# NASA SBIR 2023-II Solicitation

**PROPOSAL NUMBER:** 23-2- **A1.02-1571**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB455

**SUBTOPIC TITLE:** Quiet Performance - Airframe Noise

**PROPOSAL TITLE:** Advanced Measurement Technology for Airframe Noise Source Identification

## Small Business Concern

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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 6**
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: **24**

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**PROPOSAL NUMBER:** 23-2- **A1.04-1156**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB298

**SUBTOPIC TITLE:** Electrified Aircraft Propulsion

**PROPOSAL TITLE:** Enhanced Motor Performance via Two-Phase Thermal Management

**Small Business Concern**


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 3**
**End: 6**

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 resulting in lower efficiency. Innovative thermal management strategies can significantly enhance the performance of motors for electrified aircraft propulsion.

In this SBIR program, Advanced Cooling Technologies, Inc. (ACT) is developing 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 improve waste heat rejection from motor windings allowing for increased power density and efficiency. The Phase I program successfully demonstrated the feasibility of the concept and presented an electric motor with a 60% increase in power density over a conventional design with comparable thermal performance.

In the Phase II program, ACT will continue to lead the development and maturation of an innovative two-phase heat-transfer-based thermal management solution for electric motors. The goal of the Phase II program is to demonstrate an optimized design of an enhanced motor capable of power density of 20 kW/kg and efficiency of at least 98%.


Potential NASA Applications (Limit 550 characters):

The two-phase thermal management technology proposed 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 resulting from 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: **24**

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**PROPOSAL NUMBER:** 23-2- **A1.04-2594**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB574

**SUBTOPIC TITLE:** Electrified Aircraft Propulsion

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

## Small Business Concern


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 7**
Technical Abstract (Limit 2000 characters):

Future hybrid and hydrogen-powered zero carbon-emission electric aircraft require high temperature superconducting (HTS) electric motors to achieve power densities above 10 kW/kg while operating at temperatures above 25 K. However, the AC modes of stator coils in these motors makes it impossible to use available HTS tapes due to their large AC losses, requiring instead fine HTS wires made with the HTS-2212 material with advanced loss reducing features. The Phase I program established the feasibility of a low loss HTS-2212 cable with commercial-level operating current densities, losses and racetrack coilability. It built on our recent breakthrough development of low-loss HTS-2212 wire and cable features. Subscale and a full build (30 turn) racetrack test coil were fabricated and tested to establish and demonstrate coil ability of this cable type. This coil was also the Phase I deliverable, with test data showing in-coil operating current meeting required levels, namely, current density >200 A/mm2 at above 25K in 0.5 T field.

In Phase II, by building on the 16-wire cable design, higher winding current cable with up to 96 wires will be developed and optimized for full stator coil functionality and loss. Loss and other critical properties will be validated by coil tests, providing vital specifications to HTS motor developers, including guidance for cost-effective stator cooling. A 1 MW motor-scale prototype HTS-2212-based stator saddle coil with end region knuckle bends that enable required nesting will be developed, with performance, loss, and cool-ability validated by testing, and with this coil provided to NASA as a deliverable. By the end of the program all the design features for motor-useable HTS stators will be established, with validation of low losses, performance at operating conditions and inclusion into at least one large-scale electric plane development initiative, with the groundwork for a collaboration already established in Phase I program.
Potential NASA Applications (Limit 550 characters):

- Magnetic energy storage

- Actuators

- Power cables

- Ultra compact, higher power density, more efficient motors for a variety of specialty applications, for example for cryogenic liquid pumps

Potential Non-NASA Applications (Limit 400 characters):

- Much higher power density electric plane motors enabling zero carbon emission airplanes powered by hydrogen-oxidation in fuel cells

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

- Magnetic energy storage systems

- Particle accelerator magnets

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

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **A1.05-1513**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB565

**SUBTOPIC TITLE:** Computational Tools and Methods

**PROPOSAL TITLE:** Dynamic Adaptive Mesh Refinement for Wall Modeled LES of Complex Configurations

## Small Business Concern


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 3**
**End: 8**
Technical Abstract (Limit 2000 characters):


The objective of this proposal is the development and commercialization 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, having been demonstrated on meshes up to 8 billion cells in Phase 1.
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. The coupling of our dynamic AMR capability with NASA's FUN3D CFD code, which will be performed in Phase 2, will infuse this technology into a broad range of NASA missions and applications. Additionally, 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. There is a strong need for commercially viable and reliable WMLES among commercial and military air vehicles and propulsion OEMs and associated sub-contractors. The AMR API will also be applicable to industrial RANS and URANS applications.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **A1.06-2140**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB447

**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


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 2**
**End: 4**
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 rotor surfaces, have a considerable effect on operational and maintenance costs. Another crucial environmental condition that heavily impacts flight safety is ice accretion. This project addresses a novel erosion shield system incorporating ice-protective technology that can be applied directly to helicopter blades. The innovation is based on the concept of Super Elasticity in certain metals known as Shape Memory Alloys (or SMA's) that allow the material to elastically deform over 4% strain, making them very durable and erosion resistant. The Phase I effort focused on the design of an SMA based erosion tape with natural durability qualities as well as the ability to change phase (strain) for anti-icing properties. Superior erosion resistance was demonstrated in the superelastic material Austenite phase. The material was also demonstrated to strain when activated by heat, and break the ice bond strength with a combination of surface strain and temperature, making this a very efficient electro-thermal de-ice mechanism. 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 (eVTOL) vehicles.

Phase II will continue the development of an extremely efficient rotor blade de-icing actuator, with superior erosion resistance properties. Optimal actuator materials will be selected such that the SMA will self activate in the lower temp extremes, as well as be pulse activated electrically in a power assist mode, when the rotorcraft is in extreme icing environments. A final Proof of Concept demonstration will be perfromed at the Penn State AERTS Icing Faciity to evaluate SMA perfromance at representative temperature and cloud moisture (LWC) conditions.


Potential NASA Applications (Limit 550 characters):

This proposal provides key technologies to support NASA’s Advanced Air Mobility mission objective for reliable and safe operations of UAM vehicles during weather-related challenges. The market/application of these vehicles will be in urban and rural locations and be expected to have high use (life) in a broad range of weather conditions.

Potential Non-NASA Applications (Limit 400 characters):

An erosion shield with increased durability and built-in low-power ice protection capabilities gives it a significant market advantage over current rotor blade erosion systems. It is expected to have universal applications to new electric rotorcraft vehicles with limited available power. Other target applications include traditional helicopters and windmills.

Duration: **24**

**PROPOSAL NUMBER:** 23-2- **A1.08-1931**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB456

**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

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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 3**
**End: 5**
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: **24**

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**PROPOSAL NUMBER:** 23-2- **A1.09-2246**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB483

**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.**
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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

**Begin: 3**
**End: 5**
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/propulsors 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 blade-integrated cooling concepts that are constructed of aluminum or titanium alloys. The program will consist of integrated cooling design studies, cooling loop interface development, and prototype test article fabrication and characterization in support of the development of a ¼-scale prototype of the SUSAN aircraft concept. 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:

- Convergent Aeronautics Solutions (CAS)
- Advanced Air Transportation Technology (AATT)
- Electric Powertrain Flight Demonstration (EPFD)
- Revolutionary Vertical Lift Technology (RVLT)
- Advanced Air Mobility (AAM)
- 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: **24**

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**PROPOSAL NUMBER:** 23-2- **A1.10-2380**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB581

**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


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 6**
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 improving 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 sensor would not only operate at extreme temperatures, but also be very small/lightweight, be 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 II 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; 3) proof of principle testing and demonstration using lab-scale prototype hardware; and 4) full system prototyping and relevant environment testing/demonstration to satisfy NASA's technical readiness level expectations. If successful, Sporian will be well positioned for the post-Phase II transition efforts with NASA, DoD, and industry stakeholders.
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: **24**

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**PROPOSAL NUMBER:** 23-2- **A2.01-1414**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB604

**SUBTOPIC TITLE:** Flight Test and Measurement Technologies

**PROPOSAL TITLE:** A Transformative Approach to Flight Test for Autonomous Vehicles

## Small Business Concern


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 7**
Technical Abstract (Limit 2000 characters):


There are established processes to conduct certification flight test of conventional Parts 23 and 25 fixed wing aircraft and Parts 27 and 29 rotorcraft for a certifying agency such as the FAA. Further, NASA and the DoD have well established processes to conduct developmental test and evaluation (DT&E) and operational test and evaluation (OT&E) of prototype and experimental aircraft. For the Advanced Air Mobility (AAM) marketplace that features vehicle designs with increasing automation to full autonomous operations, new flight test technologies are required to execute flight test maneuvers safely and repeatedly when a human pilot is no longer in-the-loop. New test technologies can allow extracting data/information relevant in aircraft development from non-classical developmental type maneuvers. These technologies will include a combination of consolidated analysis and synthesis methods and the application of metrics dedicated to autonomous vehicles, to assess their capabilities in performing the required mission tasks in the absence of the onboard pilot's evaluation. The expected high relevance of Mission Task Elements (MTEs) in the emerging AAM certification process requires the capability and offers the opportunity to merge DT&E and OT&E concepts and practices from first flight to certification. While autonomous drones have been operating for the military for some time, such technologies are required here as well if these vehicles are to transition from restricted air space and in theater operations to national air space operations. To satisfy the evolving test and evaluation analytical and procedural requirements described above, a team led by Systems Technology,

Inc. (STI) proposes to create a complete prototype of the Aircraft Standardized Source for Integrated System Testing (ASSIST). ASSIST will support the flight test process from initial parameter and system identification to envelope expansion to mission capability and certification testing using 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 provides a complete flight test suite of tools 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: **24**

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**PROPOSAL NUMBER:** 23-2- **A2.02-1469**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB605

**SUBTOPIC TITLE:** Enabling Aircraft Autonomy

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

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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 2**
**End: 6**


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 established the system requirements and demonstrated 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: **24**

**PROPOSAL NUMBER:** 23-2- **A2.02-1631**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB566

**SUBTOPIC TITLE:** Enabling Aircraft Autonomy

**PROPOSAL TITLE:** Robust Encounter Avoidance and Conflict Resolution for Advanced Air Mobility (REACT-AAM)

## Small Business Concern


Firm: **Scientific Systems Company, Inc.**
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## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


In Phase I, we demonstrated initial feasibility of innovative improvements of our Robust Encounter Avoidance and Conflict Resolution (REACT) Technology to handle multiple simultaneous encounters expected to arise in the dense Advanced Air Mobility airspaces. Specifically, the innovations include an efficient implementation of evolutionary algorithms to produce a multi-segment maneuver for resolving encounters that would have resulted to near-

mid-air collisions. Another innovation is simultaneous risk assessment in the face of multiple encounters within transit corridors. Phase I showed that REACT exceeds the target level of safety of 10e-8 loss of vehicle incidents per flight hour.

SSCI proposes to further extend our existing REACT solution by incorporating additional realistic AAM constraints and data from an airspace information manager. The data will be used for maneuver generation and construction of the fitness function. To prevent cases when no feasible solution can be found, we will augment our baseline strategy by a hierarchical constraint weighting function to guarantee a feasible result.

With broader context of aircraft intent from the airspace information manager, the FORECAST module will produce improved predictions of vehicle traffic patterns and potential loss of separation. The focus will be toward the Regional Air Mobility (RAM) use case, where untowered airports and shared manned/unmanned airspace will be typical. We plan to use the Terminal Area Encounter Model as a basis for developing realistic encounter scenarios. Since high-risk phases of flight are in the terminal areas, our analysis during Phase II will focus on applications of our innovation to encounters typical during departure and arrival scenarios.

We will prepare a hardware-in-the-loop (HWIL) testbed and scenario generator to produce performance analysis of the EA-based avoidance guidance. We will compare the EA-based performance to a baseline that uses single-segment maneuvers.

Potential NASA Applications (Limit 550 characters):

The key NASA application of REACT-AAM technology is to the AAM and UTM Programs. applications are envisioned in the remote sensing missions which will use multiple collaborating UAS operating beyond visual line of sight, and where there is a need for separation assurance with other traffic and between team members. Companies that are currently involved in AAM-related development include Joby Aviation, Wisk Aero, Reliable Robotics, Merlin Labs, Xwing, and others, and are envisioned as the first users of the REACT-AAM technology on their UAS.
Potential Non-NASA Applications (Limit 400 characters):

REACT-AAM technology will be an important contributor to enabling the safe use of UAS in urban and suburban areas for BVLOS applications including parcel delivery, transportation of goods, traffic monitoring, and inspection of railroad tracks, power lines, and pipelines. A general nature of the technology makes it also applicable to ground and maritime vehicles as well as to spacecraft.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **A3.01-1447**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB609

**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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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

**Explainable AI (XAI) –** AI in which humans can understand the decisions or predictions made by the AI system – is becoming critical for many applications, and in particular, for the aviation domain. However, Machine Learning (ML) systems too often resemble “black boxes” that mysteriously convert incoming data into predicted outcomes and recommended decisions. This SBIR effort identifies a way to add **explainability** to AI and ML systems exploiting an XAI vocabulary that is unique to the Air Traffic Management (ATM) domain. The solution leverages rules, regulations, and policies that shape ATM activities, that are inherently learned within AI and ML systems. Given large quantities of historical 4-Dimensional (4D) Trajectory-Based Operations (TBO) data for training AI and ML systems, Intent Inference Learning (IIL) is used to establish XAI word "labels" on each historical data point. These labeled historical data points are used for the training of AI and ML systems, as well as for the explanations of the results of the AI or ML system.

Potential NASA Applications (Limit 550 characters):

- In-Time System-Wide Safety Assurance (ISSA) objectives
- Support intelligent “labeling” of large quantities of aviation data for NASA’s Digital Information Platform
- Support the needs of the Sky for All and Next projects at NASA
- Use of XAI in the test and evaluation of explainable ML and AI algorithms

Potential Non-NASA Applications (Limit 400 characters):

Applications:

- FAA ATCSCC Command Center
- FAA ANG-C, pursuing natural language processing and other AI techniques for ATM
- FAA AJR – SysOps systems performance analysis
- Air Navigation Service Providers (ANSP) around the world
- Airlines to improve post operations analysis with supporting explanations

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **A3.02-2641**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB332

**SUBTOPIC TITLE:** Advanced Air Traffic Management for Nontraditional Airspace Operations

**PROPOSAL TITLE:** Expeditionary BVLOS Infrastructure and UTM for Airborne Wildfire Response

## Small Business Concern


Firm: **Anzen Unmanned LLC**
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## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 7**
Technical Abstract (Limit 2000 characters):


Current aerial wildland fire management is limited by existing operational limitations imposed by regulations and manual airspace management techniques, inhibiting 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 and operating conditions of UAS operations due to VLOS restrictions

To overcome these limitations, we propose a solution composed of an **Expeditionary BVLOS Kit** and a **UTM Airspace Assistant**

- The **Expeditionary BVLOS Kit** provides a common foundation for UAS BVLOS operations and airspace surveillance. It provides:
    - Cooperative and uncooperative aircraft surveillance - detection, tracking, and alerting
    - Micro-weather surveillance and alerting
    - Local and wide-area communications
    - BVLOS UAS operations in all phases of wildland fire management (pre-, active-, and post-fire)
        - Built on Anzen Unmanned BVLOS approval blueprint used for multiple Part 107 BVLOS waivers and 44807 exemptions
        - Designed for BVLOS today and for adaptable for future BVLOS regulations
- The **UTM Airspace Assistant** is an operations center on-premise UTM implementation that leverages the kit's airspace surveillance, weather surveillance, and communications to:
    - Provide a composite airspace picture (both manned and unmanned)
    - Provide a composite micro- and macro-weather picture including real-time and predictive weather
    - Assist in identifying and mitigating conflict
    - Automate management of UAS operations

The proposed solution integrates with current wildland fire UAS, equipment, and airspace management, supplementing them with additional capability and safety - and provides a foundation for future growth, enabling more effective use of UAS, integrated ground and airborne infrastructure, enhanced airspace management, and transformative autonomy.


Potential NASA Applications (Limit 550 characters):

Advanced airborne emergency response ConOps development

Integrated UAS/manned airspace management proofs-of-concept

Automated UAS/manned airspace coordination development

Airborne wildfire response ConOps development

Expeditionary BVLOS infrastructure for drone operations research

Sensor and communications infrastructure node for evaluations and POC development

UTM resilience and IASMS testbed

Testbed for manned aircraft UAS alerting and situational awareness

Potential Non-NASA Applications (Limit 400 characters):

Wildfire and emergency response BVLOS and airspace surveillance infrastructure

Expeditionary BVLOS infrastructure for commercial BVLOS operations (e.g., inspections, survey, imagery, security)

Mobile and expeditionary airspace/ground surveillance and communication node

Integrated, field deployable UAS/manned traffic management (ATM-X)

Manned aircraft UAS alerting infrastructure

Duration: **18**

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**PROPOSAL NUMBER:** 23-2- **A3.03-2065**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB618

**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.**
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## Principal Investigator:


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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

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

The integration and digital connection of the future National Airspace System (NAS) with new entrants, such as the Unmanned Aircraft Systems (UAS) and Advanced Air Mobility (AAM), provides more pathways for hackers to attack the networked aircrafts and spacecrafts. In order to maintain cyber safety of this integration, security systems and technologies are required to enable on-board monitoring, detection, assessment, and reporting of abnormal events, suspicious behaviors, and potential threats. NASA is currently developing ground and vehicle based In-Time System-Wide Safety Assurance (ISSA) capabilities to monitor, assess and mitigate safety threats. These capabilities will be integrated into an In-Time Aviation Safety Management System (IASMS) to achieve enhanced system-level safety assessment, such as hazard identification, risk management and control, and safety performance evaluation. However, the state-of-the-art cyber technologies face several challenges when adopting into the NAS, such as limited communication bandwidth, limited onboard processing capability, limited memory, and storage capabilities, as well as lack of meaningful data for deep security analysis and modeling. 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 assessment and risk analysis, as well as advanced aviation and space cyber threat intelligence (CTI) to support comprehensive security analysis and threat mitigation. The proposed technology, will achieve a breakthrough in the computational efficiency for aviation and space systems cybersecurity assessment and risk analysis.

Potential NASA Applications (Limit 550 characters):

Our technology addresses a critical need in NASA’s strategic goals to advance the state-of-the-art in the autonomous flight operations and onboard cyber and system security. Within NASA, the Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) (UAS-NAS) Project, the Advanced Air Mobility (AAM) project, and the System-Wide Safety (SWS) project will directly benefit from ALARM. ALARM can directly provide the In-Time System-Wide Safety Assurance (ISSA) capabilities to NASA’s In-Time Aviation Safety Management System (IASMS).

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications include satellite communication programs, networks on-the-move, swarm drone/robotic networks, and UAVs. The proposed technology can be directly applied to Urban Air Mobility (UAM) systems. All aircraft need to be protected against potential cyberattacks and malware, as they rely on third party services to operate. ALARM is ideally positioned to support this aviation need.

Duration: **24**

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|---|---|
| **PROPOSAL NUMBER:** | 23-2- **A3.03-2428** |
| **PHASE 1 CONTRACT NUMBER:** | 80NSSC23PB637 |
| **SUBTOPIC TITLE:** | Future Aviation Systems Safety |
| **PROPOSAL TITLE:** | Safety Assessment of a Machine Learning-Based Runway Detector |

## Small Business Concern


Firm: **Xwing, Inc.**
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## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


**Xwing proposes to extend their award-winning statistical framework for the certification of 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 such as the detection of runway in camera images for automatic landing. However machine learning cannot be substantiated following the traditional DO-178 standard for software. Xwing thus proposes to

investigate how to implement IASMS for the safety assessment of machine learning based subsystems.

**Xwing propose to extend their certification framework to address the limitations identified in their Phase I contributions. Xwing will augment the statistical verification with formal methods to achieve "hybrid verification", thereby improving the robustness guarantees of the approach**. Xwing will continue to scale the approach to realistic Operational Domain, reduce the Sim2Real gap, and also include hardware considerations and model compilers.

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, compiled on target hardware, for certification. The framework will be validated with flight test data and used to produce example certification artifacts as part of an open Issue Paper.

Potential NASA Applications (Limit 550 characters):

- **Pathfinding for Airspace with Autonomous Vehicles (PAAV): addresses the auto-land challenge of the AV**
- **Advanced Air Mobility (AAM): the economics of AAM truly unlock through autonomy**
- **High Density Vertiplex (HDV): the safety assessment of autonomous landing on HDV landing pads could be performed**
- **System-Wide Safety (SWS): general modernization of aircraft technologies, including through machine learnin**
- **Advanced Capabilities for Emergency Response Operations (ACERO): penetrating markets with different certification rules.**

Potential Non-NASA Applications (Limit 400 characters):

**In general, the autonomous flight industry, both applicants as well as regulators, is looking for suggestions of generic certification methodologies for machine learning models. Such a proposal would benefit the whole autonomous flight industry and potentially unlock a plethora of new applications.**

Duration: **24**

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|---|---|
| **PROPOSAL NUMBER:** | 23-2- **A3.05-2162** |
| **PHASE 1 CONTRACT NUMBER:** | 80NSSC23PB452 |
| **SUBTOPIC TITLE:** | Advanced Air Mobility (AAM) Integration |
| **PROPOSAL TITLE:** | Weather Integrated Network Design Software |

## Small Business Concern


Firm: **Intellisense Systems, 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 is supporting the Advanced Air Mobility (AAM) concept for safe, sustainable, affordable, and accessible aviation (e.g., passenger and cargo transport). As operations occur in a dynamic environment in which spatial and temporal conditions vary rapidly, 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, in Phase II, to advance development of the Weather Integrated Network Design Software (WINDS) system proven feasible in Phase I. WINDS automatically designs scalable and robust weather-sensing networks to support AAM operations in the most cost-effective way possible. The web-based tool includes a database of sensing technologies and sensors ranked per performance-based weather standard tiers. WINDS leverages a mapping and topography tool to analyze system performance over the user-defined operational area and mission requirements. Its network synthesis generates a list of weather networks with clear illustrations of tradeoffs between various configurations, including cost. The network synthesis algorithm navigates an underlying rule-based regulatory model that links weather network capability to unmanned aerial system safety in specific airspace. WINDS outputs tailored system designs that refine cost, core functionality (e.g., communications), and performance to provide the most cost-effective solution possible to the AAM customer. During Phase I, Intellisense demonstrated WINDS feasibility by developing a network synthesis prototype and gathering an initial sensor catalog. In Phase II, Intellisense will develop a feature-complete prototype and demonstrate it via network synthesis and deployment at a key AAM site. At the end of Phase II, Intellisense plans to identify and onboard third-party weather provider

users to the alpha software release and secure funding commitments for continued maturation in Phases II/E.

