NASA STTR 2022-II Solicitation

PROPOSAL NUMBER:	22-2- **T5.04-1819**
PHASE 1 CONTRACT NUMBER:	80NSSC22PB154
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: **University of Illinois at Urbana-Champaign**
Address: **1110 West Green Street, IL 61801 - 3003**
Phone: **(217) 333-9116**

Principal Investigator:

Name: **Dr. Christopher Evans**
E-mail: **cevans@psicorp.com**
Address: **20 New England Business Center, MA 01810 - 1077**
Phone: **(978) 738-8159**

Business Official:

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

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Within this program, Physical Sciences Inc. (PSI) and the University of Illinois Urbana-Champaign (UIUC) are developing 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 550 characters):

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 400 characters):

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: **24**

PROPOSAL NUMBER: 22-2- **T5.05-2115**

PHASE 1 CONTRACT NUMBER: 80NSSC22PB198

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:

Name: **Sergey Sarkisov**
E-mail: **mazillo@hotmail.com**
Address: **515 Sparkman Drive, Suite 122, AL 35816 - 3417**
Phone: **(256) 489-0081**

Business Official:

Name: **Sergey Sarkisov**
E-mail: **mazillo@hotmail.com**
Address: **515 Sparkman Drive, Suite 122, AL 35816 - 3417**
Phone: **(256) 489-0081**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

NASA is seeking advanced thin-film protective coatings for sail-embedded photovoltaic (PV) solar cells. SSS Optical Technologies, LLC (SSSOT) together with Oakwood University and Solestial, Inc. proposes to develop the Polymer Anti-damage Nanocomposite Down-converting Armor (PANDA) coating that uses a polymer nanocomposite impregnated with luminescent nanoparticles (NPs) that absorb solar ultraviolet (UV) radiation and convert it into visible light suitable for PV cells. There are three innovations: (1) By absorbing solar UV PANDA improves UV stability of the solar cell; (2) PANDA combines UV shielding with the use of UV, otherwise wasted, in production of extra electricity; (3) PANDA shields the cell from high-energy cosmic radiation. During Phase I project we evaluated the feasibility of PANDA using three types of solar cells: silicon heterojunction (SHJ) from Solestial, Inc., Copper-Indium-Gallium-Selenide (CIGS) and inverted metamorphic multijunction (IMM). The cells are considered as candidates for space applications due to their light weight and flexibility. Major results of Phase I project are: (1)

PANDA coating improved the conversion efficiency of the cells by up to 5%; (2) for all three types of cells PANDA UV stability; (3) computer simulations indicated that 20-micron-thick PANDA can fully shield the solar cells from 1-MeV protons reducing radiation damage by a factor of 4. The overall goals of the Phase II effort will be (1) to optimize PANDA coating (composition, structure, and application methods) and obtain maximal conversion efficiency and operational lifetime of the coated solar cells; (2) to verify experimentally PANDA's ability to improve radiation tolerance of the coated solar cells. TRL level 5 is expected by the end of Phase II. Deliverables will include experimental data, test reports, and final technical report.
Potential NASA Applications (Limit 550 characters):

If successful, the proposed technology can be implemented as "UV stable thin-film protective coating for sail-embedded power-generation…" requested within Scope "Next-Generation Solar Sail System Technologies for Enhanced and Enabling Sailing" of topic T5.05 "Advanced Solar Sailing Technologies", Focus Area 5 "Communications and Navigation" of NASA FY 2022 STTR Solicitation.

Potential Non-NASA Applications (Limit 400 characters):

Major potential non-NASA applications of PANDA technology in the government and commercial sectors is the improvement of the efficiency of solar PV panels while protecting them from harmful UV radiation of the Sun and increasing their lifetime.The customers would be national grids and rural communities, and municipalities and private entities concerned with surveillance.

Duration: **24**

PROPOSAL NUMBER: 22-2- **T12.07-2715**

PHASE 1 CONTRACT NUMBER: 80NSSC22PB081

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**
Address: **345 Goodwin Hall, VA 24061 - 0218**
Phone: **(540) 231-4881**

Principal Investigator:

Name: **Myles Baker**
E-mail: **mbaker@m4-engineering.com**
Address: **4020 Long Beach Boulevard, CA 90807 - 2683**
Phone: **(562) 305-3391**

Business Official:

Name: **Kevin Roughen**
E-mail: **kroughen@m4-engineering.com**
Address: **4020 Long Beach Boulevard, CA 90807 - 2683**
Phone: **(562) 981-7797**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

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 550 characters):

- 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 400 characters):

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

- Unmanned aircraft
- Commercial spacecraft and launch vehicles

Duration: **24**

PROPOSAL NUMBER: 22-2- **T13.01-1499**

PHASE 1 CONTRACT NUMBER: 80NSSC22PB057

SUBTOPIC TITLE: Intelligent Sensor Systems

PROPOSAL TITLE: WIRA - Wireless Instrumentation for Rocket Applications

Small Business Concern

Firm: **Interdisciplinary Consulting Corporation**
Address: **2405 Northwest 66th Court, Gainesville, FL 32653 - 1633**
Phone: **(352) 283-8110**

Research Institution:

Name: **University of Florida**
Address: **P.O. Box 116200, FL 32611 - 6200**
Phone: **(352) 392-3983**

Principal Investigator:

Name: **William Patterson**
E-mail: **cpatterson@thinkic2.com**
Address: **5745 Southwest 75th Street, #364, FL 32608 - 5504**
Phone: **(352) 283-8110**

Business Official:

Name: **David Mills**
E-mail: **dmills@thinkic2.com**
Address: **2405 NW 66th Ct, FL 32653 - 1633**
Phone: **(352) 283-8110**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The Interdisciplinary Consulting Corporation (IC2), in collaboration with 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 550 characters):

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 400 characters):

