In response to these needs, Alphacore proposes to design and characterize an innovative radiation-hardened mixed-signal (analog & digital) library that is capable of operating at a wide temperature range which covers cryogenic temperatures (-230 °C to +85 °C). The radiation hardness includes total ionizing dose (TID) of 300krad(Si), immunity to single event latchup and functional interrupt (SEL and SEFI), and low single event upset (SEU) rate.

Alphacore's proposed mixed-signal library includes <u>three key components to any mixed-signal SoC, or ASIC</u>: a phase locked loop (PLL), an analog-to-digital converter (ADC) and a digital-to-analog converter (DAC), to be implemented in the GlobalFoundries (GF) 22nm fully depleted silicon-on-insulator (FDSOI) CMOS process (22FDX).

The 3-item mixed-signal library is not the only deliverable in this program, Alphacore will also develop a <u>set of design guidelines for the 22FDX process</u> that space mission IC designers can use to achieve both radiation-hard and highly reliable low-temperature capable systems. The guidelines will include biasing (VDD, back bias) and layout rules which mitigate deleterious effects, such as hot carrier degradation and TID. Alphacore will also develop <u>simulation models that include both TID models and low temperature models</u>. These models can be used in most common design flows.
Potential NASA Applications (Limit 550 characters):

With Alphacore's rad-hard mixed-signal library, designers can develop lightweight, high-efficieny electronics and deliver advanced capabilities for next-generation missions to planets, asteroids and comets in deep space, all without the need for heavy protective housing in high radiation and wide temperatures conditions. Future NASA missions that could benefit from this component include Europa Lander, missions to Saturn moons like Titan and Enceladus, along with the Moon-to-Mars program and the Origins Space Telescope
Potential Non-NASA Applications (Limit 400 characters):

Alphacore's rad-hard mixed-signal library can expect to enjoy significant demand in the defense sector (e.g., U.S. Space Force, hypersonic missile defense, space-based intelligence, surveillance, and reconnaissance). The commercial space market it growing as well, driven by increased government collaboration and funding, which in turn will push demand.
Duration: **6**

PROPOSAL NUMBER:	23-1- **S13.04-1563**
SUBTOPIC TITLE:	Contamination Control and Planetary Protection
PROPOSAL TITLE:	Efficient Surface Microbial Reduction on Hardware Using Polymers

Small Business Concern

Firm: **Photonic Cleaning Technologies, LLC**

Address: **1895 Short Lane, Platteville, WI 53818**
Phone: **(608) 770-0565**

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):

Key NASA technology gaps in sampling and bioreduction address recommendations in the 2013 Planetary Science Decadal Survey, the Space Biology Science plan, & the 2019 Planetary Protection (PP) Board Report. We will develop facile efficient PP methods compatible with spacecraft materials and assemblies using peelable polymer coatings that remove biota and contamination rather than sterilize them. We hypothesize creating a family of paintable polymers for facile quantitative biological/biomolecular sampling, contamination reduction, isolation & femtogram DNA replication. The proposed innovation enables surface cleaning, bioburden reduction, sterilization, sampling, & cross-contamination prevention for spacecraft materials, components, and assemblies. Our films capture, store, & allow colonization of spores -promising a polymer-based microbiological archival storage from cleaned surfaces with order-of-magnitude increased sampling efficiency. These solutions impact bioburden control and elimination & control of forward & backward contamination. They also will significantly improve sampling devices & sample processing and analysis pipelines.

Our objectives are fourfold: Objective 1: Design and synthesize biocompatible designer polymers to lift and sequester biota and biomolecules. Objective 2: Using qPCR and spectrophotometric DNA quantification on our Nanodrop instruments, we will determine the trace DNA detection limits on recovery from glass surfaces using our polymer technology. Objective 3: Replication and verification of DNA Reduction from our preliminary data: Using qPCR and spectrophotometric DNA quantification, we will replicate and verify the initial data on DNA detection and recovery on surfaces. Objective 4: Replication and statistical analysis of reduction, sampling, recovery and isolation of spores on surfaces to confirm our preliminary results as preparation for Phase II with our samples of ISS bacteria and fungi we have from the JPL Space Biology Archive.

Potential NASA Applications (Limit 550 characters):

Our “apply, dry, and peel” polymers will allow surface-specific facile Planetary Protection (PP) methods for bioburden reduction, sterilization, sampling, and cross-contamination prevention; quantitative biological/biomolecular contamination reduction; and ultimately rendering important aerospace surfaces bio-contamination-free. This includes spacecraft materials, components, and assemblies. Additional potential applications include "space preparation" and PP- compliance of hard-to-clean structures such as bulk metallic glass (BMG) gears.

Potential Non-NASA Applications (Limit 400 characters):

Post-SBIR commercialization will focus on, e.g., medical, pharmaceutical, and scientific research markets, creating and maintaining sterile and bio-contamination-free surfaces, enabling isolation and femtogram DNA replication in forensics, and providing microbiological archival storage from cleaned surfaces with orders-of-magnitude increased sampling efficiency.

Duration: **6**

PROPOSAL NUMBER:	23-1- **S13.05-2629**
SUBTOPIC TITLE:	In Situ Instruments and Instrument Components for Planetary Science
PROPOSAL TITLE:	Remote X-ray Analyzer (ReXA)

Small Business Concern

Firm: **eXaminArt, LLC**
Address: **922 San Leandro Avenue, Suite G, Mountain View, CA 94043**
Phone: **(650) 799-2118**

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):

The proposed research targets the development of a Remote X-ray Analyzer (ReXA) using X-ray fluorescence (XRF) for geochemical analysis of planetary surface materials, to be fitted to rovers or landers. The instrument differentiates from current state-of-the-art planetary XRF spectrometers in that it will not rely on a robotic arm or other deployment mechanisms. Instead of being brought in contact with or in close proximity to the surface to be analyzed, it will operate from a sufficient distance to ensure safe ground clearance as a stationary system mounted inside the host platform, or hanging from its underside. This instrument will be particularly pertinent when fitted to a small rover lacking the robotic arm necessary for deploying a contact instrument.

This development targets space deployment in a short time frame following the SBIR completion, so we will focus our development on individual technologies already at high TRL, or that can be brought to TRL-5 within the SBIR.

ReXA will allow geochemical analysis of ground surface with no mechanism while ensuring a safe ground clearance to the platform.

Potential NASA Applications (Limit 550 characters):

This development will find NASA applications in landed missions to Mars, the Moon, Mercury, Small Bodies and in general any airless or low pressure atmosphere rocky or icy body. Derivative NASA applications would be as a material characterization instrument in an orbital laboratory on-board the ISS, or high performance small sized micro XRF instruments on Earth, for planetary analog field research, or as part of a remote analytical facility for confined samples inside a sample-curation glove-box, for instance for Mars Sample Return.

Potential Non-NASA Applications (Limit 400 characters):

The development of subsystems of the proposed instrument will open new opportunities to develop products for XRF and micro-XRF analyses, and enable new generations of element mapping instruments for cultural heritage and industrial applications.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S13.07-2316**

SUBTOPIC TITLE: Energy Storage for Extreme Environments

PROPOSAL TITLE: Radiation Hardened, Programmable Battery Analog Front-End ASIC

Small Business Concern

Firm: **Alphacore, Inc.**
Address: **304 South Rockford Drive, Tempe, AZ 85288**

Phone: **(480) 494-5618**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

In response to NASA's S13.07 SBIR Phase I solicitation for *Energy Storage for Extreme Environments*, Alphacore will develop a radiation-hardened, high accuracy Battery Analog Front-End (B-AFE) Application Specific Integrated Circuit (ASIC) that can implement low-noise, high dynamic range, low-offset offset-drift Coulomb Counting (CC), high precision temperature and terminal voltage measurement embedded with Electrochemical Impedance Spectroscopy (EIS). The B-AFE ASIC will be programmable and flexible to support various energy density (>200 Wh/kg and >200 Wh/l) and battery state estimation approaches.

The proposed radiation-hardened B-AFE ASIC will provide all necessary Analog-to-Digital interface and signal conditioning functions, providing several critical modeling parameters to a processing unit. The B-AFE ASIC will enable a processing unit to run various algorithms to compute and estimate a wide variety of the state of the art in State of Charge (SOC), State of Energy (SOE), State of Health (SOH), State of Power (SOP), State of Temperature (SOT), and State of Safety (SOS) estimation algorithms on an efficient computing platform, such as radiation hardened microcontrollers.

The B-AFE ASIC will provide the user with various programmability and scalability options, including sensing gain, ADC dynamic range, sampling-rate, and calibration options for DC offsets, noise, filtering bandwidths. The B-AFE ASIC will enable state estimation options for various primary cell chemistries, including lithium carbon fluoride (Li-CFx), lithium manganese dioxide ($Li-MnO_2$), lithium thionyl chloride ($Li/SOCl_2$), and lithium sulfur dioxide (Li/SO_2).
Potential NASA Applications (Limit 550 characters):

Our battery monitor will benefit outer planet surface and aerial missions including missions listed in the 2023-2032 National Academies decadal survey: outer planet missions operating at extreme low temperatures (UOP, Enceladus Orbilander); future lander and rover missions looking to use higher specific energy batteries and need battery health monitoring on icy moons and Mars (Mars Deep Time Rover); and power management needs under temperatures of -230 to +120 °C for missions to the lunar surface (Artemis).

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications for Alphacore's battery monitor include space-based defense missions with small-satellites for the U.S. Space Force and missile defense. Soldier-portable battery applications, such as radio communication, electric vehicles, location trackers, and laser range finders and night-vision goggles all stand to benefit from our fast and real-time diagnostics tool.

Duration: **6**

PROPOSAL NUMBER: 23-1- **S17.03-1079**

SUBTOPIC TITLE: Fault Management Technologies

PROPOSAL TITLE: TEAMS Fault Management Extension for State-based Design and Simulation

Small Business Concern

Firm: **Qualtech Systems, Inc.**
Address: **100 Corporate Place, Suite 220, Rocky Hill, CT 06067**
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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):

Reliable V&V and testing of fault management (FM) during design, implementation and operations is an essential part of systems engineering design and development of critical space programs such as the SLS, Gateway and Artemis. NASA's Mission and Fault Management group currently utilizes SAM to assess nominal and FM algorithms prior to full-scale real-time testing, to proactively check potential algorithm changes before finalizing algorithm design and to search for integration issues across multiple subsystems, vehicles, and systems. However, exploring large set of state transitions driven by multiple component failure modes and their impacts is challenging for large interconnected systems such as the Gateway.

The key innovation in this proposal is to bridge the gap between state machine modeling which seeks a top-level system view for FM and the more bottom-up physical and functional failure models by connecting state machine modeling tools such as MathWorks® Stateflow and the newest revision 2 of vendor-neutral Systems Modeling Language (SysML v2), to industry-adopted and commercial FM design, analysis, and verification methods, via use of the commercial-off-the-shelf TEAMS® tool. Connecting component failure modes to their failure functions, functional failure propagation and their manifestations in various effects are suitably poised to drive a complex sequence of state transitions as modeled in SAM for various subsystems and subsystems and allows for a significantly improved coverage (e.g., through a rich set of what-if failure scenarios) for the off-nominal behavioral models as captured in SAM by incorporating the functional failure models such as in TEAMS® as their driver. Doing this combines the best qualities of each model and its associated analytical and operational capabilities to take advantages of what each tool and methodology does best. In essence, the State Machine Model and TEAMS® models will provide single sources of truth for modeling and analysis.

Potential NASA Applications (Limit 550 characters):

This technology is applicable for verification testing of NASA's next generation launch vehicle such as SLS, cis-lunar infrastructure including Gateway and deep space human exploration such as the Habitat. The Exploration Upper Stage's for which SAM is partially implemented will also be a target. The Gateway spacecraft has some simulation and vehicle models, which can be integrated into the MBSE environment and evaluated against FM robustness. Europa is also strong candidate for demonstrating the FM capabilities within SAM driven MBSE practices

Potential Non-NASA Applications (Limit 400 characters):

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

Duration: **6**

PROPOSAL NUMBER:	23-1- **S17.03-2386**
SUBTOPIC TITLE:	Fault Management Technologies
PROPOSAL TITLE:	Modular Artificial Intelligence for Faults: Local Online Watch and Efficient Response

Small Business Concern

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

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

MAIFLOWER (Modular AI for Faults: Local Online Watch and Efficient Response) leverages previous NASA investments to develop a generalized architecture for fault management that is capable of being deployed across space platforms of all kinds. We have significant experience in all of the required technologies and have already integrated them into a general MAESTRO architecture designed to be easily applied to all spacecraft subsystems.

MAIFLOWER Phase I will aim to detect, diagnose, and mitigate the effects of faults on Astrobotic's Vertical Solar Array Technology (VSAT), a rover that will egress from its lander, transit to a desired location near the lunar South Pole, "wiggle" into the lunar soil, and deploy a 60' high solar array to generate and distribute power to other lunar systems. MAIFLOWER will target faults that may occur during navigation to the destination, the leveling process performed when wiggling into the regolith, and deployment of the solar array as well as issues that may arise due to loss of communications and related to thermal management.

MAIFLOWER will augment previous NASA-funded MAESTRO technology by introducing transformers, a machine learning method commonly utilized on series data, to the space domain for fault detection. This addition will enable MAIFLOWER to not only better diagnose faults but also be alerted to novel off-nominal conditions. MAIFLOWER will make use of a suite of AI technologies: model-based reasoning, case-based reasoning, and machine learning to detect, diagnose, and triage faults as they occur; efficient algorithms to plan courses of action (COAs) and schedule a response (built on our very successful Aurora technology); and behavior transition networks to adaptively execute selected COAs to mitigate the effects of the fault.
Potential NASA Applications (Limit 550 characters):

The most direct transition target is VSAT, but other NASA spacecraft (both manned and unmanned) can significantly benefit from autonomous and intelligent fault management. Since it is an open system, other developers can use MAIFLOWER to create additional intelligent software, enabling many applications to be quickly developed for spacecraft. Besides spacecraft, our technology can be used for other large systems such as NASA ground stations. The planned Phase II demonstration of MAIFLOWER on real hardware will greatly aid in its adoption.

Potential Non-NASA Applications (Limit 400 characters):

Future manned and unmanned, deep-space and near-Earth non-NASA spacecraft can also benefit from our technology. This includes both non-NASA U.S. agencies (e.g., DoD and NOAA), foreign agencies (e.g., European Space Agency (ESA)), and commercial entities, such as Axiom Space, a current Stottler Henke customer, and Astrobotic, with whom we are teaming on several opportunities.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z7.04-2689**

SUBTOPIC TITLE: Landing Systems Technologies

PROPOSAL TITLE: Modeling Plume-Surface Interactions for Landing Pads and Untreated Ground

Small Business Concern

Firm: **Blueshift, LLC**
Address: **575 Burbank Street, Unit G, Broomfield, CO 80020**
Phone: **(850) 445-3431**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

Blueshift, LLC dba Outward Technologies proposes to develop Free Open-Source Software for simulating Plume-Surface Interactions (PSI) relevant to lunar and Martian environments. These software tools will include: 1) a two-way coupled Computational Fluid Dynamics (CFD) and Discrete Element Method (DEM) numerical modeling framework for simulating regolith-plume interactions; 2) a grain-based DEM model of regolith ejecta with accurate representation of particle size and shape distributions to predict erosion physics and ejecta dynamics; and 3) a damage calculator for identifying the location and extent of pitting and fracturing caused by ejecta impacting near- and far-field structures. These combined tools will be implemented within a massively parallelized cloud-computing environment to enable high-fidelity PSI models to aid CLPS lander companies and the design of lunar Human Landing Systems.

These proposed innovations address current limitations of PSI modeling software by increasing fidelity of the soil mechanics response of ground through utilization of a grain-based DEM regolith model capable of representing a wide range of in situ soil conditions for studies on cratering physics; erosion rates; ejecta trajectories, velocities, and momentums; and energy reductions within the plume flow field due to regolith interactions. Bonding between regolith grains within the DEM further enables study of different landing pad materials and geometries while evaluating the potential for erosion of the underlying regolith and of untreated regolith beyond the landing pad and/or landing pad apron.

These new modeling capabilities can be used to de-risk future robotic and manned missions for NASA's Moon-to-Mars campaign and directly address the needs of NASA SBIR Subtopic Z7.04 through validated, robust, and massively parallel numerical models for predicting PSI physics on other planetary bodies across a wide range of possible terrains and ground conditions.