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 Federal Aviation Administration. Safe operation of all aircraft including new electric and hybrid aircraft (e.g., Wisk Aero) requires* monitoring of the weather, and the WINDS system is an essential planning tool to address this need.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **A3.05-2209**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB370

**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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## Principal Investigator:


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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

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

Beyond Photonics is developing a high-performance wind measurement lidar system, which we have named the *Wind Beyond* lidar, that will enable reliable wind measurements to 20+ km near-horizontal ranges in the atmospheric boundary layer. Use of in-band-pumped Er:YAG laser crystals for the *Wind Beyond* transmitter allows for much higher pulse energies than are possible with low-cost all-fiber transmitter architectures. The proposed *Wind Beyond* lidar will operate at 7.5 mJ pulse energy and 1 kHz PRF, resulting in a transmitter figure of merit that is about 10x larger than typical commercially available lidar systems based on Er:fiber transmitters. The significantly lower transmitter PRF than used in most commercial Er:fiber-based lidar systems (typically 10+ kHz) eliminates range ambiguity problems and lowers signal acquisition and processing requirements. The proposed lidar operates at a very-high-transmission wavelength near 1645 nm which also supports the ability to measure winds at long distances. Even with its significantly higher pulse energy, the proposed lidar is a Class 1M eye-safe system. Although the focus of the near-term development is for wind measurement applications, operation near 1645 nm also allows for potential application to atmospheric methane and water vapor concentration measurements in the future.

The *Wind Beyond* lidar transmitter enables:

- Measurement to near-horizontal-path ranges that are 2-3 times larger (exact factor depending on atmospheric visibility) than possible with the lower performance lidars at equivalent update rates – i.e., coverage of much larger measurement volume at a given update rate.
- Measurements to the same range as the lower performance lidars but with approximately 100x the measurement update rate – i.e., coverage of a fixed measurement volume 100x faster.

A combination of very small discrete optical components and precision fabrication methods provides an innovation which allows for economical manufacturing.

Potential NASA Applications (Limit 550 characters):

NASA applications of the compact Doppler lidar include supporting Advanced Air Mobility (AAM) integration by providing 3D winds over large areas for aviation safety and management. Modified versions of the product will also allow for methane and water vapor measurements which will find application in NASA greenhouse gas concentration and flux measurement systems. The lidar technology can be used from airborne and eventually space-based platforms supporting NASA space-based 3D winds program.

Potential Non-NASA Applications (Limit 400 characters):

The long measurement range wind lidar will have significant application in wind energy and aviation safety. Airborne versions will allow for leak detection along methane gas pipelines. Compact transmitters optimized for heterodyne detection lidar will find use in DoD laser remote sensing applications that involve identifying and tracking hard targets.

Duration: **24**

**PROPOSAL NUMBER:** 23-2- **A3.02-1640**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB308

**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.**
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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The Fleet Logistics Optimization Engine (FLOE) is a multi-layered optimization system for determining the most efficient routes for deploying aircraft and ground crews for a UAS mission, building on the Uncrewed Aviation Fleet and Flight Operations Optimization (UA-FFOpt) framework developed during Phase I. In Phase II, we will further the optimizers' accuracy through streaming and modeling of weather and traffic data to produce real-time updates to the optimizers' inputs, which will help further dynamic route planning. Secondly, we will improve FLOE's data collection abilities by implementing an SQL database for aircraft management that will be critical for developing the anomaly detectors in the situational awareness subsystem designed to help UAS Service Suppliers perform better fleet and network management and make growth potential for future operations greater and safer. We will develop a feedback mechanism that utilizes the data gathered during flights to further improve the optimizers by improving the inputs' accuracy. Last, we will develop a user interface that can be used to control the entire system, including developing inputs and monitoring vehicles, weather, and traffic. These FLOE features will further fleet management capabilities as specified under A3.02 Advanced Air Traffic Management for Nontraditional Airspace Operations – Focus Area 20 Airspace Operations and Safety – Nontraditional Aviation Operations for Advanced Air Mobility (AAM).

Potential NASA Applications (Limit 550 characters):

- For the NASA AOSP program, ATM-X project and AMP sub-project, this system could be modified to provide AAM flight routings across an AAM fleet
- The UTM-based rural delivery market. NASA-UTM applications can use this tool.
- Wildfire management and support using UAS.
- AAM flights from one part of an urban area to another.

Potential Non-NASA Applications (Limit 400 characters):

- Aerial Vantage's crop surveying efforts
- Wildfire spotting and surveying operations
- Border security and surveillance
- DoD UAS surveillance and targeting operations
- Fleet and route planning for crewed flight surveillance operations
- Advanced Air Mobility fleet and route planning

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **H3.10-2121**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB508

**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.**
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Phone: **(256) 327-9012**

## Principal Investigator:

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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The MinION™ instrument developed by Oxford Nanopore is the gold standard in portable genetic sequencing. Experts in a very many technical areas are energized about the possibility of bringing DNA and RNA sequencing from the full-service laboratory to the field.
Painfully, though, the MinION is only half of the solution; field sequencing is still unfeasible. The preparation of such a genetic sample (referred to as the DNA Library), remains an intensely manual process needing a trained wet lab technician and several pieces of laboratory equipment. To achieve the elegant automation of this DNA Library preparation from a raw sample, we must first abandon the standard conventions for handling and manipulating the biological and biochemical constituents. Any other solution will possess an inefficiency and unmanageable complexity that is unsuited to the size, weight, and power (SWaP) budget of any NASA mission . In Phase I nou Systems Inc. (nSI) has demonstrated such a transformative approach. We have threaded together several cross-enabling innovations to create an instrument, nSI Xpres, that can fully automate the DNA Library prep process. Since low-biomass sequencing is our goal, we have based our protocol around the PCR-based preparation chemistry that is conventionally associated with the 16S Barcoding Kit sold commercially by Oxford Nanopore.
Innovation 1 : Soft Cleaning of Wire-Immobilized Genetic material (SCWiG)
Innovation 2: Zero-Volume Microfluidic Regions (ZVRs)
Innovation 3: Innovation: Thermal Gradient Heating/Cooling
At the completion of this Phase II effort, nSI will deliver a prototype of nSI Xpres to NASA and will provide up to two days of in-person training at NASA JSC for up to six persons.

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: **24**

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**PROPOSAL NUMBER:** 23-2- **H4.08-2666**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB292

**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 SUITE E, Concord, CA 94518**
Phone: **(925) 798-5770**


## Principal Investigator:


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## Business Official:


Name: **Ann Mulville**
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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The purpose of this Phase-II project is to continue optimizing the anti-fogging coating developed in Phase-I and begin commercializing the coating for use on NASA spacesuit helmets and other applications, such as consumer eyewear. In Phase-I a permanent and robust anti-fog coating was developed that is applied to the interior of polycarbonate spacesuit helmets. The coating is a mechanically resilient and permanent superhydrophilic layer produced by a two-step process consisting of a plasma processing pre-treatment followed by the deposition of an optically transparent diamond like carbon coating to achieve an anti-fog layer with Water Contact Angle < 10 degrees. The all-dry vacuum process consists of an oxygen plasma etching to engineer the surface of the polycarbonate, creating a well-controlled nanotextured morphology, which is key to the superhydrophilic properties, followed by plasma enhanced chemical vapor deposition of the diamond like carbon coating with high surface energy. The process is carried out at low temperatures compatible with polycarbonate materials and the two steps are performed back-to-back without breaking vacuum between steps. The process is readily scalable and compatible with large scale production volumes. The anti-fogging coating was tested for > 200 hours exposure using a breath simulator with no detrimental effect on the coating performance. The coating was also tested for exposure to cleaning fluids, IPA chemical exposure, adhesion testing per ASTM D3359, and abrasion resistance per MIL-C-48497 with no detrimental effects.

Potential NASA Applications (Limit 550 characters):

The anti-fogging coating can be used on the inside surface of NASA spacesuit helmets, such as the Extravehicular Mobility Unit (EMU) or the Exploration EMU (xEMU) pressure bubbles, or any other spacesuit helmet used or being developed for NASA.
Potential Non-NASA Applications (Limit 400 characters):

The anti-fogging coating has potential for widespread use on items such as consumer eyewear, ski goggles, face shields, etc., and spacesuit helmets from other companies, such as SpaceX.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **H4.08-2745**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB598

**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:

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## Business Official:

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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 5**
**End: 9**
Technical Abstract (Limit 2000 characters):

The Exploration Extravehicular Mobility Unit's (xEMU) helmet is a complex assembly designed to accomplish several tasks to protect and enable astronauts. In addition to maintaining a suitable environment for the wearer, it must also allow for appropriate mobility and provide a wide and undistorted view of the surroundings. A critical component of the helmet's optical system is the anti-fog coating. While previous versions of the anti-fog coating have provided suitable anti-fog performance, they have been difficult to apply, lacked mechanical or chemical durability, or resulted in unanticipated failures (e.g., outgassing of eye-irritating materials during use). This work describes the use of a new coating technology, aerosol impact-driven assembly (AIDA), to develop a next-generation permanent anti-fog coating for the xEMU helmet. We use AIDA's unique ability to tune both the refractive index and surface roughness of films to deposit a thin, transparent (>85% transmittance of visible light), and hydrophilic anti-fog coating.

Potential NASA Applications (Limit 550 characters):

The solicitation identifies anti-fog coatings for use in the xEMU helmet as an immediate need. As the coating and coating method have been shown to be substrate agnostic, there is the opportunity to apply it to other materials (other polycarbonate components, glass, fabrics) that require anti-fog functionality. More generally, the ability to deposit dozens of different materials with tunable porosity onto a variety of substrates will undoubtedly enable new applications not yet considered.
Potential Non-NASA Applications (Limit 400 characters):

Anti-fog coatings represent a $16B global market with applications in the packaging industry, automotive industry, solar industry, display industry, and the eyewear industry.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **H5.01-1351**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB434

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


Combining our proprietary Pyramid Hinge Array, with other novel mechanical and geometric solutions, we propose a disruptively compact, robust structure for Lunar Solar Power Generation – The Sunflake XL array, and Ultra Compact Quad Tower (UC4T)

Sunflake XL delivers a 175m² ultra compact Lunar Surface Solar Array, capable of delivering 50kW of power. The solar array raises up to 10 meters off the ground (achieving a total height of 17m). Sunflake XL rotates for optimal sun tracking, while the UC4T provides a stable vertical structure.

Combined together with the tower and rover-deployment system, the entire package will deliver a performance of 113 W/kg and 26 kW/m3. The system is ultra compact, lightweight, stable, and retractable.

Most important, it is based on our proven pyramid hinge technology, making it a reliable and robust solution. The novel design combines the strength, compactness, and durability of the Pyramid Hinge, with linear expanding array elements, adding a new dimension of scalability to our Sunflake solutions. The novel mechanisms can also be re-configured for different deployable solutions: antennas, reflectors, or radiators.

With a linear arm segment measuring only 2.6 m, the new design opens a new spectrum of opportunities for pyramid-hinge based designs.

In Phase I Folditure validated the design, packing efficiency, scalability, and retractability of the mechanism, through detailed mechanical drawings, analysis, and a functional prototype.

In Phase II we propose to fully develop the kinematics and structure. We plan to engineer, and build a very large-scale high fidelity kinematic prototype, while further developing, and applying the best available technologies. The design will be also proven through FEM analyses, and environmental testing. We also propose to field test the prototype deployment, with a lunar rover. This project is very well aligned with our area of expertise: developing super-compact novel folding solutions.
Potential NASA Applications (Limit 550 characters):

Sunflake XL can easily be adapted for deployable systems in microgravity.

It could be used on any form of human lander, lunar outpost, or orbital stations. Any missions that require lightweight portable high efficiency PV energy could be of interest.

The structure can be modified for deployment on Mars or other planetary missions. It can be designed to accommodate different tracking angles, anywhere from vertical to horizontal. While it is currently designed for reliable re-deployment, a lighter single-deployment system can be easily developed.
Potential Non-NASA Applications (Limit 400 characters):

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

It can be developed into a compact, re-deployable solar power generator. A stand-alone system could be deployed, programmed to track sun angles, and retracted remotely.

We are exploring DOD and other applications for remotely re-deployable pop-up PV power generation, suitable for challenging terrain and conditions.
Duration: **24**

**PROPOSAL NUMBER:** 23-2- **H5.01-2668**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB383

**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:


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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):


Ceres C-Tower is a self-contained novel solution which includes a central mast deployed 23.5m high to commission > 60kW solar arrays near lunar poles. It is capable of multiple deployment and retraction cycles, relocation, and remote operations with a long system life of at least 10 years. It has a Specific Mass > 85 W/kg & Specific Packing Volume > 22 kW/$m^3$. C-Tower is adaptable to multiple launch vehicles, mission architectures, and landers. The mechanisms are

robust under lunar dust and thermal environments. Key structural and mechanical innovations include:

- Central mast with innovative bearing assembly and unique internal cable-rigging to enable low-mass, high reliability multiple deployment, locking (without need of physical locks), and retraction under lunar gravity, dust, and extreme temperature environment. It is scalable to 50 m.
- Innovative Solar Array Deployment Arms allows for independent deployment of all solar arrays providing fault tolerance against multiple solar array deployment failures.
- Leg Mechanism provides stability and leveling with innovative footpad hinge design to minimizes stowed volume.
- Sun-Tracking Mechanism ensures optimal power generation.

During Phase I, Ceres baseline technically feasible C-Tower by performing (i) multiple system & component level trade studies, (ii) design space analysis to determine a feasible design boundary to meet the technical goals, & (iii) baseline design and verification using finite element analysis of the C-Tower mechanical systems.

For Phase II, Ceres will perform detailed design, finite element analysis, and simulations for the four C-Tower mechanisms and the integrated structure which will include analysis for lunar surface thermal cycling. Ceres will perform multiple sub-scale and scale prototype tests and simulations under relevant environments, including testing of the full scale central mast prototype under lunar gravity environment (1/6 g) which will mature the structures and mechanisms to TRL 5.
Potential NASA Applications (Limit 550 characters):

- Extend life of missions and maximize science output for polar missions.
- Potential overnight survival and revival of NASA assets
- 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 are used on lunar surface to provide communication, illumination, and observation services.

Potential Non-NASA Applications (Limit 400 characters):

Power, communications, & imaging services for commercial customers like Lander, Rover, Infrastructure, and ISRU companies, Payload Providers, International Space Agencies to meet surface demands & extended mission life. In-orbit applications include solar array deployment for large satellites, commercial space stations. Terrestrial - emergency remote deployable power, comm, and imaging tower.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **H5.05-1632**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB531

**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**
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## Principal Investigator:


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Phone: **(520) 382-1708**


## Business Official:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


This SBIR project focuses on design, fabrication, and testing of textile based strain sensors to measure the health of structural softgoods elements. In Phase I Paragon iterated through dozens of sensor configurations and down-selected to a single embroidered configuration with exceptional linear and cyclical trends. The Phase II effort will include further iteration of the down-selected design configuration to optimize for repeatability and manufacturability. Iteration and testing will utilize a dead-weight system to inform further configurations and include long duration testing of at least 1 month. Phase II will integrate conductive traces directly into the webbing to minimize wiring needed across a structure.

The SWISS Phase II effort will develop a software and electronics interface to multiplex an array of sensors, giving simple usable data output. Paragon will design and build a subscale inflatable test article, deploy the SWISS sensors on the article, and test/evaluate the system in a relevant environment of plain-woven restraint lines under constant load over a multi-week evaluation. The culminating test will utilize optical tracking to evaluate the sensor performance. Deliverables

will include the actual test article for NASA evaluation and a single-strand sensor, as well as the detailed reports therein.
Potential NASA Applications (Limit 550 characters):

Space industry applications include inflatable structures, space suits, robotic systems, and crew and cargo restraint systems.

Inflatable habitats: NASA and commercial companies are working towards “Lunar permanence” and increased inhabited space habitats in the next decade. This entails significant development and deployment of inflatable structures in space and on the moon, for example. Paragon’s SWISS technology is well positioned to play a critical role in ensuring the safety of these habitats..

Potential Non-NASA Applications (Limit 400 characters):

Our technology could make a large impact in a host of applications including the lifting and rigging industry, high-altitude balloons, safety harnesses, parachutes, machinery/bulk transport, and even automobile seatbelts.

This proposal goes into greater detail regarding the size of market, the potential for each application and the path forward.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **H6.22-1123**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB437

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

**PROPOSAL TITLE:** A Radiation Hard Network on Chip Neural Processor with RRAM

## Small Business Concern


Firm: **Green Mountain Semiconductor Inc.**
Address: **28 Howard Street # 301, Burlington, VT 05401**
Phone: **(802) 578-0028**


## Principal Investigator:


Name: **Mr. Ryan Jurasek**
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**Business Official:**

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Phone: **(802) 343-8175**

**Summary Details:**

Estimated Technology Readiness Level (TRL) :

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

**Green Mountain Semiconductor Inc. (GMS) is proposing an in-memory solution utilizing non-volatile memory (NVM) in FD-SOI technology for the solicitation H6.22-1123. While rethinking the fundamental architecture of neural networks based on the radiation hard criteria, GMS has developed a robust CIM architecture, incorporating non-volatile RAM with radiation hard characteristics for low-power and low-latency AI edge devices. Existing state of the art solutions utilize separate chips for weight storage and require large amounts of on-chip SRAM in order to load weight information and process data. While off-chip weight storage does allow for various types of memory to be used based on user application, the penalty comes in the form of weight transfer on-chip, which is not generally accounted for in the power numbers and efficiency touted by neural network chip designers. In order to limit weight movement power cost, neural networks store large amounts of data in SRAM in order to perform large batch operations. This, in itself, introduces another costly weak point with regards to space applications, that being the storage of information for extended periods of time in SRAM memory cells. GMS has been able to develop a CIM architecture that eliminates the von Neumann bottleneck by integrating all memory for weight storage on chip, significantly reducing weight movement and decreasing the total amount of SRAM, as well as the length of time that data is stored in SRAM. This unique design allows for accelerated AI inferencing, particularly for Convolutional Neural Networks (CNN), outperforming other state of the art architectures. Focusing on SRAM reduction coupled with circuit design techniques, using radiation hard NVM and radiation hardened logic the chip reaches radiation target levels required for deep space computing.**

Potential NASA Applications (Limit 550 characters):

**Potential NASA applications include any critical image processing mission where device functionality is imperative. This includes deep space missions subject to solar flares. Flight navigation is of particular interest in this respect. Habitable Worlds Observatory would be a prime candidate, requiring long life, low power, and edge computing capabilities. Lunar missions can also benefit from the innovation's low power, low leakage, and power-down, instant-on capabilities, especially when operating in extended critically low power conditions.**

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: **24**

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**PROPOSAL NUMBER:** 23-2- **H6.23-1322**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB622

**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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Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 8**
Technical Abstract (Limit 2000 characters):

VISIMO's NASA Phase II Proposal, Graceful Architecture for Mitigation of System failures (GRAMS), will continue development of a Cognitive Architecture (CA) for decision support for astronauts, primarily focused on human spaceflight missions. GRAMS is engineered for managing spacecraft operations, primarily addressing autonomous systems management for long-duration space missions. GRAMS employs a modular CA designed to detect, adapt to, and recover from both known and unknown spacecraft failures, thereby reducing cognitive load on crew and enhancing mission resilience. Key features include a Risk Identification Algorithm, Alert Generator, Failure Simulator, and Action Recommender. GRAMS operates in two configurations: Simultaneous Monitor/Training mode for monitoring and alerting, and Incident Recovery mode for failure mitigation assistance. GRAMS is not only pivotal for deep space missions but will have terrestrial applications. VISIMO’s proposed R&D addresses the need for advanced AI solutions to support mission success and safety in autonomous, deep space, and long-duration missions, aligning with NASA's strategic goals. This is critical for NASA's deep space explorations where rapid and accurate response to unforeseen incidents is crucial. Through GRAMS, VISIMO will produce a software prototype of the CA that (1) includes an intuitive, function user interface; (2) includes modular components, configuration scripts, and documentation to assist in the transition to new missions; (3) performance reports of the architecture’s ability to ingest and process live sensor data; and (4) performance reports demonstrating the reliability and accuracy of the cognitive architecture over long duration missions in a space environment. GRAMS’ modular design will allow easy adoption of the platform into new, crewed, deep space missions, as well as operating in additional spaceborne and terrestrial used cases, both human-directed and autonomous.

Potential NASA Applications (Limit 550 characters):

GRAMS is capable of supporting NASA’s Exploration Systems Development Mission Directorate (ESDMD)’s Moon to Mars program, Space Operations Mission Directorate (SOMD)’s goal for long-term human exploration missions, Aeronautics Mission Directorate (ARMD)’s terrestrial mission programs, Science Mission Directorate (SMD)’ Gateway Program, as well as various missions headed by Human Exploration and Operation Mission Directorate (HEOD), Johnson Space Center (JSC), and Ames Research Center (ARC).

Potential Non-NASA Applications (Limit 400 characters):

GRAMS is capable of supporting US Space Force’s goal of human presence in space; The Space Development Agency’s need for monitoring satellite constellations; Federal Aviation Administration’s goal to advance autonomous monitoring of airspace; LEO market Primes (e.g., HPW, IBM Research, SpaceX, Axiom Space, Northrop Grumman); Organizations seeking to establish LEO/space manufacturing operations.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **H8.01-1945**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB463

**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.**
Address: **400 Farmington Avenue, Farmington, CT 06032**
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## Principal Investigator:


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## Business Official:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


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. 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 environment has the potential to improve the quality of the films, reduce defects, and 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 a fluidic chamber LBL manufacturing device, though further steps are required to improve the scale for commercial production. The Phase I research strategy involved enhancing the precision of quantification

methods for polyion solutions, developing effective filtration methods, optimizing UV-C sterilization for bioburden reduction, and establishing *in situ* analytical tools to assess solution quality. Building on these results, this Phase II work plan will integrate these advancements into a closed-loop system for efficient, sustainable LBL manufacturing that will improve scale, reduce up-mass raw materials, and reduce waste. The deliverables will add new on-orbit tools to the established LBL manufacturing platform, 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 II SBIR work plan will optimize the use of raw materials in microgravity and will yield critical hardware components that can support efficient, sustainable, and scalable manufacturing methods for LambdaVisoin's artificial retina technology. Moreover, the purification, sterilization, and analytical techniques established in this research will provide new tools for integrating biomaterials as components for in-space production of forthcoming terrestrial-based applications.
Potential Non-NASA Applications (Limit 400 characters):

This work establishes capabilities to support commercial artificial retina production in LEO. However, the developed techniques can be adapted for many biomedical applications, including drug delivery, tissue engineering, and beyond. Strategies to improve scale, control raw material consumption, and improve unit economics will inspire new in-space production opportunities across multiple fields.
Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **H9.01-1824**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB290

**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**
Address: **26027 Huntington Lane, Unit B, Valencia, CA 91355**
Phone: **(661) 753-3592**


## 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):


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 highly sensitive Geiger-mode avalanche photodiode (Gm-APD) array receiver as a flight unit for the NASA's deep space communication demonstration program. 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 demonstrated improved quantum efficiency and a 1064 nm InGaAsP Gm-APD photon counting array sensor chip assembly using high detection efficiency arrays. Furthermore, demonstrated the technical feasibility improved data rate using a InGaAsP Gm-APD receiver array. 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: **24**

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**PROPOSAL NUMBER:** 23-2- **H9.03-1069**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB301

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


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. Such anomalies could include the spacecraft going into safe mode, missing a tracking pass from Earth, or experiencing an off-nominal operational state such as using the wrong thrusting power mode or a thruster firing malfunction. Experienced engineers use intuition and guesswork to arrive at solutions manually 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 currently no industry standard to account for anomalous activities or failure modes for low-thrust and

dynamically sensitive missions. This solution aims to address this specific deficiency in the mission planning process. The proposed solution is named CALM or Contingency Analysis for Low-thrust Missions.

