JPL 2017 Phase II SBIR Contracts

Proposal Number	Proposal Title	Company
H1.01-9317	High Capacity Multi-Stage Scroll Compressor for Mars Atmosphere Acquisition	Air Squared Inc.
Z8.02-9571	Efficient and Secure Network and Application Communications for Small Spacecraft	Antara Teknik LLC
S3.04-8513	AutoNav Mark 4: Autonomous Navigation Software	Blue Sun Enterprise Inc.
S2.01-9865	Technology Development for High-Actuator-Count MEMS DM Systems	Boston Micromachines Corporation
S3.06-8949	A Two-Phase Pumped Loop Evaporator with Adaptive Flow Distribution for Large Area Cooling	Creare LLC
Z8.01-9758	Fiber-fed Advanced Pulsed Plasma Thruster (FPPT)	CU Aerospace LLC
H9.04-8557	GaN MMIC Ka-Band Power Amplifier	Custom MMIC Design Services Inc.
H9.01-8624	High Power (50W) WDM Space Lasercom 1.5um Fiber Laser Transmitter	Fibertek Inc.
Z6.01-8732	FLASHRAD: A Non-Volatile 3D Rad Hard Memory Module for High Performance Space Computers	Irvine Sensors Corporation
S1.11-8595	WOLFEChip: Wholly-Integrated Optofluidic Laser-Induced Fluorescence Electrophoresis Chip	Leiden Measurement Technology LLC
S1.04-9669	Tunable High-Power Terahertz Quantum Cascade Laser Local Oscillator	LongWave Photonics LLC
S2.01-9655	Next-Generation Deformable Mirrors for Astronomical Coronagraphy by Utilizing PMN-PT Single Crystal Stack Actuators in integration with Driver ASIC	Microscale Inc.
S1.02-9973	Deployable Ku/Ka/W Tri-Band Cylindrical Parabolic Antenna	MMA Design LLC
S1.03-9385	Correlation Radiometer ASIC	Pacific Microchip Corporation

Proposal Number	Proposal Title	Company
S1.04-8763	A Low Power Rad-Hard ADC for the KID Readout Electronics	Pacific Microchip Corporation
S2.01-9936	Polymer Coating-Based Contaminant Control/Elimination for Exo-S Starshade Probe	Photonic Cleaning Technologies LLC
Z7.01-8404	Weaved Distributed Plastic Optical Fiber Sensor (DIFOS) SHM system	Redondo Optics Inc.
S4.01-8340	An Enhanced Modular Terminal Descent Sensor for Landing on Planetary Bodies	Remote Sensing Solutions Inc.
Z3.02-8909	Thermoplastic Forming of Bulk Metallic Glasses for Precision Robotics Components	Supercool Metals LLC
S1.02-9250	Enabling Larger Deployable Ka-Band Antenna Apertures with Novel Rib	Tendeg LLC
S2.02-8520	Redundant StarShade Truss Deployment Motor/Cable Assembly	Tendeg LLC
S4.03-8399	Advanced Ignition System for Hybrid Rockets for Mars Sample Return Phase II	Ultramet

PROPOSAL ABSTRACTS

PROPOSAL NUMBER:	17-2 **H1.01-9317**
PHASE-I CONTRACT NUMBER:	NNX17CP22P
SUBTOPIC TITLE:	Mars Atmosphere Acquisition, Separation, and Conditioning for ISRU
PROPOSAL TITLE:	High Capacity Multi-Stage Scroll Compressor for Mars Atmosphere Acquisition

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
Air Squared, Inc.
510 Burbank Street
Broomfield, CO 80020 -1604 (513) 200-3787
PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)
John Wilson
j.wilson@airsquared.com
510 Burbank St.
Broomfield, CO 80020 -1604
(303) 466-2669

Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 5
End: 7

TECHNICAL ABSTRACT (LIMIT 200 WORDS)
The proposed innovation supports technologies for In Situ Resource Utilization (ISRU) processes by collecting and pressurizing gasses from the Mars atmosphere for eventual oxygen production by use of Solid Oxide Electrolysis (SOXE). There are several ways to capture and pressurize CO2, including freezing at cryogenic temperatures, mechanical compression, and absorption. Completed studies on each approach, have generally favored cryogenic temperature and mechanical compression solutions. Recently, mechanical compression has gained momentum through the Mars Oxygen ISRU Experiment (MOXIE), which utilizes an Air Squared compressor for mechanical compression of CO2. If this approach is pursued further for a larger system, there are still several questions concerning reliability over 10,000 hours of autonomous operation in Mars environment and scalability. Air Squared plans on addressing these issues as part of Phase II.