Potential NASA Applications (Limit 550 characters):

These new modeling capabilities can be used by NASA to de-risk future robotic and manned missions for NASA's Moon-to-Mars campaign. Potential applications include evaluations of different landing vehicles for given terrains and ground conditions; identifying candidate locations for landing pads, berms, and placement of other ground structures at lunar sites of interest to reduce the risk caused by ejecta damage; and evaluation of landing pad and landing pad apron materials for mitigating viscous erosion of ground and high-velocity ejecta.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications include industrial process and hardware design for systems involving the interaction between superheated fluids and particles such as blast furnaces. Additional applications exist for massively parallelizable DEM-CFD simulations for industrial-scale modeling of systems using DEM where non-spherical particle assumptions are desired.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z8.02-1292**

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

PROPOSAL TITLE: Deep Space Navigation of Distributed Small Spacecraft Using Occultations of Celestial X-ray Sources

Small Business Concern

Firm: **Aster Labs, Inc.**
Address: **155 East Owasso Lane, Shoreview, MN 55126**
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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):

This program will develop an innovative small spacecraft navigation system using X-ray energy band observations of celestial sources by measuring the photon flux change during the time of the horizon crossing due to occultation by a planetary body, referred to as Occultation X-ray Navigation (OXNAV). Previous work by ASTER Labs has demonstrated concept feasibility of X-ray navigation (XNAV) using periodic source-based algorithms. OXNAV complements XNAV's continuous source tracking by providing measurements when sources are obscured by a planetary body. The blended XNAV+OXNAV approach will utilize both the periodic nature of the faint, stable radio and X-ray pulsars when visible, and steady, brighter sources that continually become occulted during a spacecraft's orbit. Thus, the operational prototype OXNAV software

package and hardware instrument would be capable of frequent measurement updates and continuous, accurate absolute and relative navigation. The baseline instrument is designed for small spacecraft, 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 OXNAV feasibility for relevant NASA applications with system requirements developed based on identified and characterized sources assembled into a catalog. The prototype instrument hardware design will be coupled with data processing navigation algorithms that fuse measurements in a single Extended Kalman filter. ASTER Labs' XPRESS software and a filter simulation will assess absolute and relative navigation performance under multiple cooperative spacecraft mission scenarios.
Potential NASA Applications (Limit 550 characters):

This OXNAV system will be directly applicable to NASA's distributed small spacecraft missions. The software processing and instrument will enable single vehicle navigation and coordinated relative navigation between cooperating spacecraft. The instrument can be integrated into proposed operational systems, such as LunaNet. 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 400 characters):

The OXNAV system applies directly to self-navigation of commercial spacecraft constellations. 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 operations, especially with Earth or the Moon in view.
Duration: **6**

PROPOSAL NUMBER: 23-1- **Z8.02-1426**

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

PROPOSAL TITLE: Miniature Interferometric CubeSat-Ready Optical Sub-arc-second Telescope Array Star Tracker

Small Business Concern

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

Principal Investigator:

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Business Official:

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Phone: **(310) 320-1827**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

To address the NASA need for enabling communication and navigation technologies for distributed small spacecraft beyond low Earth orbit, Intellisense Systems Inc. (Intellisense) proposes to develop a new Miniature Interferometric CubeSat-Ready Optical Sub-arc-second Telescope Array (MICROSTAR) Star Tracker for optical navigation of distributed CubeSats. The proposed high-accuracy star tracker for low SWaP (<0.25 U) CubeSat attitude determination is based on multi-aperture interferometric fringe detection modules with no moving parts. The innovations in the use of the interferometry fringe methodology developed by NASA's Jet Propulsion Laboratory (JPL), and its implementation in planar waveguide optics will enable a modular compact integration of the proposed system capable of long-term, high-accuracy attitude determination for robust CubeSats control. In Phase I, Intellisense will develop a viable conceptual design of MICROSTAR star tracker that satisfies NASA's navigation and absolute attitude determination requirements, including SWaP-C, absolute position, pointing and tracking, and power budget, demonstrate the design's feasibility by prototyping and testing key enabling technologies, and develop a Phase II plan. In Phase II, Intellisense will develop a prototype of the MICROSTAR system that will be integrated with a commercial off-the-shelf 1 U CubeSat platform to support laboratory testing and field demonstration towards development into space-qualifiable and commercially available CubeSat sensor payloads.

Potential NASA Applications (Limit 550 characters):

With its low SWaP-C design, the MICROSTAR system will be suitable for many NASA applications including lunar, Mars, and deep space distributed science missions, distributed aperture virtual telescope, small spacecraft swarm for gravimetry and transient phenomena observation, and proximity operations for inspection of space assets. Additional applications include high-precision relative attitude determination between CubeSats, UAV-to-UAV, UAV-to-manned platform, and satellite-to-satellite and ground-to-satellite optical communications.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications of MICROSTAR include commercial surveillance satellites, space telescopes (DoD), homeland security and law enforcement aerial surveillance, agricultural and geospatial imaging, high data rate FSO communication, and FSO nodes on UAV platforms. The sub-arc-second precision of MICROSTAR could also enable the scientific community to collect high-accuracy astronomical data.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z8.09-1438**

SUBTOPIC TITLE: Small Spacecraft Transfer Stage Development

PROPOSAL TITLE: Low Cost Hybrid Rocket Orbital Transfer Stage

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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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5
Technical Abstract (Limit 2000 characters):

Parabilis Space Technologies is pleased to propose the development of a high-performance hybrid rocket stage suitable for both small spacecraft maneuvering and for trans-lunar orbit injection in response to solicitation Z8.09, Small Spacecraft Transfer Stage Development. This effort leverages previous successful NASA-funded R&D at Parabilis for a “NanoLaunch” hybrid upper stage and the design of an appropriately scaled-up hybrid motor. The proposed stage is economical, non-toxic, non-cryogenic, restartable, and compatible with multiple “venture-class” launch vehicles. The stage will be offered in two sizes, one of which will be capable of delivering 25 kg payloads into translunar trajectories when launched abord a rocket-lab electron vehicle. A larger “grande” stage will be capable of injecting 60 kg payloads into translunar trajectories when launched aboard a Virgin Orbit LauncherOne, Firefly Aerospace Alpha, or Relativity Space

Terran 1. There also a clear path to the creation of larger stages that maximize the payload capacity of Terran 1 or ABL's RS1.

During Phase I, Parabilis will design, manufacture, and hot flow test a relevant scale prototype motor, significantly burning down both technical risk and the effort required for flight-like prototypes which will be tested in a subsequent Phase II effort. This development effort leverages a design from a previous NASA SBIR. This approach will rapidly and substantively reduce risk for further Phase II development.
Potential NASA Applications (Limit 550 characters):

The proposed innovation is ideal for low-cost delivery of small payloads into a translunar trajectory. This will serve NASA's lunar missions including Lunar Gateway. Parabilis will design systems compatible with a wide range of venture class launch vehicles. The proposed hybrid propulsion technology can also address other NASA needs such as an upper stage and an ascent vehicle for lunar or interplanetary sample return missions.

Potential Non-NASA Applications (Limit 400 characters):

Low-cost propulsion technology, like the proposed stage, is of direct interest to the US Air Force in at least two areas: lowering the cost of hypersonic flight testing and lowering the cost of satellite maneuvering.

The market for in-space maneuvering also includes civil and commercial remote sensing, commercial communications, and interplanetary scientific customers.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z10.01-2048**

SUBTOPIC TITLE: Cryogenic Fluid Management

PROPOSAL TITLE: A Lightweight Cryogenic Valve for Space Applications

Small Business Concern

Firm: **Orbital Cryogenics**
Address: **3823 Savannah Square East, Atlanta, GA 30340**
Phone: **(613) 618-3940**

Principal Investigator:

Name: **Earl Renaud Ph.D.**
E-mail: **earlwrenaud@gmail.com**
Address: **3823 Savannah Square East, GA 30340 - 4337**
Phone: **(613) 618-3940**

Business Official:

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Phone: **(613) 618-3940**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Orbital Cryogenics is proposing to develop a new-type of integrated-pilot linear pneumatic valve, capable of providing long-life control of cryogenic liquids and associated gasses, while meeting the low-weight requirements of flight hardware.
The valve will have a thermally isolated integrated pilot, with provisions for electrical pilot heat if required. The valve inlet/outlet can be any of several different standard interfaces, including AN-16, V-band, ISO flange, or weld-on. The valve is a center-mounted piston, linear poppet (CPLP) configuration, with an integrated pilot mounted on or within the valve body. The CPLP valve has five main parts: a center section with a piston bore mounted in the center of the flow, held in place by three integral standoffs, inlet and outlet sections mounted to the main body by through-bolted cap screws, the piston and poppet, and the pilot valve with a thermal isolator and provisions for a pilot heater. The main seal stands slightly proud of the poppet, forming an effective seal between the metal surfaces on the poppet and valve outlet. An internal flow simulation will be performed for the prototype valve to estimate pressure drop. The flow passage geometry will then be optimized for minimum pressure, then scaled to achieve the required Cv. The valve will then go through detailed design, prototype fabrication, and testing with both water and liquid nitrogen.
Potential NASA Applications (Limit 550 characters):

Valves for on-obit and earth-based cryogenic propellant and fluid management systems.
Flight weight cryogenic valve for spacecraft cryogen storage, flow control, fill/drain and vent.
COTS valves for ground-based fueling of cryogenic fueled small launch vehicles.
Onboard flow control for cryogen fueled atmospheric flight vehicles.
COTS valves for cryogenic test facilities.
Potential Non-NASA Applications (Limit 400 characters):

COTS valves for commercial on-obit and earth-based cryogenic propellant and fluid management systems
Flight weight cryogenic valve for commercial in-space cryogen storage, flow control, fill/drain and vent
COTS valves for ground-based fueling of cryogenic fueled commercial small launch vehicles and test facilities
Onboard flow control for cryogen fueled atmospheric flight vehicles (e.g. X60A, Talon)
Duration: **6**

PROPOSAL NUMBER: 23-1- **Z2.02-2601**

SUBTOPIC TITLE: High-Performance Space Computing Technology

PROPOSAL TITLE: Scalable, Variable-speed Time-Sensitive Ethernet

Small Business Concern

Firm: **Lewiz Communications, Inc.**
Address: **1296 Kifer Road, Suite 606, Sunnyvale, CA 94086**
Phone: **(408) 836-4226**

Principal Investigator:

Name: **Mr. Chinh Le**
E-mail: **chinhl@lewiz.com**
Address: **1296 Kifer Road Ste 606, CA 94086 - 5318**
Phone: **(408) 836-4226**

Business Official:

Name: **Mr. Chinh Le**
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Address: **1296 Kifer Road Ste 606, CA 94086 - 5318**
Phone: **(408) 836-4226**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters):

Time critical data requires low latency and deterministic transfer. Sensor, command and control data of mission-critical, high-reliability, real-time applications such as collision avoidance, avionics require on-time delivery. Flight control system, images from a camera of an autonomous system require real-time and must be communicated deterministically for the system to function correctly. Autonomous systems such as unmanned ground, sea, air, space vehicles, robots, etc. and industrial automation control systems, all have requirements for deterministic network. Ethernet is ubiquitous. It’s being used everywhere from small devices to high performance computing system. Its large ecosystem provides key advantages such as low cost and high availability. However, data transferred via Ethernet is “best-effort” and may be buffered - causing significant jitter and non-deterministic in delivery timing. Packets across Ethernet may be dropped by switch, routers - delivery is not guaranteed. Solutions are required to overcome these problems. 2 standards have been defined by the industry for time-critical applications: Time-triggered Ethernet (TTE) and Time-Sensitive Network (TSN). Previously, LeWiz developed TTE IP core, FPGA and software for use in endpoint and switching nodes. This proposal further extends the technology to include TSN, which has a very large commercial potential. NASA also has specific requests for TSN in its SBIR Topic including processor clustering, fault tolerant, compatible with heterogeneous networks, support low-cost devices. The proposed core would support these requirements. In Phase 1, LeWiz will enhance its existing TTE core to support TSN, compliant to IEEE standards for use in either endpoint or switching systems, scalable from 1 to 10/100Gbps and still maintain extreme timing accuracy. Thus, network products designed with this technology can be more versatile. This core provides many

advantages and can also be used for switching or SoC ASIC

Potential NASA Applications (Limit 550 characters):

Space vehicles, satellites, Lunar gateway, space telescopes, aircraft, drones, rovers, robots, autonomous systems

Potential Non-NASA Applications (Limit 400 characters):

hypersonic vehicles, space systems, satellites, aircrafts, drones, weapons, ground/sea vehicles, automobile, industrial control

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z4.05-2750**

SUBTOPIC TITLE: Nondestructive Evaluation (NDE) Sensors, Modeling, and Analysis

PROPOSAL TITLE: Millimeter/Microwave Inspection System for Concrete and Concrete Structures to Support Lunar and Martian Habitation and Infrastructure

Small Business Concern

Firm: **Texas Research Institute Austin, Inc.**
Address: **9063 Bee Caves Road, Austin, TX 78733**
Phone: **(512) 263-2101**

Principal Investigator:

Name: **Doyle Motes**
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Address: **9063 Bee Caves Road, TX 78733 - 6201**
Phone: **(512) 263-2101**

Business Official:

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Phone: **(512) 263-2101**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

NASA is preparing for the next phase of human deep space flight. As such, much of the materials, structures, and subsystem will have to be built or assembled in space. Quantitative and qualitative inspection of these components and structures will be critical to ensure safe spaceflight. Additionally, NDE sensors will be used to determine the health of structures as they age in space. Specifically, the means to assess the structural health of Lunar habitats is a particular need. Inspection tools that provide the ability to confirm production quality of habitats and other infrastructure are needed to qualify and sustain these structures for as long as they are used. Nondestructive methods available for these tasks become limited due to the environments on interest (the Moon and Mars)—the best methodology for this is millimeter/micrometer wave electromagnetic (EM) inspections. These systems do not require an atmosphere to operate, can operate in adverse environments, can penetrate deeply into materials and identify defects, discontinuities, material changes, volatiles, etc. To address this, Texas Research Institute (TRI) Austin, Inc. and Iowa State University's Center for Nondestructive Evaluation propose to develop an optimized micro/millimeter wave inspection system and analysis of concrete for creation of habitats and infrastructure on the Lunar surface, and in the future, Mars.

Potential NASA Applications (Limit 550 characters):

The process of constructing landing pads, habitats, and roads on the Moon and Mars will be different than common construction sites on Earth. These structures are a significant investment and are often safety critical structures which, if a failure occurs, would result in astronaut death. Sustainment of these structures must begin during manufacturing and must continue during habitation and/or use to ensure that natural events that may occur, such as moonquakes or micro-meteorite strikes, do not compromise these structures.

Potential Non-NASA Applications (Limit 400 characters):

Related applications include civil engineering such as inspecting FRP repairs to bridge decks and FRP wraps around concrete columns. In the petrochemical industry, the system could be used to image blockages, build-ups, and damage in fiberglass pipes, tanks, coated pipes, and pressure vessels. Military applications include inspections for corrosion under paint, radomes, and radar performance.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z4.07-1268**

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

PROPOSAL TITLE: Integrated Computational Materials Engineering (ICME) for In-Space and Extraterrestrial Surface Metal Welding and Joining

Small Business Concern

Firm: **CFD Research Corporation**

Address: **6820 Moquin Drive Northwest, Huntsville, AL 35806**
Phone: **(256) 361-0811**

Principal Investigator:

Name: **James Cole**
E-mail: **vernon.cole@cfdrc.com**
Address: **701 McMillian Way Northwest, Suite D, AL 35806 - 2923**
Phone: **(256) 726-4800**

Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

Despite the maturity of welding and related joining processes for terrestrial applications, there is limited understanding of the effects of an in-space environment on weld quality. An ICME framework leveraging physics-based process and metallurgical models, anchored by terrestrial data, is desired to predict the effects of in-space, lunar, and Martian environments on the welding process and resulting material properties. To address this need, CFD Research will establish critical elements of such a framework, namely physics-based welding process models to evaluate the relevant environmental effects (microgravity, vacuum, extreme ambient temperature), with phase field models to predict the resulting joint microstructure and properties. A machine learning model component, to enable prediction of process-structure-property relations of alloys derived from lunar and Martian in-situ resource utilization (ISRU), will be developed to provide a path for addressing uncertainty in processing and properties of those materials. The Phase II program will focus on further maturation of the developed framework, particularly simplified data transfer between models, further training and validation of the ML model to address additional trace solutes in ISRU-derived alloys, validation and application studies, and delivery of the resulting software and databases to NASA
Potential NASA Applications (Limit 550 characters):

Welding and joining processes have been deemed to be critical technologies for in-space manufacturing and repair at Gateway and other future orbiting stations. Confidence in the performance of in-space joining processes will enable NASA to circumvent the launch load and payload fairing constraints on large structures such as in-space habitats. As lunar and Martian infrastructure is developed, this framework will support manufacturing and repair of structures from ISRU materials and guide material selection from less-than-ideal feedstocks.
Potential Non-NASA Applications (Limit 400 characters):

The commercial market for in-space application of this ICME framework is expected to strongly overlap the anticipated NASA applications for manufacturing and repair. The developed models for in-space, lunar, and Martian welding will also contribute to development of metal additive manufacturing in those environments

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z5.06-2232**

SUBTOPIC TITLE: Servicing and Assembly Applications

PROPOSAL TITLE: Launch Deploy and Docking Mechanism - Half-ESPA Size

Small Business Concern

Firm: **Apech Labs LLC**
Address: **1576 Sweet Home Road Suite # 210, Buffalo, NY 14228**
Phone: **(716) 559-1500**

Principal Investigator:

Name: **James Diorio**
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Address: **1576 Sweet Home Rd Ste # 210, NY 14228 - 2710**
Phone: **(716) 264-3859**

Business Official:

Name: **James Diorio**
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Address: **1576 Sweet Home Rd Ste # 210, NY 14228 - 2710**
Phone: **(716) 264-3859**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Apech Labs has developed a Launch Deploy and Docking Mechanism concept that enables mechanical capture of small-scale spacecraft (i.e., half-ESPA, 27U CubeSat) with the structural

integrity required to survive launch loads while also maintaining the ability to release, re-dock, and accommodate fluid and electrical connections between spacecraft. To achieve all desired functions, this concept is composed of four main sub-systems; hard capture, soft capture, fluid connection, and electrical connection, each of which have components intended to be part of mating assemblies mounted on both a primary spacecraft and secondary spacecraft. All active components (i.e., motors, solenoids, electromagnets) are part of the primary spacecraft side assembly, or active assembly, which then allows solely passive components on the secondary spacecraft side assembly, or passive assembly. This approach lowers the cost and mass associated with the passive side of the mechanism.

The hard capture system leverages an actuated fastener v-band style clamp that captures two rings to rigidly mate and de-mate the two satellites. The soft capture system implements an actuated extendable boom that extends to magnetically capture the approaching satellite. The fluid coupling can be engaged or disengaged while in the docked state. The electrical coupling is always connected when docked. The system is designed to provide over 200 mate and de-mate cycles.

