NASA STTR 2022-I Solicitation

PROPOSAL NUMBER: 22-1- **T10.04-1383**

SUBTOPIC TITLE: Autonomous Systems and Operations for the Lunar Orbital Platform-Gateway

PROPOSAL TITLE: Hiawatha Spacecraft Autonomous System Health (SASH) Management System

Small Business Concern

Firm: **Nokomis, Inc.**
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Research Institution:

Name: **Carnegie Mellon University**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Reliability of electronic subsystems is crucial to autonomous missions. Initial effects of aging do not result in out-right failures, systems that experience intermittent issues without identification of the root cause are prone to sudden catastrophic failure due to the accumulated degradation of electronics. Nokomis will develop a prototype fault management /Electronics Health Monitoring system for diagnosing the Gateway spacecraft electronic subsystems for autonomous health management. While unoccupied, Gateway is at risk of unexpected events/ faults may require immediate response, and the ability to detect these conditions prior to loss of functionality enables mitigation or response actions. The autonomous nature of the system allows for rapid response following the identification of aging of components likely to lead to failure or reduced functionality to implement mitigation solutions. The system will utilize unintended electromagnetic emissions that emanate from electronic devices to identify conditions such as operational states or conditions that lead to premature aging or sudden failure. Each subcomponent of a device has a unique emissions signature directly associated with the functional state of the device aiding in maintenance and mitigation measures. Metrics extracted by analysis algorithms can differentiate between baseline and stressed system states. This effort will demonstrate the autonomous monitoring of critical subassembly health to identify possible critical failures or unsafe states, identify metrics in variation to categorize threat level and potential failure likelihood, communicate with control station to initiate protective behavior or allow for maintenance planning. Nokomis will develop and demonstrate a software module including algorithms approach to detect and categorize differences in emissions data to identify end of life risks to system electronics through the implementation of metric extraction and machine learning methods.

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

Deployment & continued operation of spacecraft is a base requirement for Moon & Mars missions. Providing abilities to protect electronics from early failure to assessment of potential failure points will increase spacecraft reliability and well as protect crewmembers. Mitigation measures / maintenance needs can be implemented before critical failures arise during unmanned periods using the system to measure remaining useful life. The technology is applicable to all electronic subsystems.

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

As electronic proliferation in control systems continues, the semiconductor and banking industries; automotive (especially autonomous control), satellite, and medical device manufacturers; telecommunication providers and the defense industry all are susceptible to unexpected downtime due to electronic failure and this technology can avoid costly system failures or and unexpected maintenance.

Duration: **6**

PROPOSAL NUMBER: 22-1- **T12.07-1417**

SUBTOPIC TITLE: Design Tools for Advanced Tailorable Composites

PROPOSAL TITLE: Tool for Thermomechanical Design of Tailorable Composites and Hybrid Material Systems

Small Business Concern

Firm: **AnalySwift**
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Research Institution:

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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

One promising solution to affordable space exploration beyond the lower Earth orbit lies in advanced tailorable composites and/or hybrid material systems (TC-HMS), which can equip lightweight space structures with reduced thermal sensitivity while retaining their strengths/stiffnesses. In contrast to conventional unidirectional fiber-reinforced composites (UDFRCs), TC-HMS have:

- Location-dependent stiffness/strength, coupling structural design with material design.
- Stiffness and strength dependent on both location and stacking sequence.

There are still major technical barriers to exploiting the full potential of TC-HMS:

- Most efforts are aimed at simple structures with special-purpose codes — there is a need for theories and codes integrated into commercial codes for the design of real TC-HMS structures.
- Most approaches are based on the classical lamination theory (CLT) and its refinements, which rely on assumptions applicable to UDFRCs but not necessarily TC-HMS — there is a need for more advanced models capable of accurately modeling TC-HMS without ad hoc assumptions.

We will develop an efficient high-fidelity design tool for advanced TC-HMS, including:

- An integrated design framework with user-friendly GUI plug-ins in MSC.Patran/Nastran and Abaqus, exploiting these tools' versatile modeling capabilities and ready to be integrated into other commercial codes.
- A versatile parameterization method capable of expanding the design space for TC-HMS; considering varying fiber orientations, ply coverages, and microscale material selection simultaneously, and accompanied by general-purpose optimizers capable of producing TC-HMS designs with optimized load paths.
- Mechanics of structure genome (MSG)-based thermomechanical micromechanics and plate/shell models designed to compute the location-dependent stiffness and strength of a TC-HMS; rigorously derived and capable of accurately predicting displacements/strains/stresses due to both loads and temperature changes.

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

- Lightweight structures for satellite buses, landers, rovers, solar arrays, antennas
- Cryogenic tanks, pressurized habitats (including hatch, access, window cutout features), and other structural components (lander truss cages, landing gears)
- Next-generation airframe technology (hybrid/blended wing body)
- Highly flexible wings, highly fatigue/damage tolerant structures for vertical lift aircraft
- Deployable composite booms, foldable panels, hinges, reflectors

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

- Better engineering and qualification of broader composite lightweight structures (with improved predictive capabilities)
- Validated design and analysis tools for the industrial realization of tailorable composites (aerospace, energy/wind, auto, marine, etc.) with reduced cost & time

Duration: **13**

PROPOSAL NUMBER: 22-1- **T7.04-2186**

SUBTOPIC TITLE: Lunar Surface Site Preparation

PROPOSAL TITLE: Design and Implementation Tools for Lunar Surface Regolith Structure Construction

Small Business Concern

Firm: **Lunar Outpost, Inc.**
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Phone: **(908) 577-4014**

Research Institution:

Name: **Michigan Technological University**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

To facilitate the return of humans to the moon in the next several years, consideration must be given to various types of infrastructure that will be required. Navigational features are promising for accurate and repeatable vehicle landings. Durable landing pads will be able to ensure stable landing and to prevent erosion of landing sites and sand-blasted abrasion of any nearby structures. Berms to deflect ejecta and particulate matter from landings are also of interest, as are numerous other similar structures. At a lower level, it is important to consider not only what structures are needed but which are possible, and how they will be constructed. To accomplish this, Lunar Outpost together with Masten Space Systems and Michigan Technological University propose a set of analytical tools, which will take such parameters as lander size and payload weight, and return a set of optimal structures to build as well as strategies for their construction, including layer-based geometries, compaction levels and verification, and more. Additionally, a set of construction tools (scrapers, compacters, etc.) will be recommended for use with Lunar Outpost rovers for In-Situ Resource Utilization of the present regolith for construction of infrastructure. A Concept of Operations describing the timeline, equipment, and procedures for this construction will also be developed under the scope of this proposal.

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

The proposed design and implementation tools for lunar surface regolith infrastructure fill a NASA strategic knowledge gap, applying lunar civil engineering technologies to produce bulk regolith structures, some of the first applications of lunar infrastructure. The design and implementation tools proposed herein therefore represent a building block of the entire future lunar infrastructure, applicable to human exploration, campaign science, and scaling of ISRU from small technology demonstrations to large-scale, operationally-useful resources.

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

Commercial operators need confidence in landing site properties as landing frequency increases. Infrastructure impacts the cost of surface ops, a critical metric in evaluating the market opportunity for economic activity. Thus, this research increases the confidence level of projections of the cislunar economy, impacting space companies' ability to raise capital and pursue their business plans

Duration: **13**

PROPOSAL NUMBER: 22-1- **T10.05-1152**

SUBTOPIC TITLE: Integrated Data Uncertainty Management and Representation for Trustworthy and Trusted Autonomy in Space

PROPOSAL TITLE: Uncertainty Quantification of Representations of Unknown Dynamic Systems through Universal Differential Equations

Small Business Concern

Firm: **Elder Research, Inc.**
Address: **300 West Main Street, Suite 301, Charlottesville, VA 22903 - 5575**
Phone: **(434) 973-7673**

Research Institution:

Name: **Iowa State University**
Address: **537 Bissell Road, IA 50011 - 2274**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 1
End: 2
Technical Abstract (Limit 2000 characters, approximately 200 words):

Cyber-Physical-Human (CPH) teams will drive future space missions, such as Artemis and future Martian exploration. Key to the success of CPH teams are *trustworthiness* and *trust*. In the context of machine agents on CPH teams, *trustworthiness* refers to whether a machine performs its intended task (and not prohibited actions) when faced with unknown physical processes. A need exists for methods that are flexible to encompass known and unknown elements of physical processes and produce outcomes that are interpretable for all members of CPH teams.

Universal Differential Equations (UDEs) incorporate information from scientific models to constrain machine learning approximators. In the work proposed here, we aim to increase the reliability of UQ in UDEs to enable more detailed analysis of uncertainty in the learned representations of dynamic systems. The potential for inclusion of physics-based priors into the learning process for UDEs could enhance trustworthiness and trust in CPH teams because it is possible to extract a closed-form differential equation from UDE-based models. However, most UDE research has focused on deterministic solutions rather than a study of the sensitivity of the identified representation.

In the work proposed here, we aim to increase the reliability of UQ in UDEs to enable more detailed analysis of uncertainty in the learned representations of dynamic systems. We will first conduct simulations of a semi-stable dynamic system in Simulink. We will demonstrate UDE learning of the equations of motion that describe the semi-stable system. Once this has been demonstrated, we will move onto the development of an advanced UQ framework for UDEs. We will build upon examples from literature (such as Bayes by Backprop), with a focus on human interpretability to increase the trust in the machine learned representation of the dynamic system.

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

Future NASA mission objectives involving Cyber-Physical-Human (CPH) teams—such as maintaining lunar habitations or preparing for Martian landing—are ones we believe may benefit. Additionally, the methods described here could be adapted to accelerate learning from Scientist-in-the-Loop analysis of high-throughput collections of planetary science data. Next generation air operations safety could likewise benefit from tools that allow interrogation of uncertainty in representations of dynamic systems where high degrees of autonomy are involved.

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

CPH teams in defense applications (e.g., small-UAS maneuvers, long-range undersea surveillance) could benefit from the capabilities proposed here. Additionally, platooning of autonomous vehicles and enhanced safety of autonomous driver aids could be achieved through more robust uncertainty quantification of representations of dynamic processes in data.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T10.04-1898**

SUBTOPIC TITLE: Autonomous Systems and Operations for the Lunar Orbital Platform-Gateway

PROPOSAL TITLE: Demonstration of Space-Qualified Environmental Evaluation Drones with Wireless Intelligent Networked Data Processing (SPEEDWINDs)

Small Business Concern

Firm: **Nanohmics, Inc.**
Address: **6201 East Oltorf Street, Suite 400, Austin, TX 78741 - 7509**
Phone: **(512) 389-9990**

Research Institution:

Name: **Duke University**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Deploying autonomous environmental monitoring hardware on Gateway is challenging because of the harsh radiation environment. Existing unmanned aerial vehicles (UAVs) used for environmental monitoring on the International Space Station (ISS) use commercial-off-the-shelf (COTS) components. To enable continuous unsupervised environmental monitoring at Gateway, Nanohmics Inc., in collaboration with Dr. Maria Gorlatova at Duke University, proposes to demonstrate SPace-Qualified Environmental Evaluation Drones with Wireless Intelligent Networked Data Processing (SPEEDWINDs). Each SPEEDWIND will have four key components: 1) a core control system built with inherently radiation hardened components, 2) a high performance COTS embedded system to enable machine learning, 3) an environmental monitoring payload with customized mission specific sensors, and 4) a wireless transceiver with adaptive networking to enable distributed operation. In Phase I, Nanohmics proposes to design a benchtop SPEEDWIND testbed combines space qualified and COTS components and demonstrate the ability of the testbed to perform distributed machine learning, such as processing fluorescence spectroscopy data, in a simulated Gateway environment.

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

The SPEEDWIND platform can enable rapid deployment of autonomous, intelligent UAVs with mission specific payloads. The ability to perform complex machine learning tasks on system decreases uplink and downlink bandwidth requirements.

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

The SPEEDWIND platform has multiple applications in the medical, defense, and industrial markets. For example, this technology could be applied to healthcare environments to perform autonomous, real-time microbial mapping with the goal of reducing healthcare-associated infections (HAIs).

Duration: **13**

PROPOSAL NUMBER: 22-1- **T12.07-2715**

SUBTOPIC TITLE: Design Tools for Advanced Tailorable Composites

PROPOSAL TITLE: Topology Optimization for Design of Highly Tailored Composites for AFP Manufacturing

Small Business Concern

Firm: **M4 Engineering, Inc.**
Address: **4020 Long Beach Boulevard, Long Beach, CA 90807 - 2683**
Phone: **(562) 981-7797**

Research Institution:

Name: **Virginia Tech**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 4
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

With the advent of automated tow placement and additive manufacturing, a designer of composite structures must deal with not only an enormous design space, but also perform a highly complex and computationally expensive analysis to determine what is a "good" design and to simulate the structural behavior. In the isotropic world of metals, there has independently been a tremendous amount of research (and success) in the development of topology optimization tools that develop design concepts that are not always obvious a priori, but that offer significant performance advantages and (with additive manufacturing) are often cheap and easy to produce. Topology optimization algorithms use a fictitious density in each finite element as a design variable, and usually optimize this "density" to find the best places to leave material in place (density 100%), and the best places to remove it (density 0%). This problem has some fundamental similarities to the design of a composite part with AFP – since AFP is essentially an additive manufacturing process, we have tight control of where to add material (and where not to) for a given ply. Our innovation extends the topology optimization approach to apply to optimum design of manufacturable AFP structures. The objective of the proposed design tool will be to optimize the tow steered laminate fiber path directly for a representative composite curved panel. As an example, a cylindrical panel with a cutout, and subjected to complex pressure and in-plane loads will be considered. The tool will be integrated with Siemens NX/NASTRAN, and eventually may be integrated into tools such as Simcenter3D and Fibersim.

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

- Highly tailored composite structures for any vehicle.
- Spacecraft structures with stringent strength, stiffness, and stability requirements
- Aircraft structure (wing skins, control surfaces, pressure vessels)
- Launch vehicle structures
- Science payload structures

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

- Commercial and military aircraft applications
- High performance ground vehicles (e.g. racing)
- Unmanned aircraft
- Commercial spacecraft and launch vehicles

Duration: **13**

PROPOSAL NUMBER: 22-1- **T5.05-2038**

SUBTOPIC TITLE: Advanced Solar Sailing Technologies

PROPOSAL TITLE: Solar Sail Integrated Antenna Technology

Small Business Concern

Firm: **Nanohmics, Inc.**
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Phone: **(512) 389-9990**

Research Institution:

Name: **Texas State University**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Nanohmics in collaboration with Texas State University intends to develop a miniaturized, flexible, and multiband PAA architecture using miniaturized, ultra-wideband antennas printed on a common solar sail material (i.e. Kapton). This will include scaling an existing antenna design to bands of interest and developing a high-power, fully-printed electronic switching architecture to advance the power handling and high-frequency operation in these printed active PAAs.