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: **24**

PROPOSAL NUMBER: 22-2- **T10.05-1152**

PHASE 1 CONTRACT NUMBER: 80NSSC22PB011

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**
Phone: **(515) 294-6938**

Principal Investigator:

Name: **Dr. Michael Fowler Ph.D.**
E-mail: **michael.fowler@elderresearch.com**
Address: **300 West Main Street, Suite 301, VA 22903 - 5575**
Phone: **(540) 266-0671**

Business Official:

Name: **Debbie Owen**
E-mail: **debbie.owen@elderresearch.com**
Address: **300 West Main Street, Suite 301, VA 22903 - 5575**
Phone: **(434) 973-7673**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Cyber-Physical-Human (CPH) teams are a key component of future space missions, such as the Artemis missions that will establish a lunar presence via autonomous agents, and future Martian exploration. To achieve mission goals, CPH teams will require machine agents with a high

degree of autonomy. If an entire system encompassing a CPH team is to be considered trustworthy and to be trusted, all members of that system—both human and machine–need to be considered trustworthy. This hinges on accurate and relevant data being provided to all members of that team in real-time to make a decision that impacts the system.

Additionally, there can be issues in spacecraft operations due to the deep institutional knowledge required of SMEs with deep training and expertise. When SMEs leave an operations team, this institutional knowledge may not be passed onto other team members, and the training process can be time consuming and costly. This knowledge is not necessarily transferable to other systems, due to the specialized nature and architecture of each spacecraft and its mission. Developing efficient system modeling and decision-making algorithms that can be implemented on multiple platforms can overcome this challenge and reduce costs for operating teams.

The potential for inclusion of physics-based priors into the learning process for UDEs has great potential for trustworthiness and trust in CPH teams. This is, in part, due to the fact that it is possible to extract a closed-form solution from UDE-based models. These equations are readily interpretable by human scientists, engineers, or other collaborators who may need to investigate or validate the representation of data learned by a machine teammate. We are focusing on how uncertainty quantification from two sources can be fused into one representation that is conducive to decision-making. We will create and implement techniques for decision-making and control that build upon this work in integrated uncertainty quantification.

Potential NASA Applications (Limit 550 characters):

Potential NASA applications cover a large number of domains due to the need to have trusted control, including satellite constellation proximity operations and mission performance optimization with cislunar operations and Artemis missions. It also applies to remote exploration vehicles in uncertain terrains and even safety-critical controls on air and space vehicles.

Potential Non-NASA Applications (Limit 400 characters):

Because of its application to safety critical control systems, this technology is also applicable for most critical infrastructure information monitoring and control systems. This can include mechanical systems seen in commercial aircraft, especially for engine monitoring, and in the control of nuclear power plants, electrical power grids, and water distribution and treatment.

Duration: **24**

PROPOSAL NUMBER: 22-2- **T15.04-1263**

PHASE 1 CONTRACT NUMBER: 80NSSC22PA965

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) 865-6720**

Principal Investigator:

Name: **Juliet Page**
E-mail: **Juliet.Page@BlueRidgeResearch.com**
Address: **29 N Market St, Suite 700, NC 28801 - 2983**
Phone: **(410) 507-0764**

Business Official:

Name: **Josh Mellon**
E-mail: **josh.mellon@blueridgeresearch.com**
Address: **29 N Market St, Suite 700, NC 28801 - 2983**
Phone: **(828) 252-2209**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Current state-of-the-art aeroacoustic models for multi-rotor electric Vertical Takeoff and Landing (eVTOL) aircraft lack sufficient validation against full-scale measurements. This research will advance the state of the art by expanding the capabilities of current aeroacoustic models and by acquiring research-quality acoustic measurements of Archer Aviation's full-scale, multi-rotor eVTOL aircraft, Midnight. These innovations will meet NASA's need to validate aeroacoustic models for full-scale, multi-rotor eVTOL aircraft. Validated aeroacoustic models will enable NASA and the advanced air mobility industry to identify vehicle configurations and operations that drive community noise, expand the understanding of eVTOL acoustic emissions, and accelerate the design cycle of full-scale eVTOL aircraft.

Blue Ridge Research and Consulting (BRRC) is partnered with The Pennsylvania State University to acquire research-quality acoustic measurements and to validate aeroacoustic models of full-scale, multi-rotor eVTOL aircraft. The team will expand the capabilities of state-of-the-art aeroacoustic models to better predict rotor-rotor and rotor-structure interactions,

broadband self-noise, turbulence ingestion noise, and stochastic noise source modulation. In partnership with Archer Aviation, the team will conduct model-informed acoustic flight tests of Midnight. The flight tests will gather research-quality acoustic data at flight conditions expected to produce rotor-rotor and rotor-structure interactions. The team will analyze the measured acoustic data to validate the aeroacoustic models for full-scale, multi-rotor eVTOL aircraft.

The team will deliver the aeroacoustic models, detailed flight test plans, and flight test data archives to NASA. The flight test data archives will include aircraft geometry and performance data, research-quality acoustic measurements, and meteorological data to support NASA's model validation efforts for full-scale eVTOL aircraft.

Potential NASA Applications (Limit 550 characters):

The proposed innovations support NASA's Aeronautics Research Mission Directorate's strategic thrust #4 for quiet vertical lift air vehicles. The acoustic measurements of Midnight will provide NASA with a research-quality dataset to validate aeroacoustic models of full-scale, multi-rotor eVTOL aircraft, with an emphasis on rotor-rotor and rotor-structure interactions. The acoustic measurements will also support NASA researchers in assessing community responses to eVTOL noise.

Potential Non-NASA Applications (Limit 400 characters):

The proposed innovations will support the advanced air mobility industry's need to design quiet eVTOL aircraft and operations. Validated aeroacoustic models will accelerate the design cycle of eVTOL aircraft by enabling industry and other government organizations to evaluate noise while designing vehicles and operations, siting vertiports, planning land use compatibility, and writing regulations.