The focus of this SBIR effort is to finalize the system layout as well as the hard capture and soft capture subsystems. The system layout will accommodate the eventual addition of the fluid and electrical couplings.

Potential NASA Applications (Limit 550 characters):

This effort will enable a common deploy and docking mechanism for ½ ESPA sized spacecraft. First, it allows for upgrade capability to a spacecraft in orbit. An example of this would be adding a new faster processing computer to an existing satellite. This technology could be useful for long term emplacements such as lunar gateway. The second use-case is implementing a standard in-orbit service port for ½ ESPA sized spacecraft. This would allow for on-orbit refueling enabling future NASA exploration missions.

Potential Non-NASA Applications (Limit 400 characters):

The Space Force is interested in a satellite system of systems an example being smaller satellites serving as sentry or decoy satellites for the larger, more expensive satellite. The telecommunications industry and government will be interested in the upgradeability the system enables, to provide longer term useability of their in-space assets.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z5.07-2160**

SUBTOPIC TITLE: Autonomous Robotic Manipulation, Utilization, and Maintenance

PROPOSAL TITLE: Handler: An End-to-End Tool for Semantic-based Manipulation using Affordance Templates

Small Business Concern

Firm: **Boardwalk Robotics**
Address: **417 East Zaragoza Street, Pensacola, FL 32502**
Phone: **(850) 346-0944**

Principal Investigator:

Name: **Brandon Shrewsbury**
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Address: **422 Fairpoint Dr, FL 32561 - 4170**
Phone: **(850) 346-0944**

Business Official:

Name: **Brandon Shrewsbury**
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Address: **422 Fairpoint Dr, FL 32561 - 4170**
Phone: **(850) 346-0944**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

We propose to research, develop, and demonstrate Handler, an autonomous semantic detection, planning, and grasping affordance module capable of fast online inference and adaptation, as well as continuous learning and improvement. Handler will work by combining semantic and primitive pose-recognition algorithms with a rich affordance template library and online grasp-finding algorithms. Uniquely, it will also feature a pipeline for expanding its semantic recognition and affordance library through continuous learning using state-of-the-art mesh generation tools. It will then estimate grasping locations from learned grasp generation models using these created meshes.

Handler will consist of four primary tools:

- **Handler Environment Constructor, which will leverage state-of-the-art object classifier and pose extraction algorithms to automatically create a digital twin of the real environment and the objects within.**
- **Handler Dynamic Affordance Template Library, which is a database of modifiable objects that encode a mesh and defined object interactions, including candidate grasp locations and suggested trajectories between grasp points. These templates can be applied to objects found by the environment constructor, and govern how they can be manipulated by robots.**
- **Handler User Interface, which allows users to view the digital twin of the environment and manage the affordance library, including tweaking existing**

affordance templates, adjusting upcoming interactions or grasp methods, or capturing perception and semantic data for construction of new templates.

- **Handler Affordance Builder, which can automatically create object meshes from captured video and use them to both train pose estimation and semantic classifier networks, as well as create new affordance templates using automatic grasp calculators.**

Potential NASA Applications (Limit 550 characters):

At the end of Phase II, we expect to demonstrate significant progress in assembly, maintenance, and logistics tasks well representative of typical NASA IVR and lunar surface activities. Development and testing will be done on the NASA robot R5 Valkyrie in order to coordinate with ongoing NASA development efforts, and also on the Nadia humanoid in order to promote cross platform capabilities, with basic demonstrations being shown on R5 in Phase I.

Potential Non-NASA Applications (Limit 400 characters):

The Handler library will overcome many barriers associated with the adoption of robotic manipulators in commercial settings. It will also lead to more reliable task performance and more situational awareness in applications involving remote robotics operations like EOD or CONMIT. Additionally, it will support online creation of affordance templates to address complex and unexpected situations.

Duration: **6**

PROPOSAL NUMBER:	23-1- **Z5.08-2298**
SUBTOPIC TITLE:	Integrated Mission Planning and Execution for Autonomous Robotic Systems
PROPOSAL TITLE:	Task and Motion Planning for Space Operations, with Human-Assisted Recovery

Small Business Concern

Firm: **PickNik, Inc.**
Address: **4730 Walnut Street, Suite 106, Boulder, CO 80301**
Phone: **(720) 513-2221**

Principal Investigator:

Name: **Sebastian Castro**
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Address: **4730 Walnut Street Suite. 106, CO 80301 - 2520**

Phone: **(607) 229-2222**

Business Official:

Name: **Lynn Regnier**
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Address: **4730 Walnut St. Ste. 106, CO 80301 - 2520**
Phone: **(413) 841-9404**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Space operations have been increasingly turning to Persistent Assets; systems that require repeated visits and/or regular maintenance over extended periods of time. To make such operations achievable from a cost perspective and dependence on human crews, relying on autonomous vehicles and robots is a common solution. However, deploying successful systems long-running space operations requires a combination of a) improved autonomous system capabilities and b) the ability for remote human operators to intervene when progress towards completing a task is blocked. Additionally, it is important to minimize the frequency of human intervention due to the cost of crewed operations (especially in situ), as well as communication delays over long distances.

We propose a system that introduces Task and Motion Planning into our existing MoveIt Studio tool. This allows remote operators to provide high-level task specifications in structured text, and the autonomous system will produce and execute a sequence of actions to meet that specification. To deal with unanticipated errors with both the world model used for planning and during task execution, we will add a mechanism to autonomously identify failures and request manual interventions from remote operators. Our proposed system will improve the autonomy capabilities of robotic systems in space, while also reducing the cognitive load on remote operators by elevating their role in human-machine teams to higher-level goal specifications and task monitoring.

Potential NASA Applications (Limit 550 characters):

Task and Motion Planning with human-assisted recovery can be applied to most space applications requiring sustained operations. This includes zero-gravity systems, including both IVA and EVA servicing tasks, as well as extraplanetary surface systems including habitats, laboratories, and construction sites.

Potential Non-NASA Applications (Limit 400 characters):

In mature markets like logistics and manufacturing, where robots operate in structured environments, autonomy advances can lead to commercially viable solutions that require less supporting infrastructure. This work also applies to markets that are less mature due to challenges of operating in the presence of humans, such as home service and hospitality, public safety, and asset inspection.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z7.01-1031**

SUBTOPIC TITLE: Entry, Descent, and Landing Flight Sensors and Ground-Testing Technologies

PROPOSAL TITLE: A Two-Color Heterodyne Interferometry Sensor for Direct, High-Speed Electron Density Measurements

Small Business Concern

Firm: **MetroLaser, Inc.**
Address: **22941 Mill Creek Drive, Laguna Hills, CA 92653**
Phone: **(949) 553-0688**

Principal Investigator:

Name: **Dr. Jacob George**
E-mail: **jgeorge@metrolaserinc.com**
Address: **22941 Mill Creek Drive, CA 92653 - 1215**
Phone: **(949) 553-0688**

Business Official:

Name: **Dr. Jacob George**
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Address: **22941 Mill Creek Drive, CA 92653 - 1215**
Phone: **(949) 553-0688**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Planetary entry and atmospheric reentry from deep space missions involve very high velocities and a significant source of vehicle heating is due to radiation from the high temperature, shock-heated plasmas formed in front of the vehicle. The next generation of reentry vehicles supporting the Artemis program and Mars exploration (e.g., the Mars Retrieval Lander) will reenter at higher velocities and experience much higher peak heat flux than previous missions. The radiative environment corresponding to different planetary entry conditions is simulated in the NASA Ames

Electric Arc Shock Tube (EAST) facility and is used to obtain shock radiation data for the validation of phenomenological models for nonequilibrium radiation transport and improved understanding of the flow physics. There is a need for developing nonintrusive, accurate, spatially and temporally resolved diagnostics of electron density beyond currently available spectroscopic techniques and also help improve the physics of radiative transport prediction models. To aid this, we plan to develop a Two-Color Heterodyne Interferometry (TCHI) diagnostic for electron number density at the requisite temporal resolution > 1 MHz and a spatial resolution of less than 5 mm. The deliverables from the Phase I effort will include an initial demonstration and quantitative measurement of the TCHI sensitivity as well as an initial assessment of feasibility and integration with the NASA EAST facility. The end-deliverables of a potential follow-on Phase II program will be a validated and well-characterized instrument with lasers and detectors that are capable of measurements of electron number density profiles to a high precision and accuracy. Given sufficient resources, the follow-on efforts may also include integration of a prototype TCHI system into the NASA EAST facility to obtain preliminary measurements and benchmarking against the existing Stark broadening diagnostic system.

Potential NASA Applications (Limit 550 characters):

The TCHI diagnostic is needed to aid tests at NASA EAST and arc jet facilities, hypersonic wind and shock tunnels. Non-intrusive measurements of electron density at high speeds and with fine spatial resolution are required for validating computational fluid dynamic modeling and simulation codes that incorporate real-gas kinetic and transport models used to predict planetary entry and earth reentry radiative heating. The diagnostics can serve as tools in high enthalpy flows that focus on testing the integrity of thermal protection systems.

Potential Non-NASA Applications (Limit 400 characters):

The capability to measure spatially and temporally resolved electron density in high enthalpy flows will be attractive to companies such as Lockheed Martin, Boeing, etc., that develop heat shields and thermal protection systems for hypersonic vehicles, and private space industries such as SpaceX, Blue Origin, etc., that develop space launch systems for low earth orbit and planetary exploration.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z7.03-2498**

SUBTOPIC TITLE: Entry and Descent System Technologies

PROPOSAL TITLE: Design and Testing of a High-Efficiency, Low-Mass, Low-Power Gas Generator

Small Business Concern

Firm: **Ultramet**
Address: **12173 Montague Street, Pacoima, CA 91331**
Phone: **(818) 899-0236**

Principal Investigator:

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Address: **12173 Montague Street, CA 91331 - 2210**

Phone: **(818) 899-0236**

Business Official:

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Address: **12173 Montague Street, CA 91331 - 2210**
Phone: **(818) 899-0236**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

Deployable aerodynamic decelerators are a low-mass, low-volume option for decelerating interplanetary spacecraft as they approach their destination. A key advantage is that, unlike a rigid aeroshell, they are not constrained by the diameter of the launch vehicle payload shroud. Deployable aerodynamic decelerators, however, require large quantities of gas for inflation. The traditional approach for inflating a deployable decelerator is to use high-pressure helium. Such systems are very simple, but the tank for such a system is very heavy. For example, to inflate a 1200-ft^3 decelerator to 30 psia at 300 K requires just over 11 kg of gas, but the titanium tank needed to contain the gas at 6000 psia would weigh over 200 kg. In this project, Ultramet will work with Pennsylvania State University and build upon previous gas generator work that is based on green ionic liquid monopropellants. Specifically, a green propellant with a low flame temperature will be catalytically decomposed using a system that requires virtually no electrical power. The resulting gases will then pass through a bed of endothermic solid that will not only cool the gas to a safe temperature (<200°C), but also generate additional gas in the process. Preliminary calculations indicate that such an approach would reduce the system mass from 212 kg to just 48 kg. It is anticipated that when optimized, even more mass savings can be realized.
Potential NASA Applications (Limit 550 characters):

Aerodynamic decelerators will be the primary NASA application, but the technology could also be used in tank pressurization systems on nearly any spacecraft or satellite because it will be lighter than current systems. Reducing the mass of the inflation system and/or tank pressurization system on a spacecraft will enable it to carry a larger instrument payload or more propellant, thus increasing the scientific capability, life, and/or delta-V capability of the mission. Gas generators could also be used to inflate habitats on the Moon or Mars.
Potential Non-NASA Applications (Limit 400 characters):

All military and commercial spacecraft, as well as missile interceptors, can benefit from the mass reduction when this technology is used for tank pressurization. Lightweight inflation systems can also be used on commercial aircraft to inflate emergency evacuation slides and for fuel tank inerting.
Duration: **6**

PROPOSAL NUMBER: 23-1- **Z14.02-2324**

SUBTOPIC TITLE: Extraterrestrial Surface Construction

PROPOSAL TITLE: Lunar Truss Design and Construction

Small Business Concern

Firm: **Bond Technologies, Inc**
Address: **1353 Wade Drive, Elkhart, IN 46514**
Phone: **(574) 327-6730**

Principal Investigator:

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Phone: **(574) 327-6730**

Business Official:

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Phone: **(574) 327-6730**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

This project will advance technology for the automated assembly of large truss towers. Assembly of truss-based structures is one of the leading candidates for establishing some of the early lunar infrastructure. Specifically, joining technologies and robotic tools are required to enable autonomous/automated assembly of tall towers as well as shelters, domes and habitats. Automated assembly using fasteners presents challenges related to the management of the large quantity of small parts, whereas an integral joining technique such as Friction Stir Welding (FSW) can reduce the need for a material handling system that feeds rivets or bolts. FSW be more easily integrated into an autonomous assembly process. With a FSW solution for robots, parts can be assembled on 7 axes (as opposed to 3 or 5 on a machining center machine), allowing the entire surface of large parts to be covered and welded in 3 dimensions. A variant of traditional FSW, Refill Friction Stir Spot Welding (RFSSW) was developed for making spot joints in overlapped materials, similar to joints made using fasteners like bolts or rivets. Some work has been done in design of space-based trusses, and also in robotic assembly of space-based structures, but an integrated solution for the assembly and joining process is still needed. This

proposal addresses the opportunity to perform automated assembly of tall towers using the energy efficient, low parts count and high joint strength method of RFSSW. It is expected that this project will raise the TRL from 2 to 4.

Potential NASA Applications (Limit 550 characters):

Assembly of truss-based structures is one of the leading candidates for establishing some of the early lunar infrastructure—for example, tall towers (50- to 80-m total height, which includes the attached payload height) for solar power generation, blast containment shields for launch and landing pads, shelters, etc.

Potential Non-NASA Applications (Limit 400 characters):

RFSSW is a replacement for a rivet gun or resistance spot welder with appropriate robotic assistance. By proving out usefulness of robotic RFSSW for structural trusses on earth, manufacturing speed and cost of such assemblies can be reduced. Beyond structural elements, target markets are rivet replacement for airplane construction and aluminum bodied ground vehicles such as cars and trucks.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z10.03-1201**

SUBTOPIC TITLE: Space Nuclear Propulsion

PROPOSAL TITLE: Robotic High-Emissivity Surface Treatments

Small Business Concern

Firm: **Polaronyx, Inc.**
Address: **144 Old Lystra Road, Unit 2, Chapel Hill, NC 27517**
Phone: **(984) 369-5688**

Principal Investigator:

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Address: **2526 Qume Drive, Suites 17 and 18, CA 95131 - 1870**
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Business Official:

Name: **Jian Liu**
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Address: **144 Old Lystra Rd., Unit 2, NC 27517 - 6330**

Phone: **(650) 387-0889**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

This NASA SBIR Phase I proposal presents an unprecedented method to make high emissivity surfaces for space radiators. Integration of laser surface processing and robotics enables fast surface structuring for any shapes and any sizes. With our successful history in a variety of laser 3D processing, this proposal has a great potential to succeed. A proof of concept demonstration will be carried out at the end of Phase 1. A prototype will be delivered at the end of Phase II.
Potential NASA Applications (Limit 550 characters):

In addition to NASA's space radiator manufacturing, the proposed laser process and structured designs can also be used in other applications, such as space vehicle, aircraft, and satellite manufacturing. PolarOnyx will develop a series of products to meet various requirements for NASA/military deployments.

Potential Non-NASA Applications (Limit 400 characters):

3D printing uses various technologies to build products for all kinds of applications from foods, toys to rockets and cars. The global 3D printing market is projected to reach $49 Billion by 2028, registering a CAGR of 21.8%. North America was the highest contributor to the global market, and is estimated to reach $16.8 Billion by 2028, registering a CAGR of 20.8% during the forecast period.
Duration: **6**

PROPOSAL NUMBER: 23-1- **Z10.04-1753**

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

PROPOSAL TITLE: Improving Ion Engine Optics Through Additive Manufacturing

Small Business Concern

Firm: **Quadrus Advanced Manufacturing, LLC**
Address: **200 Clinton Avenue, Suite 600, Huntsville, AL 35801**
Phone: **(256) 679-9189**

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):

Quadrus Advanced Manufacturing, LLC is pleased to present this Phase I proposal in which we present a plan to demonstrate the feasibility of using additive manufacturing to produce gridded ion engine optics from W-24Re. This refractory alloy promises to simultaneously improve engine life, increase structural reliability, and reduce overall manufacturing cost and lead time. The improvements we seek to demonstrate is enabled by our proven W-24Re manufacturing process, selective laser melting, which is an important emerging manufacturing approach that is proven to reduce lead time and cost, particularly for complex geometries and/or difficult-to-machine materials like W-24Re. Our proposed change in the material selection and manufacturing of the optics is the first of several planned improvements that will enable widespread adoption of GIE in future spacecraft through drastic reductions in cost and lead time.

Our AM W-24Re manufacturing solution provides several benefits.

- W-24Re has higher strength and higher elastic modulus than Mo, yet can still be formed, which improves structural reliability and aperture alignment.
- W-24Re has a lower coefficient of thermal expansion than Mo, which improves aperture alignment.
- W-24Re naturally enjoys better resistance to sputter erosion than Mo, which improves engine operational life.
- L-PBF can already achieve geometries at least equivalent to, if not better than, every engine design to have ever flown, which means it is a practical solution today.
- L-PBF manufactures components directly from the CAD model, with consistent apertures regardless of grid thickness and no cusps that occur during photochemical machining, which improves grid performance.
- L-PBF manufactures even highly complex grids in mere hours, eliminating the significant cost and lead time of carbon-carbon material acquisition, chemical vapor deposition, and final machining, with no need for mandrels of any kind.