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

Deployable/stowable, compact, efficient, multiband, beam formed, light-weight, low-cost, high data-rate, and active phased array antennas are one of the enabling technologies that can suit the needs of several NASA platforms and missions. Compatible reference missions include, Mars Cube One (MarCo) and the Near-Earth Asteroid Scout (NEAScout) missions, as well as contribute to the success of human expedition to Mars and beyond.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

By adapting this advanced performance antenna technology to low-cost, conformal substrates, it becomes lower cost and readily adaptable to nearly any footprint. Potential direct and indirect applications include RF identification tags, smart cards, electronic paper, large area flat panel displays, multi-beam and -band 5G antenna, and White Space broadband internet antenna.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T14.01-1651**

SUBTOPIC TITLE: Advanced Concepts for Lunar and Martian Propellant Production, Storage, Transfer, and Usage

PROPOSAL TITLE: Nanomaterials Based in situ Hydrogen Sensor for Oxygen Process Streams

Small Business Concern

Firm: **Innosense, LLC**
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Research Institution:

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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2

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

NASA needs an advanced sensing technology for in-situ monitoring of hydrogen (H_2) gas within high-pressure oxygen (O_2) streams. It is a critical safety component for the successful operation of regenerative fuel cells (RFCs) and in situ resource utilization (ISRU) systems. There, water undergoes electrolysis to generate hydrogen and oxygen for propulsion or energy storage. InnoSense LLC (ISL) in collaboration with University of Virginia (UVA), will develop an innovative nanomaterial-enabled **H_2 sen**sor (H2SEN^{TM}) based on ISL's patented microelectronic device platform. This project will support NASA needs expressed in 2020 NASA Technology Taxonomy, TX03.2.2 (Electrochemical: Fuel Cells), TX07.1.3 (Resource Processing for Production of Mission Consumables) and TX14.1.1 (In-space Propellant Storage and Utilization). In Phase I, ISL will: (1) design and fabricate the sensor with appropriate recognition structure, and (2) evaluate the sensor performance. Feasibility will be demonstrated by achieving sensitive and selective detection of H_2 in the concentration range of 0-4% in oxygen background with 100% relative humidity at 250 psia. In Phase II, we will optimize the sensor design, recognition chemistry and algorithm, fabricate prototypes and perform rigorous characterizations.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

During human exploration missions, H2SEN will: (1) provide accurate and real-time hydrogen concentration monitoring, and (2) ensure the safe operation of regenerative fuel cells (RFCs) and in situ resource utilization (ISRU) systems for mission success. H2SEN's versatility can be adapted to serve as general hydrogen leak detector or monitor other analytes toward meeting NASA needs.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

H2SEN will have significant commercial applications in the hydrogen economy. Examples include: (1) commercial hydrogen electrolyzers, and (2) leak detector for heavy-duty fuel cell truck or hydrogen powered aviation, and marine vehicles. As spin-off applications, H2SEN can be adapted with appropriate recognition chemistry for monitoring other environmental pollutants or toxic gases.
Duration: **13**

PROPOSAL NUMBER: 22-1- **T7.04-1066**

SUBTOPIC TITLE: Lunar Surface Site Preparation

PROPOSAL TITLE: Cislune Regolith Pathways and Landing Pads

Small Business Concern

Firm: **Cislune Company**
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Phone: **(661) 390-1060**

Research Institution:

Name: **The University of Central Florida Board of Trustees**
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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Cislune and UCF propose a site preparation architecture that relies upon in-situ resources and a small number of rovers and excavators working as a swarm to build durable lunar surfaces with size-sorted and then compacted lunar regolith. Efficient manipulation of bulk regolith via size-sorting and compaction is the most efficient architecture for lunar site preparation. We will test compaction techniques on various combinations of regolith simulant size fractions to determine the maximum strength available from compressed regolith. We will also do PSI and CFD modeling to determine requirements for landing spacecraft to determine where compressed regolith can be used.

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

Site preparation will be required on the Moon and Mars as landing sites are developed for robotic and human missions. NASA is considering the lunar South Pole of the Moon with PSR's for water ice, peaks of eternal light for power and heat, and continuous line-of-sight to the Earth

for communications which will make it the focus of intensive and repeated robotic and human operations. Crew safety is significantly improved with landing pads and a reduction in ejecta.

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

Improvements to autonomous site preparation, including surveying, grading, excavation, and compaction are extremely relevant for the terrestrial construction industry. Global construction is a $22 trillion dollar industry annually which is chronically understaffed. Autonomy is being invested in heavily here on Earth, and the lessons from lunar operations can accelerate development.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T7.04-1851**

SUBTOPIC TITLE: Lunar Surface Site Preparation

PROPOSAL TITLE: Lunar Surface Site Preparation for Landing/Launch Pad and Blast Shield Construction

Small Business Concern

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Research Institution:

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

This proposal builds on our NASA funded prototype BrickBot for technology demonstration as the first step in creating a BrickLayer system for building a lunar Launch/Landing Pad (LLP). The BrickLayer uses feedstock of raw regolith to produce bricks in a single-step lunar regolith melting, brick forming and placement method without use of grouts or mortar for landing pad creation, or for any flat hardened surface area such as roads or foundations.

To enable the brickmaking process, our proposed innovation is a multi-step process of regolith works executed by multiple machines operating autonomously or in remote control mode with step sequencing/timing to enable machine-to-machine collaboration. The process includes construction system components using two separate mobility platform types, one for landing zone site preparation and another for LLP production. The site preparation platform employs a versatile autonomous, single, compact, robotic rover for interchangeable tool implements: (a) tool for bulk sieving of large rocks from the site, (b) excavator drum bucket, derived from the NASA developed Regolith Advanced Surface Systems Operations (RASSOR) and with hauler serves a dual function of excavation and supplying regolith feedstock for the BrickLayer, (c) site leveling tool, and (d) vibrating compaction roller. The LLP production platform is a variation of the All-Terrain Hex-Legged Extra-Terrestrial Explorer (ATHLETE), a six-legged robotic lunar rover developed by NASA. The ATHLETE platform functions interchangeably for our Bricklayer production system and our Regolith Particle Acquisition and Containment (RegoPAC) system, utilized for LLP blast shield construction.

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

- Reliable Launch and Landing Pads surface access for the CLPS and ARTEMIS missions.
- Processes and equipment can be used for many planar structures for Moon and Mars infrastructure construction, i.e., foundations and roads

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

Construction, e.g., DOD / FEMA forward deployment in remote / hazardous sites
Surface mining
Environmental clean-up
Debris removal at nuclear power plants and other hazardous sites

Land reclamation
Dry bulk loose commodities handling in warehouses, distribution centers, storage (e.g., fertilizer, grain, etc.)

Duration: **13**

PROPOSAL NUMBER: 22-1- **T10.03-2033**

SUBTOPIC TITLE: Coordination and Control of Swarms of Space Vehicles

PROPOSAL TITLE: Efficient Distributed State Estimation for Swarm Robotics

Small Business Concern

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Research Institution:

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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Astrobotic and CMU will develop a real time distributed localization method named DALEC that combines local visual-inertial odometry with Ultra-wideband (UWB) range measurements between rovers to improve each vehicle's localization and provide each with information about the others' location. Because of a lack of global constraints, visual inertial odometry (VIO) will drift over time in four degrees of freedom. Range information between rovers will provide additional constraints that limit drift. To perform distributed localization, each rover will estimate its own trajectory in a factor graph of poses and receive additional condensed information from other rovers. Because the range and VIO measurements are not tightly coupled, each of the rovers can navigate on its own, and this method is inherently robust to communication outages. A key advantage of this approach is that any other constraints from sensors such as sun angle, bearing to visually observed rovers, terrain matching, and point features, can easily be added to the factor graph formulation.

The proposed technical approach is most closely related to the Decentralized Data Fusion Smoothing and Mapping algorithm (DDF-SAM2, specifically), though DDF-SAM2 assumes landmark (point) feature observations and shares the relative position of these landmarks by default. It can also be extended to share relative positions and orientations of objects rather than just the positions of landmarks. Our problem is different in that only range measurements are available from the UWB sensor, but these are measurements with error and drift models that are much simpler and do not require solving a data association or loop closing problem.

A simulation environment will be developed to assist in the development and testing of the DALEC SLAM algorithm. The simulation will produce simulated IMU, UWB, and imagery data from 4–15 rovers operating simultaneously. The simulation will then be used to test and tune the DALEC algorithm.

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

The proposed system has utility for applications such as JPL's A-PUFFER robots and NeBula autonomy architecture. This technology could also support teams of heterogeneous robots, e.g., the Perseverance rover and Ingenuity helicopter. The localization system could also be made to support non-planetary spacecraft such as orbital satellites. In this formulation, relative navigation cameras and RF ranging cross-links could be used to localize satellite constellations for uses such as distributed aperture telescopy and large baseline interferometry.

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

Higher accuracy location estimates for Astrobotic's CubeRovers would allow for a larger suite of commercial swarm-based missions. It is applicable to markets such as search and rescue and underwater exploration that often operate in inhospitable environments, have limited communications, and no GPS. Offshore underwater inspection and repair robots have similar constraints.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T11.06-2398**

SUBTOPIC TITLE: Extended Reality (Augmented Reality, Virtual Reality, Mixed Reality, and Hybrid Reality)

PROPOSAL TITLE: Shared immersive XR Hyper-Realistic Environment for Extravehicular Activity Surface Operations

Small Business Concern

Firm: **Tietronix Software, Inc.**
Address: **1331 Gemini Avenue, Suite 300, Houston, TX 77058 - 2794**
Phone: **(281) 461-9300**

Research Institution:

Name: **University of Houston**
Address: **212 E. Cullen Building, TX 77204 - 2015**
Phone: **(713) 743-5785**

Principal Investigator:

Name: **Mr. Jose Daniel Velazco-Garcia**
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Business Official:

Name: **Sicilia Liranzo**
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Address: **1331 Gemini Avenue, Suite 300, TX 77058 - 2794**
Phone: **(832) 557-1170**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

The proposed innovation is to demonstrate the feasibility of creating a shared VR and AR world with photorealistic rendering of large-scale environment. The need for advanced extended immersive reality is critical in order to support future Lunar and Martian space missions training.
NASA JSC has been using Virtual Reality for many years to train the astronauts in limited world space, for instance the interior of an ISS module, the robotics arm of both Shuttle and Station. The Artemis missions will challenge the current set of VR training capabilities and will require the move to a greater virtual world realism, to a more collaborative work environment, to a mix of multiple modalities and to the use of the continuously improving VR and AR headsets. Tietronix is proposing to develop a framework and associated artifacts development tools and workflow that provide a photorealistic multi-user multi-modality shared environment. We foresee the capability of our framework to enable AR and VR users' collaboration, and to provide a wider set of interactions and use cases as compared to immersive VR alone.

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

Complex assembly and maintenance tasks in space operational environments
NASA Gateway missions
NASA Artemis program
Lunar Rover Training
Active Response Gravity Offload System (ARGOS) project
Scientific Hybrid Reality Environment (SHyRE) project
Joint Augmented Reality Visual Informatics System (JARVIS)

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

Automotive assembly training
Airline pilot training
Power plant systems
Solar electrical generating plants operator and field technicians training
Department of Defense (DoD) large complex systems training

Duration: **13**

PROPOSAL NUMBER: 22-1- **T8.07-1822**

SUBTOPIC TITLE: Photonic Integrated Circuits

PROPOSAL TITLE: Photonic Integrated Raman Spectrometer (PIRS)

Small Business Concern

Firm: **Physical Sciences, Inc.**
Address: **20 New England Business Center , Andover, MA 01810 - 1077**
Phone: **(978) 689-0003**

Research Institution:

Name: **Georgia Tech Research Corporation (GTRC)**
Address: **926 Dalney St NW, GA 30332 - 0420**
Phone: **(404) 385-2080**

Principal Investigator:

Name: **Dr. Kyle Dorsey**
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Address: **20 New England Business Center , MA 01810 - 1077**
Phone: **(978) 738-8154**

Business Official:

Name: **Dr. William Marinelli**
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Address: **20 New England Business Center , MA 01810 - 1077**
Phone: **(978) 738-8226**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Physical Sciences Inc. (PSI) and the Georgia Institute of Technology (GT) will develop a Photonic Integrated Raman Spectrometer (PIRS) for low-SWaP spectroscopy applications. PSI and GT will use a silicon nitride photonics platform to develop a dual-stage spectrometer that enables simultaneous high bandwidth and high resolution spectroscopy with direct readout. The overall form factor of the spectrometer will be less than a square centimeter while retaining spectral resolution of better than 0.2 nm. PIRS will feature an integrated pump rejection filter for Raman spectroscopy, and provide an upgrade path to integrated light sources and detectors. PIRS will be fabricated with a scalable process, enabling NASA-fieldable devices in the near-term, while ensuring that costs are manageable.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The technology developed within this program can find application for material characterization in landing vehicles, plume sampling craft, and satellite-based scientific sensors. Specific missions that would benefit from PIRS include Goddard's Ocean Worlds Science Exploration and Analogs (OSEAN) and the Mars Exploration Rover.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The on-chip spectrometer developed within this program is a key component for low size, weight, and power spectroscopy applications including fluorescence, absorption, and Raman spectroscopy. These devices will form key components of ultra-compact chemical sensors capable of detecting biomolecules and hazardous chemical agents.
Duration: **13**

PROPOSAL NUMBER: 22-1- **T7.04-1162**

SUBTOPIC TITLE: Lunar Surface Site Preparation

PROPOSAL TITLE: Novel Payload Conveyance System - Demonstration in Planetary Berm Construction

Small Business Concern

Firm: **Contour Crafting Corporation**
Address: **215 South Douglas Street, El Segundo, CA 90245 - 4626**
Phone: **(310) 430-5255**

Research Institution:

Name: **University of Southern California**
Address: **3720 S. Flower St. 3rd Floor, CA 90089 - 0701**
Phone: **(213) 740-6064**

Principal Investigator:

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Business Official:

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Phone: **(310) 430-5255**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The focus of this STTR solicitation is construction of lunar infrastructure elements using bulk regolith and rock. The key requirement of all such construction operations will be a practical and versatile technology for effective regolith and rock conveyance which can operate in a variety of conditions and for a variety of lunar applications at highest possible energy efficiency.

All material conveyance equipment for Earth work are generally too large, and heavy and hence their design is not suitable for being flown to the Moon and operated there. Furthermore, such equipment are power-hungry and infeasible to operate using the limited energy sources accessible on the Moon. While traditional loader or truck would have to make return trips empty, CrafTram would eliminate the need for such back and forth transport of a vehicle. It is expected that CrafTram's low energy demand would allow for this continuous production.

Proposed is a novel autonomous material conveyance system called CrafTram, offering the following advantages:

- Is super lightweight and compact as compared to alternative to other material conveyance options,
- It folds to a compact size to take minimal space in the rocket cargo compartment,
- Is self-expanding upon deployment on lunar surface,
- Is capable of transporting material to and from different elevations including sharp uphill or downhill trajectories
- Uses the least possible amount of energy among all other alternatives for material conveyance.
- Operates smoothly with minimum wear, regardless of sandy or rocky terrains,
- Can convey material along sharp uphill or downhill trajectories.

The proposed effort includes analysis and design of the novel CrafTram system, and creation of a TRL 4 functioning 1/3 scale prototype of the technology. The proposed effort at the RI further includes analysis and design of a berm as the choice for demonstration structure. The CrafTram prototype is also expected to be tested in constructing a 1/3 scale berm section.

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

The proposed technology is a generic material conveyance system applicable to all regolith work activities, including the following NASA priorities:

- Bulk regolith-based launch/landing zones
- Rocket PSI ejecta and blast protection structures (e.g., berms)
- Regolith base and subgrade for hardened landing pads
- Pathways for improved trafficability
- Radiation shielding structures.

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

Other applications are all terrestrial construction activities such as wet concrete delivery from concrete trucks or mixers to multiple desired locations. CrafTram also eliminates the need for energy hungry concrete pumps and long pipes which result in significant loss of material at the end of operation.

Another application is in automated storage and retrieval system as practiced in warehousing.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T11.06-2113**

SUBTOPIC TITLE: Extended Reality (Augmented Reality, Virtual Reality, Mixed Reality, and Hybrid Reality)

PROPOSAL TITLE: Real-Time and Cloud-based Simulation Processing for Digital Twin Environments

Small Business Concern

Firm: **Buendea,LLC.**
Address: **24 Sw 22nd Road, Miami, FL 33129 - 1507**
Phone: **(305) 510-7868**

Research Institution:

Name: **University of Central Florida**
Address: **4000 Central Florida Blvd, FL 32816 -**
Phone: **(407) 823-2341**

Principal Investigator:

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Business Official:

Name: **Mr. Julian Reyes**
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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Hyper realistic digital twin environments are limited to demanding computational requirements of running accurate simulations. More so when these environments are meant to be rendered in real-time for training and XR. In order to address this problem, Buendea in collaboration with the University of Central Florida's Institute for Simulation and Training, are proposing the development of a system that enhances real-time XR capabilities for astronaut training through the off-loading and processing of demanding simulation tasks to cloud-based virtual machines.

By enabling parallel processes that run side-by-side to real-time simulations, we intend to layer microservice extensions that produce more accurate simulation models required in XR astronaut training. This effort will also demonstrate that this approach can be expanded to other parallel simulations that enhance accuracy of a digital twin without affecting real-time simulation rendering performance of an XR environment.