Duration: **24**

PROPOSAL NUMBER: 22-2- **T7.04-2186**

PHASE 1 CONTRACT NUMBER: 80NSSC22PB076

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.**
Address: **12555 West 52nd Avenue, Arvada, CO 80002 - 0000**
Phone: **(908) 577-4014**

Research Institution:

Name: **Michigan Technological University**
Address: **1400 Townsend Drive, MI 49931 - 1200**
Phone: **(906) 487-3253**

Principal Investigator:

Name: **Andrew Gemer**
E-mail: **aj@lunaroutpost.com**
Address: **12555 W. 52nd Ave, CO 80002 - 1234**
Phone: **(720) 987-4060**

Business Official:

Name: **Julian Cyrus**
E-mail: **julian@lunaroutpost.com**
Address: **17700 S. Golden Rd. #102, CO 80401 - 6019**
Phone: **(973) 738-3885**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The proposed and executed innovation is a software analysis toolset that can inform basic structural archetype requirements and construction methods and their quantitative capabilities. This tool considers a variety of design requirements including surface flatness, obstacle mitigation, relative density (compaction), gradient, size, location/orientation, expected loads, minimal energy consumption, etc. There is an inherent need for analysis tools like this to advance the infrastructure development and overall capability set of lunar surface exploration. These infrastructure features include foundations, landing pads, roadbeds, berms, ramps, trenches, excavations, and protected compaction structures. These structures are analyzed using designs and design methodologies for selecting and building necessary bulk regolith structures; test results informing the decisions and assumptions within the methodologies; and a construction system plan and concept of operations (CONOPS).

Following completion of the REGOWORKS 2.0 in Phase II and its calibration with certain experimental compaction and other data, the tool will be used to simulate the preparation of a lunar landing pad construction CONOPS which will be compared to the lunar surface site preparation experimental work that is being performed for the LuSTR21 grant by LO and MTU. REGOWORKS 2.0 data will be validated against real-world performance tests that will complete hardware-in-the-loop tests for regolith compaction. Once the tool is validated and grounded from these tests, it will be used for design and analysis in CAD and later prototyped to interface with existing Lunar Outpost robotic systems to test the capabilities to create compacted layers of regolith needed for all the site preparation structures.

Potential NASA Applications (Limit 550 characters):

The proposed capability addresses NASA's Moon-to-Mars Strategy by establishing infrastructure capabilities for lunar power generation and distribution, communications architectures, precision landing capabilities, local/regional/global surface transportation and mobility, surface depots, in-situ construction techniques, lunar habitats, and other capabilities tied to NASA's Artemis program.

Potential Non-NASA Applications (Limit 400 characters):

REGOWORKS will help commercial industry establish infrastructure critical for a vibrant lunar economy. The proposed technology and tools may support crewed and robotic missions in the coming decade through improved safety, more sustainable infrastructure, mission precursor risk reduction techniques, and expanded architectural designs for surface infrastructure.

Duration: **24**

PROPOSAL NUMBER: 22-2- **T10.04-2569**

PHASE 1 CONTRACT NUMBER: 80NSSC22PB230

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**
E-mail: **swhart@traclabs.com**
Address: **100 Northeast Interstate 410 Loop #520, TX 78216 - 4727**
Phone: **(281) 678-4194**

Business Official:

Name: **David Kortenkamp**
E-mail: **korten@traclabs.com**
Address: **100 Northeast Interstate 410 Loop #520, TX 78216 - 4727**
Phone: **(281) 461-7886**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

We propose the Multi-Agent Anomaly Resolution System (MaARS) for Automated Fault Detection, Diagnostics and Recovery (AFDD-R). Of specific interest is how MaARS can use robotic agents to support the operation & maintenance of habitats on lunar or planetary surfaces or in orbital stations such as Gateway when no human crew is present. Managing such remote robotic agents and spacecraft in the presence of severe communication constraints and limited situational awareness presents a number of challenges---particularly when unexpected faults may require immediate detection and response. To address these challenges, MaARS combines TRACLabs' PHARAOH system for integrating autonomous and semi-autonomous robotic assets into remote mission processes with the Texas A&M University DAPHNE-Anomaly Treatment system. The resulting MaARS system provides an end-to-end solution that can monitor telemetry and perform trend analysis to identify anomalies, provide a recommendation on a resolution based on a knowledge graph relating likely root causes to anomalies, and leverage robotic assets to remedy the likely faults. In our Phase I effort, we determined the requirements for MaARS and devised a suitable Concept of Operations. We developed a candidate proof-of-concept implementation that allowed Daphne to invoke and monitor PHARAOH procedures to support diagnostics---which in turn coordinated the activity of a simulated Astrobee robotic agent to perform a number of information gathering and inspection activities. We also identified a number of dimensions in which the Daphne tool-chain could be extended to engage robotic assets to perform autonomous iterative diagnoses until a confident root cause analysis is made, and to perform repair and recovery tasks using a library of PHARAOH procedure-based skills. In the Phase II work, we will develop the full MaARS prototype and demonstrate the system's capabilities in a number of NASA-relevant contexts.