Potential NASA Applications (Limit 550 characters):

Planetary spacecraft

Interplanetary spacecraft

Satellite stationkeeping

Potential Non-NASA Applications (Limit 400 characters):

Satellite stationkeeping

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z12.01-1792**

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

PROPOSAL TITLE: Minimizing volatile sublimation during excavation

Small Business Concern

Firm: **Cislune Company**
Address: **301 North Almansor Street, Alhambra, CA 91801**
Phone: **(661) 390-1060**

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):

Cislune proposes to develop a method for excavating and handling icy regolith on the Moon to minimize the loss of volatiles. The method includes temperature management and prevention of churning the ore, as most volatile loss occurs in a thin skin-depth along the exposed surfaces of the bulk material. The proposed innovation is to create a high fidelity design tool that quantifies the loss of resources during the mining and conveyance processes and appropriate design modifications of bucket drums, cutting surfaces, regolith handling, and regolith conveyance that minimize heat generation and regolith churn. The significance of this innovation is to create efficient and effective hardware that will minimize the loss of volatiles and reduce inefficiencies that reduce the value of space resources. The innovation will lead to the development of top-level designs of mining and handling systems with their concepts of operations that minimize volatile loss, informed by the best available science, without adopting expensive methods to contain the volatiles that may not be necessary.

Cislune's technical objectives in Phase I are to show a proof of concept of lunar ice mining that minimizes volatile loss due to heating or churn during excavation. We will show the kinds of volatile loss to be expected with various mining implements and processes and ways to maximize volatile extraction of not just water ice but H_2S, NH_3, SO_2, C_2H_4, CO_2, CH_3OH, CH_4, and others. Our modeling in Phase I will be extrapolated to other non-water volatiles, and in Phase II we will test with select volatiles to anchor our modeling and demonstrate in thermal vacuum processes that most efficiently extract volatiles.

Proposed Deliverables are reports documenting the design, development, and data from icy regolith excavation testing, software design tools to minimize sublimation, and high-level designs for mining and handling icy regolith that minimizes volatile loss.

Potential NASA Applications (Limit 550 characters):

Minimizing volatile sublimation during excavation applies to producing propellants and other ISRU derived products like plastics, breathable air, and more. This innovation directly maps to NASA STMD's Strategic Framework thrusts of Go - Cryogenic Fluid Management, Land - Global access to support human missions, Live - ISRU. This innovation dramatically improves cryogenic propellant production of water and other volatiles that are critical for Moon and Mars exploration and utilization.

Potential Non-NASA Applications (Limit 400 characters):

ISRU mining, manufacturing, and space tourism all benefit from more efficient production of lunar ISRU sourced propellant, breathable air, plastics, potable water, and more. Volatiles are a critical product of lunar regolith excavation, in addition to metals, ceramics, solar cells, and fibers.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z13.05-1468**

SUBTOPIC TITLE: Components for Extreme Environments

PROPOSAL TITLE: A Lightweight Freeze-Tolerant Radiator for Extreme Environments

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: 4
Technical Abstract (Limit 2000 characters):

Future space exploration missions require advanced thermal control systems (TCSs) to dissipate heat from spacecraft, rovers, or habitats to external environments. These thermal control systems must be lightweight, reliable, and able to effectively control cabin and equipment temperatures under widely varying heat loads and ambient temperatures, including the extremes of lunar night. In this context a particular need has emerged for a heat rejection technology that is both freeze-tolerant and can operate with high turndown to permit TCS operation during extreme conditions by passively varying thermal resistance, as identified by NASA in SBIR Topic Z13.05: *There are no [state-of-the-art thermal control techniques] that can vary the thermal resistance of a radiator or heat exchanger to temporarily eliminate or reduce heat rejection, but this capability is desired to enable freeze tolerance.* To meet these requirements, Creare proposes a freeze-tolerant, variable-conductance radiator for deployable heat rejection in single-phase pumped loop systems. During conditions of low thermal load, the radiator freezes its distal end allowing a limited inactive portion of the radiator to operate and to continue dissipating heat without flow blockage. In Phase I, we will prove the feasibility of the radiator concept by using bench scale tests to demonstrate the key design features for the radiator. We will then finalize the overall thermal, fluid, structural, and mechanical design of the integrated freeze-tolerant radiator complete with advanced features for micrometeorite protection and future integration with a deployment mechanism. In Phase II, we will build a prototype radiator, and demonstrate its performance in a representative thermal environment, and deliver the completed unit to NASA.

Potential NASA Applications (Limit 550 characters):

Creare's freeze-tolerant radiator is designed specifically to enable deployable heat rejection from space-borne and surface pumped loop systems. The technology would be applied to dissipate heat from spacecraft, rovers, or habitats to external environments. In addition to thermal control, this system could be used for heat rejection in power conversion cycles.

Potential Non-NASA Applications (Limit 400 characters):

An active industry is developing around use of pumped-loop thermal control systems for satellite thermal management. Several large satellite manufacturers and integrators are working to develop and implement spaceborne thermal control loops for powerful telecommunications satellites seeking to reject >10 kW. These systems would require a condensing radiator similar to Creare's proposed technology.

Duration: **6**

PROPOSAL NUMBER: 23-1- **Z13.05-1586**

SUBTOPIC TITLE: Components for Extreme Environments

PROPOSAL TITLE: Lunar Extreme Water Container (LEWC)

Small Business Concern

Firm: **MOONPRINT SOLUTIONS LLC**
Address: **1287 McD Drive, Dover, DE 19901**
Phone: **(302) 450-3963**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

NASA is developing in situ water retrieval technologies to excavate regolith-based water deposits from various regions on the lunar surface, then transport, store, and process them into potable water, propellant, fuel cell reactants, and life support consumables for Artemis missions. Part of this logistics chain is a collapsible water container that can operate in harsh environments such as lunar dust and Permanently Shaded Regions (PSRs) where extreme cold as low as -213°C (-351°F) is encountered. To this end, Moonprint Solutions will develop a Lunar Extreme Water Container (LEWC) that will support the transport of water from production or storage locations to inside pressurized habitable volumes. The LEWC is a multi-layered collapsible assembly that has a packing factor > 100:1, can be deployed in cryogenic conditions without damage, and is freeze tolerant. The LEWC is scalable in size and shape to meet operational constraints such as ergonomic handling while wearing a space suit, minimization of footprint in an airlock, and convenient stowage in vehicles. It will be minimal mass but be robust enough to meet the durability requirements of interfacing with highly abrasive lunar dust and sharp rocks in nominal and off-nominal use (accidental drop, dragging, impact) with a target use life of >500 cycles. The specialized materials used in the LEWC will be able to be flexed at cryogenic temperatures to accommodate deployment of an empty bag that is cold soaked, which is extremely challenging for polymeric materials. The LEWC will also have dust mitigation technologies to limit the transfer of lunar dust into habitable spaces.

Potential NASA Applications (Limit 550 characters):

The LEWC will support water storage and transfer needs for Artemis exploration and long-term habitation of the lunar surface. Human portable or larger storage containers are possible for water and other molecules, including cryogenic fluids, on the lunar surface. It can also be used as a highly-reliable In-Vehicle storage container on Gateway or ISS, for fluids including water, wastewater, or other fluids. Technology spin-offs include materials for space suits or lunar dust covers for robotics.

Potential Non-NASA Applications (Limit 400 characters):

The LEWC can be used to support commercial exploration or habitation on the lunar surface, including small volume water or other fluids storage and transport, and larger volume storage of a range of molecules including cryogenic fluids. It also can be used for water or other fluids / gasses on commercial space stations. Technology spin-offs can be used on lunar dust covers for robotics.

Duration: **6**

PROPOSAL NUMBER:	23-1- **A1.04-2413**
SUBTOPIC TITLE:	Electrified Aircraft Propulsion
PROPOSAL TITLE:	Aircraft Traction Inverter for Hybrid-Electric and All-Electric Megawatt-Class Vehicles

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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Phone: **(805) 704-1865**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

Empirical Systems Aerospace (ESAero) proposes to evaluate and design a traction inverter for megawatt-class aerospace applications. A specific weight reduction of 2- to 3-fold, and improved efficiency, with respect to the current state of the art, are desired. Specifically, the solicitation calls for the development of aircraft traction inverters operating in the 1,000- to 3,000V range at 500 to 2,000 A. Further target specifications include a specific power of 20 kW/kG, and an efficiency of 99.5% at full scale. With the level of analysis and design variation that come with increasing the scale of aircraft-grade inverters, ESAero proposes to conduct a trade study on component and subsystem selection, design, and creating a Bill of Materials for a 1,000-1,200V traction inverter with specifications of for fixed-wing and rotorcraft applications. This project aims to bring the technology to a readiness level between 3 and 4, preparing it for prototype design and fabrication in later work. The proposed project will focus on meeting the following specifications based on subtopic A1.04

Potential NASA Applications (Limit 550 characters):

The proposed traction inverter is applicable to all high-power electric propulsion based aircraft for NASA applications. The full-scale technical targets are to reach All-Electric Megawatt-Class Vehicles and could be designed to fit with SUSAN in a future effort.

Potential Non-NASA Applications (Limit 400 characters):

ESAero has identified that a traction inverter is applicable for use in advanced air mobility passenger vehicles as well as large unmanned air vehicles based on multi-rotor electric propulsion architecture.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A1.08-2219**

SUBTOPIC TITLE: Aeronautics Ground Test and Measurement Technologies: Sensors and Diagnostic Systems for High-Speed Flows

PROPOSAL TITLE: Multi-Quantum Cascade Laser based sensors for high-speed characterization of flow parameters in hypersonic tunnels

Small Business Concern

Firm: **IRGLARE, LLC**
Address: **3259 Progress Drive, Orlando, FL 32826**
Phone: **(310) 720-3286**

Principal Investigator:

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Phone: **(407) 733-9776**

Business Official:

Name: **Ms. Elena Lyakh**
E-mail: **elena.lyakh@irglare.com**
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Phone: **(310) 720-3286**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

The design and development of a compact, rugged, cost-scalable optical diagnostic for measuring temperatures, species concentrations, and velocities to advance research vital to enabling the next generation of high-speed air platforms is proposed. The sensor design

overcomes many challenges associated with making measurements in the extreme environments of hypersonic and reactive flows. The system is fast, obtaining MHz (up to GHz) rate measurements that can resolve fluctuations and transient events. The monolithic structure is inherently compact, which lends itself well to low-profile packaging that can be easily integrated into existing ground testing platforms with a path towards onboard monitoring for flight tests. The system is robust, as the monolithic platform and single optical path are insensitive to vibrations and misalignment from mechanical loading, and thermal management is straightforward.

Potential NASA Applications (Limit 550 characters):

•Identify species, velocity, and temperature in high-speed flows and rocket plumes

Potential Non-NASA Applications (Limit 400 characters):

Spectroscopy; hyperspectral imaging; infrared countermeasures

Duration: **6**

PROPOSAL NUMBER: 23-1- **A1.09-1251**

SUBTOPIC TITLE: Zero-Emissions Technologies for Aircraft

PROPOSAL TITLE: Single-Aisle Aircraft LH2 Storage System

Small Business Concern

Firm: **Gloyer-Taylor Laboratories, LLC**
Address: **112 Mitchell Boulevard, Tullahoma, TN 37388**
Phone: **(931) 455-7333**

Principal Investigator:

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Business Official:

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Address: **112 Mitchell Boulevard, TN 37388 - 4002**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 4
Technical Abstract (Limit 2000 characters):

GTL's breakthrough ultra-lightweight composite dewar-tank technology is game changing by providing hydrogen weight fractions in excess of 59% for small tanks, with over 70% achievable with medium scale LH2 tanks, including vacuum insulation. This capability addresses a critical need in the conversion of single-aisle aircraft from Jet-A to liquid hydrogen to eliminate carbon emissions. With GTL's composite LH2 dewar-tanks, hydrogen powered aircraft can achieve better performance than Jet-A aircraft and operate with less cost per passenger mile.

GTL is commercially developing and validating the composite LH2 dewar-tank. This commercial funded effort includes the fabrication and ground testing of multiple composite LH2 dewar-tanks that will culminate in prototype flight testing on a helicopter.

In this SBIR, GTL will examine the integration of composite LH2 dewar-tanks into single-aisle aircraft. This includes showing how the composite LH2 dewar-tank technology can meet relevant performance, operational, and safety requirements of single-aisle aircraft. The effort will also create a technology roadmap of the development, verification and validation steps needed to mature the technology from its current state to the point where it can be adopted by aircraft developers.

Potential NASA Applications (Limit 550 characters):

GTL's composite cryotanks can be used for Space Launch System upgrades, propellant depots, orbit transfer vehicles, lunar descent and ascent vehicles, reusable landers, nuclear rocket vehicles. They can also be used for terrestrial test tanks and pipelines. GTL's composite LH2 dewar-tanks can be used for NASA airplanes. Composite dewar-cups can be used with LHe for balloon telescope missions.

Potential Non-NASA Applications (Limit 400 characters):

GTL's composite LH2 dewar-tanks can be used in helicopters, drones, air taxi, small regional airplanes, single-aisle airplane, wide-body airplane, river taxi, ships, medium duty/heavy duty trucks, buses, and tanker trucks, but also includes stationary assets such as pipelines, and supply depot dewars. GTL composite cryotanks can be used for launch vehicles and spacecraft.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A1.09-1946**

SUBTOPIC TITLE: Zero-Emissions Technologies for Aircraft

PROPOSAL TITLE: Compact liquid hydrogen pump for practical fuel management on zero-emission aircraft

Small Business Concern

Firm: **Flight Works, Inc.**
Address: **17905 Sky Park Circle, Suite F, Irvine, CA 92614**

Phone: **(949) 387-9552**

Principal Investigator:

Name: **Mr. Jose Torres**
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Address: **17905 Sky Park Circle, Suite F, CA 92614 - 6707**
Phone: **(949) 387-9552**

Business Official:

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Address: **17905 Sky Park Circle, Suite F, CA 92614 - 6707**
Phone: **(949) 387-9552**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

Flight Works is proposing to expand its family of affordable yet high performance/power-density aerospace pumps to liquid hydrogen and lead a team developing new technologies for the practical integration and use of liquid hydrogen in zero-emission aircraft. While EV-powered personal air vehicles are about to transform our city skies, the battery chemistry they use limits the range achievable for aircraft with that technology. Liquid hydrogen (LH2) offers the ability to achieve zero-emission aircraft for longer range applications like commercial transports. The drawbacks associated with hydrogen are very cold temperatures and low density. Technologies are needed to obtain practical, cost-effective components and systems to handle LH2 onboard an aircraft. Aircraft manufacturers have recognized the need and opportunities, and are investing to address the challenges.

Pumps and associated fuel transfer system components are critical for an efficient onboard fuel management, whether it is for fuel transfer between tanks, supply to an internal combustion engine, or feed fuel cell electric drive engine. To be viable, a hydrogen-powered aircraft requires a product in-between existing ground-handling LH2 pumps and the exquisite pumps used in launch vehicles, with high quality in a compact package, yet at an affordable price. Furthermore, an optimum configuration must take into account system-level operational considerations. The proposed R&D effort focuses on developing a ***liquid hydrogen (LH2) pump for in-flight cryogenic fuel distribution*** and developing ***concepts for its integration in an aircraft fuel system***. During Phase II, the team will mature the design with prototype pump and associated system testing with liquid hydrogen.
Potential NASA Applications (Limit 550 characters):

The pump and associated systems to be developed as part of the proposed SBIR fit within NASA's technology development programs for zero-emission aircraft. They focus on providing one of the key elements of the system, namely a practical, cost-effective pump and associated fluid management system.

Potential Non-NASA Applications (Limit 400 characters):

Near term commercial applications include industry transforming conventional aircraft to liquid hydrogen aircraft, such as Universal Hydrogen. It also includes R&D performed by Boeing and Airbus, and the major suppliers who will supply them with cryogenic fuel systems. Other applications exist in ground transportation and in low-cost space-related transportation and lunar operations.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A2.01-2399**

SUBTOPIC TITLE: Flight Test and Measurement Technologies

PROPOSAL TITLE: Low SWaP-C, Flight-Capable Distributed Fiber-Optic Sensing Platform

Small Business Concern

Firm: **Sequent Logic, LLC**
Address: **1300 North 200 East, Suite 118, Logan, UT 84341**
Phone: **(435) 915-4425**

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):

The firm proposes to perform studies related to size, weight, power, cost reduction, and ruggedization of a flight-capable, multi-parameter distributed fiber-optic sensing interrogator for testing advanced flight vehicles including those pertaining to NASA's Integrated Aviation Systems Program (IASP) Flight Demonstrations and Capabilities (FDC) project. The technology will aid understanding of flight / spaceflight structural dynamics, leading to improved simulation models and designs as well as to improved airframe structural integrity and safety. Improved quantity and quality of operational flight measurements together with improved models will help accelerate design iterations and enable future high-performance aircraft to operate in a more predictable, efficient, and safe manner.

Potential NASA Applications (Limit 550 characters):

The proposed technology enables acquisition of real-time, in-flight operational temperature, strain, vibration, and other measurements related to structural dynamics analysis and health monitoring of airframe structures and aerodynamic surfaces.