This effort will be focused on the development of a persistent simulation layer that provides ongoing critical data for evaluation of EVA training scenarios on the Moon and Martian surface. Multi-GPU virtual machine instances will run in parallel to local XR environments and provide real-time simulations of critical mission processes, human performance, and environmental conditions. Data from these sessions will be stored and accessible for review to help improve operational XR training capabilities and simulation accuracy.

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

- NASA XR Training capabilities for Lunar and Mars Operations. Training for teleoperation of Robotics and Rovers.
- Support for projects like NASA's CHAPEA efforts where long duration stays require persistence layers.
- XR Collaboration across NASA laboratories where data is updated to be reviewed in virtual environments for Digital Transformation.
- AI/ML Simulation modeling based off real-time human and robotics training.

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

- XR Simulation capabilities for training and situational awareness in high-risk environments.
- AI/ML Simulation modeling in virtual environments with persistence state for reviews and aggregation of data.

- Development of digital twin for collaboration opportunities with aerospace industry and gamification.

Duration: **12**

PROPOSAL NUMBER: 22-1- **T11.06-2171**

SUBTOPIC TITLE: Extended Reality (Augmented Reality, Virtual Reality, Mixed Reality, and Hybrid Reality)

PROPOSAL TITLE: Hyperrealistic, precise position, multi-astronaut training with XR Redirected Walking

Small Business Concern

Firm: **Space Villages Inc.**
Address: **1044 Alderbrook Lane, San Jose, CA 95129 - 2948**
Phone: **(408) 772-8063**

Research Institution:

Name: **New York University**
Address: **665 Broadway, Suite 801, NY 10012 - 2339**
Phone: **(212) 998-2121**

Principal Investigator:

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Business Official:

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Phone: **(408) 772-8063**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

We will implement large virtual spaces dynamic saccadic redirection methods for 2 person Redirected Walking (RW) in real room/multi-room scaling XR. We'll use target numerical simulations & user scenario test data to evaluate XR performance metrics against TRL-4 goals. RW can deliver up to 10x real space walkable area in virtual space without 1 user awareness of real space. Our goal is to achieve best virtual vs. real space expansion with 2 users in same room.

We will show hyperrealistic large virtual environments rendering with high level of terrain details appropriate for surface operations & object models such as instruments, tools, vehicles, & structures. Photorealistic accurate scenarios improve full immersion sensations & training outcomes.

We will demonstrate accurate finger, hand, & object tracking for 2 rooms including tracking objects with limited visibility for typical astronaut activities, e.g., unload, transport, assemble.

We will explore novel human-computer interface methods, such as gesture commands, next step scenario guided choice/presentation from eye, hand, finger motions, etc. to determine applicability for Phase I & Phase II R&D. UX interfaces in XR can guide users, follow responses to AR visual cues, present checklists, measure appropriateness of response & use trainee or user responses to guide next step training or operations to improve memory & new eye hand coordination retention during training, operational planning, & operational management.

Our Deliverables include a theoretical framework implemented in hardware that demonstrate basic functionality & critical test environments, with key software components integrated & functionally validated to establish interoperability, with documented test performance demonstrating agreement with analytical predictions. Our (TRL-4) goal is to show breadboard systems with novel RW algorithms in a basic operating environment. All deliverables will be shown in a 2 person hands-on demo in XR.

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

XR technologies can facilitate many missions, including those related to human space exploration, for planning, training, & operations support as well as for modeling & simulation of future orbital, transportation, & stationary structures for robotic & human use. The Human Exploration & Operations Mission Directorate, Space Technology Mission Directorate, Science Mission Directorate, Artemis, & Gateway programs could benefit from this technology. The crosscutting nature of XR technologies allows it to support all of NASA's Directorates.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

More "realistic" training environments deliver better training outcomes due to improved "muscle memory". Commercial applications include training of pilots for aerospace; workplace injury reduction among construction, freight, material movers (2.8 million 2019); tele-robotics; surgical training; strength training; telepresence; education; gaming & entertainment.

Duration: **10**

PROPOSAL NUMBER: 22-1- **T15.04-1263**

SUBTOPIC TITLE: Full-Scale (2+ Passenger) Electric Vertical Takeoff and Landing (eVTOL) Scaling, Performance, Aerodynamics, and Acoustics Investigations

PROPOSAL TITLE: Full-Scale eVTOL Acoustic Measurements, Modeling, Scaling, and Validation

Small Business Concern

Firm: **Blue Ridge Research and Consulting**
Address: **29 North Market Street, Suite 700, Asheville, NC 28801 - 2983**
Phone: **(828) 252-2209**

Research Institution:

Name: **The Pennsylvania State University**
Address: **110 Technology Building, PA 16802 - 7000**
Phone: **(814) 865-8404**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

At the conclusion of Phase II, the proposed research will produce research-quality acoustic measurements and validated component models of a full-scale, multi-rotor eVTOL aircraft. Acoustic measurements and validated models will allow our team, NASA, and the advanced air mobility industry to expand our understanding of eVTOL noise. The proposed innovations will enable the industry to optimize eVTOL designs and operations to minimize community noise impacts in alignment with NASA's vision that eVTOL noise be non-intrusive when operating near people and property.

Currently, no validated tools exist to model unsteady loading noise for multi-rotor eVTOL vehicles or to scale sub-scale data to full-scale vehicles. The proposed innovation will advance the current state of the art by developing validated component noise models for unsteady loading noise sources, including rotor-rotor and rotor-structure interactions.

The Phase I objectives are to develop component models for multi-rotor eVTOL aircraft, compare the models with acoustic measurements of a 1-passenger eVTOL aircraft, and design a Phase II flight test to reduce model uncertainty. To accomplish these objectives, our team will identify existing component modeling tools and datasets and link them in a framework to assess community noise from multi-rotor eVTOL aircraft. We will compare the component model results with acoustic measurements of a 1-passenger eVTOL aircraft to validate the component models and prioritize operating conditions for Phase II flight tests. Finally, we will develop a flight test plan for acoustic measurements of a full-scale, multi-rotor eVTOL aircraft.

At the conclusion of Phase I, we will deliver acoustic measurements and component noise models of a 1-passenger eVTOL vehicle, a Phase II flight test plan with acoustic predictions, and a final report documenting the Phase I outcomes. The outcomes will help NASA and the industry accelerate the design cycle of full-scale eVTOL aircraft.

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

The proposed innovations support ARMD's strategic thrust #4 for safe, quiet, and affordable vertical lift air vehicles. The acoustic measurements will provide NASA with a research-quality dataset to validate noise models for full-scale eVTOL aircraft. The component noise models will enable accurate predictions of multi-rotor eVTOL noise, including rotor-rotor and rotor-structure interactions. These proposed innovations will help NASA accelerate the design cycle of full-scale eVTOL aircraft.

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

Acoustic measurements and validated component models for full-scale eVTOL aircraft will provide actionable information for eVTOL manufacturers and operators to identify vehicle and operational noise drivers early in the design cycle. These insights will enable the industry to optimize vehicle designs and operations that minimize community noise impacts.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T13.01-2449**

SUBTOPIC TITLE: Intelligent Sensor Systems

PROPOSAL TITLE: A Wireless, Thin-Film Surface Acoustic Wave (SAW) Sensor System for Rocket Propulsion Test Applications

Small Business Concern

Firm: **X-wave Innovations, Inc.**
Address: **555 Quince Orchard Road, Suite 510, Gaithersburg, MD 20878 - 1464**
Phone: **(301) 200-8368**

Research Institution:

Name: **New York Institute of Technology**
Address: **Northern Boulevard, NY 11568 - 8000**
Phone: **(516) 686-1062**

Principal Investigator:

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Address: **555 Quince Orchard Road, Suite 510, MD 20878 - 1464**
Phone: **(301) 200-8128**

Business Official:

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Phone: **(301) 200-8368**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA is looking for advanced sensor technologies, especially wireless embedded sensor systems, to support rocket propulsion development. The enabling technology should provide a highly flexible instrumentation solution capable of monitoring remote or inaccessible measurement locations. This sensor system should substantially reduce operational costs and evolutionary improvements in ground, launch and flight system operational robustness. It should provide an advanced diagnostics capability to monitor test facility parameters including temperature, pressure, strain and near-field acoustics. To address this critical need, X-wave Innovations, Inc. (XII) and Prof. Fang Li from New York Institute of Technology (NYIT) propose an innovative passive, wireless, high temperature embedded sensor system that is capable of providing high-bandwidth measurements of temperature, pressure and strain on both rotating and non-rotating propulsion engine components. For the Phase I program, XII will prototype an embedded sensor system and demonstrate the feasibility of the proposed technique for passive, wireless, multi-parameter measurements. For the Phase II program, XII will focus on refining the prototype system design and development with improved hardware and software. For the Phase III program, XII will focus on optimizing the prototype performance and collaborating with our commercial partners to package the sensor technology into a commercially-available system.

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

NASA has great interest in embedded sensor system with wireless data communication capabilities for a variety of applications, from ground testing, to flight testing, to in-service monitoring, etc. The proposed wireless, cryogenic temperature/pressure sensor system provides a highly flexible instrumentation solution to monitor inaccessible measurement locations such as fuel tanks for NASA's rocket propulsion test facilities.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed wireless sensor system has many market applications in different industries such as exploration, defense, aviation, and civil and environmental engineering sectors. Wireless, cryogenic pressure/temperature sensor technologies for propulsion and other applications are constantly being sought in many markets, especially those that require continuous monitoring of fuel supplies.
Duration: **6**

PROPOSAL NUMBER: 22-1- **T8.06-1605**

SUBTOPIC TITLE: Quantum Sensing and Measurement

PROPOSAL TITLE: High brightness, waveguide-based IR quantum light sources

Small Business Concern

Firm: **ADVR, Inc.**
Address: **2310 University Way, Building 1-1, Bozeman, MT 59715 - 6504**
Phone: **(406) 522-0388**

Research Institution:

Name: **The University of California San Diego**
Address: **9500 Gilman Drive, Mail Code 0934, CA 92093 - 0934**
Phone: **(858) 246-5467**

Principal Investigator:

Name: **Dr. Joshua Aller**
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Phone: **(406) 522-0388**

Business Official:

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Phone: **(406) 522-0388**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Quantum light sources are a critical need for NASA and the broader scientific community. The proposed program will develop ultra-high brightness, low loss, integrated quantum light sources in the IR spectral regime using waveguide-based technology.

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

Squeezed light

Quantum Sensing

Transition edge detectors

Quantum Communications

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

Quantum Networking

Entanglement swapping

Integrated Photonics

Frequency Conversion

Electro-optic modulators

Duration: **13**

PROPOSAL NUMBER: 22-1- **T8.07-2594**

SUBTOPIC TITLE: Photonic Integrated Circuits

PROPOSAL TITLE: Highly Efficient Atmospheric Gases Detections Using Integrated Vertical Crystal Waveguide Arrays

Small Business Concern

Firm: **Omega Optics, Inc.**
Address: **8500 Shoal Creek Boulevard, Building 4, Suite 200, Austin, TX 78757 - 7591**
Phone: **(512) 996-8833**

Research Institution:

Name: **The University of Texas at Austin**
Address: **10100 Burnet Rd., Building 160, TX 78758 - 4445**
Phone: **(512) 471-7035**

Principal Investigator:

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Business Official:

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Phone: **(512) 996-8833**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

In this program, we propose to develop a novel hand-held multiplex gas detector platform in the mid-IR range for multiple chemical detection and identification with both high sensitivity and specificity. The sensor technology in this project is based on a lab-on-chip Mid-IR absorption spectrometer incorporating vertical photonic crystal waveguide (VPCW) structures. The VPCW demonstrates significant slow-wave effects leading to enhanced sensitivity within a drastically reduced interaction length. The small geometry of VPCW is an excellent platform for miniaturized sensing and high-resolution on-chip spectroscopy unmatched by any existing technologies. Unlike the conventional approach, the device proposed herein can provide multiple analyte detections in one chip with one broadband LED source and the wavelength indifferent PDs array that offers a cost-effective, compact, and highly sensitive device without compromising the specificity for air-borne and space-borne applications. In the proposed work, our plan is to 1) design three different VPCWs on a Si wafer to exhibit multiplex detection capability with strong confinement of light in the VPCW defect core 2) fabrication and characterization of multiple VPCWs on a Si wafer with minimum interference from adjacent defect holes 3) demonstration of optical detection of CO_2, CH_4, and N_2O with targeted sensitivity of <100ppb and 4) Packaging and integration of one mid-IR LED, VPCW arrays, and matching PD arrays into our hand-held unit.

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

1. The proposed multiplex sensing system is compact and ideal for in-situ analysis of environmental gases by mounting it on an airborne and space-borne platform

2. Crucial to identifying gases on the earth or at distant planets and moons

3. The proposed platform is fully scalable to a wide range of mid-infrared wavelengths where several important analyses of NASA's interest can be found

4. Discrete component integration in a single package offers a better size, weight, and power (SWaP) advantage over any other existing spectroscopy instrument

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

1. Human Health and Safety: Ex. Identification of hazardous air pollutants (HAPs) and can be helpful to identify cause of various air borne decease

2. Defense sector: Ex. detection of toxic gases on the battlefield

and volatile organic components (VOCs)

3. Agriculture production and food safety/allergy monitoring

4. Industrial application: Ex. leakage detection of gases in oil storage and tanks

Duration: **13**

PROPOSAL NUMBER: 22-1- **T12.07-1475**

SUBTOPIC TITLE: Design Tools for Advanced Tailorable Composites

PROPOSAL TITLE: Design Tools for Lightweight Affordable Hybrid Space Exploration Cryotanks

Small Business Concern

Firm: **Nanosonic, Inc.**
Address: **158 Wheatland Drive, Pembroke, VA 24136 - 3645**
Phone: **(540) 626-6266**

Research Institution:

Name: **Virginia Polytechnic Institute and State University**
Address: **300 Turner Street Northwest, Suite 4200, VA 24061 - 0001**
Phone: **(540) 231-5281**

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA has identified a need for new technologies in support of human exploration of the Moon and manned missions to Mars that will reduce the cost of exploration, enable efficient and reliable operations in extreme environments, and implement advanced in-space assembly techniques within state-of-the-art space structures. Improvements in each of these design and manufacturing areas are critical to enabling a sustainable Lunar and Mars presence by the U.S. While many current composite designs are limited to unidirectional fiber layups and stacking sequences, NanoSonic shall utilize filament winding for ultra-high strength complex shaped composites with optimized isotropic load paths rather than quasi-isotropic properties. Highly tailored materials using additive manufacturing techniques are NanoSonic's expertise. In this STTR, we have teamed with Virginia Tech's (VT) composite coding experts to predictively yield repeatable and reliable multifunctional lightweight hybrid structures through design tools. NanoSonic will collaborate with VT to develop unique composite property analysis software via Abaqus and Python. Abaqus is a finite element analysis software. Coupled with Python scripting, the components of a geometrical model including the parts, materials, properties, steps, mechanical or thermal loads, shall be inputted in an automated manner to evaluate and estimate a proposed composite's behavior under certain conditions.

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

Potential NASA applications for the design uses include: Space Technology Mission Directorate, Artemis/HLS programs, developers of air-launched systems (Generation Orbit Launch Services; Science Mission Directorate, Aeronautics Research Mission Directorate) next-generation airframe technology beyond tube and wing configurations (hybrid/blended wing body). NanoSonic shall develop innovative a design tool with VT to form hybrid lightweight structural pressure vessels as complex shaped cryotanks.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Dual-use applications for the composites include H_2 dispensing hoses and on-board storage tanks for zero emission vehicles. Additional industries for these low cost lightweight cryotanks are in trucking, transportation, space, and medical, thereby widening commercial opportunities for H_2. NanoSonic is currently selling related advanced polymer resins that will be used in the hoses and tanks.
Duration: **13**

PROPOSAL NUMBER: 22-1- **T10.04-1854**

SUBTOPIC TITLE: Autonomous Systems and Operations for the Lunar Orbital Platform-Gateway

PROPOSAL TITLE: QuickSAT/SHERLOCK-MD, A System For Autonomous Operations And Health Management of Gateway

Small Business Concern

Firm: **sci_zone**
Address: **17133 Inavale, Holland, MI 49424 - 5656**
Phone: **(505) 205-8315**

Research Institution:

Name: **Johns Hopkins University**
Address: **3400 N Charles St, MD 21218 - 2623**
Phone: **(917) 494-1053**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

sci_Zone and John Hopkins University are proposing *QuickSAT/SHERLOCK-MD,* a system for Vehicle Health Management and Fault Detection with Fault Classification Functions. *QuickSAT,* a flight proven environment, is the framework containing the *SHERLOCK-MD* architecture providing edge-capable AI, sensing suite integration and vehicle tracking functions that are tied with the vehicle fault management system perceiving rapidly potential faults that might occur. *SHERLOCK-MD* ties into on-edge sensing suites plus on-board fault monitoring systems and vehicle health data building an internal knowledge base for event/fault classification. This data is fed into a preliminary analysis system designed to extract key features. This takes the form of anomaly detection or binary/multi-class status checks. *SHERLOCK-MD* relies on a system built on the Security Risk Taxonomy for Commercial Space Missions. By comparing symptoms evident in the data analysis with a historical database of faults and events, the diagnostic produces a set of likely candidates for mission and/or experiment failure and propose appropriate action. *SHERLOCK-MD* has the ability to feed directly into the decision support module of the incident-response architecture. Phase I shall focus on development of algorithms/code classifying detected faults using different satellite datasets, conduct a comprehensive comparative assessment, provide a detailed concept for autonomy technology to support Gateway operations including visiting vehicles and experiments, trade study of recommended supporting hardware, and a baseline demonstration of *QuickSAT/SHERLOCK-MD*.