Potential NASA Applications (Limit 550 characters):

Multiple near-term missions could benefit from the MaARS technology including ISS/Gateway robots such as Astrobee or next generation IVA manipulators, or Artemis surface robots including the LSMS, VIPER, and RASSOR platforms. Future systems that could benefit from this work includes the 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 400 characters):

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

Duration: **24**

PROPOSAL NUMBER: 22-2- **T10.05-2150**

PHASE 1 CONTRACT NUMBER: 80NSSC22PA959

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) Expanded for Multi-Agent Decision Making and Teaming

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: **1234 Innovation Dr, CO 80303 - 7814**
Phone: **(303) 492-0696**

Principal Investigator:

Name: **Alexander Barrie**
E-mail: **abarrie@aurora.engineering**
Address: **8 Cromwell Dr, ME 04473 - 3639**
Phone: **(814) 441-6410**

Business Official:

Name: **Alexander Barrie**
E-mail: **abarrie@aurora.engineering**
Address: **8 Cromwell Dr, ME 04473 - 3639**
Phone: **(814) 441-6410**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 8
Technical Abstract (Limit 2000 characters):

Operations engineers face the task of maintaining the health and functionality of a spacecraft, based on extremely limited information. This task becomes even more complicated when considering lag time between contacts, the light-time delay of bidirectional communications, and the prospect of multiple spacecraft operating simultaneously. Simple pre-programmed time tagged commands become increasingly burdensome in multi-spacecraft missions, particularly when trying to target ephemeral events in space that are difficult to predict with any accuracy.

The Module for Event Driven Operations on Spacecraft (MEDOS) puts the operations engineer on the spacecraft. MEDOS takes raw telemetry and fuses them together into physically meaningful quantities that an engineer understands – turning voltages and decay times into “methane concentration”, or turning count rates and field vectors into “plasma density”. Then, MEDOS compares the physical parameters to generalized event definitions that scientists use all the time – “when the plasma density jumps and the magnetic field reverses direction, we crossed a boundary.” MEDOS computes a mathematical distance between measured parameters and rules from engineer to provide a numerical confidence in an event occurring. MEDOS does not require any training data, discrete if/then rules, or a PhD in AI to tune the model. All that MEDOS requires is for an engineer or scientist to describe the process that they go through every day – and then MEDOS encodes that process onto the spacecraft.

MEDOS is able to analyze the ambient environment in real time, and respond to it in a way consistent with the response of an operations engineer. In Phase II we will expand MEDOS’s capability for multi-agent teaming with a new module, MADEM (Multi Agent Decision Engine for MEDOS.) We will also port the entire MEDOS framework into NASA’s core Flight System (cFS) and verify + validate MEDOS on flight qualified hardware, readying it for mission deployment.

Potential NASA Applications (Limit 550 characters):

MEDOS has secured a spot to fly on the SCENIC platform on the ISS (PI C. Wilson), and has been selected to fly on the NAMASTE effort, detecting methane from melting permafrost in Alaska (PI M. Sultana), pending Phase II completion. We have had communication with the MMS project scientist (G. Le) about infusing MEDOS into the MMS mission pending Phase II. We are also in contact with teams in earlier mission phases (GDC, 7 Sisters, Enceladus). We are also working to complement AutoNGC with MEDOS.

Potential Non-NASA Applications (Limit 400 characters):

Outside of NASA we aim to target other space players, such as NOAA and DoD, particularly for detection of and response to surface events (fires, missile launches, etc.) We will also approach the private space industry (e.g. Starlink and Iridium.) Beyond space, underwater submersibles (such as the Titan submarine) as well as mining and resource extraction system could greatly benefit from MEDOS.

Duration: **24**

PROPOSAL NUMBER: 22-2- **T8.06-1605**

PHASE 1 CONTRACT 80NSSC22PA927

NUMBER:

SUBTOPIC TITLE: Quantum Sensing and Measurement

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

Small Business Concern

Firm: **ADVR, Inc.**
Address: **31948 Frontage Road, Bozeman, MT 59715 - 8642**
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**
E-mail: **jaller@advr-inc.com**
Address: **31948 Frontage Road, MT 59715 - 8642**
Phone: **(406) 522-0388**

Business Official:

Name: **Betsy Heckel**
E-mail: **heckel@advr-inc.com**
Address: **39148 Frontage Road, MT 59715 - 8642**
Phone: **(406) 522-0388**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

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 550 characters):

Squeezed light

Quantum Sensing

Transition edge detectors

Quantum Communications

Potential Non-NASA Applications (Limit 400 characters):

Quantum Networking

Entanglement swapping

Integrated Photonics

Frequency Conversion

Electro-optic modulators

Duration: **24**

PROPOSAL NUMBER: 22-2- **T11.06-2398**

PHASE 1 CONTRACT NUMBER: 80NSSC22PB226

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: **Dr. Jose Daniel Velazco-Garcia**
E-mail: **dvelazco@tietronix.com**
Address: **12705 Coulson St., 77015 - 6227**
Phone: **(832) 404-1693**

Business Official:

Name: **Sicilia Liranzo**
E-mail: **sicilia.liranzo@tietronix.com**
Address: **1331 Gemini Avenue, Suite 300, TX 77058 - 2794**
Phone: **(281) 404-7226**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Tietronix is proposing to develop a framework and associated artifacts development tools and workflow to provide a photorealistic multi-user multi-modality shared extended reality (XR) 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. The envisioned framework is the continuation of our work during Phase I, which plans to continue the endeavors for a hardware-independent system designed to be as extendable to novel hardware as possible. It also aims to provide the ability to support the execution of complex procedures by overlaying visual cues and information superimposed to the AR and VR views, as well as auditory or other tactile inputs that may enhance training.