In response to the 2023 NASA SBIR Phase II 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 and thrust arcs from failure modes, inform mass and propellant margins, and contribute to mission risk analysis and mitigation.

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: **24**

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**PROPOSAL NUMBER:** 23-2- **H9.03-2014**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB629

**SUBTOPIC TITLE:** Flight Dynamics and Navigation Technologies

**PROPOSAL TITLE:** Improved Autonomous Navigation Through Optimal Sensor Outliers

## Small Business Concern


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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

**Begin: 3**
**End: 5**
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 outliers, an incorrect pose estimate may result, which can lead to difficulty in achieving mission goals for autonomous operations. A common approach to remove outliers is the RANSAC algorithm. But 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.

In Phase I an optimal closed-form approach to replace the RANSAC algorithm was shown 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 covariance of the sensor residuals, which is the key to remove outliers. The Phase I work showed that because the covariance is optimal, it results in a more robust approach to remove outliers than the standard RANSAC algorithm and its variants. The Phase I work focused on studying the effectiveness of the newly derived closed-form covariance in a new RANSAC-type algorithm, called the Statistical Optimal RANSAC (SO-RANSAC) algorithm.

For the Phase II work, SO-RANSAC will be further refined to include the two-camera scenario. Invariant methods will also be employed to initialize the SO-RANSAC algorithm. Also, a colored-noise filter will be implemented to handle heavy-tail errors associated with feature mis-associations. Furthermore, studies will be performed to provide the computational effort required to implement SO-RANSAC on a real spacecraft processor. All these efforts will significantly increase the TRL capability of SO-RANSAC, leading to an actual implementation capability.

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: **24**

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**PROPOSAL NUMBER:** 23-2- **H9.08-2262**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB423

**SUBTOPIC TITLE:** Lunar 3GPP Technologies

**PROPOSAL TITLE:** 5G-MOSAIC: 5G Mission-Critical Sidelink for Autonomous and Interoperable Communications in Lunar Networks

## Small Business Concern


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Communication in lunar environments requires substantial modifications to current state-of-the-art (SOTA) 5G technology. The difficult terrain and long-range requirements of lunar missions introduces critical gaps between the SOTA and requirements, including hardware, inability to communicate outside of base station range, and limited device-to-device connectivity. EpiSci's solution is to provide NASA lunar missions with 3GPP-capable solutions on terrestrial SWaP-constrained platforms. This project will develop a 3GPP compliant 5G Sidelink (SL) SWaP prototype, which enables peer-to-peer communication when outside of a 5G base station's range and enables direct handset-to-handset connectivity. EpiSci's solution is three-fold: (1) It is a 5G SL solution (which provides relay, multi-hop, and MANET capabilities); (2) it uses a realistic 5G lunar-surface model (to meet performance evaluation needs); and (3) it is a novel interface design, similar to the Small Cell Forum's 5G nFAPI interface, but modified to support 5G SL. While these three aspects provide an overall improved lunar network, EpiSci's solution includes additional enhancements to data speeds, traffic-offloading, prioritization, and reliability. These enhancements are enabled by an AI-based network manager to optimize traffic flows and modify configuration parameters to provide significant performance improvements. Furthermore, our team has developed a real-time 5G emulation (5GEM) tool, resulting in an adaptable, plug-and-play tool which allows the user to realistically model adverse terrains and observe the performance prior to deployment. Our 5G Mission-Critical Sidelink for Autonomous and Interoperable Communications in Lunar Networks (5G MOSAIC) solution will offer a communication solution with higher reliability and lower latency, ultimately contributing to the success of NASA's lunar missions.

Potential NASA Applications (Limit 550 characters):

5G-MOSAIC technology directly applies to NASA's visions to equip the lunar network with 5G capabilities while being able to maintain mission-critical and suit-to-suit and suit-to-rover communications. Our spectrum sensing and network management technologies will be application to future NASA missions such as the Artemis and Mars missions. These technologies will also be applicable to NASA's unmanned missions for transferring data through its satellite and ground networks.

Potential Non-NASA Applications (Limit 400 characters):

EpiSci's commercial business model for 5G-MOSAIC is most analogous to Red Hat's Linux. EpiSci is heavily investing in dual-use 5G technologies to become a software-defined networking company that intends to license or sell commercial-grade software development tools and the necessary training to build, run, and maintain a customizable 5G network based on the expanded capabilities such as sidelink.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **H9.08-2613**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB558

**SUBTOPIC TITLE:** Lunar 3GPP Technologies

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

## Small Business Concern


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 3**
**End: 5**


Technical Abstract (Limit 2000 characters):

In this Phase II proposal, Remcom proposes to continue and enhance our efforts to develop and deploy a complete, end-to-end modeling and simulation solution for predicting wireless propagation and network coverage for lunar scenarios. Phase I completed some of the new capabilities and demonstrated the feasibility of the others. A critical component of our solution, the ability to import lunar terrain and place objects on the terrain, was completed in Phase I.

Under the proposed Phase II effort, Remcom will complete the following features and incorporate them into Wireless InSite, our commercial modeling application:

1. Graphical user interface to create lunar materials with user-specified parameters.
2. Diffuse scattering enhancements to allow scattering from rocks buried in lunar regolith and to provide a user guide for setting parameters based on frequency, polarization, and statistical distributions of rock sizes and locations.
3. Ray-tracing and electromagnetic calculations for interactions on curved surfaces using accelerated, end-to-end path discovery and processing.
4. Extensions for post-processing results for link-level analysis of communication systems.

The bulk of our proposed effort will be in the third area. Successful completion of the new, accelerated process will speed up Wireless InSite analysis of complex scenarios by an order of magnitude or more. It will also allow more accurate modeling of electromagnetic scattering from terrain and other features that have curved surfaces rather than flat surfaces with straight edges.

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 fading, delay spread, and Doppler 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 connectivity to difficult-to-reach regions.

Potential Non-NASA Applications (Limit 400 characters):

The following new features in Wireless InSite will be directly applicable to commercial and government terrestrial studies as well as lunar studies:

- Accelerated, end-to-end path discovery and processing for faster analysis of scenarios with longer ranges over rugged terrain.
- Interactions with curved surfaces
- Extensions for post-processing for link-level analysis

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **H10.01-2385**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB606

**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**
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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 6**
**End: 8**


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 accuracy is within 1% of industry standard for single phase gas mass flow meters. 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 development and testing with nitrogen and hydrogen, but much of the development will also be applicable to oxygen, methane, and natural gas.

This tool will be an inline spool piece with embedded capacitance sensors that can be installed on a cryogenic liquid transfer line. The capacitance plates embedded in the spool piece interrogate the sensing region by emitting a low power, low frequency electric field into the flow and sensing perturbations in the electric field caused by differences in the permittivity of the flow medium.


Potential NASA Applications (Limit 550 characters):

NASA platforms are T4I's key customer in the Phase II project, with a particular focus on Stennis Space Center (SSC) to support development of liquid propulsion systems and verification testing. Other NASA applications include the Space Operations Mission Directorate and the Exploration Systems Development Mission. This product will be useable anywhere NASA is transferring liquid cryogens. Implementation of this product will minimize program time, cost, and risk to NASA scientists.

Potential Non-NASA Applications (Limit 400 characters):

Another important application where it is critical to know the mass flow rate of the fluid is in custody transfer of cryogenic fluids. Additional applications include determining the effectiveness of vacuum jacketing, piping designs, operational parameters, and thermal management schemes. Once proven to work, the technology could also be adapted for use on cryogenic tanks for fuel gauging.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **H12.05-1021**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB491

**SUBTOPIC TITLE:** Autonomous Medical Operations

**PROPOSAL TITLE:** A Crew Health Integrated Medical Exploration Response Agent (CHIMERA) platform for optimized healthcare performance

## Small Business Concern


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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):


The Crew Health Integrated Medical Exploration Response Agent (CHIMERA) platform is an integrated exploration system (Medical-501) that minimizes resource costs (Medical-201) and maximizes benefit (Medical-701) through a network of Bayesian and statistical inference models (Medical-101).

The primary objective of this Phase II work is to build upon previous work on an Autonomous Medical Response Agent (AMRA) and Phase I work on an Integrated Clinical Ensemble (ICE) to build, test, and deploy a platform that synthesizes networks of Bayesian and statistical models

with an AI Coordinator, a shared Data lake, an insights generator and a multi-crew user interface.

CHIMERA easily combines sensor data, inference models, and mission policies to allow rapid testing and validation of clinical decision support systems (CDSS) across a wide spectrum of mission architectures. This capability allows CHIMERA to scope a bespoke CDSS for each crew and mission NASA may configure in the future.

CHIMERA will be deployed as a platform during a Space Medicine Exploration Hackathon at USMA West Point testing to test its interoperable capability. CHIMERA will also be deployed as a technology demonstration of terrestrial clinical decision support at the Negentex preventive primary care clinic.

Potential NASA Applications (Limit 550 characters):

A Crew Health Integrated Medical Exploration Response Agent (CHIMERA) is a multi modal, extensible platform that allows astronauts in space and scientists and experts in mission control to collaborate asynchronously. CHIMERA will assist NASA experts to prioritize, schedule and guide continuously optimized care with limited resources across a broad set of mission profiles and objectives on the Moon, Mars, and beyond.

Potential Non-NASA Applications (Limit 400 characters):

Military: Remote autonomous critical care is essential for warfighters in peer/near-peer combat; casualties are expected to be greater than current military health capacity.

Civilian: Remote medical care is increasing. Tele-ICU and home care are  $ billion industries, CHIMERA will increase capacity to provide evidence based care globally. Preventive primary care is the future of healthcare.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **H12.05-2341**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB326

**SUBTOPIC TITLE:** Autonomous Medical Operations

**PROPOSAL TITLE:** Wearable Retinal Display Micro-Projector for Visually Assisted Autonomous Operations

**Small Business Concern**


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


NASA and Military programs utilizing see-through augmented reality head mounted display have failed to meet their human performance objectives, due to their inherent waveguide and combiner optics. This raises caution for use of see-through HMD to assist astronauts and mission specialists in autonomous medical care. Placing digital content on a screen between the user and their environment results in poor user experience on earth, in the atmosphere or in space. The image is difficult to see due to poor resolution and contrast. The environment is obscured by the waveguide and content, and the data is distracting, ultimately increasing cognitive burden. See-through devices have poor ergonomics, resulting in physical impairment. Amalgamated Vision's patented optical design is entirely different than current commercial products. The technology is founded on unique engineering and optical principles that deliver the features and performance required to satisfy NASA SBIR Phase I & II H12.05 and are aligned with the objectives of the NASA Human Health and Performance and Exploratory Medical Capabilities group. AV display is based on laser beam scanning and is a virtual retinal display. The image is projected directly on to the retina – there is no screen. The display is extremely small, lightweight (approximately 25 grams on the face and 85 grams overall) and does not obstruct the user's normal line of sight. Image quality is excellent and bright enough for direct sunlight use. AV technology provides critical "just in time" information while allowing the user an unobstructed view of their environment and the task at hand. Critical design phases have been completed and we are ready now to build a minimum viable product prototype.


Potential NASA Applications (Limit 550 characters):

The aerospace industry recognized the importance of spatial computing for improving operations. NASA requires medical support technology that will enable greater autonomy and self-reliance. The solicitation requests advanced "just in time" training modalities, enhanced procedure execution technologies, and integrated clinical decision-making support tools. Relevant applications: visual assistance and guidance for emergency medical procedures in space, to reduce need for extensive training and medical knowledge, improving safety for crew members

Potential Non-NASA Applications (Limit 400 characters):

Applications include integration of AV core display into any existing manufacturer's head-mounted display for any application – “AV inside.”

- Maintenance and repair (dual use for NASA).

- Supply & logistics (dual use for NASA).

- Warfighter and support personnel critical information, situational awareness, and object identification.

- Confidential and secure communications.

- Consumer electronics.

Duration: **18**

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|---|---|
| **PROPOSAL NUMBER:** | 23-2- **S11.01-1346** |
| **PHASE 1 CONTRACT NUMBER:** | 80NSSC23PB492 |
| **SUBTOPIC TITLE:** | Lidar Remote-Sensing Technologies |
| **PROPOSAL TITLE:** | CoDLiR: Compact Digitizing Lidar Receiver |

## Small Business Concern


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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

**Begin: 3**
**End: 5**
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.**

**Conventional LiDAR requires hundreds of coincident detectable reflected photons for a ranging measurement. However, current LiDAR technologies for long-distance ranging, backscatter, or differential absorption are increasingly moving towards single-photon sensitive (SPS) technology. Single-photon detection has become increasingly attainable. Recent advances in SiPM technology have rendered them a desirable choice here as devices have become smaller (1mm x 1mm pixel size), faster (100ps rise time) more radiation hard while requiring only 30-90V bias voltages. Enhanced sensitivity to single reflected photons for long baseline measurements will reduce required laser system power and allow for more compact optical focusing lenses and mirrors.**

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 (e.g. surface mapping, altimetry and navigation assist).**

Potential Non-NASA Applications (Limit 400 characters):

**A lightweight, power efficient, highly accurate LiDAR system is of interest to markets such as autonomous vehicles and aerial systems, which would benefit significantly from reduced power and size made possible by increased integration, lower return signal power requirements, and increased precision. Our product could be also utilized by various industries interested in orbital geospatial mapping.**

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S11.01-2397**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB366

**SUBTOPIC TITLE:** Lidar Remote-Sensing Technologies

**PROPOSAL TITLE:** Lightweight, non-mechanical, polarization-independent LiDAR beam steering system

## Small Business Concern


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

During Phase I of this project, two approaches for achieving polarization-independent non-mechanical lidar beam steering were demonstrated, and a demonstrator system was fabricated and testing. The demonstrated technology based on spatial modulation of geometrical phase has been reduced to a well-understood method for switching the pointing direction of laser beams and receiver fields of view. The Phase II project will extend these results to allow future NASA beam steering systems to electronically steer lidar transmitter, receiver, and transceiver pointing directions for any polarization of lidar radiation, and will develop the supporting technology needed to enable such systems to operate in relevant environments, especially the thermal and radiation environments likely to be encountered in future space missions. Adding polarization independence will extend the applicability of non-mechanical beam steering to additional classes of lidar, since such independence can increase the received signal by up to a factor of four with some types of lidars. The weight reduction that is obtained in future lidar systems using the developed technology will be maximized by identifying optical components with the minimum possible weight that still meet wavefront quality requirements.

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 ground and air vehicles and robots, and commercial free-space optical communications.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S11.02-1215**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB562


**SUBTOPIC TITLE:** Technologies for Active Microwave Remote Sensing

**PROPOSAL TITLE:** Optimized frequency-stabilization subsystem for a compact Rydberg laser package

**Small Business Concern**


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The overall objective of this Phase II R&D effort is to implement the optimized absolute frequency-stabilization methods tested and validated in Phase I to advance an integrated frequency-stabilization subsystem and upgrade a compact Rydberg laser package prototype for performance testing and demonstration at JPL NASA towards deployed QRR. The prototype will incorporate a ruggedized Rydberg laser that is wavelength tunable to access RF transitions at S-band and K-band with absolute frequency stability at the 100-kHz level (threshold) or 10kHz level (goal) for operation under typical vibration conditions in suborbital flight. In the Phase II effort, integrated optical atomic reference packages will be fabricated and integrated with the laser system, and stabilization electronics optimized to frequency-stabilization performance targets under target vibration conditions. Hardware upgrades of the frequency-stabilized Rydberg laser system will be implemented for automatic power optimization and leveling during wavelength tuning operations over nanometers to target RF resonances from S-band to K-band transition. The effort includes the development of actuated all-axis micro-optic couplers for on-board auto-alignment into diode and laser stages; a micro- laser with an upgraded wavelength tuner and opto-mechanical microcavity design will be evaluated and developed for robustness under DC-8 vibration environments and mitigate risk of optical beam alignment changes arising from general wear and tear in operation. A universal multi-color adaptor for plug-and-play use of sensors and probes with the prototype will be developed for demonstrations.
Potential NASA Applications (Limit 550 characters):

The specific R&D conducted under the proposed Phase II work aim to advance JPL's Quantum Rydberg Radar (QRR) effort. QRR based on Rydberg atom sensing is targeted to advance capabilities in remote sensing for Earth and space-based science missions in Surface Topography and Vegetation (STV) with a disruptive option for a small, low-cost architecture that can enable ultra-broad-band imaging to cover different observables and penetration depths that can be dynamically tuned to focus on certain bands of interest.

Potential Non-NASA Applications (Limit 400 characters):

The proposed Phase II effort is aimed at creating a robust, frequency-stabilized Rydberg laser package for Rydberg atom quantum sensing. Rydberg atom sensing has potential application in RF markets including test and measurement, DoD, aerospace, and commercial communications, THz imaging, and semiconductor inspection.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S11.02-2261**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB555

**SUBTOPIC TITLE:** Technologies for Active Microwave Remote Sensing

**PROPOSAL TITLE:** Ultra-Efficient P/UHF Band Power Amplifiers

## Small Business Concern


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## Principal Investigator:


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## Business Official:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The project will advance Power Added Efficiency (PAE) beyond current commercial offerings in the P-band/UHF-band, targeting a Technology Readiness Level (TRL) of 5-6 for the MMIC power amplifier. This effort is significant in its potential to enhance NASA's communication and navigation for Size, Weight, Power, and Cost (SWaP-C) conscious applications. It has implications for various NASA missions and programs, including the Ecosystems SAR (EcoSAR), Electra UHF Navigation Package, and follow-on Mars rovers akin to Perseverance and Curiosity. The high PAE UHF MMIC 25-watt power amplifiers resulting from this project will be utilized across 32 polarimetric transmit/receive modules within the aircraft's radar electronics unit, demonstrating the potential impact of this technological advancement.

The proposed UHF MMIC, with a PAE greater than 75%, offers benefits beyond NASA applications and holds potential for non-NASA commercial and Department of Defense (DoD) applications, including tactical radio (ground, shipborne, handheld), FirstNet Network, commercial 5G New Radio FR1, and UHF Air Traffic Control and Wind Profile Radar.

Focusing on pushing the boundaries of UHF MMIC SSPA technology, the project is poised to make significant contributions to meeting the demands for high-efficiency ultra-high-frequency applications, underscoring the project's relevance for both terrestrial and space exploration applications.
Potential NASA Applications (Limit 550 characters):

- NASA Mission/Program: Ecosystems SAR (EcoSAR)
- Next Generation UHF Relays Like The Electra UHF Navigation Package on MRO
- Mars Rovers and Landers - Follow-Ons to Perseverance/Curiosity
- Deep Space Network (DSN)

Potential Non-NASA Applications (Limit 400 characters):

- Commercial/ Defense Tactical Radio (Ground, Shipborne, Handheld)
- FirstNet Public Safety Network
- Commercial 5G New Radio FR1
- UESA UHF Phased Array Radar for DoD

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S11.04-2312**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB317

**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: 5**
**End: 7**
Technical Abstract (Limit 2000 characters):


Alphacore is developing a low cost, scalable data acquisition system (SDAS) centered around an innovative application-specific integrated circuit (ASIC) for Microwave Kinetic Inductance Detectors (MKIDs). The SDAS ASIC will have 14 bits for digitization (Analog to Digital Conversion – ADC) and 14 bits or more precision for carrier tone generation (Digital to Analog Conversion – DAC), with each channel handling >4GHz of bandwidth (instantaneous bandwidth of > 8GHz at 4GS/s per ASIC and tunable bandwidth range of 16GHz) along with an on-chip low jitter PLL while consuming very low power per detector readout chain.
In Phase I we successfully optimized, fabricated, and tested high-speed, low-power 5GS/s ADC and DAC CMOS designs, proving functionality of the chips at room temperature and pre-irradiation, completed radiation testing, and developed strategies include a sophisticated model

for improving the radiation tolerance of the parts. The single-channel SDAS ASIC prototype complete system was successfully integrated using optimized ADC, DDS and interface with DSP. Full radiation testing of the ADC was also completed with very successful results: it was established that these designs clearly meet the hardness requirements of the target missions. The ADC and DAC designs are silicon tested and optimized for resolution. A second tapeout is scheduled in Feb 2024 (using Alphacore's internal funding) that will easily surpass NASA requirements. Firmware including RTL code for AMD/Xylinx Ultrascale MPSoC has been developed and hardware demonstrated. A combination of low power, time-interleaving ADC/DACs with innovative calibration architectures enabled Alphacore's designs to achieve high frequency operation at high resolution while consuming ultra-low power. Current estimation of total power, including the MPSoC's FPGA computation, is less than 5.2W/1GHz, which will also be improved in Phase II.

Potential NASA Applications (Limit 550 characters):

Alphacore's ASIC will support NASA radiometer microwave sensors for a wide range of Earth observation missions. The ASIC can be scaled to support the KID array readout. In addition, it will offer critical data collection benefits to the "eight prioritized programs" identified by NASA in its 2023 Decadal Survey as medium-class New Frontiers Missions, namely: Centaur orbiter and lander, Ceres sample return, Comet surface sample return, Enceladus multiple flyby, Lunar Geophysical Network, Saturn probe, Titan orbiter, and Venus In Situ Explorer.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications for this technology includes future CMB experiments and transition-edge sensor bolometer and MKID type of superconducting photon. They will also help axion and weakly interreacting massive particle searches. The SDAS can also support readout for large array MKIDs used to provide visibility through degraded visual environments such as dense fog.
Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S11.04-2555**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB547

**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


Firm: **QmagiQ**
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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):

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.