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

QuickSAT/SHERLOCK-MD *NASA* applications include the Lunar Gateway itself, support for experiments on-board the *Lunar Gateway*, and use on *Lunar Gateway* visiting vehicles. ***QuickSAT/SHERLOCK-MD*** can be applied to future missions to Mars, deep space missions and even remote sensing satellites orbiting the Earth – essentially any mission requiring Vehicle Health Management and Fault Detection with Fault Classification Functions.

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

***QuickSAT/SHERLOCK-MD* has broad applications over a wide range of commercial, defense and research based vehicles. QuickSAT/SHERLOCK-MD and supporting algorithms can be integrated to a range of other assets in addition to satellites, such as aircraft, watercraft, and ground vehicles providing to the asset a means for rapid fault detection, classification and assessment.**

Duration: **13**

PROPOSAL NUMBER: 22-1- **T5.04-1819**

SUBTOPIC TITLE: Quantum Communications

PROPOSAL TITLE: Photonic Integrated Circuit Assisted Single Photon Detectors (PICA SPDs)

Small Business Concern

Firm: **Physical Sciences, Inc.**
Address: **20 New England Business Center , Andover, MA 01810 - 1077**
Phone: **(978) 689-0003**

Research Institution:

Name: **Board of Trustees of the University of Illinois (at Urbana-Champaign)**
Address: **SPA, 1901 S. First Street, Suite A, IL 61820 - 7406**
Phone: **(217) 333-2187**

Principal Investigator:

Name: **Dr. Christopher Evans**
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Phone: **(978) 738-8159**

Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Within this program, Physical Sciences Inc. (PSI) and the University of Illinois Urbana-Champaign (UIUC) will develop Photonic Integrated Circuit Assisted-Single Photon Detectors (PICA-SPDs) to increase the bandwidth and timing resolution of single-photon detectors (SPDs). Realizing low size, weight, and power (SWaP) SPDs with high saturation-rates and high timing-resolutions are critical for deploying of quantum technology in space. While the best superconducting nanowire SPDs (SNSPDs) can achieve saturation rates up to 100 MHz with timing resolutions of several 10's of ps, these also require cryogenic environments, making their deployment in space a challenge. On the other hand, single photon avalanche photodiodes (SPADs) are low SWaP and can operate at room temperature with good efficiencies (>75%); however, the timing resolution is often 50 ps (or more) and the saturation rate is typically limited to 10s of MHz.

To overcome the challenge of increasing both the timing resolution and saturation rate of SPAD arrays, our unique active-approach leverages high-speed, low-loss PIC modulators. Here, single-photon optical signals enter the PIC and are routed to a series of Mach-Zehnder Interferometer (MZI) switches. These fast, traveling-wave switches are driven by periodic signals having progressively higher frequencies to create a switch yard. As the photon stream enters each of the MZI switches, the different time-positions are routed to different outputs of each MZI, which isolates individual time-positions to enable readout using an array of SPDs. This approach enables an array of SPADs to operate together to achieve timing resolutions even surpassing SNSPDs with greatly enhanced saturation count rates to enable space-based quantum networking applications.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The development of quantum communications and networks are a key technology to enable secure communication, sensor arrays, and quantum computer networks. Our proposed technology will allow NASA to increase the bandwidth of both free-space and fiber quantum links.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

High saturation rate, low-jitter single-photon detectors are a general-purpose tool for a range of applications, from quantum networks and communication links, to imaging and healthcare applications.
Duration: **13**

PROPOSAL NUMBER: 22-1- **T4.01-1828**

SUBTOPIC TITLE: Information Technologies for Intelligent and Adaptive Space Robotics

PROPOSAL TITLE: ROM3SA: Improved Situational Awareness for Remotely Operating Versatile Semi-Autonomous Robot Systems

Small Business Concern

Firm: **TRACLabs, Inc.**
Address: **100 Northeast Interstate 410 Loop #520, San Antonio, TX 78216 - 4727**
Phone: **(281) 461-7886**

Research Institution:

Name: **University of California - Davis**
Address: **1850 Research Park Drive, Suite 300, CA 95618 - 6153**
Phone: **(530) 754-0861**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The next generation of NASA's robotic assets capable of performing tasks on the Lunar surface, in intermittently crewed spacecraft such as Gateway, or longer term deep space habitats will need to work effectively with remote human team members. While fully autonomous systems are unlikely to be available soon, NASA's robots will need to operate under the supervision and guidance of their human counterparts. To make informed run-time decisions regarding *how much* autonomy a robot should be permitted, even in the presence of non-trivial communication delays, or to assess how well a robot is performing its tasks once commanded, it is imperative that human operators have sufficient feedback to orient them about the robot's state and intentions, and what responsibilities the robot can be trusted to accomplish.

To address this challenge, TRACLabs, with Research Partner University of California Davis, will investigate data summarization tools to support shared autonomy and supervisory control when performing extended mobile manipulation tasks such as station or habitat caretaking and operations & maintenance, and surface activities such as ISRU production and regolith excavation. These tools will be used to help the human operator effectively assess robots status, informing them of whether they need to help robot systems out as necessary. We will call the proposed effort the ROM3SA (*Robot Operation Metrics for Mobile Manipulation and Shared Autonomy*) system. This work will focus on the design and implementation of suitable metrics that can be evaluated at run-time to summarize robot status to orient remote human operators and provide improved situational awareness to allow them to make better decisions.

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

Multiple near-term missions could benefit from the ROM3SA technology including Artemis surface robots including the LSMS, VIPER, Perseverance, and RASSOR platforms, or ISS/Gateway robots such as Astrobee. Future systems will that will benefit from this work includesthe in-Space Assembled Telescope (iSAT), Orbital Debris Mitigation, Commercial Lunar Payload Services (CLPS), Mars sample return, Discovery and New Frontiers, exploration mission opportunities like Titan or Europa, and various STMD technology demonstrations.

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

With the advent of so many commercial space missions, the ROM3SA technology could also serve to enhance a number of non-NASA efforts that include remote robotic operations (either on a planetary surface or in orbit) by Blue Origin, GKN Aerospace, Lunar Outpost, Motive Space Systems, Tethers, Spirit Aerosystems, Astrobotic, Axiom Space, Nanoracks, Lockheed, GM, and Boeing.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T7.05-1301**

SUBTOPIC TITLE: Climate Enhancing Resource Utilization

PROPOSAL TITLE: Single-step production of kerosene-based fuels from carbon dioxide and hydrogen

Small Business Concern

Firm: **Air Company Holdings Inc**
Address: **407 Johnson Avenue, Brooklyn, NY 11206 - 2805**
Phone: **(347) 927-4255**

Research Institution:

Name: **New York University**
Address: **665 Broadway, Suite 801, NY 10012 - 2339**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Air Company has developed carbon dioxide hydrogenation technology that produces paraffins (C8-C16 and higher) in a single step using only carbon dioxide and hydrogen gases as feedstock. The hydrogen gas is sourced using renewably powered water electrolysis, thus the only byproduct of the process is the oxygen that is coproduced from the electrolyzer. Coupling this system with direct air capture technology, for which we have a patent pending on a synthetic carbonic anhydrase analog to increase sorption efficacy, enables production of kerosene-based fuels using only air, water, and renewable electricity. Air Company has demonstrated this process at the pilot scale, producing a metric ton of products per week and operating for over 8,600 operating hours in 2021. In this proposal, we plan to use our existing data and expertise, as well as collect new experimental data, to construct the process models and provide NASA with mass and energy balance information, system energy consumption, mass, and volume, sensitivity to varied carbon dioxide feedstocks for applications on Earth and Mars, detailed descriptions of each subcomponent of the process, and a thorough risk analysis for deployment on Earth and Mars. Together with Modestino Lab at New York University, we will further provide detailed engineering models, materials sizing, and kinetic modeling for the key components of the system, specifically the carbon dioxide hydrogenation reactor. At the end of this STTR project, the technical feasibility of deploying this technology on Earth and Mars will be thoroughly assessed and delivered to NASA.

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

Our technology can be used by NASA on Earth, as a method of producing sustainable RP-1 as a drop-in replacement for the fossil fuels currently used as rocket propellant. Additionally, this technology can be used on Mars to produce a stable and storable fuel in-situ, using only the Martian atmosphere, water, and solar photovoltaic electricity. This fuel could be used to power habitats on Mars, used as rocket propellant for a return trip to Earth, or used as a chemical feedstock for further in-situ resource utilization.

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

Air Company is currently pursuing this technology for the production of sustainable aviation fuel, to help address the greenhouse gas emissions of the aviation industry. Further applications of the technology can be used to produce virtually any fuel or chemical feedstock that is currently made from fossil fuels on Earth, replacing the fossil-derived fuels and chemicals with air-derived ones.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T5.04-1093**

SUBTOPIC TITLE: Quantum Communications

PROPOSAL TITLE: Compact Temperature Tolerant Quantum Entangled Light Source

Small Business Concern

Firm: **Srico, Inc.**
Address: **2724 Sawbury Boulevard, Columbus, OH 43235 - 4579**
Phone: **(614) 799-0664**

Research Institution:

Name: **Ohio State University-Main Campus**
Address: **1960 Kenny Road, Office of Sponsored Programs, OH 43210 - 1063**
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Principal Investigator:

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Business Official:

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Phone: **(614) 799-0664**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 4
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

This proposal develops a robust low size weight and power quantum entangled light source based on time-frequency encoded states. This configuration mitigates the phase stabilization requirements inherent in more conventional coherent quantum systems. An important aspect of the source is nonlinear optic conversion from a relatively short wavelength single photon source to a longer wavelength for low loss transmission over fibers or through a free

space optical link. These elements typically require tight temperature control and can account for a substantial portion of the size weight and power budget for the source. This proposal integrates highly efficient and temperature tolerant nonlinear conversion components within the light source. Temperature tolerant design has the potential to minimize or even eliminate temperature control requirements, greatly reducing the size weight and power normally associated with tight temperature control.

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

The Spontaneous Parametric Down Converter addresses a current NASA need for low size weight and power production of entangled photons for encrypted communications systems. The proposed device offers the best solution for low loss, high efficiency, compact and thermally stable packaging. Several companies have developed crucial technologies for quantum cryptography. Development of a temperature-tolerant low size weight and power device, such as that proposed here, will enable transition of these technologies to NASA space programs.

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

The proposed technology will provide increased information security at critical US infrastructure sites including power generation and distribution stations, government labs, and defense installations. Other uses include quantum optics research and computing. It also supports improved data security for prevention or reduction of cyber-crime, benefiting industry and the general public.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T5.05-1391**

SUBTOPIC TITLE: Advanced Solar Sailing Technologies

PROPOSAL TITLE: Embedded Sail Antenna Technology

Small Business Concern

Firm: **Nexolve Holding Company, LLC**
Address: **290 Dunlop Boulevard, Southwest, Suite 200, Huntsville, AL 35824 - 1128**
Phone: **(256) 337-6752**

Research Institution:

Name: **Utah State University**
Address: **1415 Old Main Hill, Room 64, UT 84322 - 1415**
Phone: **(435) 797-9277**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

A n

A new patch antenna array composed of thin-film materials is proposed to create a significant improvement in the specific mass and specific volume of the antenna array. This innovation will enable the combination of the patch antenna array with a solar sail to address the need for a High Gain Antenna (HGA) option for deep space solar sail missions. The primary objective of the proposed research is to refine the design of the patch antenna array with capability to achieve 30 to greater than 50 dBi performance in either the X, K, or Ka frequency band. A secondary objective of the research is to present how this patch antenna array can be integrated into a solar sail architecture and deployment mechanism. These objectives will be achieved by constructing components of the patch antenna array from thin flexible materials and combining the antenna array with the structure of the solar sail. The patch antenna array deploys with the deployment of the solar sail, and the unique features of the antenna design create the required separation between the patch elements and the ground plane element of the antenna array.

A deployable HGA will enhance the capabilities of smaller spacecraft. The satellite paradigm has shifted considerably from the use of traditional large and expensive satellites to smaller and more cost-effective models. Advancements in technology are leading to small spacecraft like CubeSats developing the capabilities to perform interplanetary and deep space missions. A significant challenge associated with using smaller spacecraft for these missions is the communication framework required to transmit and receive data across such vast distances The proposed patch antenna array differs from traditional

communications solutions in the fact that the aperture size is not restricted by the size of the spacecraft. The deployable thin film HGA approach will allow the antenna to be sized according to mission needs.

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

- Solar Cruiser mission
- Europa Clipper mission
- New Moon Explorer mission
- Artemis program
- Solar Polar Imager – SPI solar sail

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

Communication Antennas:

- SpaceX – Starlink
- OneWeb – OneWeb Constellation
- Amazon - Project Kuiper Constellation
- Capella Space - Synthetic Apertures

Duration: **13**

PROPOSAL NUMBER: 22-1- **T5.05-2115**

SUBTOPIC TITLE: Advanced Solar Sailing Technologies

PROPOSAL TITLE: UV stable coating for sail-embedded PV power

Small Business Concern

Firm: **SSS Optical Technologies, LLC**
Address: **515 Sparkman Drive, Suite 122, Huntsville, AL 35816 - 3417**
Phone: **(256) 489-0081**

Research Institution:

Name: **Oakwood University**
Address: **7000 Adventist Blvd NW, AL 35896 - 0001**
Phone: **(256) 726-7558**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

SSS Optical Technologies, LLC (SSSOT) together with HBCU Research Institution (RI) Oakwood University (OU) and subcontractor Regher Solar, Inc. (RSI) propose to develop the Polymer Anti-damage Nanocomposite Down-converting Armor (PANDA) coating of solar sail-embedded PV cells that, in addition to blocking UV and ionizing radiation and being UV stable, flexible, and light weight, converts UV into visible radiation that matches the responsivity spectrum of the PV cell. This makes possible to generate extra electricity thus improving the overall PV conversion efficiency by up to 5%. PANDA coating uses a polymer nanocomposite impregnated with UV absorbing luminescent quantum dots (QDs) to shield the coating itself and the coated solar cells from UV radiation and increase PV power conversion efficiency. This is achieved by using spectrum downshifting of solar UV radiation in the QDs to visible radiation. The innovativeness of the technology has three features: (1) UV shielding is combined with the use of the UV energy, otherwise wasted, in the production of additional PV electricity; (2) UV shielding also prevents polymer photodarkening, and (3) solar spectrum conversion from UV to visible-NIR is highly efficient. The overall goal is to develop and demonstrate feasibility of a UV stable coating for sail-embedded solar cells that improve PV power output. To reach the goal, the following technical objectives are identified (1) Design and implement spectrum converting QDs and produce PANDA coatings. (2) Enable UV stability of PANDA and its perforamnce as a protector of solar cells from UV radiation and enhancer of PV conversion efficiency. (3) Conduct experiments on both UV stability and conversion efficiency, analyze experimental data and make conclusions on feasibility of the proposed ideas.