Potential NASA Applications (Limit 550 characters):

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 400 characters):

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: **24**

PROPOSAL NUMBER: 22-2- **T7.04-1851**

PHASE 1 CONTRACT NUMBER: 80NSSC22PA953

SUBTOPIC TITLE: Lunar Surface Site Preparation

PROPOSAL TITLE: Bulk Regolith Handling Technologies for Landing/Launch Pad Site Preparation and Blast Shield Construction

Small Business Concern

Firm: **Astroport Space Technologies, Inc.**
Address: **110 East Houston Street, 7th Floor, San Antonio, TX 78205 - 2990**
Phone: **(210) 404-2981**

Research Institution:

Name: **The University of Texas at San Antonio**
Address: **One UTSA Circle, TX 78249 - 1644**
Phone: **(210) 458-6472**

Principal Investigator:

Name: **Sam Ximenes**
E-mail: **sam@astroportspace.com**
Address: **110 E. Houston Street, 7th Floor, TX 78205 - 2990**
Phone: **(210) 404-2981**

Business Official:

Name: **Sam Ximenes**
E-mail: **sam@astroportspace.com**
Address: **110 E. Houston Street, 7th Floor, TX 78205 - 2990**
Phone: **(210) 404-2981**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

The Phase 2 effort further refines our Phase 1 defined CONOPS and system architecture for a lunar launch/landing pad (LLP) construction operation based on a clear description of the envisioned fleet of fixed and mobile robotic systems and how it will evolve from the first landing, and lunar operations needed to prepare the equipment to survive the first lunar night after landing and extraction from the lander. It then establishes how the LLP facility construction would take place with specific attention to the general LLP construction site layout, site setup, pad pavement construction with in-situ produced bricks from molten regolith, and finally LLP protective berm construction.

The CONOPS considers how the extensive and high-value robotic construction equipment suite could be redeployed after the LLP is complete. This includes providing local logistics support such as lander unloading and equipment delivery from its unloaded location to its destination on the Moon, supporting Lunar Base operations, constructing new infrastructure, and mining operations to extract resources for use on the Moon.

Civil engineering processes and geotechnical assessments for bulk regolith manipulations and conveyance are further developed for LLP construction using an an end-to-end system architecture approach. Specific areas of innovation include:

- A bulk regolith distribution system for hauling excavated regolith, processing at a sorting station, and sieving for feedstock production for the LLP brickmaking robots
- Definition of multiple autonomous machines and enabling machine-to-machine collaboration
- Site layout with traverse distance and path optimization
- Physics-based terra-mechanics simulations of vehicles and tool implements
- A physics-engine for plume flow surface interactions
- Prototype universal tool-implement payload adapter for interchangeable functions of the robot mobility platform

Potential NASA Applications (Limit 550 characters):

Research results will be highly relevant and applicable to multiple lunar surface construction projects: Lunar Landing Pads (LLP), roads, parking / industrial yards, foundations.

Potential Non-NASA Applications (Limit 400 characters):

Outside of the primary space markets, applications for selected technologies developed under this project may exist in:

- Global land mine / buried ordnance clearance operations
- Terrestrial infrastructure (roads and bridges) repair and maintenance
- Erosion protection (hill slopes and river banks)
- Environmental remediation

Duration: **24**

PROPOSAL NUMBER:	22-2- **T15.04-1048**
PHASE 1 CONTRACT NUMBER:	80NSSC22PB244
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**
Phone: **(386) 266-7695**

Principal Investigator:

Name: **Byron Ward**
E-mail: **byron@ward.aero**
Address: **8505 Rockledge Road, CA 91941 - 7923**
Phone: **(619) 841-2359**

Business Official:

Name: **Byron Ward**
E-mail: **byron@ward.aero**
Address: **8505 Rockledge Road, CA 91941 - 7923**
Phone: **(619) 841-2359**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Wayfarer Aircraft and Embry-Riddle Aeronautical University propose to use a 35% scale aircraft to gather aerodynamic flight test data for a novel type of distributed electric propulsion called the Integrated High Lift Propulsor (IHLP).

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 performance of the IHLP with variation of key parameters using a flexible design that enables rapid between-flight configuration changes. Automated control effector inputs for system identification and a research quality instrumentation system will be used to characterize aero-propulsive interaction. The incremental effects of the modification will be demonstrated by collecting both 35% scale and full-scale baseline flight test data, using Embry-Riddle's existing instrumented research aircraft.

The flight test program will clear technical risk and validate key technical objectives to proceed to full-scale flight test and commercial adoption. The research program will also advance flight test techniques for aircraft with strong aero-propulsive coupling and provide high-quality experimental data. This data, combined with Wayfarer's CFD and wind tunnel data, will validate and improve design and analysis tools used by NASA and industry.

This Phase II project will leverage Wayfarer's CFD and wind-tunnel based IHLP research combined with Embry-Riddle's extensive hybrid/electric flight research experience and capability to gather high quality, full scale representative experimental data with broad industry relevance.
Potential NASA Applications (Limit 550 characters):

The proposed research 1) supports the objectives of the NASA ARMD Strategic Implementation Plan for ultra efficient subsonic aircraft in addition to supporting safe, quiet and affordable Advanced Air Mobility (AAM) vehicles, 2) advances technology to increase aircraft efficiency and reduce GHG (NASA Climate Action Plan Priority 5), and 3) supplies research quality validation data for the Transformational Tools and Technologies Project (TTT)

Potential Non-NASA Applications (Limit 400 characters):

The IHLP substantially increases cruise efficiency while reducing 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: **24**

PROPOSAL NUMBER: 22-2- **T7.05-1301**

PHASE 1 CONTRACT 80NSSC22PA933

NUMBER:

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**
Phone: **(212) 998-2121**

Principal Investigator:

Name: **Stafford Sheehan**
E-mail: **staff@aircompany.com**
Address: **407 Johnson Ave, NY 11206 - 2805**
Phone: **(347) 927-4255**

Business Official:

Name: **Dr. Pat Ward**
E-mail: **pat.ward@aircompany.com**
Address: **407 Johnson Avenue, NY 11206 - 2805**
Phone: **(910) 850-7591**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 5
End: 7

Technical Abstract (Limit 2000 characters):

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 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. Phase 1 focused on developing a model that describes the CO_2 to kerosene process. While the model helped us identify the areas of uncertainty, additional operational data is still needed to build a high-fidelity model that allows us to optimize the reactor performance. To address the data gap and further support Phase 2 efforts, we will expand the model with more granular data obtained primarily by lab-scale testing and supported by available pilot scale data. We will further leverage progress made in Phase 1 to optimize our fuel production and downstream processing to inform fuel formulation and production to meet ASTM specifications to ensure the produced fuel meets the standard. At the end of this STTR project, a technical feasibility report for deploying this technology on Earth and Mars will be thoroughly assessed and delivered to NASA.