Potential Non-NASA Applications (Limit 400 characters):

The technology is applicable to harsh environments including cryogenic and space environments as well as high shock / vibe environments. Non-NASA commercial applications of the technology include commercial aerospace & aviation, pipeline monitoring, traffic / roadway monitoring, perimeter / border security, downhole oil & gas, and wind turbine monitoring.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A2.02-1374**

SUBTOPIC TITLE: Enabling Aircraft Autonomy

PROPOSAL TITLE: Low-SWaP and Low-Cost Autonomous Landing Area Confirmation Scan (AutoLACS) Tool

Small Business Concern

Firm: **Barron Associates, Inc.**
Address: **1410 Sachem Place, Suite 202, Charlottesville, VA 22901**
Phone: **(434) 973-1215**

Principal Investigator:

Name: **Dr. Nathan Richards**
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Address: **1410 Sachem Place, Suite 202, VA 22901 - 2496**
Phone: **(434) 973-1215**

Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

The air transportation system is on the verge of drastic change. Enabled by technological advances in areas including electric propulsion, computational capabilities, and machine learning, emerging vehicles have the potential to drastically lower transportation costs. Vertical takeoff and landing (VTOL) capabilities 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, the industry envisions near-future 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", cargo, and emergency 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 previously been handled by well-trained human pilots. Among the most important is the ability to autonomously confirm the suitability of a planned landing area prior to landing. The proposed autonomous Landing Area Confirmation Scan (AutoLACS) emulates the perception, cognition, and decision making of expert operators to provide an autonomous onboard capability to confirm the suitability of an intended landing area (runway, helipad, vertiport, off-field, etc.) in support of safe integration of UAS and AAM/UAM into the National Airspace System (NAS). The AutoLACS tool provides a low-cost and low-SWaP approach to identifying hazards on an intended landing surface. The key AutoLACS innovation is the use of low-cost and low-SWaP digital camera imagery (topographic photogrammetry), together with publicly available LiDAR data, to rapidly confirm the suitability of an intended landing area and to use this information to inform a multi-objective go-around/rejected-landing decision.

Potential NASA Applications (Limit 550 characters):

The AutoLACS tool directly addresses the interests of NASA's UAM Vision ConOps including enabling full responsibility for the "detection of tactical hazards" and equipping aircraft to be "highly automated and capable of performing most operations with minimal human interaction." AutoLACS addresses the ARMD strategic implementation plan's Strategic Thrust 6 (Assured Autonomy) that points to a need for safe implementation of autonomy in aviation applications. AutoLACS naturally fits into the NASA Advanced Air Mobility National Campaign.

Potential Non-NASA Applications (Limit 400 characters):

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 autonomous landing site conformation system that can be easily customized to vehicle-specific performance parameters.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A2.02-1631**

SUBTOPIC TITLE: Enabling Aircraft Autonomy

PROPOSAL TITLE: REACT-EA (Robust Encounter Avoidance and Conflict Resolution using Evolutionary Algorithms)

Small Business Concern

Firm: **Scientific Systems Company, Inc.**
Address: **500 West Cummings Park, Suite 3000, Woburn, MA 01801**
Phone: **(781) 933-5355**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

REACT-AAM seeks to improve standard collision avoidance approaches to accommodate the higher density utilization of mixed-use airspace envisioned in the Advanced Air Mobility concept. To accomplish this, SSCI proposes to develop mission-aware rerouting so that the flight path is optimized for the mission and multiple intruders.

This Detect and Avoid enhancement adds to a host of prior work in intruder detection, sensor fusion, maneuvering threat prediction, and airborne collision avoidance technologies developed over the past decade at SSCI. In prior work, we built a process for evaluating the airspace utilization models where a specific UAS would be flown, and demonstrated that selecting maneuvers from among a fixed set of motion primitives is sufficient to reach the target level of safety. In those projects, we resolved the highest risk intruder at any given moment. For AAM, we propose to fuse risk metrics from multiple threats as part of the cost function, and consider all simultaneous threats in the avoidance strategy.

We have showed that by adjusting the duration and intensity of the single maneuver that the mission path could be optimized for the most urgent threat. In this work, we seek to extend the guarantees of safety to a set of multi-sequence avoidance maneuvers that are constructed using machine intelligence through genetic algorithms. We have demonstrated as part of the DARPA CODE program that our trajectory solver implementation using evolutionary algorithms is near-instantaneous for real-time objective-based path replanning, and expect that it will be equally adept in the DAA space. Thus, we can improve performance of the mission and meet the metrics for flight safety amid multiple intruders through a heterogeneous series of dynamic responses.

Potential NASA Applications (Limit 550 characters):

REACT-AAM is applicable to NASA's UAS integration in the NAS programs, as each UAS will be required to have onboard SAA. The specific challenge will enable Urban Air Mobility and other Advanced Air Mobility components to safely maneuver in congested airspace and resolve real-time conflicts in flight paths. The technology is also are applicable to other conflict avoidance needs, such as required for orbital adjustments to avoid space debris.

Potential Non-NASA Applications (Limit 400 characters):

REACT-AAM plans amid multiple risk sources and constraints. The approach within REACT-AAM will have applicability to autonomous vehicles that are constrained by traffic laws, have comfort objectives, and must navigate among other vehicles. It could help solve autonomous navigation of narrow shipping channels in the USV domain.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A2.02-2400**

SUBTOPIC TITLE: Enabling Aircraft Autonomy

PROPOSAL TITLE: Trajectory Management to Enable Resilient Autonomy

Small Business Concern

Firm: **Xwing, 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):

Xwing is developing a certifiable Mission Management System (MMS) to enable safe and resilient autonomous operations. The goal of the MMS is to provide an Unmanned Aircraft System (UAS) with the required decision making and trajectory planning capabilities that would enable it to be self-directed and self-sufficient. The MMS continuously monitors for off-nominal conditions and initiates appropriate mitigating actions and trajectory changes, providing the UAS with a high degree of resilience to off-nominal conditions. This proposal aims to develop the onboard real-time trajectory generation capability and associated decision making elements within Xwing's MMS. Specifically, this proposal will focus on trajectory generation for (a) autonomous airborne collision avoidance consistent with any available Detect and Avoid Regulations, (b) emergency landing under total loss of thrust, and (c) associated decision making required to trigger the computation and execution of these trajectories/mission plans in a timely manner. These capabilities play a key role in enabling autonomous operations of new air travel modalities such as Urban Air Mobility and Regional Air Mobility. A key emphasis of this proposal is the development of these capabilities with the ultimate aim of being certified for use on Xwing's commercial autonomous air cargo operations.

Potential NASA Applications (Limit 550 characters):

- Advanced Air Mobility Project: The proposed trajectory generation for autonomous collision avoidance and emergency landing can be directly utilized within the context of Urban and Regional Air Mobility operations to enable these aircraft to operate in a self-directed and self-sufficient manner.
- The proposed work also aligns well under System Wide Safety project's research involving emerging, unpiloted aircraft and urban operations, thus accelerating the development of large commercially viable unmanned aircraft systems.

Potential Non-NASA Applications (Limit 400 characters):

- Widespread acceptance of proposed emergency planning capability by avionic manufacturers can reduce aviation accidents due to loss of thrust (e.g. US Airways 1549 water landing on the Hudson)
- This proposal can pave the way towards development of standards required for the certification of onboard real-time trajectory generation and decision making systems.

Duration: **6**

PROPOSAL 23-1- **A3.01-1696**

NUMBER:

SUBTOPIC TITLE: Advanced Air Traffic Management for Traditional Aviation Operations

PROPOSAL TITLE: Predicting Operational Disruption Probabilities for Arrival Planning and Flow Management

Small Business Concern

Firm: **Robust Analytics**
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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):

The ***Operational Disruption Forecasting System (ODFS)*** predicts the uncertainties in the arrival process by integrating a suite of deep learning models with live data streams and streaming analytics to forecast the possible evolution of arrivals into the terminal airspace over the next 15 hours. The innovation accomplishes that objective by leveraging knowledge of the airspace structure and procedures, assessment of weather forecast accuracy, predictions of FAA-imposed constraints, and airport capacity forecasts to present a complete assessment of the future evolutionary paths of the terminal airspace.

Beginning 15 hours ahead, ODFS generates probabilistic airport capacity scenarios based on weather forecasts, arrival and departure demand, and predictive models of weather forecast uncertainty. As the forecast window shortens, more information is incorporated into the prediction system. Predictions of possible convective weather impacts on arrival flows and runway capacity, and the potential for FAA-imposed traffic management initiatives (TMI), add more

potential for disruption to planned operations. Enroute and terminal convective weather and changes to airline schedules may create congestion at arrival fixes. A trajectory prediction model integrates those data and forecasts, generating higher fidelity predictions of aircraft ETAs to the runways.

The Robust Analytics solution develops a multi-stage analytical process that generates probabilistic scenarios at each stage. Once integrated, the scenarios form a comprehensive picture of the uncertainties along the entire arrival process. Over time, higher fidelity datasets continuously update the predictions allowing dispatchers and controllers to adjust. The core modules of ODFS are airport capacity forecasts and a trajectory prediction model. Potential impacts of other constraints – convective weather forecasts, TMI predictions, and arrival fix demand – serve as inputs to the core models.

Potential NASA Applications (Limit 550 characters):

This project supports NASA research objectives by developing algorithms and applications to predict how airport arrival flows may change with evolving and uncertain weather and traffic conditions. Our approach differs significantly from previous research efforts in its explicit treatment of uncertainty and the aim to develop tools to support decision making in an uncertain environment. Our approach illustrates the benefit of applying deep learning methods to long-standing technical challenges in traditional airspace operations.

Potential Non-NASA Applications (Limit 400 characters):

In separate meetings held with Robust Analytics from July 2022 to February 2023, three airlines stated their top priority to be improved operational efficiency at their busiest airports. Achieving that objective was hampered by uncertainties in forecasting airport conditions over the next several hours and lack of insight into FAA decisions. And that they would be interested in such a service.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A3.02-1214**

SUBTOPIC TITLE: Advanced Air Traffic Management for Nontraditional Airspace Operations

PROPOSAL TITLE: Vertiport Surface and Airspace Modeler (VSAM)

Small Business Concern

Firm: **Architecture Technology Corporation**
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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):

To explore and establish Urban Air Mobility (UAM) viability, researchers need to assess vertiport designs and the operational concepts that aim to maximize throughput of aircraft, passengers, and cargo while maintaining safety. Many of these future vertiports, especially those in urban areas, will have highly constrained airspace and limited area for surface operations. To understand how to create safe and efficient vertiport surface layouts and airspace procedures, there is a need to model and evaluate a range of vertiport characteristics under a range of operational conditions. The Vertiport Surface and Airspace Modeler (VSAM) provides the ability to design, visualize, and evaluate vertiport elements including local airspace procedures, final approach and touchdown (FATO) areas, touchdown and liftoff (TLOF) areas, taxi routes, aircraft parking spots, and recharging areas. VSAM includes automation and analysis tools that let researchers evaluate and refine vertiport surface and airspace topologies. VSAM models arrival, departure, surface, and turnaround operations to support integrated operational assessments of the vertiport surface and airspace design.

Potential NASA Applications (Limit 550 characters):

VSAM can help NASA increase the community knowledge of vertiport topologies and aspects that impact efficiency and safety. VSAM can support the development and fast-time evaluation of vertiport configuration, scheduling, and traffic management algorithms. VSAM can be integrated with other NASA simulators and the NASA ATM-X Testbed to provide a more robust evaluation capability that incorporates fast-time vertiport modeling. VSAM would help NASA and the FAA conduct research for vertiport rules and policies to help mature UAM.

Potential Non-NASA Applications (Limit 400 characters):

Existing heliports would likely be adapted for UAM. UAM operators would also need to develop many new vertiports. VSAM could help assess the conversion of existing heliports as well as the development of new vertiports. Once a vertiport was operational, VSAM would help assess its performance and model potential operational improvements.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A3.02-1708**

SUBTOPIC TITLE: Advanced Air Traffic Management for Nontraditional Airspace Operations

PROPOSAL TITLE: Near Real-Time Wildfire Prediction Alerting Service

Small Business Concern

Firm: **ATAC**
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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):

ATAC and NCAR propose to develop a near real-time Wildfire Prediction Alerting Service (WPAS). WPAS addresses Subtopic A3.02's need for providing wildland fire prediction for situational awareness that supports various stakeholders in the incident command structure. It develops automated near real-time wildfire predictions to alert stakeholders and provides applicable and timely information for strategic, tactical, and operational decision making. In the US, wildfires are becoming more severe and frequent, causing historic levels of acreage burned, structure damage, and lives lost. 2020 was the worst year with 59,000 wildfires, and 10.1 million acres and 17,904 structures burned. Fire suppression costs in 2021 were $4.3B and total costs exceeding $11B. WPAS paves the path for achieving NASA's goal of ensuring the highest safety and efficiency of operations for wildfire response by advancing the state of the art in multiple relevant areas: (1) WPAS leverages recent advances made by NCAR's WRF-Fire model to develop a high-resolution fire spread forecast system based on a numerical weather prediction model coupled with a wildland fire behavior model. (2) WPAS develops a near real-time inventory of wildfire spread predictions based on current wildfire incidents and conditions through

integration with satellite-derived fire data via NASA's FIRMS. (3) WPAS develops wildfire specific metrics and alerts providing context in terms of location and severity of the incident and categorizes each incident with an alert level to provide actionable information for field operators. (4) WPAS supports a real-time pathway for future technologies or human observations to provide updates on fire perimeters to enable the most up-to-date wildfire spread predictions. The Phase I proof-of-concept demonstration provides actionable insights to support strategic ground and aerial asset allocation, tactical firefighting strategies, operations safety and efficiency, and community safety.

Potential NASA Applications (Limit 550 characters):

(1) WPAS integration with NASA's ACERO situational awareness interfaces to provide prediction services for the fire perimeter, wildfire metrics and alerts, aircraft turbulence, winds, and smoke concentrations to improve wildfire response and safety

(2) WPAS integration with NASA's Testbed to provide what-if-scenario support for wildfire response simulations

(3) WPAS support for wildfire airspace management technology, second shift capability, and wind/fire-sensitive route optimization algorithm developments by NASA incl. flight demos and tests

Potential Non-NASA Applications (Limit 400 characters):

(1) Wind/fire hazard forecasting tool for disaster response operational units including dispatchers, air tanker, air attack, and UAS operators

(2) Integration into existing and emerging wildfire technologies from vendors covering wildfire detection, reaction, and behavior

(3) Identification of optimal locations for wildfire response asset placement for USDA/USFS, DOI/BLM, and State/City governments

Duration: **6**

PROPOSAL NUMBER: 23-1- **A3.02-1718**

SUBTOPIC TITLE: Advanced Air Traffic Management for Nontraditional Airspace Operations

PROPOSAL TITLE: Uncrewed Aircraft System Data Assimilation for Improved Wildland Fire Fighting Decision Support

Small Business Concern

Firm: **Black Swift Technologies, LLC**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 7
Technical Abstract (Limit 2000 characters):

Aerial assets are a critical tool used to fight wildland fires in areas of complex terrain. In late 2021, the first known attempt to use an air tanker at night resulted in a fatal crash that was potentially caused by strong low level turbulence. This tragedy and others like it demonstrate the need for accurate estimates of the current low-level wind field and its evolution over 3-12 hours in order ensure safe and efficient operations and to expand the operational envelope to include nighttime operations.

We propose a pilot study to demonstrate the value of collecting and assimilating targeted UAS observations to improve the representation of low-level winds and turbulence within regions impacted by active wildland fires. Black Swift Technologies (BST) will lead a partnership with NCAR/RAL and Colorado's Center of Excellence (CoE) for Advanced Technology Aerial Firefighting to tackle this challenging problem. BST will work with the CoE to obtain permission to collect UAS observations near wildland fires and the resulting data will be employed by NCAR to perform data quality assessments and data assimilation (DA) experiments using an Ensemble Kalman Filter approach which has been tailored to assimilate UAS observations. Not only will this allow for optimizing the impact of UAS borne measurements, it will also allow for determination of critical wind and turbulence criteria that are needed to support the safe operation of airborne wildland firefighting assets. Data quality assessments will be used to quantify a key outcome of this proposed effort which will be to demonstrate the degree to which UAS observations can be used to improve the accuracy of low-level winds and turbulence in the vicinity of a wildland fire and to determine how this enhanced guidance improves the safety of mixed (crewed and uncrewed) flights performed during wildland firefighting operations.

Potential NASA Applications (Limit 550 characters):

The proposed combined technologies of utilizing UAS to improve the accuracy of low altitude wind forecasts over wildfires serves several NASA needs. While NASA Ames will be the primary customer for the wildfire use case, this technology can also be expanded to advanced air mobility (AAM) use cases in both mountainous areas and in urban corridors. Other potential agency applications include NASA Earth Science programs associated with the 3D-Winds mission as articulated by National Research Council in the decadal survey.

Potential Non-NASA Applications (Limit 400 characters):

The primary users of this technology will be all groups involved in aerial firefighting such as CalFire and the Colorado's Center of Excellence (CoE) for Advanced Technology Aerial Firefighting. BST envisions integration of UAS into aerial firefighting can be accelerated by offering a service such as this that promotes safety for crewed aircraft participants that may be otherwise skeptical of UAS.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A3.03-2065**

SUBTOPIC TITLE: Future Aviation Systems Safety

PROPOSAL TITLE: Automated VuLnerability Assessment and Risk Mitigation for Future Aviation Systems Safety, ALARM

Small Business Concern

Firm: **University Technical Services, Inc.**
Address: **6411 Ivy Lane, Suite 108, Greenbelt, MD 20770**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 6
Technical Abstract (Limit 2000 characters):

The integration and digital connection of National Airspace System (NAS) with Unmanned Aircraft Systems (UAS) and Advanced Air Mobility (AAM) provides more pathways for hackers to attack the aircraft. To address this critical need, University Technical Services, Inc. (UTS) proposes to develop an automated vulnerability assessment and risk mitigation (ALARM) system, to provide real-time cybersecurity vulnerability monitoring, assessment, and mitigation for the future aviation systems safety. The key innovation of this work is the development of real-time aviation systems monitoring, machine learning (ML)-based cyber threat detection, proactive vulnerability scan and assessment, dependency-based system-level vulnerability assessment and risk analysis, and aviation cyber threat intelligence for comprehensive security analysis and threat mitigation. The proposed technology, if successful, will achieve a breakthrough in the computational efficiency for aviation systems cybersecurity assessment and risk analysis.