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

If successful, the proposed technology can be implemented as “UV stable thin-film protective coating for sail-embedded power-generation…”, Scope “Next-Generation Solar Sail System Techn.”, topic T5.05 “Advanced Solar Sailing Technologies”, Focus Area 5 “Communications and Navigation”, NASA FY 2022 STTR Solicitation. PANDA can be used to protect solar power blankets within Scope “Photovoltaic Energy Conversion”, Topic S16.01 “Photovoltaic Power Generation and Conversion”, Focus Area 2 “Power, Energy and Storage”, the same NASA Solicitation.

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

One of the major potential non-NASA applications of PANDA technology is the improvement of the efficiency of solar PV panels while protecting them from solar UV and increasing their lifetime.The customers would be national grids and rural communities and the owners of the cameras, such as the government security facilities, municipalities, and private entities concerned with surveillance.
Duration: **13**

PROPOSAL NUMBER: 22-1- **T10.03-1993**

SUBTOPIC TITLE: Coordination and Control of Swarms of Space Vehicles

PROPOSAL TITLE: Tool for Autonomous Terrain Exploration of Remote Space

Small Business Concern

Firm: **MTRI, Inc.**
Address: **3600 Green Court, Suite 100, Ann Arbor, MI 48105 - 1570**
Phone: **(734) 913-6871**

Research Institution:

Name: **Michigan Technological University**
Address: **3600 Green Court, MI 48105 - 1570**
Phone: **(734) 994-7237**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The proposed effort is a framework that supports long-term autonomous exploration efforts in unknown spaces by developing state-of-the art methods to facilitate rapid iteration and customization of search strategies for missions that have little a-priori information. The Tool for Autonomous Terrain Exploration of Remote Spaces (TATERS) is a flexible software system that allows researchers and mission designers to reduce the risk of exploration and give them the adaptability to easily pivot strategies as new mission data becomes available. This technology will help to accelerate mission times, optimize in-situ resources, and develop new search behaviors. TATERS will be able to adapt to new situational awareness information, automatically run scenarios, and produce defined metrics that quantify exploration performance. TATERS will consist of 1) a software framework to test applications of search strategies of heterogenous teams 2) the ability to adapt to new information as it becomes available 3) the ability to parametrically modify search parameters and report defined metrics and 4) an initial set of search strategies targeted for the lunar environment and mapping of volatiles.

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

TATERS can be used collaboratively by mission designers and researchers as an autonomy planning and research tool. Novel search strategies can be developed along with performance metrics, which mission designers and engineers can use to mitigate risks and optimize resources on off world missions. Multiple search strategies will give mission designers options to strategize autonomy techniques. This technology can be used to develop search strategies for exploring volatiles on the moon or mars, mapping out lava tubes, and exploring ocean worlds.

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

The need for adaptive search strategies extends to terrestrial environments. Searching for volatiles and unknowns also can be applied to the agricultural industry for soil monitoring, locating ore deposits in the mining industry, or navigating areas too dangerous for humans to enter. TATERS can also be used by university entities, such as Planetary Surface Technology Development Lab.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T10.05-2150**

SUBTOPIC TITLE: Integrated Data Uncertainty Management and Representation for Trustworthy and Trusted Autonomy in Space

PROPOSAL TITLE: Module for Event Driven Operations on Spacecraft (MEDOS)

Small Business Concern

Firm: **Aurora Engineering**
Address: **4 Redbud Court, Potomac, MD 20854 - 3731**
Phone: **(814) 441-6410**

Research Institution:

Name: **University of Colorado Boulder**
Address: **3100 Marine Street, Room 481, CO 80309 - 0001**
Phone: **(303) 735-5406**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

The Module for Event Driven Operations for Spacecraft (MEDOS) provides a key advancement along the road to autonomous spacecraft operations: a simple, computationally lightweight method for integrating knowledge (be it human expertise, AI/ML based correlations, physical relationships, etc.) into an adaptable system for translating detectable events into spacecraft actions. MEDOS will be developed by a partnership between Aurora Engineering and the University of Colorado's Laboratory for Atmospheric and Space Physics (CU/LASP), forming a team with decades of experience in operational space flight missions.

MEDOS is an adaptable system for autonomous spacecraft control. It creates new telemetry points based on analytical combinations of current and previous raw telemetry. These derived telemetry points are compared mathematically to defined events. If the current derived telemetry is a close match to a defined event, then the associated operational activity is initiated. MEDOS provides a step on the path toward trusted spacecraft autonomy in a way that is flexible, simple, and informed by underlying physical relationships.

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

As NASA is currently developing distributed space missions (DSM), or missions further from Earth, the prospect of autonomy becomes more of a necessity.We aim to address this market need by providing a general purpose interface for autonomous, event driven operations. By leveraging MMS, a NASA flagship mission, we will demonstrate proficiency towards similar future missions (notably GDC and MagCon). Upon completion of a successful Phase 2 effort, we plan to have a hardware implementation of MEDOS that can be tested on a flight opportunity.

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

As commercial entities aim for "full coverage" of large areas of the planet, the need for autonomous operation of large scale distributed missions becomes increasingly attractive. We aim to market MEDOS as a commercial off the shelf (COTS) solution that can be easily integrated with existing commercial space flight architectures. The technology could also be applied to deep sea submersibles, etc.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T12.07-1654**

SUBTOPIC TITLE: Design Tools for Advanced Tailorable Composites

PROPOSAL TITLE: Intact.Fiber: An Application Programming Interface for the Design, Simulation, and Optimization of Tow-Steered Composites

Small Business Concern

Firm: **Intact Solutions**
Address: **345 West Washington Avenue Suite 301, Madison, WI 53703 - 3007**
Phone: **(608) 469-7292**

Research Institution:

Name: **University of Delaware**
Address: **210 Hullihen Hall, DE 19716 - 0099**
Phone: **(302) 831-8626**

Principal Investigator:

Name: **Dr. Xingchen Liu**
E-mail: **Xliu@intact-solutions.com**
Address: **345 W Washington Ave Ste 301, WI 53703 - 3007**
Phone: **(608) 515-9322**

Business Official:

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Address: **211 South Paterson Street, Suite 350, WI 53703 - 4504**
Phone: **(608) 469-7292**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

The unique advantage of tow-steered composites arises from the ability to tailor and vary the stiff fiber alignment continuously. However, the existing design tools for composite structures are limited to straight fiber systems and simple geometric configurations --leading to suboptimal designs and the inability to take advantage of improvements in composite manufacturing technologies. Development and deployment of new design tools are challenging due to challenges in interoperability, automation, and user interfaces.

In this STTR project, Intact Solutions in collaboration with the University of Delaware Center for Composite Materials will develop Intact.Fiber, a commercial-grade API that provides an interoperable and extendable interface supporting the parameterization, manufacturability constraints, physical simulation, and optimization of tow-steered composites. The salient features of Intact.Fiber include: (1) towpath query interfacing different design space parameterizations, (2) geometric queries interfacing manufacturability constraint checks, (3) moment queries interfacing finite element physical simulation packages (NASTRAN), (4) Interchangeable and interoperable tow-steer composites design through optimization, (5) fabrication of tow-steered laminate designs.

Intact.Fiber will allow the rapid and automated design of advanced composites tailored to reduce weight and improve structural properties, taking advantage of expanding manufacturing capabilities and delivering drastic reductions in development time and cost. Through the interoperable and ready-to-use manufacturability constraints and finite element simulation with NASTRAN for different towpath representations, Intact.Fiber's architecture is designed to explore wide design spaces spanned by different towpath representations and optimization algorithms, delivering improved performance with optimal lightweight designs with highly tailored load paths.

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

Intact.Fiber can be used to optimize the design of

- Aircraft structures, such as wing skins and stringer-stiffener wing panels design, which is of interest to Aeronautics Research Mission Directorate
- Spacecraft launch vehicle tanks, specifically intertanks, which is of interest to the Space Technology Mission Directorate and the Artemis programs
- Rotor blades, which is of interest to NASA's Mars Helicopter mission

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

Intact.Fiber can be used to optimize the design of

- next-generation airframe technology such as the Boeing X-48 blended wing body
- Wind turbine blades, which is of interest to GE/Siemens
- Lightweight 3D printed parts that are optimized for topology and fiber orientation
- next-generation automobile (electric/gas) chassis technology

Duration: **12**

PROPOSAL NUMBER: 22-1- **T5.05-1029**

SUBTOPIC TITLE: Advanced Solar Sailing Technologies

PROPOSAL TITLE: Testing and Characterization of A Graphene/Polyethylene Nanocomposite for Solar Sail Applications

Small Business Concern

Firm: **Gossamer Space**
Address: **116 Beth Drive, Lansdale, PA 19446 - 5253**
Phone: **(828) 582-9051**

Research Institution:

Name: **University of Notre Dame**
Address: **5627 Osage Lake DR, APT 2A, IN 46545 - 1297**
Phone: **(574) 440-1217**

Principal Investigator:

Name: **Dr. Seunghyun Moon**
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Address: **5627 Osage Lake DR, APT 2A, IN 46545 - 1297**
Phone: **(574) 440-1217**

Business Official:

Name: **Mr. Charles West**
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Address: **116 Beth Dr, PA 19446 - 5253**
Phone: **(828) 582-9051**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Notre Dame University has recently developed graphene/polyethylene film (PE graphene) that has low density and vastly superior strength compared to any previously existing polymer film. We propose to work with Notre Dame University and Utah State University to adapt this film for space applications such as solar sails.

The performance of solar sails is strongly affected by the ratio between the reflecting area of the sail and the mass of the craft. Current generation sails use coated 2.5 micron polyimide films (CP-1) which are extremely delicate to handle and deploy. The PE Graphene nanocomposite has lower density and vastly superior strength compared to CP-1. In terms of specific strength, the new film material outperforms even the best commercial fibers (such as Dyneema) and can offer dramatically improved performance for solar sails. At the same thickness, it offers roughly 70% of the mass of existing solutions and 50x the strength.

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

The polyethylene/graphene nanocomposite film we are adapting for use in space could dramatically improve the performance of solar sails, solar cells and deorbiting devices. If made into a cable form, the extremely high specific strength can also improve the performance of tether and centrifugal launch launch applications.

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

This PE graphene film could be a key component of commercial solar sails.

Duration: **12**

PROPOSAL NUMBER: 22-1- **T10.03-1349**

SUBTOPIC TITLE: Coordination and Control of Swarms of Space Vehicles

PROPOSAL TITLE: Assembly of Large Aperture Space Telescopes in Cislunar Space Using a Swarm of Autonomous Small Satellites

Small Business Concern

Firm: **Ten One Aerospace LLC**
Address: **1012 10th Street NorthEast, Washington, DC 20002 - 3720**
Phone: **(202) 964-3668**

Research Institution:

Name: **Board of Trustees of the University of Illinois (at Urbana-Champaign)**
Address: **SPA, 1901 S. First Street, Suite A, IL 61820 - 7406**
Phone: **(217) 333-2187**

Principal Investigator:

Name: **Susan Martinis**
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Address: **SPA, 1901 S. First Street, Suite A, IL 61820 - 7406**
Phone: **(217) 333-2187**

Business Official:

Name: **Christopher Roscoe**
E-mail: **chris@tenonespace.com**
Address: **1012 10th St NE, DC 20002 - 3720**
Phone: **(202) 964-3668**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA and industry are expressing a growing interest in autonomous robotic in-space assembly and servicing of large aperture space telescopes in cislunar space and at Sun-Earth L2 (SEL2). The recently launched James Webb Space Telescope (JWST) will operate at SEL2 for about 5-10 years until fuel for station keeping and attitude maneuvers is depleted. At this point JWST will essentially become inoperable as it was not designed to be serviced or refueled. With a multi-billion-dollar price tag, it is essential that the technology is developed to enable future telescopes to be serviced autonomously in space. In addition to autonomous in-space servicing, autonomous in-space assembly of telescopes will allow for much larger telescopes that cannot be launched as a single payload. The probability of detecting Earth-like planets orbiting other stars is correlated to the size of the telescope aperture. To date, space telescopes such as JWST, have had to be designed to fit within the fairing of a particular launch vehicle and unfold after launch. This obviously presents numerous technical and programmatic challenges, which could be mitigated with advancements in technology for autonomous in-space assembly. Of course, autonomous in-space assembly also presents several challenges, some of which we will address in the proposed work. For the design reference mission, we consider autonomous assembly of a large aperture space telescope mirror that consists of multiple hexagonal components. We will use a distributed scheduler that tasks each agent in the system to retrieve a mirror component from a nearby cargo vehicle and place the mirror segment into a unique place within the primary mirror. Agents will plan their motion so as to reach their target goals while avoiding collisions. We will advance the start-of-the-art by developing a scalable interactive motion planner to ensure collision avoidance while satisfying constraints associated with the underlying dynamics.

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

The proposed work is applicable to many types of on-orbit servicing, assembly and manufacturing missions. For example, NASA's Earth science orbiters, cislunar spacecraft and space telescopes operating at Lagrange points could all benefit directly from development of the proposed technology. In this particular proposal, we address technological challenges associated with autonomous in-space assembly of large aperture telescopes that are too large to be launched as a single payload. The technology is by no means limited to space applications.

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

The commercial sector has shown great interest in on-orbit satellite servicing missions to extend the lifetime of operational Earth orbiting assets. The proposed technology is applicable to commercial as well as military satellites. The technology is also applicable in other non-space scenarios that require decision making and path planning where human intervention is impractical or impossible.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T8.07-1782**

SUBTOPIC TITLE: Photonic Integrated Circuits

PROPOSAL TITLE: Femtosecond Laser Inscription of 3D Waveguide Beam Splitters and Integrated Photonic Circuits for Mid-IR sensing

Small Business Concern

Firm: **Aktiwave**
Address: **150 Lucius Gordon Drive, West Henrietta, NY 14586 - 9687**
Phone: **(585) 355-2706**

Research Institution:

Name: **Rochester Institute of Technology**
Address: **54 Lomb Memorial Drive, NY 14623 - 0000**
Phone: **(585) 475-5629**

Principal Investigator:

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Business Official:

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Phone: **(585) 355-2706**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

We propose to develop a three-dimensional (3D) mid-infrared (mid-IR) Photonic Lantern (PL) based on femtosecond laser inscription (FLI) technology. FLI of PLs allows converting the atmospheric seeing-limited signals captured by the telescope into diffraction-limited signals. A linear arrangement of the single-mode outputs can be further realized to form the virtual input slit of a spectrograph. The inherent 3D nature, scalability, and the ability to integrate many on-chip functions make FLI an attractive fabrication technique for photonic integrated circuits (PIC), as opposed to the multi-step planar waveguide technologies relying on costly, large-scale microelectronics foundry techniques. The FLI of a 3D, 1x8, mid-infrared waveguide beam splitter and a 1x8 photonic lantern will be demonstrated during the project's Phase I and II period. Three technical objectives are defined: 1: Determine the optimum geometry for a 1x8 waveguide splitter. Objective. 2: Experimentally investigate the impact of laser parameters and WBS geometry on WBS performance. .and 3: Demonstrate a 1x8 waveguide beam splitter operating in the mid-infrared region. The ultimate goal of this proposal is to establish an FLI technology platform for fabricating integrated photonic circuits.

The FLI-based, low SWaP PIC technology will be useful for NASA in lidar receiver for new Earth Science measurements such as the detection of carbon monoxide, free-space laser communications, mid-infrared heterodyne spectroscopy, and astrophotonics for exoplanet detection. The non-NASA applications include spectroscopy, optical communications, medical and clinical research, quantum computing, quantum information, and quantum metrology.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

- **Mid-IR sensing**: on-chip detection of carbon monoxide, methane, formaldehyde...
- **Lidar remote sensing**: integrated photonic circuits for compact and lightweight lidar sources, spectrograph and receivers, with significant cost, size, weight and power reduction.
- **Free space communications**: deep space optical transceiver and ground receiver.
- **Astrophotonics for exoplanet detection:** analysis of star properties (chemical composition, age and radial velocity).