In Phase I, we successfully developed and demonstrated a low-force hybridization process for megapixel FPAs. We will apply this process to develop 2Kx2K FPAs in Phase II with high pixel operability and yield.

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: **24**

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**PROPOSAL NUMBER:** 23-2- **S11.05-1484**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB453

**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:


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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):

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 advance the development of its In-Situ Depolarization, Attenuation, and Scattering (IDEAS) sensor. IDEAS is submersible to >300 m, is configured for ship-based and in-water deployments, 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. 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 uses this data to calculate the diffuse attenuation coefficients based on a user-defined light field. IDEAS operates at wavelengths ranging from 355 nm to 1064 nm and is designed for unattended operation. In Phase II, Intellisense will develop a prototype with minimal size, weight, and power consumption that is ocean submersible to 300 m or deeper. It 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 will allow NASA to refine its models of particulate count versus water color as measured by its satellite-based sensors.

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: **24**

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**PROPOSAL NUMBER:** 23-2- **S11.05-1627**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB396

**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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## 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):

Atmospheric aerosol impair efforts to retrieve information regarding the Earth's surface, including oceans and have important impacts on climate and air quality. 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, difficult to maintain, and at risk of causing gaps in this vital measurement. We propose development of a next-generation aerosol probe that realizes a modernized implementation of integrated side scattering for accurate sizing of submicron particles. The project goal is to provide an aircraft-ready, life-cycle supported instrument capable of serving 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 core of the probe could be adapted for ground/laboratory use, opening more applications: air quality monitoring, clean room monitoring, and academic aerosol research.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S12.01-1797**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB379

**SUBTOPIC TITLE:** Exoplanet Detection and Characterization Technologies

**PROPOSAL TITLE:** Surface Finish Improvement in MEMS Deformable Mirrors for High Contrast Imaging

## Small Business Concern


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## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

This proposal aims to make fundamental progress in one of NASA's core objectives: to explore Earth-like exo-planets using space-based Coronagraphs that null starlight speckles using deformable mirrors (DMs), enabling planet detection. One NASA-identified technology gap is the need for compact, ultraprecise, multi-thousand actuator DMs with surface topography errors of less than 1nm RMS. 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 ~5nm-rms by topographic print-through on the mirror surface. BMC proposes a modified manufacturing process developed in Phase I research to eliminate print-through. The new process will lead to production of DMs with surface figure errors measuring 1nm-rms that will fill this technology gap for space-based coronagraphs as proposed for future NASA missions, namely the Habitable Worlds Observatory.

Potential NASA Applications (Limit 550 characters):

Deformable mirrors with reduced high spatial frequency topography have a few astronomical NASA commercial applications. There are a number of mission concepts and testbeds that require the wavefront control provided by the proposed high actuator count deformable mirrors. These include the Habitable Worlds Observatory (HWO) mission concept and the High Contrast Imaging Testbed 2 (HCIT2), currently at NASA JPL.
Potential Non-NASA Applications (Limit 400 characters):

*Ground-based astronomy:* The planned Extremely Large Telescopes such as the Giant Magellan Telescope and such as the Thirty Meter Telescope and the European ELT.

*Space surveillance and optical communications:* Funded by Department of Defense, these have classified agendas.

*Microscopy:* Modalities include multi-photon fluorescence and localization microscopy such as (STED, STORM, PALM and MINFLUX).
Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S12.01-1848**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB462

**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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## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


Discovery of life beyond the Earth will have profound intellectual and spiritual impact on humanity. NASA's Habitable Worlds Observatory (HWO) will make this discovery but only if the technology to overcome the obstacles to making these observations continues to advance. Exoplanets can be 10 billion times dimmer than their star making observations extraordinarily difficult. Researchers around the country have gradually improved coronagraph designs and test beds working towards the goal of achieving 1E-10 contrast. The PI of this proposal has delivered key components to researchers at NASA Ames, NASA GSFC, Space Telescope Science Institute, Caltech and the University of Notre Dame. This includes reflective and transmissive apodizers patterned with carbon nanotubes that scavenge diffracted light from the stars which can swamp the light from the planet. Carbon nanotubes are among the darkest materials ever fabricated and when applied to components enable new observations. The apodizers have excellent wavefront error and throughput and are enabling technology. This SBIR will fund additional improvements in apodizers including better reflective coatings, darker carbon nanotubes, improved patterning and enhanced characterization techniques. Two dozen next generation apodizers will be delivered to collaborators at the institutions listed and at the Unversity of Arizona and University of California in Santa Cruz. Other next generation components include carbon nanotube coated Lyot Stops and Focal Plane masks. Next generation designs and components will drive improvements as our collaborators test coronagraph architectures and refine their models. The variety of designs and improved coronagraph components will reduce risk to the HWO program by allowing a virtuous design, fabricate and test cycle to help determine the most promising path towards direct imaging of Exoplanets and characterization of their atmospheres.


Potential NASA Applications (Limit 550 characters):

High Contrast Imaging - Enabling technology beyond the Earth Habitable Worlds Observatory Search for Life Extreme stray light control for all NASA instruments. PACE OCI entrance slit was developed for NASA and flight qualified for use. LISA and Laser Communications for Duplex Telescopes

Earth Science instrument stray light control and calibrators - improving observational efficiency, reducing cost, enabling new science

Potential Non-NASA Applications (Limit 400 characters):

CNT coated Apodizers Lyot Stops, Focal Plane Masks, baffles- extreme stray light control for nearly all optical systems operating in high contrast regimes. This includes autonomous driving and commercial imaging.

Calibrators are used in precision optical instrumentation in chemical , optical and other sensing in commercial and DOD

Applications in Art and High Fashion watches

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S12.01-1988**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB597

**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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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

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

Space electronics must feature a certain radiation tolerance to meet a mission's life span. In addition, the size, weight, and power (SWaP) are usually constrained. Modern HV electronics are usually built with integrated circuits (ICs) that contain high-voltage (HV) MOS transistors whose threshold voltages will shift negatively if exposed to ionizing radiation, resulting in malfunction of the electronics. This project aims at developing radiation-resistant device-matched class AB HV amplifier-array ICs. 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. Device-matched amplifier configuration is a newly developed design that its operation is insensitive to the threshold-voltage shifts, thus such amplifier-array ICs are expected to be radiation-resistant, and these ICs are needed to build a miniaturized deformable mirror (DM) driver for a space coronagraphic instrument (CGI). Two radiation-resistant HV amplifier-array ICs will be prototyped by this Phase II effort, each contains 128 HV amplifiers, one for driving MEMS actuators, and the other one for driving stacked PMN actuators.

Potential NASA Applications (Limit 550 characters):

The to be developed two radiation-resistant class AB HV amplifier-array ICs can be used to build miniaturized DM drivers for space-based 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 tolerance are a concern. Such systems include but are not limited to space-based optical communication.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S12.01-2589**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB498

**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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## 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), high throughput (>70%) spectrometer leveraging arrayed waveguide gratings (AWGs) on a $Si_3N_4/SiO_2$ photonic integrated chip (PIC). Our groundbreaking approach introduces a reusable delay line (RDL) as a transformative alternative to the traditional multitude of waveguides. This innovation not only drastically reduces the device's footprint, potentially by a factor of 1000, but also enhances chip stability and reduces the weight, power, and cost (Swap-C) .

The spectrometer PIC will feature an inventive integration with a linear InGaAs detector array at the output and will incorporate fiber coupling at the input. This strategic design is meticulously crafted to yield a highly functional device housed within a butterfly package. The result is a substantial reduction in form factor (< 20 $cm^3$) when compared to prevailing competitors (~ 200 $cm^3$).

This cutting-edge, high-resolution, and high-throughput integrated spectrometer are poised to make significant contributions, not only in applications such as the detection of exoplanets using the Precision Radial Velocity (PRV) method, but also in commercial markets where bulk spectrometer are currently used. The potential impact of this technology is underscored by its innovative design and promising advancements in performance, reliability and cost.

Potential NASA Applications (Limit 550 characters):

The development of a high resolving power, high throughput integrated spectrometer holds the promise of creating an exceptionally compact instrument with versatile applications across various NASA-related projects. Potential uses include sensors, lidar, laser ranging, as well as medical and health applications. New Integration Photonics, Inc. is committed to exploring opportunities for collaboration with NASA, aiming to integrate this innovative technology into future NASA missions, including endeavors related to exoplanet detection.

Potential Non-NASA Applications (Limit 400 characters):

Our compact spectrometers hold significant potential for various applications, such as academic labs, on-field geological measurements for mining or oil & gas exploration, pharmaceutics, food & beverages, agriculture, medical point-of-care applications, and quantum and environmental sensing. Looking ahead, the integrated chip holds the promise of full integration into consumer electronics.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S12.03-1867**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB516

**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


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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):

The need for highly accurate and cost efficient deterministic polishing methods on a variety of materials is apparent. Diffraction limited, low cost, and low weight normal-incidence mirror systems are required to enable telescopes for missions of all sizes, ranging from CubeSats to Probe and Flagship missions. A solution that is applicable to any size and material is crucial.

Elastic Emission Machining can achieve these tolerances and is scalable while remaining highly precise with highly stable removal rates. EEM is a chemical polishing method which causes low-energy, non-damaging collisions to occur between particulates and the substrate surface. These gentle collisions do not directly remove material from the surface. Chemical reactions occur between the particulates and the surface whereby the particles become chemically bound 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 the particle – and its attached substrate atom – from the substrate, thereby producing an atomic-level machining operation. This type of material removal process does not inject heat, nor does it damage the atomic lattice structure, preventing sub-surface damage. Due to the material being removed efficiently from the surface by the polishing particulate, a Beilby layer is not allowed to form and “heal” over the optical surface. During the Phase I effort it was successfully demonstrated on Ultra Low Expansion Glass (ULE) and Zerodur.

Mirror support through mitigation on light-weighted ULE and Zerodur substrates was also a goal which OptiPro wished to complete in this Phase I project. Support print through is a problem with light-weighted mirrors in which the support structures are apparent in the mirror surface which EEM can address and solve. These factors were found to be successfully mitigated during the project and successful correction of light-weighted mirrors was accomplished.

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: **24**

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**PROPOSAL NUMBER:** 23-2- **S12.06-2123**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB523

**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


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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):

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 dispersions 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.

The Phase II effort will focus on prototyping Microshutter Array (MSA) interconnects packages and testing these packages for reliability in harsh conditions. The project will further optimize the printable materials and sintering processes to facilitate robust thermo-mechanical and electrical interconnections.

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: **24**

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**PROPOSAL NUMBER:** 23-2- **S13.01-1619**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB487

**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**
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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):


Motiv proposes to enable the continued search for life's origins through the development of an extremely lightweight manipulation system used for scientific sampling. The L-GRAS accomplishes this by preserving precious mass required to reach remote destinations and delivering robustness to the harsh environments, which are becoming more preferential for scientific interest. Motiv intends to leverage the lessons learned during Phase I of the L-GRAS effort to a) architect a lightweight, extreme environment manipulation system which can be augmented with end-effectors befitting of the destination and b) advance the TRL of the system via prototyping and testing of the robotic system in Phase II. Several technological advances manifest themselves within L-GRAS and differentiate the system from prior robotic architectures. Examples of these technologies are specialized actuation seals to protect against dust and contamination incursion, cryogenic operable motor control avionics which inherently reduce mass and power needs, light weighted actuators, and modular flex arrangements to easily allow scalability of the system


Potential NASA Applications (Limit 550 characters):

The L-GRAS architecture offers scalability for a variety of potential NASA applications. Discovery and New Frontiers destinations interested in pursuing remote sampling on small moons, comets, and asteroids are now addressable. Missions which intend to land on celestial systems with fractional or microgravity environments best leverage the proportional mass savings and controllability to execute delicate sample transfer operations. Lastly, L-GRAS enables small Mars mobility platforms intended to support remote science or fetch operations.

Potential Non-NASA Applications (Limit 400 characters):

Commercialization of access and regular missions to the Moon are underway. With repeated future successes of landings on the Moon, scientific sampling missions will grow in demand through CLPS. The L-GRAS presents as a critical tool to support lunar science efforts. Additionally, manufacturing and outfitting tasks which are rooted in ISRU developments will also benefit from L-GRAS scalability.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S13.03-2542**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB318

**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.**
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: 3**
**End: 5**
Technical Abstract (Limit 2000 characters):

Alphacore proposes to design and characterize a radiation-hardened analog library that 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 analog library includes three key components to any mixed-signal SoC, or ASIC: a phase locked loop (PLL), an analog-to-digital converter (ADC) and a digital-to-analog converter (DAC).
The 3-item analog library is not the only deliverable in this program, Alphacore will also develop a set of design guidelines for the 22FDX process 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. These models can be used in most common design flows.
Radiation testing of the DAC is also underway to establish that these designs clearly meet the hardness requirements of the target missions.
During Phase II, Alphacore will not only support CMOS IP development for the most harsh NASA mission environments, but also cover critical immediate needs in other areas such as the High-Performance Spaceflight Computing (HPSC) Chiplet, a radiation-hardened multi-core processor. NASA also will be developing single board computer based on this chiplet. These components are supposed to bring NASA (and DoD) two orders of magnitude improvement in their space computing capabilities.

Potential NASA Applications (Limit 550 characters):

Alphacore's radiation-hard analog library can help NASA design lightweight spacecrafts for future deep space missions. The low-mass will also keep costs low, and can accommodate multiple deep space missions. Future NASA missions that could benefit from components designed using Alphacore's rad-hard library include Europa Clipper and the Titan Saturn System Mission, along with the Moon-to-Mars program and the Origins Space Telescope

Potential Non-NASA Applications (Limit 400 characters):

The technological advancements needed to maintain leadership in defense capabilities will require significant innovation in space components, and with the growing presence of the DoD in space (e.g., Space Force, hypersonic missile defense), Alphacore's solution will be in high demand. It will also benefit low-temperature applications such as infrared cameras and quantum computing

Duration: **24**

**PROPOSAL NUMBER:** 23-2- **S13.03-2774**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB543

**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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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 5**
**End: 7**
Technical Abstract (Limit 2000 characters):


The Phase II proposal addresses the development of advance high energy density capacitors, for use in Power Processing Units (PPUs) of spacecraft, probes and landers, that are designed to operate in extreme temperature environments, with particular focus on cryogenic temperatures. Operating capacitors at cryogenic temperature presents unique challenges that need to be addressed to ensure a high level of reliability and performance. Space missions to planetary bodies that are distant from the sun, as well as lunar regions that are permanently shadowed, require electrical components with low temperature survivability and predictable and stable functionality at temperatures in the range of +125$^{o}$C to -240$^{o}$C. Furthermore, resistance to radiation exposure is a key requirement to reduce the added weight and volume of radiation

shielding. The Phase I development demonstrated that NanoLam™ capacitor elements have excellent parametric stability from a cryogenic temperature of 5$^{o}$K (liquid helium) to 160$^{o}$C. Comparison with state-of-the-art technologies shows that the NanoLam$^{TM}$ capacitors, have superior extreme temperature performance and multiple times higher energy density (J/cc) and specific energy (J/gr). The Phase II development is designed to produce and evaluate complete capacitors that comprise stacks of capacitor elements connected in parallel and packaged in a high temperature polymer box. The packaged parts will be tested using a series of environmental, electrical and mechanical tests. These will include, accelerated life tests at different conditions of voltage, temperature, vacuum and gamma radiation, to simulate operating conditions at different environments, and to facilitate the development a life-law to predict long term performance. Components will be supplied to NASA personnel for further tests and integration into low voltage advance controller units of dynamic power conversion systems, and high voltage PPUs for Hull Ion Thruster propulsion systems.

Potential NASA Applications (Limit 550 characters):

Potential NASA applications include Power Processing Units (PPUs) for photovoltaic arrays, 20V and 300V for electric propulsion, such as Hall Ion thruster systems. A more stringent application is PPUs of Dynamic Radioisotope Power Systems (DRPS), designed for future deep space missions such as the Saturn moons and planned missions to the shadowed side of the moon. Capacitors used in DRPS spacecraft, landers and probes need to operate in cryogenic temperature environments as well as in the presence of radiation both internal and external.

Potential Non-NASA Applications (Limit 400 characters):

NanoLam$^{TM}$ capacitors have a wide range of applications, that includes DC-link capacitors for inverters of hybrid and electric vehicles, medical instrumentation such as defibrillators both implantable and external, PPUs for aerospace applications, DOD and DOE applications that require capacitors with unique performance characteristics, and industrial applications such as power supplies.
Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S13.04-2102**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB390

**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**
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**Principal Investigator:**

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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 9**

Technical Abstract (Limit 2000 characters):

Recent evidence shows that the cleanrooms 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. Current metagenomics 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. MGEAS addresses these issues with 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 optimization for reads classification and genome assembly. As part of the phase I project ChromoLogic i) successfully evaluated two state-of-the-art genome amplification or enrichment techniques for NGS library preparation. ii) optimized kmers and various bioinformatics parameters for microbial taxa classification based on raw reads and iii) provided taxa reports for JPL environmental samples (wipes and swabs) and identified taxa with radiation, disinfectant resistance. In Phase II we propose to combine our achievements with a) the novel use of SMART accessory blocks for lab-work automations, and various techniques to improve nucleic acids yield and assay repeatability, b) state of the art DNA preparations, enrichment and amplifications followed by NGS sequencing, and c) Bioinformatics pipeline optimization for reads classification, genome assembly and adjacent DNA linked reads sequencing (Hi-C) for radiation/disinfectant resistant elements origin tracing (in species and environments). We will also expand our statistical modeling tests to improve accuracy and sensitivity of assays to fit NASA needs and we will build interactive software visualization tools for easier user navigation of taxa data and sample statistics.

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):

MGEAS tech has potential applications in the medical device field as a point-of-care (POC) deep DNA/RNA sequencing service for real-time pathogen identification. MEGAS technology can also be useful for pharmaceutical manufacturer's environmental monitoring programs where the technology can be marketed as a rapid way to identify microbes found as part of their environmental monitoring procedures.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S13.05-1353**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB519

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

**PROPOSAL TITLE:** Cs Atom Interferometer Laser

## Small Business Concern


Firm: **Opto-Atomics Corp.**
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## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

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 essential in multiple 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 continue the development of 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 built a prototype and evaluated its performance. We also investigated the size, weight, and power (SWaP) metrics of CSAIL. Based on these studies, the basic feasibility of the technology has been successfully demonstrated. In Phase II, we will construct an integrated brassboard prototype and demonstrate the full feasibility of the technology.

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: **24**

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**PROPOSAL NUMBER:** 23-2- **S13.05-1769**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB430

**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:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 6**


Technical Abstract (Limit 2000 characters):

Fibertek proposes the development of a low size, weight, and power in situ Lunar Lidar in support of NASA's Artemis missions. The lidar will be engineered for the harsh lunar environment and thereby have additional utility to NASA for general planetary exploration. The lidar is vehicle or astronaut mounted; provides high-resolution point-cloud data for developing centimeter-scale terrain maps via simultaneous localization and mapping (SLAM) processing; and supports real-time, non-GPS navigation, obstacle detection, and hazard avoidance.

Phase I testing established feasibility for Phase II by reducing major environmental risks including low temperature survival, operation in a vacuum, and radiation survivability with low Single Event Function Interrupt (SEFI) rates. The lidar operated after thermal vacuum cycles down to -150°C and core lidar electronics (lasers, detectors, and custom application-specific integrated circuit (ASIC)) exhibited no destructive radiation effects or performance degradation. Phase II will engineer updates to the housing and power supply electronics, as well as perform random vibration and radiation testing.


Potential NASA Applications (Limit 550 characters):

The Lunar Lidar particularly targets the NASA Artemis mission in support of the Human Exploration and Operations Mission Directorate (HEOMD).

- NASA Artemis III/ IV. On schedule to support 2028 mission
- NASA Lunar Terrain Vehicle contractors
- Future NASA Mars and situ exploration of planetary bodies

Potential Non-NASA Applications (Limit 400 characters):

The proposed technology can support multiple commercial and DoD endeavors.

- Commercial Lunar Surface Economy Companies
- NASA LIFT 1 Mission
- Commercial Lunar Payload Service (CLPS) Provider and their customers, rovers
- NASA Human Lander Contractors
- DoD and Space Development Agency (SDA) are increasingly interested in the Cis-Lunar environment

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S13.05-1970**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB639

**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:


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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

**Begin: 3**
**End: 5**

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) along with a full, practically unlimited mass range (from 10 Da to 10,000 Da), 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 with no overlap of ions with different $m/z$, which results in the whole mass range being recorded. 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. We estimate the mass spectrometer weight as about 3 kg and power consumption less than 50 W (without vacuum pumps).

Initially, the mass spectrometer will be operated with a laser/desorption ionization ion source using tightly focused pulsed UV laser. LDI mode of operation allows direct organics detection in complex matrices with minimal sample preparation. High mass resolving power provided by the multireflection TOF mass analyzer will allow to differentiate compounds with nearly identical molecular weights, e.g. leucine (monoisotopic mass 131.095 g/mole), and creatine (monoisotopic mass 113.059 g/mole). Later, we will extend its applications for gas chromatography-electron impact (GC-EI) ionization and other ionization methods, including, but not limited, to ionization at elevated pressures, such as laser spray and electrospray (ESI).

Potential NASA Applications (Limit 550 characters):

The proposed miniature TOF-MS relates to the NASA SBIR topic, soliciting instruments with increased resolution and reduced SWAP for in situ planetary missions. In addition to the primary application for in-situ detection and unambiguous amino acid and other prebiotic organic molecule identification in solid samples, this technology can be used for 1) identifying minerals on the Moon, Mars, and asteroids; 2) monitoring gas samples chemical composition.

Potential Non-NASA Applications (Limit 400 characters):

A miniature TOF-MS with thermal desorption and EI ionization can analyze environmental samples on-site. Low mass resolving power gas chromatography (GC) MS instruments are currently used, but the proposed instrument's high mass resolving power eliminates the GC separation step, thus increasing analysis speed and eliminating helium consumption.