Potential NASA Applications (Limit 550 characters):

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 400 characters):

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: **24**

PROPOSAL NUMBER: 22-2- **T10.03-1993**

PHASE 1 CONTRACT NUMBER: 80NSSC22PB100

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: **MTRI, Inc.**
Address: **3600 Green Court, Suite 100, MI 48105 - 1570**
Phone: **(734) 994-7237**

Principal Investigator:

Name: **Richard Chase Ph.D**
E-mail: **rachase@mtu.edu**
Address: **3600 Green Court, Suite 100, MI 48105 - 1570**
Phone: **(734) 994-7237**

Business Official:

Name: **Gregory Leonard**
E-mail: **gregmtri@gmail.com**
Address: **3600 Green Court, Suite 100, MI 48105 - 1570**
Phone: **(734) 913-6871**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

NASA currently has multiple missions focused on exploration of extraterrestrial bodies in our solar system, both by autonomous platforms alone, in teams, and in collaboration with long-duration human habitation, all of which require advanced levels of autonomy. TATERS will develop mission planning and high level collaborative autonomy capabilities for swarms of surface and satellite vehicles that would allow NASA and other groups to be able to deploy autonomous teams of robots into previously unexplored spaces. TATERS Phase II will focus on maturation of the planning,analysis, and interface capabilities developed in Phase I for such missions. Phase I focused primarily on traversal analysis for individual and teams of robots in reference scenarios at the south pole of the moon that incorporated both scientific exploration and construction tasks. Phase II will expand and enhance the methods used in Phase I, increase fidelity of the testing environment by incorporating scientific data sources and models, integrate with existing NASA software products, and demonstrate transition feasibility through hardware-in-the-loop testing with UGVs. When planning complex missions with extended operation times, risk analysis requirements, expected autonomy requirements, and relatively high uncertainty of science objectives and mission execution, the ability to perturb any and all variables under consideration during planning is critical for identifying system failure modes. The traversal planning approach used by TATERS is novel in its ability to incorporate data across multiple resolutions, which enables pre-mission planning for high-level multi-agent coordination, rapid risk analysis of traversals through Monte Carlo testing, as well as integration into a navigation stack with real-time sensor stream and updates. Therefore, the TATERS approach demonstrates

interoperability between human-in-the-loop navigation and control and autonomy stacks implemented on deployed platforms.

Potential NASA Applications (Limit 550 characters):

TATERS focuses on transitioning technologies into the Moon to Mars mission such as coordination of in-situ autonomous robotic platforms and vehicles, the transition path into mission planning and autonomy stacks for platforms used in scientific, exploration, and site construction mission, and human mission support tasks. The collaborative autonomy enabled by TATERS is a necessary step towards development of vanguard robotic teams that can proceed ahead of human teams in missions in extreme environments.

Potential Non-NASA Applications (Limit 400 characters):

TATERS can be used in terrestrial environments, by enabling collaborative autonomy of field robotics in unstructured environments, such as firefighting, disaster response, maritime, and defense applications. The graph representation used to store environmental information was developed to be easily stored, modified, and shared, making them well-suited products for distributed low-SWAP systems.

Duration: **24**

PROPOSAL NUMBER:	22-2- **T11.06-2113**
PHASE 1 CONTRACT NUMBER:	80NSSC22PA972
SUBTOPIC TITLE:	Extended Reality (Augmented Reality, Virtual Reality, Mixed Reality, and Hybrid Reality)
PROPOSAL TITLE:	Photorealistic EVA Simulation and Analytics for Real-Time 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:

Name: **Julian Reyes**
E-mail: **julian@buendea.com**
Address: **24 sw 22nd road, Apt, Suite, Bldg. optional, FL 33129 - 1507**
Phone: **(305) 510-7868**

Business Official:

Name: **Julian Reyes**
E-mail: **julian@buendea.com**
Address: **24 sw 22nd road, Apt, Suite, Bldg. optional, FL 33129 - 1507**
Phone: **(305) 510-7868**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 2
End: 6
Technical Abstract (Limit 2000 characters):

In XR simulations for digital twins and astronaut training, the need for accuracy and precision is critical. Environments on the Moon and Mars will prove unpredictable and challenging, especially given the requirements for greater autonomy and reduced reliance on Earth-based support due to communication delays. Training for such missions necessitates simulations that not only emulate these environments but also achieve hyper realistic fidelity. Given the limitations of current state-of-the-art real-time rendering in real-time game engines, the solution to this growing demand for realism resides in more advanced computational strategies, specifically the utilization of parallelization.

For Phase II of our NASA STTR proposal, Buendea and University of Central Florida's will focus developing state-of-the-art parallelization techniques, combined with the latest advancements in hardware and software, which can significantly enhance the realism and efficiency of astronaut training in XR environments and digital twins. By leveraging parallel processing, real-time simulations in XR can achieve higher frame rates, more detailed environments, and real-time feedback, all of which are essential to crafting high-fidelity EVA training modules.

Potential NASA Applications (Limit 550 characters):

1.NASA Artemis Training Simulator

The continued development of training simulations to support Artemis astronaut training.

2.Digital Twin Simulation Test Bed

Using the development of the STTR to produce a highly accurate test bed for Lunar and Mars surface operations and conceptualization

3.Mission Control Video Game

The development of a video game that allows anyone to become an astronaut and envision what the future of human space exploration holds.