Potential NASA Applications (Limit 550 characters):

The proposed technology addresses a critical need in NASA's strategic goals to advance the state-of-the-art in autonomous flight operations and onboard systems cybersecurity. Within NASA, the Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) (UAS-NAS) Project, the Advanced Air Mobility (AAM) project, and the System-Wide Safety (SWS) project will directly benefit from ALARM.

Potential Non-NASA Applications (Limit 400 characters):

ALARM's applications are for communications satellites, networks on-the-move, swarm drone networks, and UAV ops. This directly applies to Urban Air Mobility. All aircraft need to be protected from cyberattacks and malware, as they rely on 3rd party services and could be digitally connected. ALARM is positioned to support burgeoning UAS and UAM manufacturers, operators, customers, and regulators.

Duration: **6**

PROPOSAL NUMBER:	23-1- **A2.02-1398**
SUBTOPIC TITLE:	Enabling Aircraft Autonomy
PROPOSAL TITLE:	Autonomous Mission Planning for Aircraft

Small Business Concern

Firm: **Cornerstone Research Group, 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):

The increased use of autonomy in aircraft can offer a number of benefits including faster response times, ability to utilize more incoming sensor data, and reduced reliance on highly trained personnel. Developers, integrators, and regulators of autonomous technologies must build trust within the aircraft community that these technologies are capable of operating in spaces formerly occupied by manned operators. There are a number of challenges that must be overcome for integration of more advanced autonomous technologies within aircraft. Autonomous aircraft must be capable of safely operating when faults occur and be capable of performing safe, controlled landings when it is not possible to proceed to their original destination. These platforms must be capable of receiving input from multiple disparate sensors and understanding what this sensor data means for the aircraft and its environment. They must be able to respond in real-time as the environment changes in response to weather, other vehicles, or changes in the vehicle's condition itself. Technology that could enable an autonomous aircraft to respond rapidly and reliably to changes in the environment or in the vehicle would significantly increase the space over which these platforms can operate. In this program, Cornerstone Research Group, Inc. (CRG) will develop and demonstrate a system for performing in-flight changes to aircraft missions in response to new information.
Potential NASA Applications (Limit 550 characters):

- Urban air mobility
- Autonomous or remotely piloted aircraft
- Energy efficiency

Potential Non-NASA Applications (Limit 400 characters):

- Aeromedical transportation
- Cargo delivery
- Disaster response

Duration: **6**

PROPOSAL NUMBER: 23-1- **A3.02-2641**

SUBTOPIC TITLE: Advanced Air Traffic Management for Nontraditional Airspace Operations

PROPOSAL TITLE: Expeditionary BVLOS Infrastructure and UTM for Airborne Wildfire Response

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):

Current aerial wildfire management is limited by existing operational limitations imposed by regulations and manual airspace management techniques, preventing integration of new aircraft types such as UAS. Core issues preventing optimal use of the wildfire response airspace are:

- Lack of integrated planning and deconfliction between manned aircraft and UAS
- Lack of manned aircraft situational awareness of UAS operations
- Limited range of UAS operations due to VLOS restrictions

The proposed integrated expeditionary BVLOS infrastructure and UTM solution will enable safe integration of UAS in the restricted airspace during a wildfire response. The solution addresses the core issues through:

- A mobile expeditionary ground-based surveillance system composed of one or more BVLOS infrastructure system nodes that can operate independently or in a connected environment
- A UAS Service Supplier (USS) with an integration framework (OSIF) bridging mobile nodes through mobile RF networks and providing consolidated situational awareness

The surveillance system will provide cooperative and noncooperative manned aircraft surveillance coverage to the USS. Using the surveillance data, the USS provides:

- Manned aircraft situational awareness to the UAS operator, ground-based Operations Center, and other wildfire responders
- UAS operations situational awareness to the Operations Center and other wildfire responders as well as to manned aircraft operators through the Operations Center and the USS

In addition, the USS provides the infrastructure for strategic deconfliction of planned UAS operations with other air operations, including both UAS and manned.
The system's expeditionary ground-based surveillance provides not only a common operating picture of all airborne operations in the area, but also enables the use of today's inventory of UAS assets to be used for beyond visual line-of-sight (BVLOS) operations – greatly expanding the operational efficiency of UAS for emergency response operations.

Potential NASA Applications (Limit 550 characters):

Integrated UAS/manned airspace management proof-of-concept

Automated UAS/manned airspace coordination development

Airborne wildfire response ConOps development

Mobile expeditionary BVLOS infrastructure

Expeditionary BVLOS infrastructure for drone operations research

Mobile sensor and communications node for technology evaluations and proof-of-concept development

UTM resilience testbed

Testbed for manned aircraft UAS alerting

Potential Non-NASA Applications (Limit 400 characters):

Wildfire and emergency response BVLOS and airspace surveillance infrastructure

Mobile expeditionary BVLOS infrastructure for commercial BVLOS operations (e.g., inspections, survey, imagery)

Mobile airspace/ground surveillance and communication node

Integrated UAS/manned traffic management (ATM-X)

Manned aircraft UAS alerting infrastructure

Duration: **6**

PROPOSAL NUMBER:	23-1- **A3.05-2209**
SUBTOPIC TITLE:	Advanced Air Mobility (AAM) Integration
PROPOSAL TITLE:	Long-Range Compact Economical Lidar for Wind Profiling

Small Business Concern

Firm: **Beyond Photonics, LLC**
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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5
Technical Abstract (Limit 2000 characters):

Wind events, turbulence, wind shear, etc., are continuing to cause accidents and fatalities for aviation. As NASA strives to bring aviation services to more location, including urban locations, and increasingly relies on autonomous operation, the requirement to mitigate incidents caused by winds is imperative. To this end we propose a high-performance long-range wind profiling coherent-detection lidar system that achieves the NASA stated objectives and requirements. The system will provide high precision measurements beyond 20 km near-horizontal range in most conditions within the atmospheric boundary layer. The performance is achieved with a novel and optimized lidar system design. Since coherent lidar signal detection sensitivity favors pulse energy over pulse repetition rate, the increased range performance is enabled by the use of a high-energy crystal-based transmitter in contrast to a typical lower-pulse-energy fiber-based

transmitters. This lidar operates at an optimal atmospheric transmission wavelength near 1.6 micron. Reliability and cost improvements are accomplished by miniaturization and advanced manufacturing techniques. The staff at Beyond Photonics have decades of experience in the development and deployment of remote sensing lidars and radars throughout the world, and we are confident that we can successfully execute the development of this affordable advanced high-performance lidar system. For the Phase 1 program we will leverage our experience to design and build a breadboard novel transmitter as the first step in the development of the lidar. Phase II would advance this to a complete brassboard coherent detection lidar transceiver.

Potential NASA Applications (Limit 550 characters):

NASA applications of this high-performance long-range lidar, include on-going efforts for aviation, PBL 3D-winds (e.g. NASA LaRC's Wind-SP effort), and future developments directed at global winds; ground-based and airborne lidar programs; eyesafe remote laser spectroscopy applications for measurement of atmospheric methane and water vapor constituents; tracking fast-moving space debris and asteroid hazards; and other shortwave-IR wavelength instrument developments in the 1.5-to-2.0 micron wavelength region.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA uses of the lidar include DoD wind profiling, hard target/space debris tracking/imaging and research/industrial applications requiring very compact and environmentally robust transmitters at eyesafe SWIR wavelengths. Development is planned for this compact high-performance remote-sensing instrument for winds and other sensing applications which will result in significant commercial sales.

Duration: **6**

PROPOSAL NUMBER: 23-1- **A3.03-2370**

SUBTOPIC TITLE: Future Aviation Systems Safety

PROPOSAL TITLE: Continuous Autonomy Runtime Monitoring to Assure Consistent Operational Safety

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):

Advances in aviation offer significant potential benefits in the transportation of packages and passengers by uncrewed aircraft systems (UAS). These aircraft can improve efficiency, reduce costs, increase safety, and provide new capabilities in various industries. However, before uncrewed aircraft can be widely adopted, they must be shown to be safe. New advances in artificial intelligence and robotics can provide the fundamental components, but they can be challenging to certify using existing standards. Although machine perception and motion planning can be trained to detect and recognize hazards, they cannot be verified to a sufficient level ahead of time, making it difficult to meet aerospace certification standards.

This Phase I proposal introduces a methodology to incorporate high-performance components for uncrewed aircraft in a way that guarantees a high level of assurance. Known as runtime assurance (RTA), this concept wraps less-trusted functions with high assurance functions. We propose to develop and demonstrate RTA logic as it applies to two capabilities related to critical UAS system failures and proximity to people and property: obstacle avoidance and safe landing, both of which are essential to a safe response during a forced landing event. We will demonstrate RTA logic in a modern multi-core processor architecture and validate it through the introduction of seeded faults in the autonomous landing system's software and sensors. This methodology will scale to address all functions necessary for safe flight and provide regulators, insurers, and end users the confidence needed to accelerate adoption.

Potential NASA Applications (Limit 550 characters):

Runtime assurance is broadly a good option for providing assurance for complex functions. RTA can be used in space flight for critical functions such as guidance, navigation, and control, which are essential for safe and successful space missions. For example, NASA has used RTA in its Mars rovers to ensure safe and reliable navigation over rough terrain and to avoid obstacles. This can be extended to include simulated environments and hardware-in-the-loop testing to ensure that RTA system functions correctly under a wide range of conditions.

Potential Non-NASA Applications (Limit 400 characters):

A major challenge of the introduction of autonomous, uncrewed aircraft in the national airspace is the need to ensure safe operation while pushing for efficiency. This work provides assurance of complex autonomy functions that would otherwise be challenging or impossible to certify using existing methods. This work is applicable to commercial delivery of people/packages and police/firefighter use.
Duration: **6**

PROPOSAL NUMBER: 23-1- **A3.05-1898**

SUBTOPIC TITLE: Advanced Air Mobility (AAM) Integration

PROPOSAL TITLE: Atmospheric Winds LIDAR Profiler

Small Business Concern

Firm: **Systems & Processes Engineering Corporation**
Address: **4120 Commercial Center Drive, Suite 500, Austin, TX 78744**
Phone: **(512) 479-7732**

Principal Investigator:

Name: **Dr. Scott Sifferman**
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Address: **4120 Commercial Center Dr, Ste 500, TX 78744 - 1068**
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Business Official:

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Phone: **(512) 691-8171**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 6
Technical Abstract (Limit 2000 characters):

Systems & Processes Engineering Corporation (SPEC) is proposing an Atmospheric Winds LIDAR Profiler system to improve understanding and study of atmospheric 3D winds conditions while fitting in a CubeSat-style (1000 cm^2) volume. The planned system is a single-channel fiber optic-based, eye-safe wind LADAR that includes a MEMS inertial measurement unit (IMU), image comparison, and GPS inputs to obtain a global stabilized coordinate 3D image which allows coherent updating. This feature is key for the wind detection function, as it allows coherent voxel updates over a second, necessary for detecting low speed air currents and determining the vector direction of the air current using changing view angle during pitching and direction changes. The system utilizes telecom fiber components to achieve low cost and miniature sizing. The proposed system will combine mature LIDAR and LADAR system elements already within the SPEC product portfolio.

Potential NASA Applications (Limit 550 characters):

Applications include sensing of 3D winds along the entire atmospheric air column from sea level to the stratopause. Capturing wind velocity information throughout the atmosphere is a significant opportunity to improve and enhance current atmospheric fluid models, leading to benefits such as better flight vehicle design and flight planning, improved climate modeling, and improved weather forecasting – which has benefits both for civilians and for NASA flight planners, who can be better prepared for weather impacts when making future schedules.

Potential Non-NASA Applications (Limit 400 characters):

The most significant worldwide application is dramatically improved flight safety instrumentation for all commercial aircraft. Other applications range from atmospheric, weather prediction, and climate science to airframe engineering and design, light aircraft wind mapping, wind field detection for airports and wind turbine fields, and for pollution and hazardous gas release mapping.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H9.03-1006**

SUBTOPIC TITLE: Flight Dynamics and Navigation Technologies

PROPOSAL TITLE: In Situ Algorithm for Orbital Debris Characterization

Small Business Concern

Firm: **Redtower Enterprises, LLC DBA Redtower Labs**
Address: **5020 Night Hawk Drive NorthEast, Rio Rancho, NM 87144**
Phone: **(202) 213-6258**

Principal Investigator:

Name: **Mr. Steve Rojas**
E-mail: **steve.rojas@redtowerlabs.com**
Address: **3721 Fulton St. NW, DC 20007 - 1343**
Phone: **(202) 213-6258**

Business Official:

Name: **Mr. Steve Rojas**
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Address: **3721 Fulton St. NW, DC 20007 - 1343**
Phone: **(202) 213-6258**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

Millimeter sized orbital debris is effectively outside the range of current tracking capabilities which means the data being used to assess and mitigate risk is significantly lacking -- specifically for the small to medium sized debris population. The need for better methods and techniques to characterize the existing and future debris field outside the range of remote sensors was highlighted by the National Academy of Sciences in 2011:

"The medium size range, approximately 5 mm to 10 cm for orbital debris, is the most difficult to characterize, with only episodic radar measurement campaigns contributing to knowledge of the environment, yet the risk (probability of collision times consequence) may be the greatest in this size range. Undoubtedly, impacts with debris in the medium size range should be occurring much more often than collisions between trackable objects..."

There are an unknown but likely very large number of satellites currently in orbit that have been struck by small to medium size orbital debris, survived with no major degradation in performance, but nevertheless registered the anomalous dynamic perturbation event in their control system data stream. We are seeking funding to productize a new type of algorithm that exploits these preturbation anomalies and can be loaded in situ on new and existing satellites to characterize the small to medium debris environment.

Our algorithm can be placed on satellites designed, built, and deployed specifically to characterize the debris environment, or, existing satellites that are in orbit for other purposes but contain basic information about the satellite's movement. Unlike any in situ capability now available, the algorithm proposed here can provide low cost accurate estimates of important debris environment characteristics such as impact velocity, density, and associated satellite damage.

Potential NASA Applications (Limit 550 characters):

NASA applications that would benefit from our technology are wide ranging since orbital debris in the small to mid sized regime pose a threat to both manned and unmanned missions across the spectrum. Better characterization of the orbital debris environment would improve the data that underpins current tools, such as ORDEM, used to estimate and mitigate the risked posed by orbital debris. MADCAP would also significantly benefit since our technology would provide an avenue for characterizing debris in deep space using in situ spacecraft.

Potential Non-NASA Applications (Limit 400 characters):

There is currently a "data deficit" in the space situational awareness business that remote sensing technologies alone cannot remedy. As a result, safe and sustainable commercial operations in space will increasingly be threatened by orbital debris. Our product represents a lower cost pathway to solving the data deficit problem: simply characterize, upload, and begin collecting data.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H9.08-1650**

SUBTOPIC TITLE: Lunar 3GPP Technologies

PROPOSAL TITLE: Lunar Access Network Supporting 5G and Beyond

Small Business Concern

Firm: **MTI Systems, Inc.**
Address: **5929 Talbot Road, Lothian, MD 20711**
Phone: **(410) 507-0234**

Principal Investigator:

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Business Official:

Name: **Colleen McGraw**
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Phone: **(410) 507-0234**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

We propose to research and plan development for a Radio Access Network (RAN) design for Lunar exploration based on the current 3GPP standards for 5G NR in Release 17, and capable of continuous integration of new 3GPP releases. This upgradeability will represent a significant departure from a rigid hardware approach, for instance used in planned 4G LTE demonstration, and will enable the best use of lunar network assets given their uncertain schedules, lifetimes, and ever-changing mission needs. This approach fuses the excellent properties of NASA's work on Software Defined Radio (SDR) platforms with 3GPP-based system architecture and standards. Resulting hardware and software designs based on SDRs for the gNodeb and User Equipment (UE) will be suitable for development into a low Size Weight and Power (SWaP) long life lunar environment tolerant package for operational deployment. We will address the neartime RAN Intelligent Controller (RIC) and control applications, traditional non-RAN core network and the non-realtime RIC and control applications. We will collaborate with NASA to assess 5G application from today's plans through service initiation, growth and

development to define the general requirements for distributed network control (5G core network and Open-RAN (O-RAN) RIC) and 3GPP gNodeB and UE functionality. We will then identify adaptations of O - RAN components necessary to provide 5G distributed network functions and associated hardware and software which meets the demands of lunar exploration. From this research, we will define a path forward for Phase II development of a prototype gNodeB hardware/software platform. We will also investigate sidelink architectures and capabilities for PNT that can be integrated over time through software updates. The envisioned outcome is a hardware/software package suitable to be integrated with any systems that are deployed such as Astronaut suits, robotic explorers, fixed platforms, orbiting relays, and Gateway.