Duration: **24**

**PROPOSAL NUMBER:** 23-2- **S13.05-2543**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB552

**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**
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## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


The study of the ratio of deuterium to hydrogen (D/H) isotopes allows the determination of whether the water originated from comets and asteroids, or it was formed through processes such as solar wind implantation or outgassing from a moon's interior. This information can provide insight into the early history and formation of the moon and the inner Solar System, with significant implications for future lunar exploration and the

development of sustainable space exploration programs. We have designed an innovative quantum sensor for D/H ratio measurement in water using spin centers as a probe for detecting nuclear spins of the isotopes. The proposed sensor indirectly measures the D/H ratio by interrogating shallow spin centers included within the walls of a container using optical and a combination of radio frequency (RF) and microwave (MW) signals. By confining the sample in a small container volume, this proposed sensor limits the effects of diffusion noise and enhances the sample's polarization without requiring hard to implement techniques such as hyperpolarization, thus providing higher resolution capability using simpler setups. Due to their low-cost and improved size, weight and power consumption, the proposed sensors could cover the growing need for robust sensors with small footprints suitable for *in-situ* measurements in space missions. The principal Phase II deliverable will be a compact, robust, room-temperature quantum NV-NMR sensor optimized for application to address measurements of D/H ratio in water. This device involves a bottom illumination/detection configuration, adding a microfluidic transparent chamber for optical readout and a coplanar waveguide (CPW) to deliver MW multi-pulse sequences. We will characterize device performance, including magnetic-field sensitivity, noise, and power consumption to confirm the device's effectiveness for NASA requirements and aligning with device simulations.

Potential NASA Applications (Limit 550 characters):

We have demonstrated in this project a novel sensor for measuring D/H ration in water. The competitive advantage of our sensor is that it will simplify the device by integrating the sensor and electronic components into a single chip, leading to improved predictability and sensitivity unparallel to classical NMR systems. They are exceptionally small and would thus be very well suited for nanosats or picosats as their size, power, and complexity restrictions are most severe.

Potential Non-NASA Applications (Limit 400 characters):

The development of nano-NMR quantum sensors based on diamond or SiC will likely lead to an array of additional sensing and information processing technologies such as radiation hardened sensors as well as potentially quantum memories for quantum communication and various components for quantum computation. The spin defects are also sensitive to electric fields, temperature, and other fields.

Duration: **12**

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**PROPOSAL NUMBER:** 23-2- **S13.05-2629**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB425

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

**PROPOSAL TITLE:** Remote X-ray Analyzer (ReXA)

**Small Business Concern**

Firm: **eXaminArt, LLC**

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## Principal Investigator:

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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

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 TRL4-5 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 proposed development will open new opportunities for the company to develop products for XRF and micro-XRF analyses, and enabling new generations of element mapping instruments for cultural heritage and industrial applications. The proposed work on quantitative analysis methods will directly apply to the current products marketed by the company (XRD/XRF, microXRF, ...)

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S13.07-2316**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB320

**SUBTOPIC TITLE:** Energy Storage for Extreme Environments

**PROPOSAL TITLE:** Radiation Hardened, Programmable Battery Analog Front-End ASIC

## Small Business Concern


Firm: **Alphacore, Inc.**
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## Principal Investigator:


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## Business Official:


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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

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

In response to NASA's S13.07 SBIR solicitation, 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. Alphacore will leverage existing designs and evaluation results to develop a CMOS-based, radiation-hardened (to 1 Mrad total ionizing dose) Coulomb counting ΣΔ ADC-based ASIC.
To significantly improve the radiation tolerance, Alphacore will implement the battery monitoring circuitry in the XFAB 180nm high-voltage (HV) silicon-on-insulator (SOI) process. SOI processes are known to provide excellent benefits in terms of SEEs, but TID has been a problem. Alphacore has already fabricated and TID tested three important building blocks of the system, LDO, BGR and Flyback converter and hardness beyond 300krad(Si) was proven.
Phase II efforts will focus on layout, integration and CMOS fabricating and testing of the designed CC and EIS system IC, incorporating necessary risk reduction tests, detailed design reviews, and test plans. The principal Phase II deliverable will be a prototype B-AFE system provided to NASA for reliability and durability testing. The CC+EIS concept developed in Phase I will be adapted to full-size cells to assess system capabilities over a dynamic range of charge/discharge cycles. Long-term testing, following NASA ESTA standards, will be employed to evaluate the safety and performance of the full-scale design. During Phases II and III, algorithm development for SoC estimation of Li/CFx primary cell batteries will commence, utilizing direct calculation, model-based, and data-driven approaches.

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: **24**

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**PROPOSAL NUMBER:** 23-2- **S14.01-2650**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB503

**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**
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## Principal Investigator:


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## Business Official:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


The Spacecraft Anomaly Resolution Knowledgebase (SPARK) is a coupled anomaly database, space environment database from 1986-present, a powerful analytics software package, and an intuitive user interface -- all hosted in a secure cloud-native infrastructure. It builds on past, current, and new anomaly databases, employs powerful analytical techniques, and is interoperable with other spacecraft-related tools. It improves the ability of spacecraft owners, operators, and other stakeholders to understand and potentially mitigate space weather environments adversely affecting space assets. SPARK addresses the SBIR topic call for “products that directly aid in spacecraft-anomaly resolution and assist end users such as spacecraft operators.”

SPARK extends the relevant SPRINTS 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 resolution 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):

Our primary NASA customer is the Goddard Space Flight Center and their supported Spacecraft Orbital Anomaly Report System (SOARS) application. SPARK can potentially improve SOARS ability for data access and analysis. Additional customers may also include NASA JPL, who have a more restricted anomaly database that SPARK may be suitable to provide secure interfacing for. Finally, NASA CCMC is a potential user and customer for their role in supporting anomaly resolution for supported NASA spacecraft missions.

Potential Non-NASA Applications (Limit 400 characters):

NOAA Space Weather Prediction Center (SWPC) to support anomaly resolution.

NOAA Traffic Coordination System for Space (TraCSS) to support space situational awareness with environmental data and anomaly resolution.

Coordinated Group for Meteorological Satellites (CGMS) to support anomaly databasing and resolution.

The space insurance and reinsurance industry is also a potential customer.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S14.01-2686**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB576

**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**
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**Principal Investigator:**

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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

**Begin: 6**
**End: 8**
Technical Abstract (Limit 2000 characters):

This “Improved Forecasting of Operational Solar and Geomagnetic Indices” (SGI) work will significantly improve existing operational thermospheric density forecasts that are applicable to low Earth orbit (LEO) space traffic management. This work will build upon results from new SGI forecast algorithms for the solar S10 and geomagnetic Dst indices that match or outperform existing forecasting methods. Those improvements, when added to operations, will expand redundancy, bolster resiliency, and enhance accuracy in the resulting thermosphere densities in LEO. This work will test those improvements in an operationally relevant environment as they are transitioned from technology readiness level (TRL) 6 to TRL 8. The redundant S10 index will use the National Solar Observatory (NSO) ADAPT algorithm to obtain this solar irradiance index forecast out to 7 days using solar source surface magnetic information, adding physical information to the forecast beyond what is currently done with simple linear predictive techniques. The improved Dst forecast applies machine learning (ML) for the 6-day and 2-day forecasts by using ACE or DSCVR solar wind information and by using solar images. This University of Colorado set of algorithms substantially improves the 6-hour forecast and will replace the existing Anemomilos Dst output now provided plus offer uncertainty assessment. The probabilistic 2-day forecast will inform issue/no issue decisions for the Anemomilos Dst, which is used operationally. Direct users of the advances include NASA Conjunction Analysis Risk Assessment (CARA), USSF 18th SDS, Department of Commerce (DoC) Office of Space Commerce (OSC), and commercial LEO satellite operators. This forecast of Dst will also be made available for community assessment through the NASA CCMC CME Scoreboard with an automated upload capability to be developed.

Potential NASA Applications (Limit 550 characters):

This work supports NASA’s Grand Challenges to *i*) solve important space-related problems; *ii*) radically improve existing capabilities; or *iii*) deliver new space capabilities. For Challenge 1 (expand human space presence), this work helps mitigate space debris collision hazards by improving the USSF HASDM thermospheric density forecasting system used by NASA’s Conjunction Analysis Risk Assessment (CARA) group. This work directly supports the solicitation for research that advances operational and commercial space-weather science and technology.

Potential Non-NASA Applications (Limit 400 characters):

There are 4 use cases for improved solar and geomagnetic driver forecasts: *i)* defense domain awareness, *ii)* civilian agency satellite operators, *iii)* commercial satellite operators, and *iv)* international space traffic management. Growth occurs in each area because of the tremendous expansion of the number of active satellites in LEO necessitating an improved ability to mitigate collision hazards.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S14.02-1131**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB404

**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.**
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## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

NASA is interested in electromagnetic sounding of ionospheric and magnetospheric plasma density structure at radio frequencies from kilohertz to MHz region. The majority of such soundings rely on passive sensing, i.e., they use either naturally occurring radiation or using transmitters of opportunity such as global navigation satellite system or ground-based transmitters used by world's navies to transmit commands to submarines. Active sensing using the 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. Efficient generation of low frequency waves, however, requires physically large antennas which essentially precludes their deployment in space.

CRG is working to develop a completely novel type of transmitter for active sensing in the ionosphere and magnetosphere based on the induced transitions between highly excited Rydberg-atom energy levels. The advantage of such a transmitter is based on the fact that an atom makes an efficient electrically small radiator. Dr. Latypov of CRG first proposed it as a solution to the long-standing problem of submerged submarine communication with the air/space platforms (Latypov, 2022). Now, CRG considers its potential applications in space.

The scope of this project is to evaluate the Rydberg atom-based technologies for potential NASA applications. The environment in space is significantly different from the environment on Earth's surface and can vary depending on the location and other factors. Therefore, performance of the transmitter in space may significantly differ from its performance on the ground. CRG therefore will also review how the space conditions affect the performance of conventional antennas and investigate their possible impact on the Rydberg atom-based low frequency radiator.

Potential NASA Applications (Limit 550 characters):

- Low frequency transmitter for space applications
- Geophysical surveying using low frequency electromagnetic waves
- Underwater surveying using low frequency electromagnetic waves

Potential Non-NASA Applications (Limit 400 characters):

- Submerged submarine communications
- Near field LF communication for Internet of Things
- VLF for space platforms to probe ionosphere and magnetosphere
- VLF injection for controlled precipitation of radiation belt electrons
- Beyond line of sight communication
- Geophysical surveying using LF electromagnetic waves
- Through-the-earth communication for mining applications

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S15.02-2265**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB458

**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


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## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Safe successful fluids handling is essential aboard low-g spacecraft for BPS experiments, life support equipment, plant and animal habitats, fuels, coolants, etc. Due to the unfamiliar, unearthly, and unforgiving low-g environment, special engineering considerations must be made to account for the large length scale capillary flows that occur when the role of gravity is greatly diminished. Unfortunately, the fundamental and applied challenges governing such 'capillary fluidics' phenomena are significant, compounded by our limited access to prolonged low-g environments, and our less than stellar success at performing seemingly simple tasks—like those required for routine wet lab operations, such as in situ sample preparation in the orbiting laboratory of the ISS.

Though NASA faces numerous low-g fluids challenges relating to sample preparation, there is hope to find solutions via the new state-of-the-art. Following our Phase I survey of the BPS community, we focus on a down-selected list of 'challenge problems' of cross-cutting value to NASA and the commercial aerospace community. To stakeholder 'requirements,' we then design, build, and demonstrate 12 prototypes of varied complexity addressing sample prep unit operations: resealable vials, low-g well plates, pipetting workstations, custom microscope slides, graduated bubble separating syringes, degassing substrates, passive liquid and bubble separators, and more. Our Phase II goal is to bring these devices and more to flight fidelity, greatly accelerating the establishment of a kit of plumbing parts (solutions) for safe routine wet lab activities aboard spacecraft.

Potential NASA Applications (Limit 550 characters):

Due to the broadly applicable cross-cutting nature of the low-g fluidics devices pursued in the Phase II, our customers are expected to include government and commercial entities including NASA who would be an immediate and direct customer as it relates to science aboard spacecraft. We also expect commercial spaceflight operators to utilize the technology for similar needs. Medical and biological researchers are expected to provide the largest supply of customers as space station access becomes more affordable, routine, and reliable.

Potential Non-NASA Applications (Limit 400 characters):

The novelty of our design approach is its nearly singular application to the low-g environment. Though we do pursue omni-gravitational solutions, our true niche is where the impact of gravity is quite small. However, we nonetheless pursue terrestrial applications for our material, filters, and design methods finding applications in microfluidics, biofluidics, OOC, LOC, and POC diagnostics.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S16.02-1352**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB626

**SUBTOPIC TITLE:** Dynamic Power Conversion

**PROPOSAL TITLE:** Electronic Controller for Sunpower Stirling Power Convertor

**Small Business Concern**

Firm: **Wecoso, 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):

While many spaceborne systems utilize solar arrays for onboard power generation, a number of applications including deep space exploration and planetary missions must instead utilize alternate forms of power generation due to the lack of solar power flux and / or the incompatibility of large solar arrays with mission constraints. For such systems, an attractive option is to utilize a radioisotope heat source coupled to a high-efficiency thermal / electrical power converter such as the Sunpower Robust Stirling Convertor (SRSC).
To this end, the West Coast Solutions (WCS) and Sunpower, Inc. team has successfully completed a Phase I development program for the Stirling Convertor Space Controller (SCSC). As its name implies, the SCSC is intended to be a space-compatible controller and power bus interface unit for the SRSC. The SCSC provides control for the SRSC, while also conditioning generated power such that it is compatible with the general spacecraft 28V bus for purposes related to battery charging, powering connected systems, etc.
The Phase I program included the design of a preliminary SCSC Flight Model system, including identification of critical space-compatible electrical components with sufficient packaging and radiation hardness characteristics for use in the intended environments. The proposed Phase II program continues SCSC maturation with an Engineering Model produced and qualified to TRL 6 via relevant environmental and functional testing.

Potential NASA Applications (Limit 550 characters):

Any mission employing RPS, particularly deep space exploration and lunar power installations as this approach offers the key advantage of operating continuously over long-duration space missions, largely independent of changes in sunlight, temperature, charged particle radiation, or surface conditions like thick clouds of dust.

Potential Non-NASA Applications (Limit 400 characters):

Deep space exploration and lunar power installations for DoD and potentially future commercial players, as well as potential DoD LEO applications demanding a more resilient power source.

Duration: **17**

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**PROPOSAL NUMBER:** 23-2- **S16.03-1967**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB424

**SUBTOPIC TITLE:** Guidance, Navigation, and Control

**PROPOSAL TITLE:** Precision Ion Nano Thruster

## Small Business Concern


Firm: **Espace, 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):

We are proposing the development of a new miniaturized and low power “nano-thruster” instrument, the Precision Ion Nano-Thruster (PINT) to perform very fine thrusting for precision attitude and trajectory control of space platforms.The precision actuator design builds on previous R&D results and experience, and proven technologies developed in collaborations between Espace Inc. and the MIT Space Propulsion Laboratory and includes new electrospray emitters (tested in Phase I) designed and optimized to operate in the pure ionic regime, for exceptional stability, thrust resolution and extended lifetimes. The development effort focuses on the precision control of small thrusts and impulses and the minimization of foot-prints.The PINT thrusters represent *“a mission-enabling technology with significant size, weight and power, cost, and performance (SWaP-CP) improvements over the state-of-the-art commercial off-the-shelf (COTS) capabilities”*, thus satisfying Scope 1 of the Guidance, Navigation, and Control (GNC) Sensors and Actuators requirements. Within Scope 1 they are also *“actuators that enable arcsecond-level control capabilities for large space telescopes, with improvements in SWaP requirements”*and can be applicable to support *“milliarcsecond-class pointing performance on spaceborne pointing platforms”.*The ultimate objective of the PINT development is a rugged, industrially and economically manufactured miniature instrument providing high precision controlled thrusts and impulses for advanced space platforms. The PINT thrusters will be fabricated and characterized during Phase II, and several prototypes will be delivered for qualification and flight tests.

Potential NASA Applications (Limit 550 characters):

The PINT thruster applications are in high precision control of space platforms attitude or trajectories. Potential user projects include: fractionated observatories with tight relative pointing and positioning requirements; multi-element interferometric instruments; constellations; lunar or interplanetary probes with fine trajectory adjustments; optical or laser systems with tight pointing and stabilization. PINT has applications in NASA science missions for astrophysics, heliophysics, and geophysics and in interplanetary or lunar probes.

Potential Non-NASA Applications (Limit 400 characters):

The PINT thruster applications are in high precision control of space platforms attitude or trajectories. Potential uses include: constellation fine control, sensor or laser systems tight pointing and stabilization, orbital management, station keeping, risk mitigation, drag compensation.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S16.08-1120**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB505

**SUBTOPIC TITLE:** Atomic Quantum Sensor and Clocks

**PROPOSAL TITLE:** Spectroscopy-grade lasers and PICs operating around 674 nm

## Small Business Concern


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## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


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: **24**

| | |
|---|---|
| **PROPOSAL NUMBER:** | 23-2- **S16.08-2009** |
| **PHASE 1 CONTRACT NUMBER:** | 80NSSC23PB621 |
| **SUBTOPIC TITLE:** | Atomic Quantum Sensor and Clocks |
| **PROPOSAL TITLE:** | Optical Frequency Synthesizer for Quantum Applications |

## Small Business Concern


Firm: **Vescent Photonics, Inc.**
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## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


Vescent Technologies (Vescent) proposes to develop a compact, low-power, ruggedized, and fully automated optical frequency comb (OFC) operating in the visible/near-infrared spectrum (400-1000 nm) to enable space-deployed optical clocks and Rydberg-atom based quantum sensors. The proposed solution will simultaneously meet the challenging performance requirements and the low size, weight, and power (SWaP) required to enable several of the

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, including relativistic geodesy, autonomous spacecraft navigation, very long baseline interferometry (VLBI), and space-based gravitational wave detection. Likewise, Rydberg-atom based quantum sensors offer similarly dramatic improvements over their classical counterparts for electric-field and microwave measurements. However, all the key optical clock platforms (e.g., based on Sr and Yb atoms/ions) and Rydberg-atom based quantum sensors can only operate reliably in laboratory environments. This is largely due to their reliance on the environmentally susceptible, high-SWaP infrastructure required to frequency stabilize multiple lasers across the visible/near-infrared spectrum. As an alternative, our proposed solution leverages the OFC's broad spectral range and precise mode spacing to perform frequency stabilization of all relevant quantum state-preparation lasers simultaneously to the OFC itself, thereby significantly reducing both SWaP and complexity of the optical clock or quantum sensor. However, there is a clear and critical gap in field-deployable, low-SWaP, OFCs operating at relevant visible wavelengths. Our proposed solution exploits rugged nonlinear micro-optic modules in telecom-style packaging to synthesize arbitrary visible wavelengths 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: **24**

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**PROPOSAL NUMBER:** 23-2- **S16.08-2021**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB306

**SUBTOPIC TITLE:** Atomic Quantum Sensor and Clocks

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

**Small Business Concern**


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## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 3**
**End: 4**

Technical Abstract (Limit 2000 characters):


This SBIR program will lead to the development of key photonic components for use in high performance quantum sensors and clocks. AdvR proposes to develop ultra 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: **24**

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**PROPOSAL NUMBER:** 23-2- **S16.08-2115**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB510

**SUBTOPIC TITLE:** Atomic Quantum Sensor and Clocks

**PROPOSAL TITLE:** Miniature Laser System for Cs Atom Interferometer

## Small Business Concern


Firm: **OEwaves, Inc.**
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## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The objectives of Phase II of this SBIR project are to design, assemble, test and demonstrate a complete fiber based laser system satisfying the specified requirements of NASA's proposed Space-based Quantum Gravity Gradiometer. The laser systems will be comprised of two frequency stabilized ultra-narrow linewidth lasers, combined with an optical amplifier in one package, with a PM fiber output. The fiber coupled laser system will have the following performance parameters:

1. Linewidth <1 kHz
2. Wavelength corresponds to Cs D lines (852 nm and 894 nm)
3. 300 mW output power
4. Volume of optical module under 500 c.c. (not including driving electronics)
5. Total power consumption for the entire system under 10 W
6. Modulation frequency up to 10 MHz
7. A roadmap to achieving system lifetime over 50,000 hours.

Within the scope of the Phase II effort, OEwaves will:

- Develop a physical model and design the optimal optical and mechanical package for the laser system prototype.
- Perform extensive analytical and numerical study of the proposed design including the thermos-opto-mechanical evaluation of the entire system.
- Fabricate resonators with optimal morphology and optimal host material to achieve the target performance for linewidth, and for frequency stability greater than $10^{-14}$.
- Prepare Phase II Final Report.
- Deliver a complete system for a Cs based QGG, meeting the specified performance parameters. The properties of the system will be measured and validated by a NASA customer.

Potential NASA Applications (Limit 550 characters):

The proposed technology is suitable for designing quantum sensors being considered for NASA missions, such as the Space Quantum Gravity Gradiometer. Low noise lasers, which are part of the system proposed here, are also being considered for advanced optical communications systems being developed at NASA, also missions such as LISA will benefit from what the lasers offer. Finally, NASA is developing quantum key distribution systems, which will also benefit from the low noise performance, small SWaP and rugged packaging of lasers proposed here.

Potential Non-NASA Applications (Limit 400 characters):

The most adjacent segment is the general area of quantum technology. 80 companies worldwide are developing quantum computing, quantum sensor, quantum communication and quantum network systems for commercialization. The advent of advanced optical communication systems such as 6G, satellite systems and Artificial Intelligence are yet other areas that require high performance, low noise lasers.

Duration: **18**

**PROPOSAL NUMBER:** 23-2- **S17.02-1729**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB602

**SUBTOPIC TITLE:** Integrated Campaign and System Modeling

**PROPOSAL TITLE:** Collaborative Multidimensional Trade Space Analysis Capability

## Small Business Concern


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 5**
**End: 7**

Technical Abstract (Limit 2000 characters):


The Collaborative Tradespace Capability (CTC) addresses critical areas of interest to NASA: improving model interoperability, managing varying levels of fidelity/uncertainty, characterizing and selecting optimum candidates, and rapidly and iteratively operating across a distributed collaborative environment.

SSI and our partner Sandia National Laboratories (SNL) have shown through the Phase I effort, via research, proofs-of-concepts, and examples, that the CTC can be achieved at multiple levels of integration and automation to more rapidly update system models and use these integrated system models to assess design in performance, cost, and risk/schedule while also accounting for uncertainty using the Whole Systems Trade Analysis Tool (Tool) and other like multidisciplinary trades tools.

This is accomplished by creating a high-level CTC design, improving System Model interoperability, leveraging commercial capabilities to compose digital threads, and accounting for uncertainty within the already powerful WSTAT capability, which accounts for cost, schedule/risk, and performance. The effort will extend NASA's DE capability by using and connecting current models with a System Model that will interface with the Whole System Trades Analysis Tool (WSTAT) with new uncertainty reduction methods.