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

- Spectroscopy: replace the optical components which are highly susceptible to alignment
- Optical communications: monolithic integration of passive and active photonic devices.
- Medical and clinical research: Lab-On-Chip and biomedical monitoring sensors
- Quantum computing, quantum information, and quantum metrology

Duration: **13**

PROPOSAL NUMBER: 22-1- **T10.04-2569**

SUBTOPIC TITLE: Autonomous Systems and Operations for the Lunar Orbital Platform-Gateway

PROPOSAL TITLE: Multi-Agent Anomaly Resolution System (MaARS)

Small Business Concern

Firm: **TRACLabs, Inc.**
Address: **100 Northeast Interstate 410 Loop #520, San Antonio, TX 78216 - 4727**
Phone: **(281) 461-7886**

Research Institution:

Name: **Texas A&M Engineering Experiment Station**

Address: **400 Harvey Mitchell Parkway South, Suite 300, TX 77845 - 4375**
Phone: **(979) 458-4969**

Principal Investigator:

Name: **Stephen Hart**
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Address: **100 Northeast Interstate 410 Loop #520, TX 78216 - 4727**
Phone: **(281) 678-4194**

Business Official:

Name: **David Kortenkamp**
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Phone: **(281) 461-7886**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

The goal of this effort is to develop the Multi-agent Anomaly Resolution System (MaARS), which will provide NASA with an Automated Fault Detection, D
TRACLabs and Texas A&M University (TAMU) are well-placed to provide a solution to this topic and address the challenges associated with providing aut

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

MaARS ability to perform automatic fault detection, diagnosis, and resolution for a remote habitat will be of interest to NASA's Artemis (including Gateway) and OSAM missions. Future n

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

The proposed MaARS architecture will benefit several commercial customers and will be offered as an add-on to existing PRIDE customers. For example, Baker Hughes has already exp
Duration: **13**

PROPOSAL NUMBER: 22-1- **T6.08-1473**

SUBTOPIC TITLE: Textiles for Extreme Surface Environments and High Oxygen Atmospheres

PROPOSAL TITLE: NanoLayered Extruded Textiles for Extreme Surface Environments and High Oxygen Atmospheres

Small Business Concern

Firm: **Nanosonic, Inc.**
Address: **158 Wheatland Drive, Pembroke, VA 24136 - 3645**
Phone: **(540) 626-6266**

Research Institution:

Name: **Virginia Polytechnic Institute and State University**
Address: **300 Turner Street Northwest, Suite 4200, VA 24061 - 0001**
Phone: **(540) 231-5281**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 4
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA has identified a need for state-of-the art textile materials in support of the new Exploration Extravehicular Mobility Unit (xEMU) spacesuit that will protect astronauts during lunar surface exploration and operations in extreme environments. NanoSonic is a small, advanced materials company with expertise in additively manufactured (AM) polymers and composites for use in for high oxygen environments. We have worked extensively with our STTR partner, Virginia Tech, on the development of new nanolayer extruded (NLE) filaments and electrospun nonwovens that offer unique properties unavailable through traditional processing methods. In this STTR, NanoSonic offers our NLE processed extreme environment materials as new textiles for the Environmental Protection Garment (EPG) of the xEMU's which acts as the first line of defense on spacewalks. Our related textile materials offer protection from flammability in oxygen-rich atmospheres, although have not been woven or electrospun into their ultimate systems to date. Specifically, our filaments have been evaluated for resistance to combustion in our custom-built vertical burn test chamber within an atmosphere of 36% oxygen and atmospheric pressure. These materials in their panel form passed the vertical burn test for fire retardance in a modified NASA-STD-6001B procedure for material screening. Here, NanoSonic and VT shall work with our partner at Bally Ribbon Mills to weave the new garments. The new textiles shall benefit garments for the International Space Station, Human Landing System (HLS), Artemis, Gateway, and Orion.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Potential NASA applications for NanoSonic and VT's nanolayered extruded textiles include the xEMU as the next-generation spacesuit which will benefit several space programs, namely the International Space Station, Human Landing System (HLS), Artemis, Gateway, and Orion.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Non-NASA applications for the nanolayered extruded materials include terrestrial applications, medical protective equipment, and aerospace systems and material ranging from lightweight COVID killing 3D printed masks to new firefighting turnout gear.
Duration: **13**

PROPOSAL NUMBER: 22-1- **T12.07-1295**

SUBTOPIC TITLE: Design Tools for Advanced Tailorable Composites

PROPOSAL TITLE: Design Tool for Highly Accurate Shape and Structural Evaluation of Space Antennas and Structures made with Tailorable Composites - SMART

Small Business Concern

Firm: **L'Garde, Inc.**
Address: **15181 Woodlawn Avenue, Tustin, CA 92780 - 6487**
Phone: **(714) 259-0771**

Research Institution:

Name: **University of North Texas**
Address: **1155 Union Circle #305250, TX 76203 - 5017**
Phone: **(940) 565-4877**

Principal Investigator:

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Business Official:

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Phone: **(714) 259-0771**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 4
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

For structures used in space communications (e.g., antennas) and structural support (e.g., booms and trusses for solar arrays), it is extremely important to have the ability to predict their deployed shape and structural behavior after they have been stowed for weeks or even months prior to launch. For the STTR proposal to NASA, L'Garde and the University of North Texas (UNT) will develop a design tool for the prediction of the material properties of tailorable composites used in space structural systems, as well as the accurate prediction of their structural and shape behavior, initially focusing on antennas made from membrane surfaces of revolution, e.g., membrane paraboloid with stiffening radial ribs and outer perimeter toroidal ring support. The design tool proposed will enable prediction of the materials properties from the percentage constituents of its elements.

For the Phase I STTR, L'Garde and UNT will collaborate in developing the framework of a design tool that will accurately predict the structural properties and resulting on-orbit surface shape of a "design reference" hybrid antenna that consists of shape memory alloy (SMA) or shape memory composite

(SMC) material and membranous RF reflective surface. For a non-inflated antenna configuration, the radial antenna ribs made of SMA dictate the final surface shape accuracy and hence, it is very critical to have a design tool that can be used to determine the material stiffness, geometric and other structural characteristics – before and after stowage. The design tool developed will also be applicable to other hybrid geometries including space frames and hinge deployers for solar arrays. Both one-way and two-way SMAs will be investigated.

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

A design tool that can predict accurately the kinematic and structural performance of space structures will add to NASA's analytical toolset. The proposed design tool will enable the prediction of the surface shape evolution of dish antennas to within 1mm surface accuracy and includes communication antennas between earth and space, space-to-space communications as well as assessment of the structural capabilities of deployable structural supports for solar panels and other gossamer systems like a very large solar sail.

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

Potential non-NASA applications include use of the design tool to be added to library of analytical codes to augment the suite of analyses in commercially available finite element codes for structural analysis. DoD, industry and academia will also find use for it especially for the prediction of hybrid structures incorporating elements that differ in stiffness by more than an order of magnitude.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T15.04-1855**

SUBTOPIC TITLE: Full-Scale (2+ Passenger) Electric Vertical Takeoff and Landing (eVTOL) Scaling, Performance, Aerodynamics, and Acoustics Investigations

PROPOSAL TITLE: Wind Tunnel and Flight Testing of Scalable Modular Aerial Research Testbed

Small Business Concern

Firm: **Empirical Systems Aerospace, Inc.**
Address: **3580 Sueldo Street, San Luis Obispo, CA 93401 - 7338**
Phone: **(805) 275-1053**

Research Institution:

Name: **Cal Poly Corporation**
Address: **One Grand Ave, CA 93407 - 0035**
Phone: **(805) 756-1645**

Principal Investigator:

Name: **Nick Brake**
E-mail: **nick.brake@esaero.com**
Address: **P.O. Box 595, CA 93448 - 9665**
Phone: **(805) 275-1053**

Business Official:

Name: **Andrew Gibson**
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Address: **3580 Sueldo St., CA 93401 - 7338**
Phone: **(805) 704-1865**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 5
End: 7
Technical Abstract (Limit 2000 characters, approximately 200 words):

The proposed program seeks to mature aerodynamic, aero-acoustic and performance modeling of e-VTOL vehicles during the transition phase of flight through the empirical testing of ESAero's Scalable Modular Aerial Research Testbed (SMART) aircraft. The SMART aircraft is a subscale vertical take-off and landing (e-VTOL) vehicle designed with unique demonstrated capabilities (NASA SBIR Phase II 80NSSC19C0094) to represent multiple different UAM configurations, perform dynamic flight test maneuvers and collect data collection for system identification. During this Phase I effort ESAero, in partnership with Cal Poly San Luis Obispo(RI), will develop the detailed flight test plan, generate expected aerodynamic and acoustic flight test results, and asses the current propulsion and instrumentation systems and develop system upgrades for the SMART vehicle as necessary. These actions will provide the necessary technical inputs to then execute the flight test plan safely during a phase II effort. In Phase I ESAero will also coordinate with the FAA to put in place a part 107 waiver to execute the free flight transition testing in phase II as well.

This effort will allow ESAero to develop a testing capability that will provide a step change in data accessibility for NASA and the wider transportation community. In recent years the development of eVTOL vehicles has observed a ramp-up of initiatives driven by start-up companies that are focused on developing and maturing a proprietary commercial product or service. However, the developments of eVTOL technology bring a series of engineering challenges that must be well understood by regulatory, safety, and government planning agencies at all levels before eVTOLs significantly impact transportation systems. The proposed program will support this transformation by planning for (Phase I) and testing transition phase flight maneuvers (Phase II) with a scalable reconfigurable vehicle designed specifically for eVTOL flight testing.

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

The Phase I effort will make a leap forward toward non-proprietary data validation datasets and a technology testbed for investigating the critical transition phase of flight aiming to serve NASA research teams. The SMART vehicle will provide the AAM National Campaign with an alternative developmental flight test provider and another vehicle provider with the unique aspect of being non-proprietary allowing for increased information exchange and collaboration. Being scalable, non-proprietary, and designed for test will drive demand within NASA.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

ESAero will leverage the increased maturity of SMART developed under this effort to provide a scalable validation vehicle for customers beyond NASA to further push the demonstration and validation of eVTOL technologies. Specific applications include the development of Individual Blade Control rotor technology on the SMART platform funded under the DoD's AFWERX program (Phase I: FA864921P0168)
Duration: **13**

PROPOSAL NUMBER: 22-1- **T4.01-2647**

SUBTOPIC TITLE: Information Technologies for Intelligent and Adaptive Space Robotics

PROPOSAL TITLE: A Software Framework for Advancing Perception Capabilities for Rovers Operating in Harsh Lunar Environments

Small Business Concern

Firm: **Protoinnovations, LLC**
Address: **100 43rd Street, Pittsburgh, PA 15201 - 3100**
Phone: **(412) 916-8807**

Research Institution:

Name: **University of Wisconsin-Madison**
Address: **500 Lincoln Dr, WI 53706 - 1380**
Phone: **(608) 772-0914**

Principal Investigator:

Name: **Dr. Dan Negrut**
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Address: **500 Lincoln Dr, WI 53706 - 1380**
Phone: **(608) 772-0914**

Business Official:

Name: **Dimitrios Apostolopoulos**
E-mail: **da1v@protoinnovations.com**
Address: **100 43 Street, PA 15201 - 3100**
Phone: **(412) 916-8807**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

ProtoInnovations in collaboration with the University of Wisconsin-Madison proposes to architect, design, develop, and validate a **high-fidelity modeling and sensor simulation software and perception algorithms for surface hazard detection in harsh lunar-like environments**. The space robotics community currently lacks an end-to-end software suite that simulates the appearance and granular-terrain mechanics of lunar-like environments. As NASA prepares for progressively complex and longer future lunar surface missions, surface robot systems will require higher performance and autonomy capabilities to carry out mission-critical tasks. This includes performing reliably and traversing successfully through previously unexplored lunar terrain in harsh environments. To achieve this, perception algorithms will need to advance significantly to enable high-performance autonomy in dynamic lunar surface conditions.

For this project we aim to design and develop a software suite consisting of a simulation environment that replicates harsh lunar surface conditions, lunar-terrain mechanics, and exploration rovers with various sensing capabilities. The simulation platform will have interfaces similar to those present on current NASA prototype rovers. This will maximize infusion potential for the deployment of software on future missions utilizing various rover platforms and provide continuous development and monitoring of performance on their digital counterparts. In addition, we will leverage the simulation platform to research, develop and validate perception algorithms to enable object/hazard detection under harsh conditions which commonly occur on the lunar surface: low lighting, oblique lighting, long shadows, permanent shadows, irregular reflectance, and soft soil (lunar regolith), excessive slip and sinkage. Robust perception under these conditions will enable new autonomous capabilities for future surface mobility systems and enhance safe mission operations.

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

Cited as a need in subtopic T4.01, this project focuses on robust rover perception for the purpose of critical hazard detection under extreme conditions to prevent failure scenarios in future lunar surface missions. Additionally, the proposed framework contains some core elements of an end-to-end ground software. This provides a multitude of opportunities for the development of advanced autonomy capabilities pre-fight and could also be developed as an analysis and performance monitoring tool for in-flight use.

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

Advances made in the Chrono environment under this project will enable new simulation capabilities for all-terrain vehicles in defense and earthmoving applications. New perception algorithms for hazard detection in special environmental conditions such as low lighting, long shadows, etc., would be applicable to various field robotic applications in agriculture, defense, and mining.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T6.08-1881**

SUBTOPIC TITLE: Textiles for Extreme Surface Environments and High Oxygen Atmospheres

PROPOSAL TITLE: Spacesuit Cover against the Abrasive Lunar Environment (SCALE) & eXploration Textile for high Oxygen eNvironments (xTON)

Small Business Concern

Firm: **Paragon Space Development Corporation**
Address: **3481 East Michigan Street, Tucson, AZ 85714 - 2221**
Phone: **(520) 903-1000**

Research Institution:

Name: **North Carolina State University at Raleigh**
Address: **Wilson College of Textiles NC State-TECS, Campus Box 8301, NC 27606 - 8301**
Phone: **(919) 515-0257**

Principal Investigator:

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Address: **Wilson College of Textiles NC State-TECS, Campus Box 8301, NC 27606 - 8301**
Phone: **(919) 515-0257**

Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

NASA has entered a new era of human space exploration with the Artemis Program, hoping to establish a long-term presence on the Moon. In order to meet the needs of that program, new textiles will have to be developed to keep astronauts safe, while still enabling them to perform at their best. In the solicitation, NASA has identified two specific areas for textile innovation: (Part A) the Exploration Extravehicular Mobility Unit (xEMU) Environmental Protection Garment (EPG), and (Part B) crew clothing fabrics for shirt-sleeve environments in oxygen-rich atmospheres. Paragon Space Development Corporation (Paragon) and North Carolina State University (NCSU) propose a new EPG for the xEMU, known as the Spacesuit Cover against the Abrasive Lunar Environment (**SCALE**), to address the challenges in Part A, and a new clothing material, known as the eXploration Textile for high-Oxygen eNvironments (**xTON**), to satisfy the requirements in Part B. **SCALE** uses a bio-inspired design, with a hard exterior and soft interior, to give the outer layer of the EPG enough strength to withstand the abrasiveness of lunar dust without reducing its flexibility and comfort. Hard mineral platelets will be grafted on to a soft polymer scaffold in a manner that mimics the Bouligand-type arrangement observed on *Arapaima gigas*, one of the largest freshwater fish in the world. **xTON** clothing will be made from a commercially selected spun yarn. This project proposes to explore a variety of knitting and weaving strategies to develop novel comfort fabrics for the crew. Different test methods will be applied to prototypes of **SCALE** and **xTON**, with a subcontract to a third party (Bud Labs) for the lunar abrasion tests. Finally, Paragon will assess the two materials' TRLs and paths to commercialization.

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

NASA is looking for innovative textiles for spacesuits and crew clothing during the Artemis missions. Two major gaps identified indicate a lack of commercial-off-the-shelf textiles that meet extreme environment requirements and a lack of knowledge of the effects of lunar dust on them. This work will benefit several space programs, including the International Space Station, Human Landing System, Gateway, and Orion. This work will directly benefit NASA with unique technological advancements that contribute to human spaceflight exploration.