Potential NASA Applications (Limit 550 characters):

Potential NASA application is to enable mobile and fixed radio frequency wireless communications capability for lunar exploration that meets 3GPP standards for 5G and beyond through providing Open Radio Access Network (O-RAN) central and distributed control implemented in gNodeB elements, User Equipment interfaces, distributed and centralized unit functions, and RAN intelligent controller functions implemented in a low size, weight and power package and enable NASA to purchase such communications as a service.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications for Non-Terrestrial Networking control of 5G and beyond are growing in importance and maturity. These include edge applications for robustness, resiliency, and expansion beyond what ground based commercial cellular networks expect, and bringing 5G connectivity to satellite networks, high altitude air vehicles to enable 5G and beyond communications capabilities.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H4.08-1135**

SUBTOPIC TITLE: Anti-Fog Solutions for Spacesuit Helmet

PROPOSAL TITLE: Permanent, Transparent Anti-fog Coating for Spacesuit Helmets

Small Business Concern

Firm: **Lynntech, Inc.**
Address: **2501 Earl Rudder Freeway South, College Station, TX 77845**
Phone: **(979) 764-2200**

Principal Investigator:

Name: **Nathaniel Hawthorne**
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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):

Fogging of polycarbonate spacesuit helmets is detrimental to astronaut safety and to the success of the mission. Currently used anti-fogging methods are temporary, and require the reapplication of a coating before each use. These temporary solutions have been shown to delaminate during use and have led to eye irritation and temporary blindless during spacewalks. Potential permanent solutions NASA has tested lack in durability and are prone to coating damage and delamination during cleaning. NASA seeks the development of a permanent anti-fog solution that (i) maintains visible light transmission above 70%, (ii) can be applied with uniform thickness, (iii) can be applied to objects regardless of geometry, and (iv) has demonstrated durable anti-fogging properties, such as maintained clarity over 216,000 steam cycle exposures, coating stability over 100 cycles of wiping with deionized water and a soft wipe, and a grade of 5B on the ASTM D3359 adhesion test. To address these requirements, Lynntech will leverage its experience with coating development to fabricate a permanent, durable, anti-fog coating that can be applied to polycarbonate. In the Phase I project, Lynntech will demonstrate the proof of concept by applying our coating to flat polycarbonate and verifying the durability of its anti-fogging properties. Additionally, Lynntech will develop an application method for coating curved objects, such as a prototype spacesuit helmet, to be utilized in Phase II.
Potential NASA Applications (Limit 550 characters):

The development of a permanent, durable anti-fog coating will be advantageous to NASA. The primary NASA application of this innovation would be as a permanent anti-fog coating on the interior of current and future spacesuit helmets. This would mitigate the risk of an astronaut-involved accident induced by lack of visibility.
Potential Non-NASA Applications (Limit 400 characters):

The developed anti-fog coating may be broadly applicable to equipment where fogging is a safety concern and a permanent transparent coating would be advantageous, such as scuba masks, ski goggles, automotive windshields, endoscopes, and dental mirrors. Additionally, it may find use on equipment in industries where mitigating fogging may improve quality of life, such as sunglasses and oven windows.
Duration: **6**

PROPOSAL NUMBER: 23-1- **H4.08-2666**

SUBTOPIC TITLE: Anti-Fog Solutions for Spacesuit Helmet

PROPOSAL TITLE: Anti-Fog Coatings for Spacesuit Helmets

Small Business Concern

Firm: **Acree Technologies Incorporated**
Address: **1037 SHARY CIRCLE STE E, Concord, CA 94518**
Phone: **(925) 798-5770**

Principal Investigator:

Name: **Mike McFarland**
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Address: **1037 Shary Circle, Suite E, CA 94518 - 4700**
Phone: **(925) 798-5770**

Business Official:

Name: **Ann Mulville**
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Address: **1037 SHARY CIR STE E, CA 94518 - 4700**
Phone: **(925) 798-5770**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4

Technical Abstract (Limit 2000 characters):

The purpose of this project is to demonstrate the feasibility of applying a permanent anti-fog coating on the interior of polycarbonate spacesuit helmets. The coating uses a mechanically resilient and permanent Superhydrophobic (SH) coating consisting of an optically transparent Diamond Like Carbon (DLC) and a proven 2-step plasma processing technique to achieve an anti-fog, self-cleaning, SH-DLC layer with Water Contact Angle (WCA) >150° and small roll-off angle. The all-dry process consists of an oxygen plasma etching to engineer the surface of the polycarbonate to create a well-controlled nanotextured surface, which is key to superhydrophobicity, follow by physical vapor deposition of a thin DLC coating with low surface energy at a deposition temperature compatible with polycarbonate materials. The SH coating will be applied using Acree's large volume batch coating systems and etchers.

Potential NASA Applications (Limit 550 characters):

The antifogging coating will be used on the interior of spacesuit helmets.

Potential Non-NASA Applications (Limit 400 characters):

The coating can be used on such items as sun glasses, ski goggles, safety glasses, eye glasses, face shields, etc., where a permanent, tough, scratch and abrasion resistant, antifogging coating is highly desirable.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H4.08-2745**

SUBTOPIC TITLE: Anti-Fog Solutions for Spacesuit Helmet

PROPOSAL TITLE: Permanent Anti-Fog Coatings Produced Via Aerosol Impact Driven Assembly

Small Business Concern

Firm: **Swift Coat, Inc**
Address: **2424 West Desert Cove Avenue, Phoenix, AZ 85029**
Phone: **(623) 363-2687**

Principal Investigator:

Name: **Peter Firth**
E-mail: **peter@SwiftCoat.com**
Address: **611 W. Mclellan Blvd, AZ 85013 - 1132**
Phone: **(623) 363-2687**

Business Official:

Name: **Peter Firth**
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Phone: **(623) 363-2687**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 7
Technical Abstract (Limit 2000 characters):

The proposed innovation is an antifog coating for polycarbonate substrates applied using a unique deposition technology. The deposition technology, Aerosol Impact Driven Assembly (AIDA), is a dry spray coating process capable of producing thin films with tunable porosity and

surface roughness. By using AIDA to optimize the porosity and surface roughness of SiO_2 films, a super-hydrophilic, mechanically durable and chemically stable anti-fog coating for polycarbonate can be produced. The durability of the film combined with the ability to uniformly coat large area, irregularly shaped, objects makes it an idea candidate to replace the anti-fog coating currently used on the EMU helmet. Initial tests suggest that the anti-fog coating has the potential to outlast the useful life of the EMU helmet.

The investigators have previously used AIDA to deposit durable anti-fog coatings onto glass substrates. While initial results on polycarbonate substrates are positive, there remains much opportunity to optimize the coating design and thus performance for polycarbonate. The main objectives of the work can be broken down into four tasks:

1. Use optical simulation software to help design coatings with ideal optical properties for polycarbonate.
2. Produce the simulated coatings using AIDA and evaluate the coatings' optical and anti-fog performance. Further iterate on the design if necessary.
3. Subject coatings that meet optical and anti-fog specifications to durability tests meant to simulate use in an EMU helmet. Iterate on the design if necessary to meet durability requirements.
4. Demonstrate that a coating that meets optical, anti-fog, and durability specifications can be reproduced on large areas.

The deliverable of this project will be >20 samples of polycarbonate sheets coated with the best performing coating for more intense evaluation by NASA.
Potential NASA Applications (Limit 550 characters):

The solicitation identifies anti-fog coatings for use in the EMU helmet as an immediate need. As the coating and coating method have been shown to be substrate agnostic, it can be easily applied to other materials (glass, metals, fabrics) that require ant-fog functionality. More generally, the ability to deposit dozens of different materials with tunable porosity (and thus tunable refractive index, dielectric constant, and heat transfer properties) onto a variety of substrates will undoubtedly enable new applications not yet considered.
Potential Non-NASA Applications (Limit 400 characters):

The company is currently engaged with leading manufacturer of polycarbonate lenses do develop a coating with similar functionality.

The company has previously engaged with skylight manufactures and commercial refrigeration companies who want to reduce/eliminate the appearance of condensation. A durable anti-fog coating is a potential solution to both problems.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H5.01-2668**

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

PROPOSAL TITLE: C-Tower: A scalable, deployable/retractable, and mobile truss mast to commission relocatable 50-kW class vertical solar arrays on the lunar surface

Small Business Concern

Firm: **Ceres Robotics Inc.**
Address: **916 Irving Street #371176, Montara, CA 94037**
Phone: **(650) 274-3709**

Principal Investigator:

Name: **Udit Shah**
E-mail: **udit.shah@ceresrobotics.com**
Address: **916 Irving Street, CA 94037 - 1176**
Phone: **(540) 204-3218**

Business Official:

Name: **Michael Sims**
E-mail: **Michael.Sims@ceresrobotics.com**
Address: **916 Irving Street #371176, CA 94037 - 9812**
Phone: **(650) 274-3709**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

Ceres C-Tower is a deployable/retractable truss-mast to commission foldable or rollable solar arrays, at least 10-m from the lunar surface and can generate 60kW peak power (BOL). The system has specific power of > 120 W/kg and specific volume > 45 kW/m3 (BOL). Structural mechanisms innovations of the C-Tower are proposed for this SBIR:

(1) Central Mast - Truss mast with 28 m extension and can be scaled up to 35 m, designed to function under gravity and has the advantage of being lightweight and reliable.

(2) Solar Array Deployment Arms - Mechanism of deployment and retraction for solar array.

(3) Sun-Tracking Mechanism

(4) Deployable legs for stability and levelling

The mechanisms are self-contained system capable of multiple (more than 10) deployments and retractions cycles with a long system life of at least 10 years. The two mechanisms are designed for surviving loads greater than those specified in the General Environmental Verification Standard (GEVS), GSFC-STD-7000A; ensuring the system is adaptable to multiple launch vehicles, mission architectures, and landers. The mechanisms are being designed to be dust tolerant.

C-Tower structural mechanisms which form the core development area of this contract work is being designed and developed in-house by Ceres and is currently at TRL 2. Detailed design and analysis of the mechanisms will be completed during the Phase I period, including loading and stability under transport, deployment/ retraction cycles, and mechanical loading. Components prototypes will also be tested as part of this effort to bring the proposed elements to TRL 3.

For future Phase II, full system structural prototype will be developed and will undergo extensive functional testing and environmental testing including full-scale deployment/retraction tests, stability tests, vibration tests, and drop tests to bring the system to TRL 5.

Potential NASA Applications (Limit 550 characters):

- Extend life of missions and maximize science output for polar missions
- Support Human Missions and Habitats
- Meet power needs for ISRU, lunar bases, infrastructure, landers, and rovers.
- Driver for keeping overall systems costs lower for future missions.
- Towers used on lunar surface to provide communication and observation services

Potential Non-NASA Applications (Limit 400 characters):

- Lander and rover providers can utilize C-Tower to both meet surface payload demands and potential overnight survival/revival post lunar night.
- Payload providers can utilize to maximize their science output and are potential customers.
- Used on Earth to setup at diaster or war zones to provide communications services
- Licensing to a solar array company

Duration: **6**

PROPOSAL NUMBER: 23-1- **H5.05-1632**

SUBTOPIC TITLE: Inflatable Softgoods for Next Generation Habitation Systems

PROPOSAL TITLE: Softgoods Webbing Integrated Strain Sensor for Inflatable

Small Business Concern

Firm: **Paragon Space Development Corporation**
Address: **3481 East Michigan Street, Tucson, AZ 85714**
Phone: **(520) 903-1000**

Principal Investigator:

Name: **Ted Southern**
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Business Official:

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Phone: **(520) 903-1000**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 4
Technical Abstract (Limit 2000 characters):

In this effort, Paragon will design, fabricate, and test 3 different styles of webbing integrated strain sensors. The design of these sensors will utilize Paragon's significant experience in soft goods manufacturing for the space industry and include trade studies, electrical integration, and rapid design iteration. These tests will demonstrate the tensile accuracy, cyclic hysteresis, and creep hysteresis of each of these sensors. Using the experimental results obtained, Paragon will perform a down select for follow on development of the best sensor.

Potential NASA Applications (Limit 550 characters):

Potential NASA Applications for this innovation include long-life strain sensors integrated into the webbing of inflatable habitats for the next generation of space stations. This could provide NASA additional insight into the safety of these structures during flight. This innovation can also be adjusted for use on EVA tethers and space suits and inflatable lunar habitats.

Potential Non-NASA Applications (Limit 400 characters):

Beyond NASA this innovation can have market applicability in commercial space endeavors – including inflatable space stations, EVA tethers, space suits, and lunar habitats. The innovation has applicability beyond space as well. Webbing integrated strain sensors could be used as a low cost solution to replace load cells during crane rigging & lifting operations

Duration: **6**

PROPOSAL NUMBER: 23-1- **H6.22-1123**

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

PROPOSAL TITLE: A Radiation Hard Neural Processor With Embedded MRAM

Small Business Concern

Firm: **Green Mountain Semiconductor Inc.**
Address: **28 Howard Street # 301, Burlington, VT 05401**

Phone: **(802) 578-0028**

Principal Investigator:

Name: **David Mann**
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Address: **28 Howard St Ste 301, VT 05401 - 5986**
Phone: **(607) 341-0204**

Business Official:

Name: **Mr. Ryan Jurasek**
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Address: **28 Howard St #301, VT 05401 - 5986**
Phone: **(802) 578-0028**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 1
End: 3
Technical Abstract (Limit 2000 characters):

Green Mountain Semiconductor Inc. is proposing a design and method for evaluation pursuant to the solicitation H6.22-1123. The hardware proposal is a radiation hard neural processor with embedded MRAM in an FD-SOI process; however, much of the innovation is put into the evaluation of error tolerance and design solutions to statistical radiation effects. Most fault tolerant design solutions imply a negative impact on device performance. Size, power and speed can all be degraded from additional design solutions to prevent faults from radiation. In order to create the most efficient neural processing hardware, an evaluation of the impact to the design, and more specifically, what subsystems of the design cause the highest fault rate, must be done. This can be accomplished in software using statistical models in hardware verification simulation. By building a technology specific utility for fault injection, critical subsystems can be evaluated and corrective design solutions (i.e. redundancy, dice latches, error correction codes, device selection and other methods) can be used to reduce the fault rate optimally. This technique can be taken further in scope to evaluate the fault tolerance of trained neural networks during inference. For future work, it will be possible to train networks while applying statistical fault injection to allow the network to become naturally resistant to radiation induced fails.

Potential NASA Applications (Limit 550 characters):

Potential NASA applications include any critical mission where device functionality is imperative. This includes deep space missions subject to solar flares. Flight navigation is of particular interest in this respect.

Potential Non-NASA Applications (Limit 400 characters):

Non-Nasa applications may include a multitude of terrestrial and near space applications:

- Robots working in environments with elevated radiation levels (nuclear power plants, cleanup operations following nuclear accidents or acts of warfare)
- Life-critical systems such as operating room equipment and implanted medical devices
- Sensitive and safety-critical automotive controls
- Aerospace electronics

Duration: **6**

PROPOSAL NUMBER: 23-1- **H6.22-2282**

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

PROPOSAL TITLE: Event-Based Sensing and Navigation Technologies (EBSNT)

Small Business Concern

Firm: **VisSidus Technologies, Inc.**
Address: **590 Lipoa Parkway, Suite 224, Kihei, HI 96753**
Phone: **(386) 868-2227**

Principal Investigator:

Name: **Bogdan Udrea**
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Phone: **(206) 227-8075**

Business Official:

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Phone: **(206) 617-2445**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

The Event-Based Sensing and Navigation Technologies (EBSNT) project aims to develop, integrate, and test a perception and planning avionics suite and associated on-board software in response to NASA's Subtopic "H6.22 Deep Neural Net and Neuromorphic Processors for In-Space Autonomy and Cognition" within the scope of "Neuromorphic Software for Cognition and Learning for Space Missions." EBSNT forms the foundation of a Relative Pose Determination and Control Subsystem (RPDCS) integrated on board a Servicer Space Vehicle (SSV) that performs Rendezvous, Proximity Operations, and Docking (RPOD) with a Client SV (CSV). The RPDCS uses a hybrid architecture
of event-based sensors, interconnected Spiking Neural Networks (SNNs) and traditional sensors, actuators, and von Neumann computers that enables the SSV to autonomously i) determine the relative pose and pose rate, i.e., relative translation and rotation velocities, between the SSV and a goal feature on the CSV; ii) plan a relative trajectory that places the SSV at a commanded relative pose with respect to the specified feature of the CSV; iii) perform translation and attitude maneuvers to acquire and maintain the commanded relative pose; and iv) monitor the health status of the SSV and take appropriate action to ensure mission safety in case of SSV component and subsystem failure.

Potential NASA Applications (Limit 550 characters):

On-orbit Service, Assembly, and Manufacture missions and multi-spacecraft human and robotic solar system exploration mission.

Potential Non-NASA Applications (Limit 400 characters):

Derived technologies are applicable to aerial drone swarming and convoying with applications ranging from intelligence collection to urban air mobility to package delivery.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H6.23-1322**

SUBTOPIC TITLE: Spacecraft Autonomous Agent Cognitive Architectures for Human Exploration

PROPOSAL TITLE: Autonomous Agent Cognitive Architecture for Spacecraft Operations

Small Business Concern

Firm: **VISIMO, LLC**
Address: **520 East Main Street, Suite 200, Carnegie, PA 15106**
Phone: **(412) 615-4372**

Principal Investigator:

Name: **Alexander Moskowitz PhD**
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Business Official:

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Phone: **(412) 615-4372**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters):

Deep-space missions will require spacecraft to overcome unknown problems and unexpected system failures in novel regimes without the support of Earth-based communication or resources. Reliable autonomous systems are needed to assist crew with managing and executing missions, and responding to unanticipated system failures and anomalies, thereby reducing cognitive burden of the crew and time spent on troubleshooting and preventative maintenance.

VISIMO proposes an autonomous agent Cognitive Architecture (CA) to identify and mitigate system failures on deep-space missions. The CA will locate problems, notify the most relevant spacecraft system or human team, and map solutions to unexpected problems. VISIMO has partnered with Hewlett Packard Enterprise (HPE), who has offered their Spaceborne Computer-2, located aboard the ISS, as a venue for Phase II testing and validation of VISIMO's solution in relevant operational contexts, allowing VISIMO access to the International Space Station (ISS).