Potential Non-NASA Applications (Limit 400 characters):

Hyper realistic visualization and XR training for a wide range of industries that require maximizing processing power to simulate for real-world applications such as aerospace simulation, XR Training, digital twins, architectural visualization

Duration: **24**

PROPOSAL NUMBER: 22-2- **T5.05-2204**

PHASE 1 CONTRACT NUMBER: 80NSSC22PB129

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:

Name: **Thomas Murphey**
E-mail: **tmurphey@opterusrd.com**
Address: **815 14th St SW, Suite C200 , CO 80537 - 6649**
Phone: **(505) 250-3006**

Business Official:

Name: **Thomas Murphey**
E-mail: **tmurphey@opterusrd.com**
Address: **815 14th St SW, Suite C200 , CO 80537 - 6649**
Phone: **(505) 250-3006**

Summary Details:

Estimated Technology Readiness Level (TRL) :

Begin: 4
End: 5

Technical Abstract (Limit 2000 characters):

Opterus and the University of Colorado, Boulder propose Solar Sail Tubular Mast (SSTM), a lightweight version of our patented High Strain Composite (HSC) Trussed Collapsible Tubular Mast. SSTM represents a paradigm shift in deployable boom technology, poised to set high standards of structural efficiency, deployment simplicity, and cost-effectiveness for deployable boom systems.

The SSTM represents a significant advancement in structural capabilities, transitioning from the modest structural efficiency of an open cross-section TRAC boom to the high performance of a trussed tape-spring boom. SSTM enables simple, low-risk solar sails up to the 10,000 m² scale and mitigates the need for complex guywire systems, spin-tensioning, or elaborate deployment mechanisms. SSTM also achieves an exceptional mass-to-area ratio of 5 g/m² for both the sail and boom components. SSTM booms are also inherently low cost because they are fabricated using automated and mold-based processes that greatly reduce manual/touch labor.

Potential NASA Applications (Limit 550 characters):

Possible NASA mission infusion includes Solar Cruiser, High Inclination Solar Mission, and Solar Polar Imager. Each NASA solar sail mission concepts require 30m rollable boom systems. The closed cross section SSTM provides higher structural performance than open boom variants or bi-stable closed cross section booms which enable Solar Cruiser and the larger 10,000sqm solar sail mission concepts. The fundamental technology is also readily applied to high power solar arrays required for SEP and moon to mars objectives.

Potential Non-NASA Applications (Limit 400 characters):

Non-NASA applications include high power solar arrays, tensioned planar arrays, and other large area deployable space structures that required large aperture areas and low mass structures. High power solar arrays are a key market fit and the company is developing space solar power beaming structures concepts using similar boom technologies with defense customers.

Duration: **24**

PROPOSAL NUMBER: 22-2- **T8.07-1524**

PHASE 1 CONTRACT NUMBER: 80NSSC22PA980

SUBTOPIC TITLE: Photonic Integrated Circuits

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

Small Business Concern

Firm: **CFD Research Corporation**
Address: **6820 Moquin Drive Northwest, Huntsville, AL 35806 - 2900**
Phone: **(256) 361-0811**

Research Institution:

Name: **University of Washington**
Address: **4333 Brooklyn Ave NE, Box 359472, WA 98195 - 9472**
Phone: **(650) 906-8666**

Principal Investigator:

Name: **Karthikeyan Lingasubramanian**
E-mail: **karthik.linga@cfdrc.com**
Address: **6820 Moquin Dr NW, AL 35806 - 2900**
Phone: **(256) 726-4800**

Business Official:

Name: **Silvia Harvey**
E-mail: **proposals-contracts@cfd-research.com**
Address: **701 McMillian Way Northwest, Suite D, AL 35806 - 2923**

Phone: **(256) 715-6918**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

Reconfigurable and adaptive hardware systems are essential parts of NASA applications due to the uncertainties and variations caused by extreme operational conditions, radiation effects, modifications of standard and requirements, varying user preferences and high development cost. 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 Programmable Photonic Integrated Circuit (PIC), that will have significantly lower SWaP-C. 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 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 applications 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 identified Sb2S3 and Sb2Se3 as promising PCM with low loss (<1.0 dB), high extinction ratio (>10 dB), high cyclability (>1,000 switching events), and multi-bit operation. We also fabricated individual PIC components with electrical actuation that can improve scalability. Using a reduced order modeling (ROM) based simulation platform, we simulated a programmable PIC system with electrical actuation and optical communication. In Phase II, we will simulate simple RF filters in the programmable PIC, 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 550 characters):

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 400 characters):

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: **24**

PROPOSAL NUMBER: 22-2- **T6.08-1881**

PHASE 1 CONTRACT NUMBER: 80NSSC22PB144

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:

Name: **Dr. Wei Gao**
E-mail: **wgao5@ncsu.edu**
Address: **Wilson College of Textiles NC State-TECS, Campus Box 8301, NC 27606 - 8301**
Phone: **(919) 515-0257**

Business Official:

Name: **Elizabeth Hernandez**
E-mail: **ehernandez@paragonsdc.com**
Address: **3481 East Michigan Street, AZ 85714 - 2221**
Phone: **(520) 382-1790**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

NASA has entered a new era of human space exploration with the Artemis Program, hoping to establish a long-term human presence on the Moon. To meet NASA needs, new textiles will have to be developed that keep astronauts safe, while still enabling those astronauts 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. To address these challenges in Part A of NASA's call, **Paragon Space Development Corporation (Paragon) and North Carolina State University (NCSU) are developing a new EPG outer layer material for the xEMU known as the Spacesuit Cover against the Abrasive Lunar Environment (SCALE).** SCALE uses a bio-inspired design, with segmented corundum chips to give the outer layer of the EPG enough strength to withstand the abrasiveness of lunar dust without significantly reducing its flexibility. The second area of textile innovation identified by NASA (Part B) is crew clothing fabrics for shirt-sleeve environments in oxygen-rich atmospheres. Those oxygen-rich atmospheres also carry an increased risk of fire, which necessitates the use of flame-retardant materials whenever practicable, including in the clothing worn by the crew. To that end, **this proposal also introduces a new clothing material, known as the eXploration Textile for high-Oxygen eNvironments (xTON) that will be comfortable and flame retardant.**

Potential NASA Applications (Limit 550 characters):

SCALE will be incorporated into the spacesuit EPG to provide greater abrasion resistance for lunar exploration EVAs. Additionally, lunar space operations will require flexible, abrasion-resistant fabrics for thermal covers on a variety of equipment like camera covers, stowage bags, and collection sample containers.

xTON will be used to provide crew clothing that is flame retardant in 36% oxygen at 8.2 psia, resistant to wear from abrasive lunar regolith, free of volatile materials, releases a minimal amount of lint, and odor-free.