The CTC aims to be a 10x+ game changer in rapidly navigating architecture and technology trades, requirements development, and design optimization through an integrated lens of cost, schedule, and performance. The CTC enables efficient exploration of multidimensional trade spaces as large as $10^{150}$. The CTC enables distributed collaboration, rapid iteration, and using existing authoritative sources to improve NASA's ability to design successful missions.

Potential NASA Applications (Limit 550 characters):

The proposed CTC product 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 while considering cost and schedule. It is suitable for any NASA project within or across its Centers where design options exist, iteration is necessary, uncertainty is high, and a complex programmatic and design space makes trade-offs challenging to assess.

Potential Non-NASA Applications (Limit 400 characters):

There is a significant opportunity for CTC, given the thrust of Digital Engineering and System Modeling, which are not well connected to trade study tools integrating cost, risk/schedule, performance, and uncertainty. SSI is highly confident in bringing on current commercial clients as interested partners across Aerospace, Automotive, Medical, and Defense during a Phase II effort and beyond.

Duration: **24**

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|---|---|
| **PROPOSAL NUMBER:** | 23-2- **S17.03-1079** |
| **PHASE 1 CONTRACT NUMBER:** | 80NSSC23PB551 |
| **SUBTOPIC TITLE:** | Fault Management Technologies |
| **PROPOSAL TITLE:** | TEAMS Fault Management Extension for State-based Design and Simulation |

**Small Business Concern**

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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

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

Reliable testing and V&V 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. FM is challenging to design, implement, and verify in the presence of numerous failure scenarios cutting across various subsystems and disciplines. In turn, the ***hardware***, ***software***, and ***operational*** mechanisms are equally diverse, and the processes to design, implement, and verify them need to integrate and operate ***diverse*** subsystems. Powerful ***MBSE*** tools for FM design, implementation, and verification include State Analysis Model (SAM) to discover ***algorithm***, procedure, sequencing, and other errors, prior to testing and to assess potential design changes.

The SAM models are effective in capturing state transitions during nominal and off-nominal states and determine if mitigating actions are effective given the transition to an off-nominal state. However, exploring very large set of potential state transitions driven by different component failure modes and their impacts can be challenging, and manual creation of such models with more complete coverage can be arduous for large interconnected systems such as the SLS or the Gateway.

QSI plans to integrate TEAMS® analytic capabilities with ***design*** and ***simulation software*** such as NASA's SAM to provide ***live detection, evaluation, diagnosis and recovery*** from failures. The team proposes a TEAMS® software interface for the SAM modeling environment, that (1) performs FM analysis of a system design modeled in SAM, (2) enables the FM design to be evaluated in an operational context by performing ***SHM*** functions during simulations that can

support an extensive set of component-level physical and functional failure scenarios, (3) supports ***trade studies*** to evaluate merits of FM Fault Protection schemes; (4) enables "System" level assessment and visualization of FM qualities implicit in the SAM State Machines.

Potential NASA Applications (Limit 550 characters):

This FM capability is relevant to future SMD/HEOMD missions, such as Multi-Purpose Crew Vehicle, Human Landing System, Orion Crew Vehicle, and ECLSS system, SLS. Artemis Mission – Lunar Lander, cis-lunar infrastructure including Gateway and deep space human exploration such as Habitat, and Moon to Mars mission are prime targets. Other targets include Deep Space missions such as Europa Orbiter, InSight lander mission, and Mars Science Laboratory. Earth orbiters such as Landsat-9 are also targets. Arcus X-ray telescope is another target platform.

Potential Non-NASA Applications (Limit 400 characters):

Commercial space launch vehicles (e.g., SpaceX), Geosynchronous earth orbit (GEO), Medium earth orbit (MEO), Low earth orbit (LEO), Space Command ground segments, DoD, USAF, US Navy, commercial aviation, military systems e.g., NORAD, JSF, Navy shipboard platforms, Submarine Commands, BMD systems, UAVs, UMGs, model-based design of space missions/satellites, supporting infrastructure Space services.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S17.03-2386**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB593

**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.**
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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):


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. The MAIFLOWER Phase II effort will develop a robust, near-operational prototype to detect and diagnose 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. In Phase II, MAIFLOWER will be expanded to cover mechanical faults during additional scenarios (such as Sun tracking and unwinding) as well as faults for the external electrical power system (EPS). Astrobotic will be intimately involved in Phase II development, which it will support by providing schematics and diagrams of subsystems, real data from mechanical testing labs to validate MAIFLOWER's algorithms, and requirements for MAIFLOWER's integration onboard a physical VSAT artifact for actual mechanical testing.

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, which 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 responses (built on our highly 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 the 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 spacecraft used by non-NASA U.S. agencies (e.g., DoD and NOAA), foreign agencies (e.g., the 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: **24**

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|---|---|
| **PROPOSAL NUMBER:** | 23-2- **Z1.05-1674** |
| **PHASE 1 CONTRACT NUMBER:** | 80NSSC23PB348 |
| **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


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 6**


Technical Abstract (Limit 2000 characters):

In Phase II, Astrobotic has refined the outputs based on learnings in Phase I, and identified the following as the key outputs to achieve in the Phase II efforts:

- Refined design requirements for a cable assembly (including connector) in a mission environment. Focus will be on the cable and connector in lieu of the reel, based on findings in Phase I.

- Cable design trade study modifications. Focus will be on manufacturing methods, unique materials, radiation and thermal design analysis, and minimization of mass while maximizing performance (frequency and throughput at a distance).
- Cable manufacturer and connector manufacturer engagements and prototyping. Focus will be on manufacturing capabilities at long lengths with consistency, and connectors that can withstand the power levels and extreme environments.
- Detailed designs for the cable, and connectors, to generate a complete cable assembly. Designs will be modified based on trade studies, and full assembly will be performed to allow for assembled testing.
- Fabricated Prototypes (2 rounds) of Cables (1000ft each round) and Connectors
- Cable and connector test procedures and test results. Two sets of testing will be performed, including characteristic impedance, capacitance per unit length, high power efficiency throughput, dielectric breakdown, mechanical strength, accelerated life, EMI/EMC testing, and dusty thermal vacuum (TVAC) testing.
- Analytical simulations of the cable design and correlation to test results. Simulations include LTSpice circuit simulations, ANSYS electromagnetic simulations, and analytical hand calculations.

At the conclusion of these efforts, the high fidelity prototype cable assembly will have been tested in a relevant environment achieving TRL 6. This will address critical gaps in technology as identified by NASA, assessing temperature swings and space radiation level analysis. This will ensure the cable technology supports up to 10kW power transfer with low mass materials.

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 assembly proposed here is a critical enabling technology of Astrobotic's lunar power grid, LunaGrid, which will allows 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: **24**

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**PROPOSAL NUMBER:** 23-2- **Z1.05-1735**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB509

**SUBTOPIC TITLE:** Lunar and Planetary Surface Power Management and Distribution

**PROPOSAL TITLE:** BLUE-PLUME - Blue Laser Planetary and Lunar Management of Electrical Power

**Small Business Concern**

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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

NASA's Moon to Mars Objectives underscore the need for a novel lunar & Martian power grid, essential for continuous human, robotic operations, and scalable to industrial power levels. Traditional electrical grid designs use heavy copper or aluminum wires and are neither economically nor logistically practical. The ability to power moving rovers or short-term stations enhances exploration scenarios, crucial for diverse tasks across missions. The technology also enables a centralized approach, eliminating the need for complex cable networks associated with traditional grids.

The Phase I project showcased the feasibility of NUBURU's blue laser power beaming solution. The technology was advanced to TRL level 4 with a laboratory prototype. Phase II builds on this success, focusing on high-power receiver development and extending the range of the blue laser transmitter. This approach is a breakthrough in laser power beaming, offering an efficient, adaptable, and cost-effective solution.

Phase II will advance the technology in three key areas: 1) Validation of thin-film solar cell technology at high power densities, 2) Demonstration of multi-kilometer long-range power beaming, and 3) Scaling up the blue single-mode laser source. NUBURU will demonstrate a high-power receiver at 200-500W at 1-3 km range and a long-range laser source at 5-50W capable of 10+ km range, collectively elevating the TRL level to 5.

Blue laser power beaming is a transformative innovation for lunar and planetary power distribution, offering distinct advantages over competitors reliant on inferior infrared (IR) or green

laser technologies. Blue lasers present low Size, Weight, and Power (SWaP) design, clear visibility aiding navigation, and efficient direct diode technology. The blue wavelength allows us of advanced direct bandgap, thin film solar cells, ensuring higher conversion efficiency compared to IR. The visible blue laser additionally provides navigational benefits to remote sites.

Potential NASA Applications (Limit 550 characters):

This technology is directly aligned with the mission goal of NASA's Artemis program, which aims to return humans to the moon on a permanent basis. This lunar and future Martian project will require dynamic high-power transmission to remote areas. Blue laser remote power beaming is an ideal solution for this key mission need. The BLUE-PLUME system will allow for deployment of an adaptable and scalable power grid on both the moon and mars.
Potential Non-NASA Applications (Limit 400 characters):

Lunar power beaming solutions are needed beyond NASA, including DARPA's LunA-10 program which seeks to develop a lunar electrical grid in < 10 years. In addition, laser power beaming has promise for terrestrial applications, including remote power solutions, disaster relief, and DoD contested logistics. Its adaptability and wireless transmission offer innovative possibilities for many industries.

Duration: **20**

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| **PROPOSAL NUMBER:** | 23-2- **Z1.05-2323** |
| **PHASE 1 CONTRACT NUMBER:** | 80NSSC23PB323 |
| **SUBTOPIC TITLE:** | Lunar and Planetary Surface Power Management and Distribution |
| **PROPOSAL TITLE:** | Radiation-Tolerant, High-Voltage Bidirectional DC-DC Converter PMIC |

## Small Business Concern


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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

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

Alphacore proposes the integration of a 10kW, 100V to 5000V bidirectional DC-DC PMIC controller. A multi-chip package (MCP) approach to integration, in conjunction with inductive isolation, yields a single PMIC controller with tremendous savings in space and cost. The PMIC in combination with external WBG FETs implements a dual active bridge (DAB), bidirectional DC-DC converter module that can draw energy from the photovoltaic panel or the battery or, in combination with an inverter, from the grid. Alternatively, it can efficiently charge the battery or deliver energy to the loads when necessary.
The PMIC can be part of a DC system or an AC grid. One of the topologies capable to implement seamlessly a unidirectional or bidirectional power flow is the digitally controlled DAB converter, whose phase shift sign determines the direction of the energy flow. DAB has the electrical advantages of wide voltage operation range, zero voltage switching via resonant transition of all devices, low switching and conduction losses, minimum device voltage stresses, and easier bidirectional control. The DAB also has favorable magnetics trade-offs: well-utilized transformer core, low transformer losses, and small series inductor sustaining low volt-seconds. Exceptionally high efficiencies have been demonstrated for this architecture.
In Phase I, Alphacore successfully designed and simulated the PMIC controller, as well as the DC-DC converter module. Critical system building blocks (LDO, BGR and flyback converter) have been already fabricated and were tested in a Cobalt 60 chamber, showing the effectiveness of the implemented radiation hardening techniques. This test data lowers the risk of the proposed Phase II program.

Potential NASA Applications (Limit 550 characters):

The low-profile, lightweight, high efficiency GaN/SiC PMIC significantly advances the robustness, reliability, and safety of the electricity infrastructure. It 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 on icy moons and Mars (Mars Deep Time Rover); and power management needs for missions to the lunar surface (Artemis).

Potential Non-NASA Applications (Limit 400 characters):

The 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 those needs, with specifications that exceed its known competitors.
Duration: **24**

**PROPOSAL NUMBER:** 23-2- **Z2.01-2398**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB611

**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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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**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 heat flux is 1.0MW/$m^2$. Furthermore, NASA requires candidate technologies to transport heat 3-10 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 the six-month Phase I program, TAT successfully developed the first ever large format high temperature oscillating heat pipes, which firmly demonstrated the technology's feasibility for the target application. In Phase II, ThermAvant will further advance the state-of-the-art (SOTA)
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 3 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: **24**

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**PROPOSAL NUMBER:** 23-2- **Z2.01-2742**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB614

**SUBTOPIC TITLE:** Spacecraft Thermal Management

**PROPOSAL TITLE:** Robust Two-Phase Cooling Technology for Megawatt Space-Based Systems

**Small Business Concern**


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


After 20 years serving the American space thermal control systems amicably, the leading capillary-pumped heat transport technology - Loop Heat Pipes (LHPs) - has finally run out of capacity to offer the ever-increasing demand for spacecraft power. LHPs contained no mechanical moving part to wear out or break down, hence, highly reliable for space applications. The simplest and most rational approach was to employe a mechanical pump to augment the capillary pumping head of the LHP. In fact, NASA Goddard had tried in in the 1980s time frame and the results were not very well-received simply because the mechanical pumps especially the gear-type were notoriously unreliable, lasting no more than 1,000 hours of service. In 2004-2005, TTH Research Inc. introduced an Advanced concept of LHP - called Advanced LHP or A-LHP - in which any pumping device could be utilized to assist the capillary pumping. One variant of the A-LHP called for a bearingless pump to be added in-line to the LHP liquid return line. Since the bearingless pump was originally developed for the bio-medical technology as a blood pump, it could not withstand the high fluid pressure of Ammonia. Nevertheless, a Freon 11 breadboard test unit was constructed and performance tested and the results were very encouraging. Subsequent efforts to design an Ammonia version of the Freon 11 pump ended up in a complete failure and the researched had to be put a shelf for 10 years. In 2015, by sheer serendipity, another type of bearingless pump manufactured by Levitronix was discovered. The pump was of centrifugal (impeller) type having a single impeller embedded with permanent magnets to (i) employ magnetic levitation (MagLev) to suspend itself in the fluid while inside a hermetically-sealed casing AND (ii) be magnetically driven by an external electro-manetic motor. The MagLev allowed liquid to flow through without impedance. More importantly, more than one unit can be used for redunancy or enhanced capacity.


Potential NASA Applications (Limit 550 characters):

Every NASA space missions would require some amount of thermal control and management of the onboard payloads. The LHP provided that service to NASA since the early 2000s for the transport requirements of 1 few hundreds Watt-meters to more than 10kW-m. But now with NASA Artemis program planned to establish a base camp for humanity on the surface of the

Moon, requiring at least one-order-of-magnitude enhancement of heat transport over the existing LHP. The Hybrid Loop was proposed for that purpose as a consequence.

Potential Non-NASA Applications (Limit 400 characters):

Besides NASA, the U.S. Departments of the Air Force and the Navy maintain their own fleet of satellites. They have the same needs as NASA as far as space missions are concerned. In addition, with the All-Electric initiative, high power electronics as well as electric vehicles (EV), surface ships, even air planes are need the heat transport capacity of systems like the Hybrid Loop.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z2.02-1495**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB559

**SUBTOPIC TITLE:** High-Performance Space Computing Technology

**PROPOSAL TITLE:** Real-Time Hardware Configurable Coprocessors

## Small Business Concern


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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

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

This project will prototype a coprocessor companion for radiation-hardened computers that can boost system performance by exploiting the parallel resources and reconfigurability of commercial Field Programmable Gate Arrays (FPGA). The prototype builds upon a feasibility study that investigated using dynamically reconfigurable coprocessing circuitry integrated into 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 2021 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 prototype a coprocessor system that 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. The proposed prototype will perform object detection on incoming camera data using a sequence of coprocessor steps that are dynamically swappable including filtering, edge detection, and pattern recognition. The prototype will undergo fault-injection testing and two rounds of radiation testing.
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.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z2.02-2601**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB467

**SUBTOPIC TITLE:** High-Performance Space Computing Technology

**PROPOSAL TITLE:** Scalable, Variable-speed Time-Sensitive Ethernet

## Small Business Concern


Firm: **Lewiz Communications, 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: 6**
Technical Abstract (Limit 2000 characters):


Time critical data requires low latency and deterministic data transfer. Sensor, command and control data of mission-critical, high-reliability, real-time applications such as collision avoidance, avionics require on-time delivery of critical information. Autonomous systems for sea, air, space vehicles, ground vehicles, robots, etc., all have requirements for time critical transfer. Ethernet is ubiquitous - being used everywhere. Its large ecosystem of products and services provides key advantages - low cost, high availability. Not to mention the countless engineers and service technicians for servicing such technology. However, data transferred via Ethernet network is “best-effort” causing significant jitter and non-deterministic. Packets across Ethernet may be dropped. Delivery is not guaranteed. Solutions are required to overcome these problems in endpoints and network equipment (e.g., bridges, switches, etc.)
2 standards defined by the industry for time-critical applications: Time-triggered Ethernet (TTE) or SAE AS6802 and Time-Sensitive Network (TSN). LeWiz developed TTE technologies (IP core, FPGA switch, endpoint chip and software) for use in endpoint and switching nodes for NASA and DoD. LeWiz also developed a time-critical Ethernet IP core for either TTE or TSN (TTSN Core). TTSN Core can be used in endpoint or network infrastructure systems supporting speed up to 10Gbps and beyond. In Phase 2 (24 months), we propose to extend TTSN technology to (1) support the new IEEE802.1DP/SAE-AS6675 TSN for Aerospace

Standard, (2) develop a multi-port, fault-tolerant bridge system for bridging TTE and TSN networks for aerospace applications and (3) develop the software for the bridge system and to support the testing. This proposal supports the new TSN aerospace standard; provides solutions for NASA to be compatible with TTE systems and networks deployed by NASA for space vehicles, Lunar Gateways, and likely Moon base camps and others in the Artemis Program and beyond.

Potential NASA Applications (Limit 550 characters):

NASA applications:

Networking endpoints, switches, bridges, gateways

sensors and backbone on-board networks for flight control, landing control, instrumentations, payloads, navigation systems, scientific processing, image processing, communication sub-systems for satellites, space stations, vehicles, space habitats

robots, rovers, helicopters

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications: sensors and on-board networks, flight/landing control, instrumentations, payloads, navigation systems, networking, image processing, communication sub-systems for satellites, space stations, air/space/ground/sea vehicles, hypersonic/weapon systems.

Commercial: Industrial control, wind turbine, commercial aircrafts, Army copters, medical equipment, automotive, and many others

Duration: **24**

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|---|---|
| **PROPOSAL NUMBER:** | 23-2- **Z4.05-2659** |
| **PHASE 1 CONTRACT NUMBER:** | 80NSSC23PB310 |
| **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:

Name: **Victor Grubsky**
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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 6**
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) proposed and developed in Phase I Time-Synchronized X-Ray Compton Tomography (TESERACT) technology. TESERACT approach 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 and background scattering signal, 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 offers simplified and more user-friendly operation, achieving higher-quality scans with reduced operator effort. In Phase I, ATC demonstrated the feasibility of the TESERACT technology by developing the required data processing algorithms, as well as fabricating and testing a prototype system, with final technology readiness level (TRL)-4. In Phase II, ATC plans to develop a complete TRL-6 TESERACT system with multiple new performance-enhancing features and adaptability to a wide range of NDE tasks, and demonstrate its inspection 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, producing high-fidelity, quantitative scan data suitable for accurate 3D

component reconstruction, free from signal artifacts, with user-friendly functionality. TESERACT will increase the effectiveness of on-ground material development and quality control tasks for space exploration missions, such as Orion and SLS. TESERACT can also provide an effective solution for in-space NDE applications on the ISS and Lunar Orbital Platform-Gateway.

Potential Non-NASA Applications (Limit 400 characters):

Potential commercial applications of the TESERACT technique include the NDE of lightweight aerospace materials, such as multilayer aluminum and composite structures, honeycomb panels, COPVs, and spacecraft heat shielding. Additionally, TESERACT has significant applications in the oil and gas industries, for example, detecting corrosion in pipelines through layers of thermal insulation

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z4.07-1268**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB386

**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**
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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):

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 Integrated Computational Materials Engineering (ICME) framework leveraging physics-based process and metallurgical models , anchored by terrestrial and flight 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), and grain structure evolution models addressing both fusion from the melt and coarsening in the heat affected zone.

During the Phase I effort, models for evaporation effects on the weld melt pool were evaluated and a compact, efficient approach to incorporating these effects into multiphysics welding process simulations was developed. Additional model components necessary for such simulations to address in-space laser welding were identified, and weld pool state information was used to predict the solidification microstructure. In this Phase II effort, CFD Research will adapt and validate software to fill the remaining gaps in an ICME framework for in-space welding process developers, establish data transfer to link melt pool scale welding simulations with prediction of the resulting grain structure, and validate the linked software against historical and upcoming flight data. Application studies will be performed to develop and mature the simulation and analysis workflow, followed by documentation and delivery of the resulting software and test cases to NASA.
Potential NASA Applications (Limit 550 characters):

Welding and joining processes are critical technologies for in-space manufacturing and repair at Gateway, other future orbiting stations, and sustained lunar presence. Confidence in the performance of in-space joining processes will enable NASA and commercial firms developing orbiting infrastructure to circumvent the launch load and payload fairing constraints on large structures such as in-space habitats, reduce technical risk, and optimize payload packaging efficiency to launch system components.
Potential Non-NASA Applications (Limit 400 characters):

The commercial market for in-space application of this ICME framework will strongly overlap the anticipated NASA applications for space-based manufacturing and repair. The proposed tools can accelerate both learning from recently announced in-space welding demonstrations, and the transition to routine application. The developed capabilities will also benefit in-space metal additive manufacturing.
Duration: **24**

**PROPOSAL NUMBER:** 23-2- **Z5.06-2232**

**PHASE 1 CONTRACT** 80NSSC23PB334

**NUMBER:**

**SUBTOPIC TITLE:** Servicing and Assembly Applications

**PROPOSAL TITLE:** Launch Deploy and Docking Mechanism - Half-ESPA Size: Phase II

## Small Business Concern


Firm: **Apech Labs LLC**
Address: **1576 Sweet Home Road Suite # 210, Buffalo, NY 14228**
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## Principal Investigator:


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## Business Official:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


Apech Labs is offering NASA a satellite launch-hardened deploy and docking mechanism (LDDM) for the half-ESPA size class. LDDM is envisioned as a product family with extensibility to ESPA and ESPA-grande applications. The mechanism is divided into an active and passive half. The active half includes an actuated fastener V-band hard capture system, and a scissor style actuated boom soft capture mechanism. The passive half only requires a V-band flanged ring and passive capture probe to enable basic launch/docking capability. The mechanism will be reusable for a minimum of 200 docking cycles. Phase I of the program culminated with a preliminary design and functional brassboard hardware. Phase II of the program will mature the design to a prototype level, add electrical and fluid couplings, environmentally test the system in key environments, and demonstrate docking performance. Apech Labs is a 2020 startup with extensive experience in complex aerospace product development and electromechanical actuation. We will bring these capabilities to bear to provide the best possible offering to NASA.