VISIMO will refer to the system as **GR**aceful **A**rchitecture for **M**itigation of **S**ystem failures, or **GRAMS**, which highlights the important properties of the architecture—that it is designed using principles of Graceful Extensibility; that its emergent networks allow it to identify "unknown unknowns;" and that the system not only identifies possible failures, but also provides mitigations to the appropriate recipient.

The CA connects to the ISS, Moon to Mars, and Advanced Exploration Systems (AES) missions. The proposed Phase I application will be tested against a realistic model of the Atmosphere Control and Supply (ACS) subsystem of an Environmental Control and Life Support System (ECLSS), such as that used on the ISS, to confidently determine feasibility and reliability.

Potential NASA Applications (Limit 550 characters):

GRAMS will identify and mitigate spacecraft system failures on deep-space missions by locating problems, mapping solutions for dynamic environments, and detailing potential consequences of mitigation actions. The software will thereby reduce the cognitive burden on crew members and time spent on preventative maintenance, maximizing crew time for research and scientific exploration.

Potential Non-NASA Applications (Limit 400 characters):

GRAMS supports improved autonomy in situations that require high levels of assurance in dynamic environments, including certification of land, air, and sea autonomous vehicles. The tool can also be used for risk and failure monitoring of non-vehicle systems like the management of nuclear and chemical plants through alerting personnel of upcoming risks and engaging automatic safety systems.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H8.01-2301**

SUBTOPIC TITLE: Low-Earth Orbit Platform and Microgravity Utilization for Terrestrial Applications

PROPOSAL TITLE: Feasibility study for an automated Machine Learning analytics platform applied to muscle tissue chips in-space manufacturing process control

Small Business Concern

Firm: **G-Space, Inc**
Address: **1266 Parkington Avenue, Sunnyvale, CA 94087**
Phone: **(408) 391-5912**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

G-SPACE proposes a new process that integrates microgravity and artificial intelligence (AI) into a real-time analysis solution with potential future endeavors to become a predictive capability. This process will allow informed experimental tests and ultimately drug therapy decisions to be systematically discovered. The platform's user interface will allow researchers to easily design and execute experiments, monitor results, and refine their hypotheses. The platform's capabilities will significantly reduce drug discovery timelines, increase the success rate of drug candidates, and ultimately improve patient outcomes.

In partnership with Micro-gRx, G-SPACE proposes this feasibility study to demonstrate its platform use to the simulation of sarcopenia conditions both terrestrially and in-space, which have been shown to enhance cellular functions relevant to drug discovery and eventual FDA approval. Currently there are No FDA approved drugs for sarcopenia. A hallmark of sarcopenia is a progressive pathology characterized by the loss of muscle mass and strength in those over 60 years old. The age-related effects on muscle tissue is difficult to model in cell systems because of genetic differences and tissue heterogeneity in patients and it is most desirable to eliminate reliance on animal studies. The unmet medical need is a standardized platform that can provide a solid reference and evaluate patient-specific tissue pathophysiological responses to potential therapeutics in real time.

Potential NASA Applications (Limit 550 characters):

The G-Space analytic platform **will help the NASA microgravity R&D community to make an accelerated shift towards translation of microgravity science into applications. The G-SPACE "microgravity explorer" version will increase access and understanding of the potential benefits of microgravity to non-traditional commercial players and stimulate terrestrial demand. The proposed study will demonstrate the value of G-SPACE AI software platform to TOC through validation via the Micro-gRx MPS systems.**

Potential Non-NASA Applications (Limit 400 characters):

The products will be essential in ensuring that the muscle MPS can meet FDA requirements for certification and provide a standardized way to evaluate the degradation process and the effectiveness of various drugs and methods. As the database grows, the model will ultimately allow for widespread access to this groundbreaking technology.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H9.01-1824**

SUBTOPIC TITLE: Long-Range Optical Telecommunications

PROPOSAL TITLE: Asynchronous Geiger-mode photon counting arrays for deep space optical communications

Small Business Concern

Firm: **3D-SensIR, Inc**
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Principal Investigator:

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Phone: **(805) 813-7401**

Business Official:

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Phone: **(661) 645-1624**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 6
Technical Abstract (Limit 2000 characters):

Long range laser optical communications offer advantages of higher bandwidth and better accuracy over RF communications. NASA has demonstrated higher bandwidth data transmission using laser optical communication links. Recently, MIT-LL designed and delivered high sensitive Geiger-mode avalanche photodiode (Gm-APD) array receiver as a flight unit for the NASA's deep space communication demonstration program. This will be a first successful demonstration of a Gm-APD receiver technology in space. For many future missions, improvement in detection efficiency, radiation hardness, larger format and space qualifiable Gm-APD photon counting array receivers are needed. We propose a space qualifiable 1064 nm InGaAsP Gm-APD photon counting array receiver with improved photon detection efficiency (PDE). PDE will be improved by increasing the quantum efficiency using reflective layers and increasing the carrier avalanche probability. Our mesa design with a proprietary passivation process offers low dark count rates and improved radiation hardness, In Phase I we plan to demonstrate a 1064 nm InGaAsP Gm-APD photon counting array sensor chip assembly using high detection efficiency arrays. Furthermore, working with NASA, we will establish requirements for a space qualifiable receiver array. The successful completion of Phase I will demonstrate the technical feasibility of a photon counting array receiver with improved sensitivity.

In Phase II, we will design, build, and demonstrate a radiation hard 32 x 32 photon counting array receiver with improved sensitivity. We will conduct radiation tests to demonstrate improved radiation hardness. We will deliver an engineering development unit to NASA for evaluation. In addition, we will deliver a flight ready receiver design that will meet specifications for a space mission.

Potential NASA Applications (Limit 550 characters):

NASA applications include deep space optical communications missions, future space missions to earth's moon, Mars, and humans to Mars. Other potential applications include LIDAR for entry, descent, and landing sensor systems, autonomous rendezvous and proximity operations.

Potential Non-NASA Applications (Limit 400 characters):

There has been considerable interest in military and commercial space LaserComm applications. Potential military applications include tracking and identification of hypersonic missiles, beam control sensors for high power laser weapons, vibrometry, direct detection LADAR, and synthetic aperture LADAR.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H5.01-2119**

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

PROPOSAL TITLE: Trussed Collapsible Tubular Mast and Deployer Development

Small Business Concern

Firm: **Opterus Research and Development, Inc.**
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Phone: **(505) 250-3006**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 3
End: 4
Technical Abstract (Limit 2000 characters):

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

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

In the proposed effort Opterus will work closely with current NASA Lunar Vertical Solar Array Technology (VSAT) program participants to develop requirements for critical structural elements of R-ROMA and demonstrate feasibility of implementation in future architectures through large-scale ground testing.

Potential NASA Applications (Limit 550 characters):

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

Potential Non-NASA Applications (Limit 400 characters):

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

Duration: **6**

PROPOSAL NUMBER: 23-1- **H8.01-1742**

SUBTOPIC TITLE: Low-Earth Orbit Platform and Microgravity Utilization for Terrestrial Applications

PROPOSAL TITLE: Plasma based growth of diamond semiconductor in microgravity with controlled color centers for quantum applications

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):

The overall goal of this project is to successfully prepare diamond films with controlled color centers in microgravity, suitable for various terrestrial quantum technologies being pursued for extensive commercial applications in quantum sensing, quantum cryptography, quantum computing and quantum information processing. The major technical issues currently include realization of distinguishable emission, improving photon collection efficiency and other practical issues, all related to material quality, control of color centers (their location and distribution) and manufacturing technologies. There is an opportunity to address the above issues and develop a clear understanding of controlling mechanisms in the growth and incorporation of color centers through microgravity experiments that can eventually lead to manufacturing facilities in space. We aim to conduct microgravity experimental studies in four years from the start of Phase I. An existing plasma based printer, originally developed as an alternative to inkjet and aerosol jet printing and successfully commercialized, will be adapted into a plasma reactor in the proposed project. Availability of this hardware significantly reduces the risk in the proposed effort.

The Phase I effort will demonstrate the capability of growing diamond using the plasma printer operated in a plasma enhanced chemical vapor deposition mode and methane-hydrogen precursors. Diamond films will also be printed using diamond nanopowder ink. Silicon color centers will be incorporated onto the diamond films from both cases above simply by injecting silicon ink into the plasma printer. In addition to these preliminary demonstrations, the Phase I effort will prepare a clear plan for the microgravity preparation of diamond films with controlled

color centers, assess modifications necessary for the plasma printer for microgravity operation, and conduct design and process development studies for successful microgravity experiments.

Potential NASA Applications (Limit 550 characters):

This proposal is in line with the goals of the NASA INSPA program. As with past successful microgravity crystal growth and thin film growth studies, the present project seeks to gain better understanding of diamond thin film growth characteristics and color centers through experiments in controlled microgravity environment. The knowledge gained has the potential to eventually lead to manufacturing facilities in space to produce diamond thin films with controlled color centers needed in all quantum technologies.

Potential Non-NASA Applications (Limit 400 characters):

Potential applications are quantum technologies such as quantum sensing, quantum cryptography, quantum computing and quantum information processing. These applications are not only vital for national security but also for future economy. Countries that control the intellectual property and manufacturing would gain huge economic benefits. This is also in line with the CHIPS Act of 2022.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H8.01-2471**

SUBTOPIC TITLE: Low-Earth Orbit Platform and Microgravity Utilization for Terrestrial Applications

PROPOSAL TITLE: Microgravity-Enhanced Molten-Core Fibers (MEMO)

Small Business Concern

Firm: **DSTAR Communications**
Address: **4531 Dulcinea Court, Woodland Hills, CA 91364**
Phone: **(805) 501-9399**

Principal Investigator:

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Phone: **(805) 501-9399**

Business Official:

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Address: **4531 Dulcinea Ct, CA 91364 - 6119**

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 5
Technical Abstract (Limit 2000 characters):

DSTAR Communications proposes to implement the new fiber manufacturing process on board the International Space Station (ISS) to mitigate the challenges of environmental sensitivity and brittleness of exotic fiber materials. The proposed Microgravity-Enhanced Molten-Core Optical Fiber (MEMO Fiber) development encapsulates the challenging crystal and glass fiber structures inside environmentally stable and mechanically strong outer cladding glass. The Phase I SBIR study defines the optimal outer cladding materials for scalable fiber production on the ISS. The most promising core-cladding combinations with the best commercial and scientific value are optimized for manufacturing in space and produced in sample quantities on the ground. The goal of the Phase II development is to establish a debris-free MEMO fiber manufacturing process, pass the safety reviews and fabricate MEMO fibers on board of the ISS. The scalability of the MEMO fiber manufacturing will be further developed with the goal of kilometer-length fiber production runs on the ISS. The processing of MEMO fibers will be optimized to demonstrate vitrification and crystallization of the core materials. The samples of new MEMO fibers will be delivered to NASA and provided to the key industry partners for setting up Phase III sustainable manufacturing plans of MEMO products in space.
Potential NASA Applications (Limit 550 characters):

The new molten-core fiber manufacturing in combination with microgravity-enhanced processing targets sustainable optical fiber manufacturing in space. Advanced encapsulation enables vitrification and crystallization studies of the new materials. The advanced probes will improve new propulsion development, space vehicle assembly and in-space reliability characterization of aging space assets. The broadband infrared fibers will deliver new opportunities for orbital debris characterization, remote atmospheric studies and exoplanet search.
Potential Non-NASA Applications (Limit 400 characters):

The new fibers would benefit automated quality control for critical paints and coatings across multiple industries, from semiconductor processing to automotive manufacturing and aerospace assembly. The capture of temperature and infrared spectrum is essential for the multi-billion-dollar endoscope and medical instrumentation market, environmental monitoring and critical infrastructure management.
Duration: **6**

PROPOSAL NUMBER: 23-1- **H10.01-1095**

SUBTOPIC TITLE: Advanced Propulsion Systems Ground Test Technology

PROPOSAL TITLE: Ultra-High Pressure Variable Flow Control Valve - 8-inch Floating Piston Valve

Small Business Concern

Firm: **C-Suite Services, LLC**

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Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 3
Technical Abstract (Limit 2000 characters):

The technical objectives are:

1. Redesign existing 8-inch FPV for variable flow control
2. Model the modified FPV with CFDs to validate the C_v
3. Research the best seal geometry and material, validated with CFD cases
4. Design a system that will control the flow of the 8-inch prototype
5. Determine whether SLM Metal 3D Printing additive manufacturing can be used for some or all of the FPV parts.

Potential NASA Applications (Limit 550 characters):

NASA supports fluid management technology advancements that improve safety and reliability, while reducing costs; an existing 8-inch Floating Piston Valve (FPV) prototype that is modified for variable flow control will meet those challenges at minimal costs to NASA; modification of the prototype will provide faster results at a lower cost to accomplish complete.

Potential Non-NASA Applications (Limit 400 characters):

Variable flow control valves are used in agricultural, industrial, and mobile industries to provide smooth operation, low-pressure drop, and rapid response for precise fluid control. The main benefit for using a variable flow control valve is its ability to control difficult-to-handle high-pressure gaseous fluids.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H10.02-2671**

SUBTOPIC TITLE: Autonomous Operations Technologies for Ground and Launch Systems

PROPOSAL TITLE: Automated Ground Test and Launch Operations Using AI and Machine Learning

Small Business Concern

Firm: **Aphelion Aerospace, Inc.**
Address: **5815 West 6th Avenue Unit 2D, Lakewood, CO 80214**
Phone: **(321) 289-0872**

Principal Investigator:

Name: **Matthew Travis**
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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):

Aphelion Aerospace is developing an ultra-low-cost rapid response launch system utilizing a novel environmentally friendly storable propellant mixture. A key component of our operational concept requires extensive automation from manufacturing through orbital insertion. What we propose under this SBIR topic is to conduct research and trade studies, research necessary to advance the automation of our ground test and launch operations software and processes by leveraging machine learning and artificial intelligence.

Our work will focus on several key areas. First, we will refine technologies to support automated propellant and fluid handling and management including hardware conditioning, propellant loading, monitoring and integrated health and status management during launch operations. As

part of this work, we will develop sensor and software systems required for health monitoring fault management and real time corrective actions for propellant and propulsion systems of the launch vehicle. Systems that we develop will require both reactive and predictive capabilities to prevent off-nominal events and take corrective action when they do occur.

The purpose of this research is also to study use of this technology for remote and off-Earth applications. This is especially important when considering operations that take place on the lunar or Martian surface where communications delays render real time human control impractical or infeasible and the environment is unfavorable for extended human presence.

Potential NASA Applications (Limit 550 characters):

A primary potential NASA application is modernizing and improving the capabilities of existing test and launch facilities, such as those at Stennis and Kennedy Space Center. Additionally, there are applications for sample return missions from Mars or other locations. There is also a potential for utilization in human spaceflight systems to enhance reliability and crew safety during prelaunch and launch operations.

Potential Non-NASA Applications (Limit 400 characters):

Commercial spaceports will find potential applications of this technology, especially ones that are developing or modernizing their infrastructure. Other launch providers, commercial or government, will potentially license this technology for incorporation into their own launch vehicles and ground support systems. There are potential non- aerospace applications in the transportation industry.

Duration: **6**

PROPOSAL NUMBER: 23-1- **H12.05-2341**

SUBTOPIC TITLE: Autonomous Medical Operations

PROPOSAL TITLE: Amalgamated Vision NASA SBIR Phase I

Small Business Concern

Firm: **Amalgamated Vision, 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: 7
Technical Abstract (Limit 2000 characters):

Amalgamated Vision (AV) is an engineering company designing optics for head mounted display (HMD). AV's optical engine is intended to be an OEM component that is vendor and content agnostic. It can be integrated into the electromechanics of any HMD for a user experience that avoids the common visual and physical impairments associated with current HMD systems. Based on laser beam scanning, virtual retinal display, and a patented diffuser/pancake lens design, our system provides superior image quality and ergonomics in an incredibly small, lightweight, non-obstructive form factor with high-resolution, extreme brightness, a large exit pupil, and deep color saturation with minimal color aberration. Images are projected directly onto the retina using a pupil relay system - there is no waveguide or combiner screen. No eye tracking is necessary. Superior performance is due to 1:1 on axis, symmetric optics that are predominantly reflective, with geometry that corresponds exactly to the MEMS laser scanner output. There is no 2D unfolding or field distortion. Light output maintains a 2000 nit, class 1 laser status visible in outdoor sunlight. Laser safety interlocks are present. Small size and ultra near to eye position (<16mm) allows for monocular true augmented reality or binocular "look down" reference display, depending on user needs and complexity of data presented. All versions are non-obstructive to the normal visual field, allowing for 100% situational awareness. Field of view depends on the module size - currently either 43°x25° or 24°x13.5°. Resolution is 1920 x1440 "pixels" in the larger module with a volume <.03cc; the smaller module is less than half this size. Key components can be plastic, and weight of the larger module is <20 grams; the smaller module 9 grams. IP is patent protected. Our 2020 NASA iTech award-winning technology is based on widely available components from mature industries and is ready for rapid development, fabrication, and utilization.

Potential NASA Applications (Limit 550 characters):

AV's optical engine, integrated into hands-free wearable displays, will be a critical component of informatics dependent medical care for crew members without immediate access to healthcare professionals during long-duration missions. AV technology is directly applicable to NASA's LunaNet program which will create an information network in space and is in line with the NASA Human Health and Performance Directorate initiatives for AR enhanced procedural & technical guidance, training and fitness while limiting physical and cognitive impairment.

Potential Non-NASA Applications (Limit 400 characters):

AV optics inside an ergonomically correct non-obstructive, hands free, wearable device providing high image quality for simple or complex data transforms the concept of HMDs. Potential applications are broad: military combat and non-combat missions, industry maintenance & repair, warehouse & supply logistics; healthcare; disaster response; real-time navigation; consumer electronics.

Duration: **6**

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