Potential Non-NASA Applications (Limit 400 characters):

SCALE could be used for high-wear activities like sportswear, personal protective equipment, protective casing for sensitive devices, mining, and construction applications.

xTON could be used to make comfortable, flame retardant clothing/covers for firefighting PPE for firefighters, industrial workers, and military personnel that are likely to encounter fires or extremely hot environments.

Duration: **24**

PROPOSAL NUMBER: 22-2- **T10.03-2033**

PHASE 1 CONTRACT NUMBER: 80NSSC22PA952

SUBTOPIC TITLE: Coordination and Control of Swarms of Space Vehicles

PROPOSAL TITLE: Efficient Distributed State Estimation for Swarm Robotics

Small Business Concern

Firm: **Astrobotic Technology, Inc.**
Address: **1016 North Lincoln Avenue, Pittsburgh, PA 15233 - 2132**
Phone: **(412) 682-3282**

Research Institution:

Name: **Carnegie Mellon University**
Address: **5000 Forbes Ave., PA 15213 - 3890**
Phone: **(678) 365-1243**

Principal Investigator:

Name: **Kyle Lassak**
E-mail: **kyle.lassak@astrobotic.com**
Address: **1016 North Lincoln Avenue, 15233 - 2132**
Phone: **(412) 682-3282**

Business Official:

Name: **Andrew Horchler**
E-mail: **andrew.horchler@astrobotic.com**
Address: **1016 N Lincoln Ave, PA 15233 - 2132**
Phone: **(216) 272-3882**

Summary Details:

Estimated Technology Readiness Level (TRL) :

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

DALEC is a robust distributed localization system for real-time state estimation and mapping of networked members including spacecraft, rovers, and even astronauts in GPS-denied environments such as the lunar surface. DALEC is an innovative state estimation framework based on state-of-the-art factor graph methods combined with a wireless communication system leveraging efficient mesh networking protocols that together can be used to localize agents with various sensing modalities (e.g., visual odometry, LiDAR). A distributed system like DALEC offers spacecraft and rover networks an inherently more robust and reliable means of localization compared to centralized methods utilizing a central processing node, reducing mission and program risk by eliminating a potential single point of failure.

In this Phase II effort Astrobotic with CMU, will mature and extend the Phase I DALEC software, APIs, and core distributed localization algorithms, develop models of UWB ranging and wireless comms protocols, enhance simulation tools and deploy DALEC software to relevant embedded compute to iteratively test and improve performance in support of demonstrating system performance through hardware-in-the-loop, robotic motion capture, and field testing.

Potential NASA Applications (Limit 550 characters):

A key near-term mission need and use case for DALEC is robust localization and tracking for heterogenous teams of crew, rovers, and assets/instruments on the lunar surface. Extravehicular Activity and Human Surface Mobility Program (EHP) is evaluating candidate technologies that augment astronaut navigation knowledge during extravehicular activities (EVA). DALEC's robust distributed localization is ideally suited to support multiple astronauts while also tracking location of multiple rovers and science instruments.

Potential Non-NASA Applications (Limit 400 characters):

DALEC has potential applications beyond NASA, including commercial space companies. Astrobotic will be able to utilize this technology in its' CubeRover product line. Providing these rovers with higher accuracy location estimates would allow for a larger suite of swarm-based missions.

Duration: **24**

PROPOSAL NUMBER: 22-2- **T4.01-2647**

PHASE 1 CONTRACT NUMBER: 80NSSC22PB163

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: **21 N. Park St., Suite 6301, WI 53715 - 1215**
Phone: **(608) 262-3822**

Principal Investigator:

Name: **Ms. Brenda Egan**
E-mail: **preaward@rsp.wisc.edu**
Address: **21 N. Park St., Suite 6301, WI 53715 - 1215**
Phone: **(608) 262-3822**

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: 3
End: 5

Technical Abstract (Limit 2000 characters):

University of Wisconsin-Madison (UWM) in collaboration with ProtoInnovations propose to architect, design, develop, and validate a high-fidelity modeling and sensors 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 to enable high-performance autonomy in dynamic lunar surface conditions.

Phase II of this STTR, will further mature the simulation platform to generate higher fidelity data leading to the development and maturation of perception algorithms for detecting terrain hazards. The focus during Phase II will mainly be on the following:
1. Further improve the simulation platform to generate higher fidelity perception data
2. Develop a unified perception system to detect excessive wheel sinkage and embedded obstacles near the rover's wheels

Potential NASA Applications (Limit 550 characters):

The advanced perception capabilities and associated technologies developed with this project boast several important advantages relevant to efficient and safe autonomous operation of robotic exploration systems. The development of an advanced simulation framework will also inform and enable the development of newer, high-performance rover systems for the Moon and Mars.

Potential Non-NASA Applications (Limit 400 characters):

The technologies developed under this project can potentially be applied to new robotics platforms for future advanced mobility systems. We will continue to grow in the space robotics market by further strengthening our partnership with commercial space companies, and offering our algorithms and simulation capabilities to a host of private enterprise missions.

Duration: **24**

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