We have signed a Memorandum of Understanding with Moog to provide technical and business insights and to explore becoming a commercialization partner.

Potential NASA Applications (Limit 550 characters):

Potential NASA applications for LDDM include the hosting of scientific payloads with the ability to deploy/undock them as desired. Similarly, LDDM's thermal and electrical interface allows hosting of satellite upgrade hardware. LDDM also provides large satellites and persistent platforms (e.g. Gateway) the capability to host smaller satellites for inspection/repair purposes. LDDM enables on-orbit refueling and other ISAM capabilities. LDDM can be adapted as a standard payload-hosting interface for LSITP payloads.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications primarily include spacecraft separation and spacecraft refueling. LDDM is primed for use as a separation system with the added capability of enabling future serviceability/upgradeability for client craft, including refueling, and repair, and upgrade services. LDDM supports DOD uses including satellite system of systems, enhanced mobility, and enemy spacecraft manipulation.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z5.07-2713**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB536

**SUBTOPIC TITLE:** Autonomous Robotic Manipulation, Utilization, and Maintenance

**PROPOSAL TITLE:** Dexterous Whole-Body Manipulation for Robotic Lunar Operations

## Small Business Concern


Firm: **PickNik, Inc.**
Address: **4730 Walnut Street, Suite 106, Boulder, CO 80301**
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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):

**Autonomous robotic systems will play a critical role in NASA's efforts to develop and sustain a manned presence in cislunar space, on the lunar surface, and beyond. However, operating these systems through highly asynchronous connections presents significant challenges beyond normal terrestrial or near-earth applications. Moreover, plans to employ robots for mission infrastructure such as habitats or in-situ production of oxygen or propellant, or for expanded science applications in the absence of humans, drastically increases the demands on the movement and manipulation capabilities of the robot. To meet these demands, we must both increase the mobile and dextrous manipulation capabilities of these systems, as well as ensure that human operators have the necessary tools to operate them with confidence. Building on our previous work in fault management and recovery for complex motion planning and execution, we will augment our platform for supervised autonomy to enable execution of complex mobile manipulation tasks with high degrees of operator confidence. We will build a representative hardware system with multiple arms and a mobile base, and integrate it into our software application. Finally, we will assemble behavior trees to demonstrate using supervised autonomy to complete relevant lunar construction, science, or habitat caretaking tasks in a representative ground environment.**

Potential NASA Applications (Limit 550 characters):

**Our Phase II work will develop confidence in autonomous, complex robots including mobile base and multi-arm systems which will be utilized on the Artemis program, martian operations, and intra-vehicular robot technology for science utilization and spacecraft caretaking. A mobile base enables movement throughout a human habitat, through airlocks, and around the lunar surface. Multi-armed systems provide flexibility and ability including crawling, multiple camera views for inspection and manipulation tasks, and grasping and assembling structures**

Potential Non-NASA Applications (Limit 400 characters):

**PickNik's software product, MoveIt Pro, has applications for commercial space customers in the areas of commercial Low Earth Orbit destinations (CLD), In-Space Servicing, Assembly, and Manufacturing (ISAM), lunar and planetary missions. On earth, we have worked in manufacturing, warehouse management, defense, agriculture, and marine (oil rig maintenance, deep sea exploration) environments.**

Duration: **24**

**PROPOSAL NUMBER:** 23-2- **Z5.08-2056**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB389

**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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## Business Official:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 6**
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.

Humans may feel prohibited from placing full trust in their robot collaborators due to current robots' inability to observe all communications from their partner, draw usable inference from the contextual clues of the interaction, and respond in a courteous manner.

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, where the human's gaze lingers, body posture, and robot registered events) during the execution of the task and fuses the information into a singular natural language transcription of events. This transcript is queried by a large language model (LLM), 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 the necessary actions 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 component capabilities of PAL in simulation and the complete system in a physical, representative manufacturing setting.

Potential NASA Applications (Limit 550 characters):

The innovations proposed under PAL support NASA's strategic goals toward the development of autonomous systems, specifically with a focus toward Multi-Modal and Proximate Interaction (TX04.4.1), 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: **24**

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**PROPOSAL NUMBER:** 23-2- **Z7.01-1031**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB482

**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 in NASA EAST Facility

**Small Business Concern**


Firm: **MetroLaser, 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):


Planetary entry and atmospheric reentry involve very high velocities and a significant source of vehicle heating is the radiation from the high temperature, bow shock-heated plasmas formed in front of the vehicle. The radiative environment corresponding to different planetary entry conditions is simulated in the NASA Ames Electric Arc Shock Tube (EAST) facility, and there is a need for developing nonintrusive, accurate, spatially and temporally resolved diagnostic of electron number density to help improve the physics of radiative transport prediction models.

The objective of the Phase II effort is the refinement and delivery of a high-speed electron number density sensor using two-color heterodyne interferometry (TCHI) for the EAST facility. Specifically, we will build on the promising initial results from Phase I and develop a compact, robust and validated TCHI sensor integrated with EAST. Based on our initial data and additional opportunities to refine the sensor, we anticipate that electron density measurements below $10^{12}$ $cm^{-3}$ with spatial resolutions of < 1 mm are feasible at 1 MHz rate.

1. Further optimize and validate the TCHI system performance using surrogate plasmas.
2. Build a more compact and robust TCHI transmitter and detector platforms, including an all-fiber detection system.
3. Compare the free-space and fiber detection implementations of TCHI in a shock tube test.
4. Build a laser schlieren system for accurate detection of the shock front arrival to serve as a trigger source for the TCHI sensor.
5. Perform final integration, testing, and system performance checks at the NASA EAST facility.

The Phase II deliverables will be progress reports, a final report, two instruments – a laser-schlieren system for shock front detection and the TCHI sensor, validated with measurements in the EAST facility along with their user manuals.

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: **24**

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**PROPOSAL NUMBER:** 23-2- **Z7.03-2364**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB363

**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**
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## Principal Investigator:


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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

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

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. 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 utilizes 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 is developing a TPS that can have thermal layers added after the weaving process using needle punching techniques. This effort is based on the work from the original proof of concept. It was proven that in an lab enviroment that a nonwoven webbing made of chopped insulation layer yarn fibers was able to bond to the insulation layer of the HEEET material. Continuing research will prove that the additive layer can be manufactured to increase the thickness while maintaining the fiber volume of the insulation layer of HEEET. This continued work will utilize two different manufacturing techniques for the nonwoven webbing that will be needle punched to the insulation layer, air laid web delivery (Rando) and wet laid web delivery (Southeastern Nonwovens). These two techniques will be explored to scale the thickness of the Additive Insulation Layer(AIL) to 0.5" opening options for variable thickness TPS with increased speed to manufacture.

Potential NASA Applications (Limit 550 characters):

The proposed technology for additive insulation layers on HEEET material 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. This 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 and other less aggressive entry environments.
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: **24**

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**PROPOSAL NUMBER:** 23-2- **Z7.04-2689**

**PHASE 1 CONTRACT** 80NSSC23PB373

**NUMBER:**

**SUBTOPIC TITLE:** Landing Systems Technologies

**PROPOSAL TITLE:** Modeling Plume-Surface Interactions for Landing Pads and Untreated Ground

## Small Business Concern


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


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## Business Official:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


Outward Technologies with support from its subcontractor Astrobotic Technology proposes to continue developing Free Open-Source Software (FOSS) for simulating Plume-Surface Interactions (PSI) relevant to lunar and Martian landing conditions. These software tools 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 lunar regolith ejecta with accurate distributions of grain types, sizes, and shapes capable of receiving input from the plume model to predict erosion physics and ejecta dynamics; 3) a damage calculator for identifying the location and extent of pitting and fracturing produced by soil ejecta impacting near- and far-field surfaces; 4) a calibrated and validated set of model input parameters to fit the soil mechanics response of ground obtained from PSI experimental data, to include time-dependent crater geometry and ejecta trajectories and velocities; and 5) a demonstration model incorporating the full capabilities of this developed software to simulate PSI during a landing event at large-scale, deployed in a massively parallel

cloud computing environment. These combined tools and calibrated model inputs will enable high-fidelity PSI models to be run in a reasonable time to aid Commercial Lunar Payload Services (CLPS) lander companies such as project partner Astrobotic in planning for near-term missions, while also enabling design studies of lunar Human Landing Systems (HLS). Test performance will be documented to demonstrate agreement with analytical and experimental predictions of PSI across a range of conditions. The results of these proposed Phase II efforts represent a robust engineering and analysis tool for NASA and its commercial partners in the design and evaluation of landers in support of the Moon-to-Mars program and missions to other planetary bodies.

Potential NASA Applications (Limit 550 characters):

NASA applications include the design and validation of lander systems and hardware to facilitate safe touchdown of spacecraft on planetary surfaces while not causing unacceptable risk from rocket plume impingement. This proposed work will provide multi-disciplinary coupled analysis tools, plume-surface interaction models, and multi-scale simulation tools under TX09.4.5 Modeling and Simulation for EDL for configuration definition and design verification and validation for landing systems that cannot be tested in an operational environment.

Potential Non-NASA Applications (Limit 400 characters):

Potential non-NASA applications include sale of engineering support services to Commercial Lunar Payload Services (CLPS) providers for evaluating lunar lander systems, landing sites, and lander control strategies using high-fidelity PSI simulation software. Additional applications include the evaluation of sensor and payload design, and their placement on a lander to reduce risks posed by ejecta.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z8.02-1426**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB454

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

**PROPOSAL TITLE:** Miniature Interferometric CubeSat-Ready Optical Sub-arcsecond 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:


Name: **Dr. Tin Aye**
E-mail: **notify@intellisenseinc.com**

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

**Business Official:**

Name: **Selvy Utama**
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Phone: **(310) 320-1827**

**Summary Details:**

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 5**
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 in Phase II to continue the development of the new Miniature Interferometric CubeSat-Ready Optical Sub-arcsecond Telescope Array (MICROSTAR) Star Tracker for optical navigation of distributed CubeSats. This high-accuracy star tracker for low–size, weight, and power (SWaP; 0.25 U) CubeSat attitude determination is based on multi-aperture interferometric fringe detection modules with no moving parts. The innovative 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 that is capable of long-term, high-accuracy attitude determination for robust CubeSat control. In Phase I, Intellisense developed a laboratory prototype of MICROSTAR's key technology and demonstrated its performance parameters, including high-accuracy attitude positioning for navigation, high-precision pointing and tracking for long-range optical communication, and optimal power budget for extended operational longevity. We also developed 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 for development of space-qualifiable and commercially available CubeSat sensor payloads.

Potential NASA Applications (Limit 550 characters):

With its low-SWaP-C design, MICROSTAR will be suitable for many NASA applications, including lunar, Mars, and deep space distributed science missions, and for distributed aperture virtual telescopes, small spacecraft swarms for gravimetry and transient phenomena observations, and proximity operations for inspection of space assets. Additional applications include high-precision relative attitude determination between CubeSats and 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-arcsecond precision of MICROSTAR could also enable the scientific community to collect high-accuracy astronomical data.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z8.09-1067**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB497

**SUBTOPIC TITLE:** Small Spacecraft Transfer Stage Development

**PROPOSAL TITLE:** Cryogenic Transfer Stage for Beyond Low Earth Orbit Access

## Small Business Concern


Firm: **New Frontier Aerospace, Inc.**
Address: **1020 Industy Drive, Tukwila, WA 98188**
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## Principal Investigator:


Name: **David Gregory**
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Address: **1020 Industy Drive, WA 98188 - 4801**
Phone: **(253) 246-7182**


## Business Official:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


The proposed innovation is a transfer stage spacecraft, Bifröst, a high thrust vehicle for rapid orbital transfer both as an upper stage on commercial launch vehicles and reusable orbital

maneuvering vehicle, enabling both NASA and commercial missions. Rapid access to most of these orbits today is nonexistent especially for small spacecraft. A longer term application of the technology is a scaled-up Mjölnir engine for expendable and reusable launch vehicles to improve performance, reliability, and safety with much lower green-house gas (GHG) emissions.

Potential NASA Applications (Limit 550 characters):

Bifröst is a transfer stage spacecraft powered by the Mjölnir engine and optimized for small spacecraft and venture class launch vehicles. From low earth orbit a 3,000 lb gross Bifröst can deploy a 400 lb payload to geostationary earth orbit, >200 lbs to any location in cislunar space, and >110 lbs to Venus and Mars transfer as well as earth escape velocity. Bifröst avionics support deep space applications with communications and payload support. Scaling the tankage to 20,000 lb gross, 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 beyond low earth orbit. The Mjölnir engine and Bifröst spacecraft will be
available for orbit transfer, lunar lander, or related capabilities.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z8.09-1438**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB530

**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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Phone: **(855) 727-2245**

**Business Official:**


Name: **David Brynes**
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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

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


Parabilis Space Technologies is proposing Phase II 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 will leverage both the successful Phase I and a 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.

During Phase I, Parabilis designed, manufactured, and hot fire tested a near full-flow rate prototype motor at sub-duration and sub-motor external dimensions. This significantly reduced both technical risk and the effort required for flight-like prototypes which will be tested in the proposed Phase II effort. The Phase I motor test showed smooth catalytic ignition, stable combustion, and good combustion efficiency.

During Phase II, the flight vehicle systems engineering will be updated, and an updated full-scale motor prototype will be manufactured and then hot fire tested at Parabilis’ rocket test facility. Multiple test/design cycles will be performed with the goal of maximizing performance and characterizing the motor over the equivalent of the full duration operating range and obtaining regression characteristics such that fuel residuals can be minimized in future designs. In parallel, a flight weight pump and feed system will be designed that meets the requirements of the stage architecture. This development path addresses the most critical items for implementing the innovation.

Potential NASA Applications (Limit 550 characters):

The proposed innovation is ideal for low-cost delivery of a 25-35kg payload, similar to the CAPSTONE/NRHO Pathfinder, into a translunar trajectory. A lower-than-maximum payload, or an elliptical parking orbit will provide sufficient delta-V for delivery into lunar orbit.

The proposed hybrid propulsion solution can address other NASA needs including an upper stage for small LVs capable of taking payloads to LEO, a low-cost transfer vehicle for interplanetary missions, or an ascent vehicle for sample return missions.

Potential Non-NASA Applications (Limit 400 characters):

Hybrid propulsion is of direct interest to the USSF. Hybrid propulsion provides a storable, safe “standby” solution for 24-hour callup missions, protect space assets from threats at lower cost

than existing systems, and provide lower-cost hypersonic flight testing or target drones. The civil and commercial market includes remote sensing, commercial comm, and interplanetary scientific customers.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z8.13-1189**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB305

**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**
Address: **1400 West 122nd Avenue, Westminster, CO 80234**
Phone: **(720) 545-9191**


## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

In response to the 2023 NASA SBIR Phase II solicitation subtopic Z8.13, “Space Debris Prevention for Small Spacecraft,” Advanced Space, LLC proposes to mature 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 Satellite Collision and Risk Assessment using Machine learning. In Phase I, SCRAM featured a trade study of Recurrent and Transformer Neural Networks (NNs) to develop autonomous risk analysis for spacecraft collision avoidance. These new applications of ML provide early predictions of future collision risk trends (Collision Risk Prediction Tool) and validation of collision avoidance maneuvers (Debris Catalog Screening Tool). 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 further developed with the goal of future implementation into current COLA ConOps for space agencies such as the NASA Conjunction Assessment Risk Analysis (CARA) team. This framework has similar applications for mega-constellations and private Space Domain Awareness (SDA) providers. Mr. Matthew Popplewell will be the Principal Investigator (PI) for the proposed project. Mr. Popplewell has experience leveraging ML to alleviate human-in-the-loop bottlenecks for a variety of autonomous spacecraft operations.

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. Since this technology is reliant on CDMs that were initially developed for CARA, it could seamlessly integrate within CARA and reduce the number of conjunctions considered in operations. This autonomous step screens trajectories, resulting in fewer CDMs flagged for further monitoring and less human-in-the-loop effort for operators.

Potential Non-NASA Applications (Limit 400 characters):

Commercially, SCRAM will be adapted for cooperative space traffic management needs at the Dept. Of Commerce (TraCCS) and mega-constellations (e.g., OneWeb). For national security, SCRAM will reduce overhead expenses and be used for space situational awareness of adversarial satellites. Lastly, SCRAM will be applied to data curation and validation of state estimates for space objects in a catalog.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z8.13-2038**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB441

**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**
Address: **20210 86th Avenue Court East , Spanaway, WA 98387**
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## Principal Investigator:

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## Business Official:

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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

With the proliferation of Earth-orbiting spacecraft across commercial, exploration, and national security missions, space traffic and debris management is emerging among the major challenges facing 21st-century spacecraft. With the growth of new satellite traffic comes a corresponding and significant increase of space debris hazard and the associated risk of orbital collisions. Increasingly, there are calls for active end-of-life measures to de-orbit inactive spacecraft.

An efficient, readily available, onboard propulsion system is necessary to provide in-space maneuvering and deorbit capabilities for future smallsats operating in LEO. Hybird is developing a retrobraking propulsion system, named RT-5X, whose initial application is focused on deorbit of small 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 (throttleable and restartable)
3. Flexibility across constellation and spacecraft bus sizes
4. High in-class propulsive performance (Isp up to 300s)
5. Hazard avoidance maneuvering and orbit raising in addition to end-of-life servicing

Potential NASA Applications (Limit 550 characters):

RT-5X can be used to perform satellite deorbit, collision avoidance, or other in-space delta-V maneuvers on a range of NASA smallsat missions across technology demonstrations, Earth observation missions, or similar mission sets. RT-5X is aligned with NASA smallsat low-cost mission objectives for low-cost maneuver and deorbit.

Potential Non-NASA Applications (Limit 400 characters):

Hybird's deorbit propulsion system presents applications across commercial and defense mission sets to deorbit proliferated spacecraft constellations following end-of-mission. While the primary application is deorbit, the hybrid propulsion's restartability allows for multiple burns and could be additionally used for collision avoidance, orbit raising, last mile delivery, or other maneuvers.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z10.01-1304**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB410

**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:


Name: **Lucas O'Neill**
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## Business Official:


Name: **Patrick Magari**

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Address: **16 Great Hollow Road, NH 03755 - 3116**
Phone: **(603) 643-3800**

**Summary Details:**

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 6**

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 completed detailed design of the valve and preliminary design of the actuator, fabricated a prototype valve, and made flow and leakage measurements to demonstrate compliance with NASA requirements. Our Phase I testing showed our valve offers higher flow capacity in a smaller, lighter package compared with commercial alternatives. In Phase II, we will update our valve design using lessons learned, integrate it with our space-rated actuator, and conduct valve testing under representative operating conditions (in a vacuum environment at cryogenic temperatures). 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: **24**

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**PROPOSAL NUMBER:** 23-2- **Z10.01-2454**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB419

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


Dynovas' Composite Cryogenic Hydrogen Insulated Lined (C-CHILL) Storage system provides a novel solution that specifically addresses NASA's call for technologies enabling a liquid hydrogen compatible composite tanks for reusable systems such as spacecraft, surface systems, and hydrogen aircraft for long-duration storage of liquid hydrogen. The system is designed to be 25%-60% lighter than traditional tanks by using a Type IV COPV inner tank with carbon nanotube impregnated resin overwrap which improves structural toughness and micro-cracking resistance. This solution was developed based on previous technologies that have a proven track record for cryogenic storage, and advances in composites to achieve long-duration cryogenic fluid storage and new technologies involving cryogenic storage systems, specifically addressing the unique mission requirements for cryogenic hydrogen compatibility with composite construction, however the modular nature of the C-CHILL system allows it to be modified for storage of various alternative cryogenic materials. The C-CHILL system will be demonstrated at TRL 6 in Phase II via sub/full scale operation of key elements of the system, including a polymer permeation liner, carbon composite filament wound CNT resin impregnated overwrap, vacuum jacketed thermal insulated outer tank structure, and low CTE metallic vacuum sealed port interface components. All systems are designed for the lunar environment at cryogenic temperature ranges. Dynovas will support burst, leak, vacuum, permeation, fatigue, and pressure qualification testing in cryogenic environments, and assembly and acceptance testing within its state-of-the-art space composite structure development and manufacturing facility. The Phase I successfully fabricated a scale model of the C-CHILL system, with demonstrations of

several key technologies to achieve a feasible design for a cryogenic storage, to be further developed to a full scale model in Phase II.

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: **24**

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**PROPOSAL NUMBER:** 23-2- **Z10.03-2502**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB616

**SUBTOPIC TITLE:** Space Nuclear Propulsion

**PROPOSAL TITLE:** High-Emissivity CVD Dendritic Rhenium Coatings for NEP Radiator Panels, Phase II

## 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: 3**
**End: 5**

Technical Abstract (Limit 2000 characters):

Nuclear-electric propulsion (NEP) can significantly reduce mission durations for space exploration by providing substantially greater propulsion efficiency over chemical propulsion. NEP development is dependent on advances in several key technology areas, one of which is the primary heat rejection subsystem, which will account for a significant portion of the total spacecraft mass. Improved radiator panels, with lighter weight and higher emissivity, are needed, enabling reduced panel size for a reduction in the overall vehicle mass and more effective heat rejection for a more efficient propulsion system. The state-of-the-art space radiator material system uses carbon/carbon (C/C) or titanium panels with integrated titanium heat pipes. To increase radiator emissivity, Ultramet is depositing a thin, highly emissive dendritic rhenium coating on carbon and titanium with minimal effect on overall weight. In Phase I, coated coupons of representative carbon and titanium materials were sent to the University of Michigan for characterization and testing. Coating survivability was demonstrated through exposure at various angles to ion bombardment from a Hall thruster ion plume, with microscopic imaging and emissivity measurements done before and after exposure. The dendritic microstructure and high emissivity of the rhenium coatings were unaffected after ion exposure in most cases. In Phase II, Ultramet will team with ThermAvant Technologies to demonstrate the increased heat rejection provided by the dendritic rhenium coating on additively manufactured titanium, diffusion-bonded titanium plate, and C/C subscale radiator panels with integrated titanium heat pipes. Coated subscale panels of each material will be fabricated and tested in relevant in-space operating conditions in a thermal vacuum chamber at NASA Glenn Research Center. A full-scale radiator panel design and manufacturing plan will be developed based on the results of the demonstration 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 requires 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 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: **24**

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**PROPOSAL NUMBER:** 23-2- **Z10.04-1969**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB293

**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**
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Phone: **(281) 526-0518**


## Principal Investigator:


Name: **Dr. Franklin Chang Diaz**
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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


This proposal addresses technology innovation within the sub-topic Z10.04 “High Temperature, High-Voltage Electric Propulsion Harness Connectors and Cables” moving from Phase I to Phase II in response to NASA’s 2023 SBIR Phase II solicitation. In Phase I of this project, Ad Astra developed and completed the design of the fourth generation (Gen-4) “Rhino Horn,” the step-down, low impedance section of the VASIMR radiofrequency (RF) transmission line. The VASIMR is a high power, RF-driven two-stage plasma rocket and this component must handle up to 120 kW of steady-state RF power to the engine’s second stage. Also in Phase I, a numerical model was developed to digitally assess the Rhino Horn performance. A sub-scale test article that reproduced the main thermal characteristics of the Rhino Horn was built and

tested in vacuum to help validate both the numerical model and the team's assumptions on weight savings, manufacturability, and ease of assembly. The positive Phase I results point to a full-up construction of the unit in Phase II and an integrated test in Ad Astra's VX-200SS thruster. Therefore, these are the main Phase II objectives. Also, the Phase I numerical model will be further validated with experimental data from these tests. A detailed report of results and lessons learned will also be produced. Three generations of Rhino Horn designs have preceded the Gen-4, each with improved thermal management over its predecessor. The new design continues this trend. The proposed Gen-4 Rhino Horn introduces several modifications capturing lessons learned by the Ad Astra team experimenting with the three prior designs. These improvements, in aggregate, have resulted in a more thermally effective, electrically robust, compact, and lightweight assembly. It is worth noting that while our focus has been the Rhino Horn, the proposed innovation is systemic in nature and hence relevant to the low impedance step-down section of the VASIMR first stage "ionizer" as well.