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

SCALE applications include commercial space stations and any industries where ruggedized protection may be necessary, ranging from extreme sports to desert applications. **xTON** has fashion spin-off potential and fire-resistant applications for aviation, race car driving, oil rig operations, firefighting, and other industries.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T12.07-1523**

SUBTOPIC TITLE: Design Tools for Advanced Tailorable Composites

PROPOSAL TITLE: Design and Optimization Toolkit for Advanced Tailorable Composites

Small Business Concern

Firm: **CFD Research Corporation**
Address: **6820 Moquin Drive NorthWest, Huntsville, AL 35806 - 2900**
Phone: **(256) 715-6918**

Research Institution:

Name: **University of Dayton Research Institute**
Address: **300 College Park, OH 45469 - 0101**
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Principal Investigator:

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Phone: **(256) 726-4800**

Business Official:

Name: **Silvia Harvey**
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Phone: **(256) 715-6918**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Lightweight, advanced structural materials are needed to enable affordable space exploration beyond lower Earth orbit. Composites have been studied and used for these applications for decades, but are still limited to off-optimal, quasi-isotropic designs. Integration of dissimilar fiber layups and novel matrix materials in the composite structure can lead to significant improvements in material properties and performance. However, there is currently no commercial tool to evaluate and design advanced highly tailorable composites with optimal load paths and minimized thermal expansion coefficients.

In the proposed effort, CFD Research and University of Dayton Research Institute (UDRI) will develop a dual-mode finite element method-based composites design toolkit to model and predict material performance based on various input parameters and loading conditions. Relevant material systems and demonstration cases will be selected in consultation with NASA. Complex mesh generation will be performed in Python, and thermo-structural modeling will be conducted in a well-established FEM software. The toolkit will be flexible, modular, and adopt and open architecture to provide insight into the workflow. Two modes of operation will be enabled: manual parameter selection by the user; and an automated optimization mode, that reads in parameters and constraints from the users, and then performs sensitivity analysis and optimization across the design space.

In Phase I, we will develop the modeling framework and demonstrate key functionality on a representative case. During Phase II, the team will incorporate a detailed composites processing modeling software for more realistic fiber architectures and to assess manufacturability and processing conditions. We will perform microscale damage analysis, and upscale and homogenize material modeling to capture the component or part scale performance under use conditions as part of the overall design workflow.

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

Any NASA application requiring lightweight, advanced materials could benefit from this solution, including:

- pressurized structures, e.g., crew modules/habitats
- dry and unpressurized structures, e.g., thermally stable telescope arrays like the Large Ultraviolet / Optical / Infrared Surveyor, solar arrays, truss structures for landers and rovers
- smaller structural composites, e.g., brackets and hinges
- damage/fatigue-tolerant structures

Directly supports NASA programs including Artemis/HLS, air-launched systems, and next-generation airframes.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

This composite design toolkit will benefit government agencies (DoD, DOE) and contractors (GE, Rolls Royce, Lockheed Martin) developing high-temperature materials for adverse environments, e.g., gas turbine engines, hypersonic vehicles for defense and commercial platforms. Other commercial applications: wind turbine blades, sporting equipment, medical devices and protective equipment, automobiles.

Duration: **13**

PROPOSAL NUMBER: 22-1- T6.08-1716

SUBTOPIC TITLE: Textiles for Extreme Surface Environments and High Oxygen Atmospheres

PROPOSAL TITLE: Multi-Functional Environmental Protection Garment Shell Textile for Extreme Surface Environments

Small Business Concern

Firm: **STF Technologies, LLC**
Address: **18 Shea Way Suite 101-102, Newark, DE 19713 - 3448**
Phone: **(716) 799-5935**

Research Institution:

Name: **University of Delaware**
Address: **210 Hullihen Hall, DE 19716 - 0099**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

New textile and material solutions are needed to meet the challenging environments that will be encountered during extended Lunar exploration missions. We propose a novel textile technology platform combining fibers made from inherently flame retardant and ultra-low temperature compatible materials, new fabric architectures that improve intrinsic dust penetration resistance properties, and tailored finishes/coatings to further improve physical and dust tolerant properties. Hybrid fabric architectures will create flexible but tough environmental protection garment (EPG) textiles that efficiently resist dust and abrasion. Finishes including shear thickening fluid and superhydrophobic coating will be used to maximize physical hazard protection and ease of dust removal. The challenging combination of EPG shell textile requirements necessitates such an approach that leverages all of the potential aspects of fabric design. The base fabric developed for the EPG will possess inherent flame retardant and dust-resistant properties and is amenable to adaptation for use in crew clothing.

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

Space suits - environmental protection garment shell fabrics

Space suits - dust-resistant covers, including gas permeable

Inflatable habitats

MMOD/secondary ejecta shielding and/or stuffed Whipple shields

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

Personal protective equipment

Hazmat (chem-bio) suits

Firefighter turnout gear/flame-resistant clothing

First responder apparel

Duration: **13**

PROPOSAL NUMBER: 22-1- **T8.07-1524**

SUBTOPIC TITLE: Photonic Integrated Circuits

PROPOSAL TITLE: Programmable Photonic Integrated Circuits (PICs) for Radio Frequency (RF) applications

Small Business Concern

Firm: **CFD Research Corporation**
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Phone: **(256) 715-6918**

Research Institution:

Name: **University of Washington**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Reconfigurable and adaptive hardware systems are essential parts of NASA applications due to the unavoidable uncertainties and variations due to extreme operational conditions, radiation effects, modifications of standard and requirements, varying user preferences and high development cost. Moreover, adaptability at the hardware level provides increased flexibility and capabilities. While electronic version of such systems is widely being used in NASA applications, they incur significant size, weight, and power, and cost (SWaP-C).

We propose a photonic reconfigurable hardware, Programmable Photonic Integrated Circuit (PIC), that will have significantly lower SWaP-C compared to electronic counterparts. The proposed programmable PIC will be fabricated using phase change materials (PCM) that enables non-volatile, compact, low-loss, and broadband switches that can be mass produced through well-established integrated circuit (IC) fabrication process.

In spite of the reduction in feature size that can affect resolution and bandwidth, the photonic platform will enable loss-less controlled passage of light and allow the PIC-based spectrometer to provide equal or higher efficiency compared to the state-of-the-art. Also, the compact integrated design will enable constructive augmentations that can improve efficiency without compromising on SWaP-C.

In Phase I, we will work on the design of the programmable PIC using a reduced order modeling (ROM) based simulation platform. We will calculate the performance characteristics, including the sensitivity to key design parameters, and derive guidelines for improved design.

In Phase II, we will optimize the design to meet NASA requirements, build a prototype, and experimentally verify the performance of programmable PIC, including as a function of radiation effects and temperature variations. Promising designs will be delivered to NASA.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The programmable PIC is aligned with multiple NASA 2020 Technology Taxonomy areas like TX05: Communications, Navigation, and Orbital Debris Tracking and Characterization Systems, TX08: Sensors and Instruments, TX10: Autonomous Systems, and TX17: Guidance, Navigation, and Control (GN&C). The ROM-based design and analysis software will be a Cross-Cutting capability that directly supports the efficient development, verification, and qualification of photonics-based instruments to meet a variety of NASA requirements across multiple missions.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The programmable PIC can be applied in a variety of fields that need reconfigurable and adaptive hardware systems. Some examples include developers of micro/nano-satellites, avionics, automotive, telecommunication, consumer electronics and industrial data processing.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T11.06-1681**

SUBTOPIC TITLE: Extended Reality (Augmented Reality, Virtual Reality, Mixed Reality, and Hybrid Reality)

PROPOSAL TITLE: Hyper-realistic Elastically Computed Topologies in Adaptive Reality Environments (HECTARE)

Small Business Concern

Firm: **Diamond Age Technology LLC**
Address: **15714, Crestbrook Drive, Houston, TX 77059 - 5218**
Phone: **(713) 730-9909**

Research Institution:

Name: **University of Colorado Boulder**
Address: **OCG, 3100 Marine Street, Room 481, 572 UCB, CO 80303 - 1058**
Phone: **(303) 735-7821**

Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Hyper-realistic Elastically Computed Topologies in Adaptive Reality Environments (HECTARE) enables detailed terrains at planetary-scale by prioritizing the storage, cache, and retrieval of underlying large-scale, land-form data and generating realistic and interactive surface detail in real-time. This terrain system acts as the backdrop for a scene in which specific geological features, assets, and events can be integrated. To navigate this large-scale terrain while immersed in a conference-room-scale, physical environment, multiple, redirected walking techniques are being explored with particular attention to algorithms that solve for more than one person in the physical space, who are not in aligned virtual spaces. For Phase I, the simulation environment will be used as a testbed for assessing the impact of these redirected walking techniques as well as assessing many other potential capabilities of the simulation environment. Research and development in this simulation environment will include the topics of low-gravity physics, precision of tracking, including when objects are occluded, the realism of avatars, and interactivity of detailed models. In addition to the virtual simulation environment, we will be researching and developing solutions for mixed-reality interfaces that support the handling of tools, interaction with large assets (e.g. habitat), and dynamic walkable terrain through a combination of swarm robotics, props, and haptic gloves. Novel Human-Computer Interfaces (HCI) will be core to the development of this emerging technology as we work at the interface between data-rich, complex digital environments in the virtual world and the complex real-world humans and their physical assets. We anticipate validation of the proposed innovations and technology solutions at TRL-3, by the end of Phase I.

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

Mixed-reality, simulation environments can provide more effective and efficient training tools, and transition to operational infrastructure during live missions. These simulation environments can be applied to the preparation for missions to the Moon and Mars as a training tool for astronauts, a testbed for engineers, a simulation space for mission planners, and a communications medium for public outreach. Real-time terrain models have robotic applications. Phase II physiological digital-twins have application in the Human Research Program.

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

Hyperrealistic simulations are applicable in most industries, particularly those where the work environments and assets are not accessible or pose safety risks. Detailed, large-scale environments have applications in disaster response and process operations facilities. Swarm robotics apply to factory automation. Human digital-twins have applications in medical and retail.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T5.05-2204**

SUBTOPIC TITLE: Advanced Solar Sailing Technologies

PROPOSAL TITLE: Solar Sail Tubular Mast

Small Business Concern

Firm: **Opterus Research and Development, Inc.**

Address: **815 14th Street SouthWest, Suite C200, Loveland , CO 80537 - 6649**
Phone: **(505) 250-3006**

Research Institution:

Name: **Regents of the University of Colorado**
Address: **3100 Marine Street, Room 481, 572 UCB, CO 80303 - 1058**
Phone: **(303) 735-6692**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Solar Sail Tubular Mast (SSTM) is a lightweight version of Opterus' patented High Strain Composite (HSC) Trussed Collapsible Tubular Mast (T-CTM). SSTM is a high-performance truss of tape-springs with structural mass efficiency twice that of trusses of solid rods (e.g. coilable longeron masts) and four times better than traditional non-trussed CTMs. SSTM booms are inherently low cost because they are fabricated using automated and mold-based processes with minimal touch labor. Opterus is currently proving out similar booms (optimized for high load applications) at the 20m (65 ft) length scale using the same materials, tooling, curing, and fabrication equipment that will be used here. Processes are only limited in length by the facility, currently 120m (400 ft). This effort will optimize and develop booms with a linear mass density of less than 50 grams per meter while maintaining the stiffness and strength to support 10,000 m^2 and larger high performance sail systems. SSTM provides a lower cost and lower risk solution by avoiding spin deployment and stabilization complexities. The complexity, challenge, and risk of cable stays (guywires) are similarly not needed with SSTM. Prototype booms will be designed, fabricated, and tested. SSTM is enabling for the next generation of 10,000 m^2 large class solar sails for multiple heliophysics missions including HISM (High Inclination Solar Mission), SPI (Solar Polar Imager), and next generation space weather monitoring missions. SSTM can also enable a faster transit to deep space, which is needed for the Interstellar Probe Mission.

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

While optimized for sail sails, SSTMs are also performance enhancing and enabling for a broad range of deployable boom applications. These include satellite and lunar surface solar power systems, large science antennas and instrument booms, telescope sunshades, telescope occulter systems, and lunar towers.

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

DoD and commercial applications additionally include large communications and sensor platforms. SSTMs are also enabling for large area thermal and RF shield systems.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T13.01-1499**

SUBTOPIC TITLE: Intelligent Sensor Systems

PROPOSAL TITLE: WIRA - Wireless Instrumentation for Rocket Applications

Small Business Concern

Firm: **Interdisciplinary Consulting Corporation**
Address: **5745 Southwest 75th Street, #364, Gainesville, FL 32608 - 5504**
Phone: **(352) 283-8110**

Research Institution:

Name: **University of Florida**
Address: **207 Grinter Hall, PO Box 115500, FL 32611 - 5500**
Phone: **(352) 392-9267**

Principal Investigator:

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Business Official:

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Address: **5745 Southwest 75th Street, #364, FL 32608 - 5504**
Phone: **(407) 697-3697**

Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

The Interdisciplinary Consulting Corporation (IC2), in collaboration with the Interdisciplinary Microsystems Group at the University of Florida (UF), proposes to develop a wireless instrumentation system, including both data acquisition and sensors, that reduces the high costs and complexity of deployment, use, and maintenance of traditional centralized, wired instrumentation systems, while meeting the requirements of current rocket-propulsion ground testing applications and potentially other ground-based and in situ space-flight testing.

Traditional instrumentation systems and providers often promote a single type of general-purpose data-acquisition channel that can “do it all”, or at most a few different types of data channels targeting specific applications. However, few of the potentially hundreds of different types of sensors require the full capabilities of each channel in the general-purpose system. This results in bulky, overly complex systems that do not make full use of the system’s capabilities, resulting in increased cost, power consumption, and data communication requirements for the entire instrumentation system.

The proposed innovation replaces the centralized, high-cost, high-performance instrumentation system with a distributed network of wireless, low-cost, requirement-optimized smart sensor nodes. The requirement-optimized hardware, reduced deployment costs, improved data accuracy, and increased installation flexibility are provided by removing wiring constraints, creating a system with a higher total value per channel. The system also allows for continual sensor health monitoring by distributing some intelligence to each node and will ensure the data collected with the system will be NIST traceable. These innovations provide the customer with the ability to significantly increase the total number of deployed measurement points for less than the total system deployment cost of traditional wired instrumentation systems.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

This system not only benefits the testing of next-generation rocket propulsion systems, but adds to the capabilities of the NASA Stennis Space Center, Marshall Space Flight Center, and the Propulsion Test Office at White Sands Test Facility (WSTF). It is also viable for other NASA ground- and flight-test facilities due to the ease of the system’s deployment. The system capabilities could also be expanded beyond rocket-propulsion ground test to include monitoring during other ground tests and potentially in situ testing including spaceflight.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

This system could also find use in a multitude of research, defense, and commercial applications where precision measurements are required in difficult to install locations or retrofitted into infrastructure that is unconducive to wired systems. Including commercial aerospace test infrastructure, harsh chemical processing and manufacturing facilities, and power infrastructure.
Duration: **13**

PROPOSAL NUMBER: 22-1- **T15.04-1048**

SUBTOPIC TITLE: Full-Scale (2+ Passenger) Electric Vertical Takeoff and Landing (eVTOL) Scaling, Performance, Aerodynamics, and Acoustics Investigations

PROPOSAL TITLE: Integrated High Lift Propulsor

Small Business Concern

Firm: **Wayfarer Aircraft Research and Development**
Address: **8505 Rockledge Road, La Mesa, CA 91941 - 7923**
Phone: **(619) 841-2359**

Research Institution:

Name: **Embry-Riddle Aeronautical University-Daytona Beach**
Address: **600 S. Clyde Morris Blvd., FL 32114 - 3900**
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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

Wayfarer Aircraft and Embry-Riddle Aeronautical University propose to gather full scale aerodynamic and acoustic flight test data of a novel type of distributed electric propulsion called the Integrated High Lift Propulsor (IHLP) by modifying an existing instrumented research aircraft. The IHLP substantially increases cruise efficiency and reduces the thrust and power required for lift augmentation via blowing. As a fundamental aerodynamic device, the IHLP is applicable to many aircraft types, sizes, and missions, including uncrewed and piloted Advanced Air Mobility, public safety, and military applications.

The overall program will characterize the aerodynamic and acoustic performance of the IHLP with variation of key parameters, clearing technical risk to enable incorporation on new or modified aircraft designs. The high-quality flight test data collected will also validate and improve design and analysis tools, including the ability to correctly capture design variations.