The proposed innovation is a Martian Atmosphere Scroll Compressor (MASC). Dealing with the low pressures of the Martian atmosphere, the MASC functions like a vacuum pump utilizing Air Squared scroll compressor technology. During Phase I, Air Squared tested several orbiting and spinning scroll prototypes on CO2 at a wide range of discharge pressures and superior

efficiency was demonstrated with lower discharge pressures. Parallel efforts by NASA-JPL on MOXIE, showed no performance degradation of the SOXE at reduced pressures down to 4.4 PSIA. Additionally, reducing the cathode pressure provides more margin against starting to electrolyze CO. For this reason, Air Squared has decided to focus exclusively on collection-only in an attempt to concentrate efforts on a lightweight and efficient MASC, supporting oxygen generation. The following proposed Phase II work will further develop both a spinning and orbiting scroll MASC for providing 2.7 kg/hr of CO_2 at discharge pressures between 4.4 and 15 PSIA.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

Where size, weight, and power are at a premium, the MASC excels, making it a perfect fit for military and commercial aerospace markets. The MASC could replace state of the art air compressors in On-Board Oxygen Generation Systems (OBOGS) which recycles cabin atmosphere in military aircraft, eliminating the need for heavy and tightly temperature controlled liquid oxygen tanks, thereby extending mission lengths and increasing pilot performance. Air Squared has an existing partnership with Cobham Manufacturing to produce scroll air compressors in their OBOGSs and once testing is completed, the MASC would be a next-generation upgrade for military aircraft. A spinning scroll compressor design, like the MASC, would minimize space and weight needs while maintaining versatile compatibility with several different military aircraft.

Integrated as an air compressor for aviation potable water systems, the MASC could provide more efficient, lighter, and smaller solution to the commercial air transportation industry. The MASC could reach a market already established in Air Squared’s partnership with Airbus to retrofit their current potable water system. The adaptive MASC would solve previous reliability issues through its less complex spinning scroll design. If successful, the spinning scroll MASC will provide a pathway for tailoring the technology to the additional compressor and vacuum pump applications in the commercial aerospace industry.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

To meet NASA’s ambitious goal of human exploration of Mars, the MASC provides in-situ resource utilization for the production of oxygen and fuel derived from the CO_2 rich Martian atmosphere. Designed to minimize size, weight, and power requirements without compromising efficiency, the MASC is applicable to NASA’s many atmospheric collection and monitoring demands. Engineered for the collection of CO_2 for the Mar Rover 2020 mission, the MASC is a next-generation evolution of Air Squared’s successful MOXIE scroll compressor, re-imagined for human exploration of space. Scaled up, the MASC would apply to storage and utilization of CO_2 on future Mars missions to supply the raw materials for oxygen and fuel production. Scaled down, the MASC could be integrated onboard NASA’s crewed spacecraft to collect and analyze atmospheric particulate to monitor the safety of the astronauts on board. Additionally, the MASC could fulfill the atmospheric monitoring and safety needs on board the ISS by collecting CO_2 and other toxins and regulating the breathable environment. Via a low power, compact, and reliable design, the MASC could reduce space transit fuel costs for Mars exploration crews by supplying them with oxygen and fuel for the journey back home.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It

is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)
Machines/Mechanical Subsystems
Pressure & Vacuum Systems

PROPOSAL NUMBER:	17-2 **Z8.02-9571**
PHASE-I CONTRACT NUMBER:	NNX17CP24P
SUBTOPIC TITLE:	Small Spacecraft Communication Systems
PROPOSAL TITLE:	Efficient and Secure Network and Application Communications for Small Spacecraft

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
Antara Teknik, LLC
5233 Castlereigh Court
Granite Bay, CA 96746 -7123 (916) 622-6960
PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)
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madalier@antarateknik.com
5233 Castlereigh Court
Granite Bay, CA 96746 -7123
(916) 834-4729
Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 5
End: 7
TECHNICAL ABSTRACT (LIMIT 200 WORDS)
For complex missions that are away from Earth's resources, there is an unmet need for more autonomous operations with minimal Earth contact. Additionally, secure proximity- and autonomous-communication among various types of space vehicles are needed to implement complex and time-varying networks of spacecraft and sensors, which are capable of sharing rich, near-real-time streams of information. Efficient, secure, mission-configurable, and dynamic key management and cipher suites supporting multiple QoS levels for the bundle protocol are required to augment current and future Delay and Disruption Tolerant Networking (DTN) solutions to satisfy these mission requirements. Antara's innovation will enhance the security of NASA's DTN implementations, specifically, the Interplanetary Overlay Network (ION), and deliver a standards driven adaptation of the Constrained Application Protocol (CoAP) over the bundle protocol (CoAP-over-bp). Phase II activities include the development of *tara*CoAP Cyber-Physical Autonomous Asset Observation and Management module. Further R&D will drive the Elliptical Curve Crypto Key Management and Distribution module, the interoperable AntaraTek Cipher Suite for BPSec, and the scalable *tara*CoAP to TRL-7. The AntaraTek software will also be tested with ISS DTN payload communications (e.g., TReK).