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
• Re-boost/orbit maintenance of large space stations in LEO with high-power SEP

Duration: **19**

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**PROPOSAL NUMBER:** 23-2- **Z12.01-1792**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB394

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

**PROPOSAL TITLE:** Minimizing volatile sublimation during excavation

**Small Business Concern**

Firm: **Cislune Company**
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## Principal Investigator:


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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


**Cislune proposes the construction of a percussive bucket drum mechanism with Ultrasonic Assisted Cutting teeth and predictive software to minimize sublimation during lunar ice mining. The technology will enable the efficient collection of water ice from icy regolith. In this Phase II effort, Cislune will design and manufacture PERDEX (PERcussive Drum EXcavator) along with associated software. We will demonstrate PERDEX's capabilities compared to standard bucket drums in a Thermal Vacuum (TVAC) chamber to satisfy the requirements for reduced sublimation and heating during excavation. PERDEX is a self-contained bucket drum solution capable of excavating lunar regolith in various forms and strengths. Cislune has performed a variety of experiments and modeling in Phase I that will inform the design and approach of PERDEX.**

**Cislune has been developing new technologies for managing and processing dry and icy lunar regolith. We will leverage technology from the Rover that Cislune developed during the NASA Break the Ice Lunar Challenge (BTILC) to efficiently and rapidly collect icy lunar regolith. The experiments and models from Phase I showed a significant reduction in sublimation for larger conglomerate chunks versus the fine material that will result from the scraping action of a standard bucket drum. The goal of PERDEX is to focus on generating the larger conglomerates while minimizing sublimation, energy input, and heating. The UAC teeth allow deeper penetration into the material and ensure the fracturing behavior operates in the weaker shear domain instead of the strong compressive domain of the material.**

**Adapting the PERDEX technology has the potential to reduce energy consumption, and by extension energy input into the regolith, by up to 70%. And by retaining the heritage of the bucket drum architecture, the design allows scalable excavation in large quantities of dry overburden as well as the significantly tougher icy lunar regolith.**


Potential NASA Applications (Limit 550 characters):

**The goal of this research is minimizing volatile sublimation during excavation that 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: **24**

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**PROPOSAL NUMBER:** 23-2- **Z12.01-2563**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB372

**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**
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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

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

Blueshift LLC d/b/a Outward Technologies proposes to continue development of a Multi-stage Oxygen and Regolith Resource Extractor (MORRE) for the production of high purity minerals and metals in addition to oxygen from lunar regolith. 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 little 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. The MORRE system not only enables 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 II project is to raise the technology readiness level of the MORRE system from TRL4 to TRL5. A medium fidelity prototype reactor will be manufactured and tested. Thermodynamic and kinetic models will be developed and validated through MORRE prototype testing in a relevant vacuum environment.

Potential NASA Applications (Limit 550 characters):

The primary application within NASA's technology roadmap is TX 07.1 In-Situ Resource Utilization. The MORRE system can be incorporated into several future NASA missions to produce purified minerals and metals including silica, magnesium, alumina, and iron, and secondary refining of these minerals to produce high-purity silicon and aluminum for in-space production of robotic components, PV cells, and wiring. The MORRE system will enable low-cost fabrication and construction of infrastructure elements for towers, habitats, cabling, and more.

Potential Non-NASA Applications (Limit 400 characters):

In lunar markets, the production of high purity materials from regolith are of high interest to commercial customers for use in structural materials, thermal/radiation shielding, and refined minerals for further material processing. In terrestrial markets, applications focus on extractive vacuum metallurgy for the recovery of co-products from a mixed ore feedstock.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z13.05-1586**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB486

**SUBTOPIC TITLE:** Components for Extreme Environments

**PROPOSAL TITLE:** Lunar Extreme Water Container (LEWC)

## Small Business Concern


Firm: **MOONPRINT SOLUTIONS LLC**
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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 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, or in habitable vehicles. Moonprint Solutions will develop a Lunar Extreme Water Container (LEWC) that will support the transport of water to the lunar surface from earth, storage of water on the lunar surface over long periods of time or support the transport of water from production or storage locations to inside pressurized habitable volumes. The LEWC is a multi-layered collapsible assembly made from high-strength lightweight materials, has a packing factor (ratio of deployed to stowed volume) > 100:1 (objective), can be deployed in cryogenic conditions without damage, and is freeze tolerant (9% volume expansion). It is also designed to provide dust mitigation when operated in the lunar dust environment by EVA crews in space suits and survive repeated use when exposed to rocks and dust on the lunar

surface. 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 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.

Potential NASA Applications (Limit 550 characters):

The LEWC will be used for water storage and delivery to the Moon from earth, aboard space stations, and in support of ISRU activities. It can be used similarly for Mars missions. In addition, modified LEWCs can be used for storage of cryogenic propellants, and other fluids on the lunar surface. The LEWC can also be used as a pressurized container for logistics transport between vehicles while on the lunar surface. LEWC materials will support space suits, dust covers for robots, deployable vehicles, protective covers, and habitats.

Potential Non-NASA Applications (Limit 400 characters):

The LEWC can be used by commercial space station operators for the transportation and storage of potable water, or and gases and liquids required. The materials can also be applied to a range of uses including commercial space suits, protective covers for robotic systems working in austere environments (industrial or military), and deployable shelters for use in polar environments.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z13.05-2221**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB333

**SUBTOPIC TITLE:** Components for Extreme Environments

**PROPOSAL TITLE:** Regolith Immune Linear Actuator Family: Phase II

## Small Business Concern


Firm: **Apech Labs LLC**
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## Principal Investigator:


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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 7**
Technical Abstract (Limit 2000 characters):

Apech Labs is offering NASA a Regolith Immune Linear Actuator Family. The solution achieves full immunity to the lunar environment using an all-metallic impermeable 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. Phase I of the program culminated with a preliminary design and functional brassboard hardware testing. Phase II of the program will mature the design to a prototype level and test the system in representative environments. Apech Labs is a 2020 startup with extensive experience in complex aerospace product development and electromechanical actuation. We will bring these capabilities to bear to provide the best possible offering to NASA.

Potential NASA Applications (Limit 550 characters):

NASA applications for RILAF include usage in NASA CLPS missions and Artemis missions, where linear actuation technology can enable lunar surface missions including construction (habitats), destruction (excavation), and cargo conveyance (pallet legs, jacks, conveyors). RILAF is a perfect fit for lunar and Martian exploration technology designed as part of NASA's Break the Ice Challenge. RILAF is also applicable to in-space cryogenic actuation needs including propellant handling and satellite mechanisms.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications for RILAF are highlighted by in-space and terrestrial cryogenic actuation applications, including rocket engine isolation valves, satellite mechanisms, propellant handling, cryogenic liquid production, and medical equipment. RILAF supports commercial planned extraterrestrial exploration equipment and ISAM/ISRU use cases.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z14.02-2324**

**PHASE 1 CONTRACT** 80NSSC23PB375

**NUMBER:**

**SUBTOPIC TITLE:** Extraterrestrial Surface Construction

**PROPOSAL TITLE:** Lunar Truss Design and Construction

## Small Business Concern


Firm: **Bond Technologies, Inc**
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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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


Building on the Phase 1 results, the Phase II proposed work will produce an automated assembly technique that can build a 50m tower on the lunar surface. This will be demonstrated at a TRL level 5 or above. Additionally, advancements to RFSSW machine design for survivability in the lunar environment will be shown, and design improvements will be made that benefit both extraterrestrial and earth-based products.

The relevance and significance of the proposed Phase 2 innovation to the original topic are directly aligned to the overall objective of contributing to the development of lunar infrastructure manufacturing processes. These efforts also apply to Mars habitat construction methods for infrastructure.

RFSSW joining technology is inherently energy efficient, but an additional benefit is the possibility to manufacture truss elements using solid state processing such as friction extrusion (FE). Should friction extrusion be implemented, the geometry of the truss elements is well suited to the length and cross-sectional capabilities of a moon-based FE system.
Potential NASA Applications (Limit 550 characters):

Beyond earth, RFSSW is a low energy flexible and high strength joining process that, with modifications to the machinery for off-earth operation, can be applied to various manufactured products. Considering plans for lunar habitation and preparation for the journey to Mars, the market for lunar RFSSW is not insignificant.
Potential Non-NASA Applications (Limit 400 characters):

Applications like airplane manufacturing can use automated management of the RFSSW weld head on a robot end effector. Automotive use of aluminum is increasing, and body sheet metal is a good application for RFSSW. This project improves the suitability of RFSSW for aviation and automotive applications.
Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **H9.08-1650**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB488

**SUBTOPIC TITLE:** Lunar 3GPP Technologies

**PROPOSAL TITLE:** Lunar Access Network Supporting 5G and Beyond

## Small Business Concern


Firm: **MTI Systems, 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):

Lunar Access Network Supporting 5G and Beyond – Phase II: MTI Systems, as a follow on to Phase I feasibility results will develop and mature capabilities for implementing lunar 5G. Phase I products included Lunar 3GPP radio access network requirements, resource requirements for lunar 5G New Radio access network processing, plans to realize a flexible access network in lunar qualified hardware, Phase II technology development plans, and a final report. Using these results, MTI Systems will develop test and demonstrate with suitable flight like hardware and emulated gNodeB, and base station, a 5G User Equipment software stack to mature the UE software to TRL 6. As an integral part of this effort, the software will be developed so that it is ready to be matured for flight demonstration. The set of features to implement UE software for the lunar environment does not currently exist and implementing it for lunar exploration application with very low Size Weight and Power (SWaP) is very challenging. 3GPP based lunar communications introduces a whole new paradigm for space communications systems and networking leveraging a vast and growing commercial technology base for terrestrial communication which provides many advantages over legacy approaches such as high bandwidth, scalability, efficiency, low cost, and efficient use of spectrum. MTI Systems will implement in an Open RAN approach to enable a competitive and diverse ecosystem of compatible communications equipment as well as interoperability and the ability to rapidly mature the software for human-rated application.
Potential NASA Applications (Limit 550 characters):

MTI Systems Lunar 5G development is specifically targeted at Artemis including all platforms that must communicate: orbiters, landers, rovers, habitats, astronauts, and fixed and mobile robotic payloads and infrastructure. The approach is inherently extensible to Mars exploration, and other NASA robotic and human spaceflight missions. Additionally, it has the capability to serve the aeronautics technology mission by enabling uncrewed air vehicle communications advances.
Potential Non-NASA Applications (Limit 400 characters):

MTI Systems Lunar 5G developments have potential for UE applications with challenging network dynamics / environments, and need for low SwAP including: space defense, missile defense, public safety radios, uncrewed and crewed air vehicles, oceangoing vehicles, areas where links are difficult and where ad hoc mesh networks must be established. They are also applicable to private networks.

Duration: **18**

**PROPOSAL NUMBER:** 23-2- **S11.01-2002**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB296

**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 the lifeforms on Earth. They influence the environment, the atmosphere, and the global climate. The science community has spent tremendous efforts on the observation of ozone concentration in the atmosphere. Differential Absorption Lidar (DIAL) 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' single frequency UV lasers at 308 nm and 343 nm based on all-fiberized Master Oscillator Power Amplifier (MOPA). The proposed lidar has the advantage of being suitable to perform observations on various carrying 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 343 nm laser will be generated from the third harmonic of AdValue Photonics' 1030 nm IR laser. The

amplification of the above-mentioned 1030 nm and 1535 nm laser will utilize AdValue Photonics' proprietary high-peak-power large-mode-area Yb and Er doped fiber amplifiers. Subsequently, we aim to assemble a stratospheric ozone lidar with such fiber-based lasers and perform ozone observations. In terms of the lidar transmitter, we have demonstrated a 343 nm laser from the Third Harmonic Generation of a 1030 nm laser and delivered a 308 nm laser to NASA GSFC with different operating parameters. The ultimate goal of this SBIR Phase II proposal is to deliver a prototype stratospheric ozone lidar to NASA so that NASA scientists have a workable lidar to test its capability, and at the same time providing critical feedbacks on the system with the consideration of NASA's scientific pursuits.
Potential NASA Applications (Limit 550 characters):

The proposed compact, robust, reliable, efficient, maintenance-free, and anti-vibrational stratospheric ozone lidar 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 demand of monitoring ozone concentration in the atmosphere has progressively become higher from the public community. The proposed ozone lidar will find its applications among atmospheric research, air quality monitoring. As a result, it will greatly increase the temporal and spatial coverage of ozone observation for the betterment of the environment, the atmosphere, and the global climate.
Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **S15.02-1255**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB625

**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.**
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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):


Critical for human space exploration, microbiology research can study effects of microgravity and space ionizing radiation on biological organisms. Existing microfluidic cartridges for cell and organism growth and metabolism research in space require sample loading and full system assembly on Earth, using highly specialized equipment and specially trained personnel, which limits the pace of research advancement.

Our proposed Microfluidic Biospecimen Cartridge (MBC) system is a highly compact, standardized platform that allows loading, sealing of biological samples, automatic perfusion and monitoring of specimen growth without the need for specialized personnel or equipment. Once closed, the unit is entirely self-contained, minimizing contamination risk, and enabling safe handling of a wide variety of biological specimens in a microgravity environment. The cartridge contains 16 sample wells for parallel experiments with maximum flexibility and all reagents and waste are contained within the cartridge.

This Phase II aims to demonstrate a working MBC unit (cartridge and instrument) that can be used for routine ground experiments and in space simulators. Specifically, Wainamics proposes to further optimize the MBC unit developed in Phase I by adding a one-way liquid reservoir injection port, an optical observation window, and another media reservoir. Following this optimization, we will start up pilot manufacturing to produce 1000 cartridges. In parallel, the custom prototype instrument for routine field and laboratory use will be completed and tested in a zero-gravity environment, and cross-kingdom unit compatibility for culturing will be demonstrated, including mammalian cells, bacteria, and algae.

The MBC system, designed for high volume manufacturing, would be the first commercial, self-contained cell culture growth and perfusion system. Together with a dedicated MBC instrument, this compact, standardized platform can be used routinely for field research or in space.


Potential NASA Applications (Limit 550 characters):

The compact MBC and instrument offer simplified, consistent performance and reduced development time and cost which can be useful for a wide range of NASA applications including:

- Microbiology experiments on the ISS
- CubeSat, Artemis III, Gateway missions
- Ground experiments with multiple specimens, allowing rapid transferring of the same experiment protocol to ISS experiments
- Studying effects of radiation and gravity on various genetically modified biospecimen, including yeast, bacteria, algae, plant, and mammalian cells

Potential Non-NASA Applications (Limit 400 characters):

Standardized, low-cost, and portable, the MBC's adaptability to different environments and scenarios makes it a valuable asset for various fields and disciplines such as:

- STEM education
- Field research for portable biospecimen growth and monitoring
- Environmental monitoring

Duration: **18**

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|---|---|
| **PROPOSAL NUMBER:** | 23-2- **S17.01-2320** |
| **PHASE 1 CONTRACT NUMBER:** | 80NSSC23PB560 |
| **SUBTOPIC TITLE:** | Technologies for Large-Scale Numerical Simulation |
| **PROPOSAL TITLE:** | Rapid Data Analytics Platform using Machine Learning |

## Small Business Concern


Firm: **RNET Technologies, Inc.**
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## Summary Details:

Estimated Technology Readiness Level (TRL) :

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

NASA's vast collection of simulated, experimental, and observational datasets has paved the way for groundbreaking advancements in addressing real-world physical challenges. In particular, NASA has made significant investments in developing state-of-the-art simulation software for climate modeling, aerodynamics, space vehicle launch environments, etc. These software tools along with large computing resources available to NASA scientists enable highly detailed simulations of physical phenomena. There is a need to address the big data bottleneck so that these data can be efficiently stored, shared, and analyzed while providing accessibility to a range of users, from the scientists with large HPC resources at their disposal to downstream users lacking the said resources.

In this Phase II SBIR project, RNET and FAU will develop an advanced data management and analytics platform that is designed specifically to address the big data challenges associated with high-fidelity scientific simulation data hosted by NASA and other agencies. We employ a "reduce-then-analyze" strategy. Our approach combines modern machine learning and traditional computational mechanics based discretization to provide robust and interpretable compression. The use of a computational mechanics framework makes the compressed data amenable to accelerated data analytics without the need to first decompress. The platform aims to provide best-in-class compression-to-error ratios, exceptionally fast point-wise decompression, and a geometry-preserving data format to significantly reduce computational, storage, and bandwidth costs. Seamlessly assimilated into existing scientific data analytics pipelines (e.g., NetCDF, HDF5, PANGEO) and engineered to operate on a wide range of compute resources, this powerful platform will ensure that scientists across all levels of expertise can harness the transformative capabilities embedded in highly detailed simulation datasets.

Potential NASA Applications (Limit 550 characters):

The platform will have an immediate impact on applications that deal with huge volumes of scientific data. NASA programs that would see a near-instant impact from this platform include the Earth Information System (EIS), the Earth Science Data and Information System (ESDIS) Project, the EarthData Citizen Science for Earth Systems Program (CSESP), the Making Earth System Data Records for Use in Research Environments (MEaSUREs), and the ESDS MultiMission Data Processing System Study.

Potential Non-NASA Applications (Limit 400 characters):

Beyond NASA, the proposed platform will have an immediate impact on industries that use high-fidelity simulation data as part of an informed decision-making process, including the Automotive industry, the Aerospace industry, and the Oil and Gas industry.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z7.04-2593**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB349

**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: 4**
**End: 6**


Technical Abstract (Limit 2000 characters):

Astrobotic proposes the continued development of “Floatinator,” a one-of-its-kind, tunable lunar and planetary gravity simulator for terrestrial testing of plume-surface interactions (PSI) and cratering. Floatinator will consist of a hot-fire test chamber capable of dropping at a controlled acceleration to simulate a low gravity environment within the test chamber’s reference frame. For example, accelerating the test stand at ⅚g (8.19 m/s²) would provide a ⅙g (1.62 m/s²) lunar gravity reference frame inside the chamber. By providing a relevant gravity environment, Floatinator will control for a major variable—Earth gravity—which limits the applicability of all ground-based PSI and cratering testing to date. This novel test platform will enable collection of valuable data on the effects of lander dust plumes on lander systems, onboard payloads, landing sites, and nearby surface infrastructure. Floatinator will be made commercially available for testing services to the aerospace community, including companies actively developing the landers, surface infrastructure, and services for upcoming CLPS, Artemis, and commercial missions. Floatinator will allow for a range of controlled accelerations, enabling it to simulate the surface gravity of the Moon, Mars, asteroids, and other celestial bodies. Fine tuning the desired

acceleration will also result in data that can help validate models that are being developed to predict PSI effects in reduced gravity environments.

Potential NASA Applications (Limit 550 characters):

NASA has an ongoing need for increased fidelity PSI data, both for landing on the Moon and for future missions to Mars, asteroids, and outer icy moons. Floatinator will enable NASA to conduct terrestrial hot-fire testing at a variety of simulated gravity conditions to validate or challenge existing PSI models and generate new models for estimating ejecta and cratering effects of landings on various parts of the Moon. This data will benefit programs ranging from CLPS to HLS, each of which is supporting a variety of new lander designs.

Potential Non-NASA Applications (Limit 400 characters):

Floatinator offers university researchers a unique, price-effective platform for testing simulated regolith physics in different gravity environments. Floatinator will also benefit private companies developing their own PSI models and/or developing lander propulsion systems, as they seek to mitigate the ejecta created by their thrusters.

Duration: **24**

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**PROPOSAL NUMBER:** 23-2- **Z13.04-1296**

**PHASE 1 CONTRACT NUMBER:** 80NSSC23PB411

**SUBTOPIC TITLE:** Lunar Dust Filtration and Monitoring

**PROPOSAL TITLE:** Low Maintenance Lunar Dust Filtration

## Small Business Concern


Firm: **Creare, LLC**
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## Principal Investigator:


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**Summary Details:**

Estimated Technology Readiness Level (TRL) :

**Begin: 4**
**End: 5**

Technical Abstract (Limit 2000 characters):

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 from particle loading. Crewed lunar missions will generate a lot of dust from EVAs and need to be low maintenance. The AHFS has low pressure drop resulting in a low power draw from a blower. The system is highly efficient in collecting all particles of interest including ultrafine, fine, and coarse. In Phase I, we successfully demonstrated the performance of the AHFS breadboard unit with measured collection efficiencies of >99.97% for all particles. Our system also demonstrated regeneration by collecting and then depositing lunar simulant dust in a bin. In Phase II, we will build a fully automated 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 is critical for the Artemis and Gateway programs supporting the Exploration Systems Development Mission Directorate. Creare's AHFS can improve performance over HEPA style filters while being low maintenance and have no consumables during the mission duration. We have developed the unit for the lunar environment, and the system can be adapted for microgravity including long duration space stations.

Potential Non-NASA Applications (Limit 400 characters):

Commercial space companies that are developing crewed spacecraft can use Creare's AHFS to gain the same performance benefits as NASA. Our initial discussions with two of these companies have been promising. Beyond supporting the space market, this technology has applications with industrial markets such as healthcare and cleanroom facilities where uptime and maintenance are high priority.

Duration: **24**