This Phase I proposal will leverage Embry-Riddle's extensive hybrid/electric flight research experience and capability, combined with Wayfarer's existing IHLP research to predict the propeller-wing interactions and overall vehicle performance, develop the flexible and rapidly reconfigurable research testbed design, and develop the flight test plan for acquisition of high-quality flight test data in Phase II. The modification of an existing research aircraft into a reconfigurable distributed electric propulsion testbed will enable a rapid and cost-effective STTR program gathering high quality data with broad industry relevance.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed research supports the objectives of the NASA ARMD Strategic Implementation Plan for ultra efficient subsonic aircraft as well as safe, quiet and affordable Advanced Air Mobility (AAM) vehicles, advances technology to increase aircraft efficiency and reduce GHG (NASA Climate Action Plan Priority 5), and will supply research quality validation data for the Transformational Tools and Technologies Project (TTT).

NASA Technological Taxonomy TX15.1.1, TX15.1.4, TX15.1.5, TX15.1.6
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

The IHLP will increase cruise efficiency and reduce the thrust and power required for Distributed Electric Propulsion, resulting in higher performance, more efficient, and more economical aircraft in defense, public safety roles such as disaster response and air ambulance, and many civil markets including super STOL, thin-haul, regional mobility, and short haul cargo.
Duration: **13**

PROPOSAL NUMBER: 22-1- **T4.01-2229**

SUBTOPIC TITLE: Information Technologies for Intelligent and Adaptive Space Robotics

PROPOSAL TITLE: Rad-Hard Adaptive Dual-Mode Event-Based Vision and Perception for Autonomous Robot Operations

Small Business Concern

Firm: **Alphacore, Inc.**
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Research Institution:

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 4
End: 6
Technical Abstract (Limit 2000 characters, approximately 200 words):

In response to NASA STTR topic T4.01, Information Technologies for Intelligent and Adaptive Space Robotics, Alphacore Inc. in partnership with the Arizona State University (ASU) School of Earth and Space Exploration will develop a low-SWaP-C, high-performance, *extreme* perception and vision system for autonomous robot operations. Our novel radiation-hard adaptive dual-mode neuromorphic (event-based) vision system configuration is designed to provide terrestrial autonomous robot-comparable 3D object detection, depth estimation, mapping, and tracking functionality for future use on lunar and planetary surfaces.

Our approach is to recognize that ultra-high performance terrestrial state-of-the-art image processing microelectronics hardware likely will not be available. To address this constraint, our solution is to instead selectively reduce or throttle the image data from the image sensors to the downstream image processing microelectronic hardware. By selectively (and significantly) reducing the image data rate from the camera(s), lower performance space-qualifiable image processing electronics will then be able to provide the needed functionality on the now much sparser information from image data. The challenge is reducing the image data rate, while still providing the terrestrial-comparable state (pose and velocity) estimation, 3D object detection, depth estimation, mapping, and tracking functionality needed for autonomous operations.

We propose to solve this challenge by replacing existing conventional space-grade CMOS frame-based cameras with a novel radiation-hardened version of a Dynamic and Active Pixel Vision Sensor (DAVIS) dual-mode image sensor , which combines a conventional global-shutter CMOS camera with an event-based image sensor (EBS) in the same pixel array. In practice, event-based image sensors can reduce the downstream computational burden by an estimated one to two orders of magnitude.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

Future NASA missions that could benefit from these advancements include the Lunar Gateway, expected to be unmanned for 92% of the time and thus, rely heavily on robotic systems for maintenance and repair, and a planned 'tunnel-bot' to pierce through the icy surface on Europa to study the space underneath. It can also help the Cold Operable Lunar Deployable Arm (COLDArm) project, one of NASA's technologies being developed to enable future missions to extreme environments on the Moon, Mars, and ocean worlds such as Jupiter and Saturn moons.

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

Alphacore's solution can be applied for use in maintenance and repair of defense and commercial space systems. Alphacore's radiation-hardened perception technology can help add autonomous capabilities to defense unmanned aerial vehicles and autonomous terrestrial platforms, such as future robotic combat vehicles and optionally manned fighting vehicles.
Duration: **13**

PROPOSAL NUMBER: 22-1- **T4.01-1810**

SUBTOPIC TITLE: Information Technologies for Intelligent and Adaptive Space Robotics

PROPOSAL TITLE: Microgravity Environment Autonomy for Robotic Spacecraft (MEARS)

Small Business Concern

Firm: **Orbit Logic, Inc.**
Address: **7852 Walker Drive, Greenbelt, MD 20770 - 3208**
Phone: **(301) 982-6232**

Research Institution:

Name: **University of Dayton Research Institute**
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Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 1
End: 3
Technical Abstract (Limit 2000 characters, approximately 200 words):

Orbit Logic is teamed with the University of Dayton Research Institution (UDRI) to develop the Microgravity Environment Autonomy for Robotic Satellites (MEARS) solution. MEARS is an effort to merge existing technology elements associated with robotic asset onboard sensing and perception, autonomous planning and response, and inter-asset communication for coordination – into a high-reliability architecture that leverages the ROS 2 (and the evolving Space ROS) open software projects to facilitate data interaction between modular elements. Orbit Logic is bringing our mature Autonomous Planning System (APS) solution for asset-level resource planning and decentralized planning to accomplish mission-level goals with a team of heterogeneous, networked assets. UDRI is bringing its motion control, trajectory planning and team navigation planning capabilities, which have been realized in their Real-Time Adaptable Autonomy Kernel solution (RT-AAK), components of which can be flexibly built and deployed to CPU, GPU and FPGA-based computing resources. UDRI is employing advanced online learning-enabled model predictive control (MPC) techniques to achieve effective AI/ML capabilities. Both APS and RT-AAK are modular, layered solutions with strong synergy that together will be highly enabling technology for a variety of space robotic applications. The Phase I effort will define a unified architecture combing the technologies, using ROS 2 as the mechanism for standardizing the module interfaces to ensure interoperability. This work will be intentionally aligned with the ongoing work of the Space ROS initiative. Our initial use cases will target robotic team collaborative mission in microgravity environments, notably operations of heterogeneous teams in asteroid fields with initially unknown and highly dynamic objects of interest. UDRI's Autonomous Systems Lab, with hardware in the loop and high-fidelity dynamics simulation, will be used for prototype verification and validation.

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

MEARS will be highly applicable to exploration missions targeting the asteroid belt, comets, Mars and the outer planets. Significant communication delays to and from Earth makes it essential that individual swarm assets employ adaptive decision-making and coordinate effectively to operate successfully in challenging dynamic environments. Reliability is of paramount importance for these distant missions. MEARS will incorporate high-heritage technologies such as CFE/CFS and Space ROS for mission assurance.
Potential Non-NASA Applications (Limit 1500 characters, approximately 150 words):

Heterogeneous air/ground teams for search and rescue and fire prevention/mitigation. Mine detection/mitigation. Cave exploration/rescue. Mapping/acquisition for data analytics. Underwater vehicles performing bottom survey and feature inspection. Highly reliable autonomy software for space station inspection/maintenance. Complex multi-vehicle rendezvous and docking.
Duration: **13**

PROPOSAL NUMBER: 22-1- **T5.04-2446**

SUBTOPIC TITLE: Quantum Communications

PROPOSAL TITLE: Diamond Quantum Memory

Small Business Concern

Firm: **Systems & Processes Engineering Corporation**
Address: **4120 Commercial Center Drive, Suite 500, Austin, TX 78744 - 1068**
Phone: **(512) 479-7732**

Research Institution:

Name: **University of California - Santa Barbara**
Address: **California Nanosystems Institute, Elings Hall, CA 93106 - 6105**
Phone: **(805) 893-8089**

Principal Investigator:

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Business Official:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2

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

As quantum systems for information processing and communication continue to grow in size and complexity, novel methods of transferring and storing quantum information are needed. Quantum memory elements must retain quantum information much longer than their processing counterparts, transfer information quickly and efficiently to and from processing and flying qubits, be capable of heralding entanglement and teleportation events across a quantum network, and be scalable to large numbers of qubits. Hybrid mechanical systems, which use mechanical oscillators to control and connect quantum elements, are poised to fulfill just such a role and have grown in prominence in recent years due to their ability to couple to a wide variety of quantum systems and the number of practical advantages mechanical systems have over their photonic analogues. Furthermore, optomechanical crystal (OMC) devices, which leverage interactions between light and mechanical motion, have demonstrated many of the requirements for quantum memories. We seek to build upon previous efforts at implementing an OMC quantum memory by using diamond as a host material and coupling our diamond OMCs to a highly-coherent silicon-vacancy center spin as a long-lived quantum memory element. By adding this additional memory component and using diamond as our host material, we aim to develop a quantum memory and quantum communication platform that is resistant to optical absorption heating that has plagued silicon implementations and which can be scaled up and integrated into large-scale quantum networks.
Potential NASA Applications (Limit 1500 characters, approximately 150 words):

The proposed diamond quantum memory will serve as a a scalable building block for quantum network nodes, providing an integrated quantum memory and quantum entanglement distribution system for NASA's goal of developing a quantum network for distributed quantum computing and sensing applications.

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

The proposed system fulfills an anticipated need in the commercial quantum computing sector for quantum networking elements between diverse implementations of quantum computers. By enabling links between quantum processing nodes, our system will expand the possibilities for and power of distributed quantum computation for commercial applications in quantum cryptography and quantum simulation.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T13.01-2230**

SUBTOPIC TITLE: Intelligent Sensor Systems

PROPOSAL TITLE: Machine-Learning (ML) Enabled Reliable Multi-Modal Sensor Operation for Rocket Propulsion Systems

Small Business Concern

Firm: **Alphacore, Inc.**
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Research Institution:

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Principal Investigator:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 2
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Alphacore and its Research Partner, Arizona State University, will develop a framework for self-calibrating sensors, backed by artificial intelligence with in-field calibration capabilities. In Phase I we will prove the feasibility of our approach by modeling MEMS and electronics-based pressure, temperature, strain, and acoustics sensors, designing electrical tests to correlate with physical characteristics, and designing a hardened parametrizable self-test IP. In Phase II we will fabricate test and prototype circuits that implement and validate the work done in Phase I, as well as extend the concepts developed in Phase I to other types of sensors.

Phase I of this program will target capacitive pressure sensors, electronics-based temperature sensors, and a MEMS based acoustic sensors. In developing the self-test IP, Alphacore will make every effort to accommodate a large portion of the commercially available collection of MEMS sensors. The self-test IP specifics will be determined based on research on commercially available devices.

This project will develop methodologies for 2-tier calibration of sensor-based machine learning systems. The goal of sensor front-end calibration is to maintain highest level of sensor performance throughout the operation. To this end, the sensor hardware is monitored and calibrated continuously in real-time based on the readings built-in self-test monitors. These monitors are implemented as electrical excitation units with an area overhead less than 5% and negligible performance impact. The monitors can be used for extracting sensor performance as well as determining an error model to calibrate the software. Sensor hardware calibration can be in terms of changing bias conditions or determining sensor offset and sensitivity that converts the voltage/current reading back to the value of the physical stimulus, i.e., pressure or acceleration.

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

Alphacore's intelligent sensors will give NASA the ability to monitor the performance and the level of strain within test structures and systems, helping engineers access more accurate info to guide advancements and risk mitigation in future systems designs. Prominent programs include propulsion system testing at Stennis Space Center, Artemis II crew vehicle and Space Launch System, the Lunar Gateway, Moon-to-Mars, and the Origin Space Telescope as well as mission concepts such as the FARSIDE, LUVOIR, HabEx, Lynx X-ray Observatory and AXIS.

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

Primary customers for monitoring sensor are in testing and designs to modernize defense capabilities like missile launch systems and nanosatellite constellations for hypersonic missile defense. Commercial spaceflight and re-launchable vehicles and satellite-based weather, global intelligence companies, high-speed vehicles, flight control systems, and autonomous vehicles can use proposed sensors.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T8.07-2014**

SUBTOPIC TITLE: Photonic Integrated Circuits

PROPOSAL TITLE: Electro-Optic Photonic Integrated Circuits in Thin Lithium Niobate

Small Business Concern

Firm: **Phase Sensitive Innovations, Inc.**
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Phone: **(302) 286-5191**

Research Institution:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 1
End: 4
Technical Abstract (Limit 2000 characters, approximately 200 words):

Lithium niobate ($LiNbO_3$) has been a widely used electro-optic (EO) material since the 1970's. Large electro-optic (EO) coefficients and lower third-order nonlinearity compared to other III-V materials (e.g., InP, Si) make $LiNbO_3$ an ideal candidate for active photonic devices. Although indium phosphide (InP) and silicon (Si) -based foundries are already established, a $LiNbO_3$-based foundry is something unimaginable until now. Recently, advances in crystal ion sliced (CIS) films of $LiNbO_3$ on insulator (TFLNOI), which guide optical modes almost 20 times smaller than their bulk-$LiNbO_3$ counterparts have emerged as an answer to some of these issues. Now, strip-loaded waveguides can be used to tightly confine the optical mode, allowing smaller electrode gaps, decreased $V\pi$, tighter bending radii and PIC compatibility. With this advance in thin-film technology, photonic integrated circuits (PICs) in the $LiNbO_3$

platform can now be realized, paving the way for future $LiNbO_3$ platform-based foundries. Our goal is to investigate fundamental building blocks for TFLNOI PICs and ultimately demonstrate the utility of these unit-cells to produce an EO modulator that will reduce the footprint of standard Mach-Zehnder Modulators and bring improved DC and high-frequency EO response.

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

Thin-film $LiNbO_3$ on insulator (TFLNOI) PICs can be leveraged for: analog photonic links that possess gain, THz/sub-mmW/mmW sensing, antenna remoting, optical switching, generating entangled photon pairs, etc. In addition to being useful for many applications, TFLNOI is chemically stable, enables the replacement of heavy coaxial cable with lightweight electromagnetic interference insensitive fiber. The proposed research has potential use in systems both on and off of this planet for NASA.

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

A reduction in SWaP-C, in comparison to currently existing $LiNbO_3$ devices. TFLNOI PICs outperform conventional Si PICs in terms of operational bandwidth and optical power handling making them ideal for next generation links. The technology can provide a method to layout devices akin to Si photonics without experiencing the struggle of process development and device modelling.

Duration: **13**

PROPOSAL NUMBER: 22-1- **T10.05-2368**

SUBTOPIC TITLE: Integrated Data Uncertainty Management and Representation for Trustworthy and Trusted Autonomy in Space

PROPOSAL TITLE: The Exploration Medical Ecosystem Design Infrastructure (ExMEDI): system to build trust within Cyber-Physical-Human (CPH) teams.

Small Business Concern

Firm: **NYRAD, Inc**
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Phone: **(321) 482-4944**

Research Institution:

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Summary Details:

Estimated Technology Readiness Level (TRL) :
Begin: 3
End: 5
Technical Abstract (Limit 2000 characters, approximately 200 words):

In conventional practice, medical systems requirements for human spaceflight are considered towards the end of the project's space systems engineering phases, leaving little room for the integral medical requirement codification within spacecraft design parameters (NASA ExMC, 2021). As mission character increases in length and remoteness, the level of care and required medical capabilities increase dramatically, stressing the need for human-centered focus (Lyons, 2018). The longer and more remote the mission, the greater the need for human-centeredness. This can be achieved by incorporating a human-centric approach from the early stages of defining key mission architecture parameters and constraints of mission and vehicle/habitat planning. "[Human] spaceflight has reached a critical moment where the transition to a human-centric mission architecture must become a reality if exploration missions are to succeed" (Antonsen, 2017).

The Exploration Medical Ecosystem Design Infrastructure (ExMEDI) is a Cyber-Physical-Human (CPH) medical ecosystem that will support the health, medical autonomy, and decision-making of crews during future space missions. ExMEDI will facilitate (A) specification of medical capabilities required for specific future spaceflight contexts, and integrate (B) in-flight onboard support of crew's health during the mission.

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

Gateway and Artemis human lunar exploration system for crew health and performance would benefit greatly from the ExMEDI system. Other human deep space exploration endeavors in the future including asteroids and Mars would also find this system useful.

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

There is a huge increase in commercial human space exploration which will need autonomous on-board medical systems such as ExMEDI in both LEO and deep space. As well this type of autonomous medical assistance technology will be useful for isolated terrestrial human platforms such as Antarctica, oil and natural resource platforms, undersea exploration and military deployments.

Duration: **13**