Additionally, the software will be infused to rad-hard FPGAs and future compute platforms such as the High Performance Spaceflight Computing chiplet. Utilizing the ION framework will lower the cost and the time to develop a high TRL solution and reduce implementation risk. Antara's innovations will deliver higher security and performance relative to existing system technology, support complex and time-varying networks, scale to large networks, and enable secure communications for the Solar System Internet. Successful deployment of the innovation will address NASA technology gaps TA5.3.1 and TA5.3.3 and enhance the state-of-art for DTN implementations.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

Public Service and Safety: The technology will provide interoperable communications and real-time information sharing among Department of Homeland Security/FEMA first responders during disasters to effectively mitigate against threats and hazards.

Defense and Intelligence: The innovation will integrate with existing and future Software Defined Radio based communications devices and Situational Analysis/Battle Management apps to rapidly infuse emerging DTN based capabilities in order to enhance the resiliency of Mobile Ad-hoc Networks and securely extend the reach of forward deployed forces to increase tactical agility, facilitate collaboration, coordinated actions, and robust access to mission-critical data, information, and knowledge.

Commercial/Internet of Things: The innovation will securely enhance IoT applications in stressed environments such as cargo and vehicle tracking, global asset tracking, smart-city Machine to Machine communications, and humanitarian relief monitoring.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

The proposed efficient and secure low-power communications system, based on delay and disruption tolerant inter-networking, is a horizontal, fundamental enabling capability which will support multiple NASA applications and missions including the Solar System Internet. The proposed innovations will be applicable to planned and new missions by enabling the integration of standards-based, low-power, and secure key management and application communication components to the DTN network architecture/ION to provide scalable, flexible and secure bi-directional communications for swarms of spacecraft, satellite, and other applicable systems. Antara's innovations will directly support NASA use-cases such as ISS DTN communications and Autonomous Operations and Complex Network Topologies as described in TA5.3. The successful deployment of the innovations in space will help lower operational costs of systems by replacing manual scripting and commanding of individual spacecraft communications links. Additionally, the innovations will enable secure proximity communications and autonomous communication among various types of space vehicles to implement complex and time-varying networks of spacecraft and sensors that are capable of sharing rich, near-real-time streams of information.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)

Simulation & Modeling

Autonomous Control (see also Control & Monitoring)

Man-Machine Interaction

Robotics (see also Control & Monitoring; Sensors)

Ad-Hoc Networks (see also Sensors)
Architecture/Framework/Protocols
Network Integration
Algorithms/Control Software & Systems (see also Autonomous Systems)
Command & Control
Prototyping

PROPOSAL NUMBER:	17-2 **S3.04-8513**
PHASE-I CONTRACT NUMBER:	NNX17CP77P
SUBTOPIC TITLE:	Guidance, Navigation and Control
PROPOSAL TITLE:	AutoNav Mark 4: Autonomous Navigation Software

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
Blue Sun Enterprise, Inc.
1942 Broadway Street, Suite 314
Boulder, CO 80302 -5233 (720) 394-8897
PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)
Christopher Grasso
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1942 Broadway Street, Suite 314
Boulder, CO 80302 -5233
(720) 394-8897
Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 4
End: 7
TECHNICAL ABSTRACT (LIMIT 200 WORDS)
The growing number of missions in deep space, from Discovery class missions like Psyche and Lucy down to very small spacecraft like Lunar Flashlight, is driving the need for standardized, flexible, full-featured flight software for spacecraft guidance, navigation, and control (GNC). Autonomous GNC allows a spacecraft to perform most of its own navigation activities without the need for ground-based personnel and DSN time, reducing cost and required DSN contact time, saving money, and allowing specialized navigation personnel from different NASA centers to be easily shared among missions.
Autonomous GNC activities include:
-spacecraft positioning
absolute and relative (helio, planet, small-body)
relative to small bodies, other spacecraft for rendezvous
-orbit determination
-target tracking of bodies, apertures, spacecraft, ground-based assets
-trajectory derivation
-low-thrust maneuvering for Solar Electric Propulsion (SEP)
-ephemeris calculations

AutoNav from the Jet Propulsion Laboratory implements these functions, and components have flown on Deep Space 1 and Deep Impact. With an appropriate application of software development process to reengineer the code, a new AutoNav Mark 4 could be made available as a commercialized product meeting NASA Class B software standards, thereby enabling its easy inclusion on a wide variety of NASA and non-NASA missions.
AutoNav Mark 4 source code is to be designed and tested to be compatible with a variety of different CPUs (e.g. SPARC, PPC, Intel), real-time operating systems (VxWorks, RTEMS), and flight software cores like NASA Core Flight System. This approach allows AN4 to be deployed in the widest-possible set of environments:
-within STRS-compatible space radios (Iris, UST)
-in the flight software load of the spacecraft C&DH
-in a dedicated stand-alone instrument like the Deep Space Positioning System
AutoNav Mark 4 provides highly capable autonomous GNC while saving missions money

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

Since AutoNav Mark 4 works with any flight software core, it could be applied to non-NASA spacecraft: DoD, NOAA, and ESA missions are prime candidates. International release of software should be possible under ITAR controls. AutoNav Mark 4 could be directly applied to commercial launch vehicles in order to calculate ascent maneuvers, including for human access to space.

Installing AutoNav Mark 4 just on small commercial missions having a CubeSat form factor would allow these missions to proceed at reduced cost, removing much of the need for expensive navigator personnel time. This would free missions from having to implement these capabilities, leading to better reliability of navigation, simpler mission conops, more cross-mission synergy, and lower barriers of entry for less experience providers like universities and commercial providers.

Future commercial human spaceflight could utilize AutoNav Mark 4 for on-board spacecraft navigation and trajectory calculation. This would be most useful in the event of a communications failure, allowing the astronauts to autonomously calculate a return trajectory for re-entry and landing without any interactions with ground-based expertise. It would also allow a low earth orbiting mission to track down and rendezvous with other spacecraft or the International Space Station for servicing, cargo transfer, personnel transfer, and the like, without requiring contact with the ground or extensive ground interactions.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

AutoNav Mark 4 is applicable to any space mission requiring any of the following:
-spacecraft positioning
absolute and relative (helio, planet, small-body)
relative to small bodies, other spacecraft for rendezvous
-orbit determination
-target tracking: bodies, apertures, spacecraft, ground-based assets
-trajectory calc
-maneuver calc
-low-thrust maneuvering for Solar Electric Propulsion (SEP)

-ephemeris calc

All mission perform many of the above activities, often using ground-based processes that are slow and expensive. Commercialized on-board autonomous navigation as provided by AutoNav Mark 4 can be targeted at the whole range of LEO, GEO, and interplanetary missions, large and small.

AutoNav Mark 4 for low-thrust missions (including Psyche and Next Mars Orbiter) would allow a dramatic reduction in navigation and trajectory calculation costs by moving the bulk of these activities onboard. Long missions like these would incur even larger savings using AN4 than more modest missions.

AutoNav Mark 4 is directly applicable to JPL's Deep Space Positioning System. By using a commercialized AutoNav, JPL would avoid most development costs, providing only new algorithms from its Navigation Section to plug into the AutoNav Mark 4 architecture.

Human spaceflight could use AutoNav Mark 4 for navigation and trajectory calculation in the event of communications failure, allowing safe reentry the atmosphere and landing without ground interaction.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)
Optical
Navigation & Guidance
Relative Navigation (Interception, Docking, Formation Flying; see also Control & Monitoring; Planetary Navigation, Tracking, & Telemetry)
Autonomous Control (see also Control & Monitoring)
Algorithms/Control Software & Systems (see also Autonomous Systems)
Attitude Determination & Control
Sequencing & Scheduling
Image Processing

PROPOSAL NUMBER:	17-2 **S2.01-9865**
PHASE-I CONTRACT NUMBER:	NNX17CP76P
SUBTOPIC TITLE:	Proximity Glare Suppression for Astronomical Coronagraphy
PROPOSAL TITLE:	Technology Development for High-Actuator-Count MEMS DM Systems

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
Boston Micromachines Corporation
30 Spinelli Place
Cambridge, MA 02138 -1070 (617) 868-4178

PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)
Steven Cornelissen
sac@bostonmicromachines.com
30 Spinelli Place
Cambridge, MA 02138 -1070
(617) 868-4178 **Ext:** 207

Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 3
End: 3

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

Boston Micromachines Corporation proposes high-precision deformable mirror (DM) systems with one hundred actuators across the active aperture, corresponding to almost eight thousand actuators in the device's circular aperture, using an innovative new approach for packaging and integration. The proposed work focuses on a technology gap that NASA has identified as critical for space-based exoplanet imaging: production techniques for small-stroke, high-reliability, high-precision deformable mirror systems. The main objective in this Phase II project is to substantially increase the state-of-the-art for the number of actuators in a compact MEMS DM system using microelectromechanical systems (MEMS) production processes and employing a multiple-layer approach to integrating routing line layers in the device. MEMS DMs will be bonded to custom manufactured printed circuit boards using conductive epoxy bonds and flip-chip alignment based on a new stencil printing process demonstrated in the Phase I project. The proposed work includes testing and evaluation of surface topography of DMs before and after bonding and assessment of actuator yield and reliability.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

High-actuator-count deformable mirrors have a few commercial applications. The following applications apply to products produced by Boston Micromachines (BMC) that will benefit from increased actuator count and reduced cost.

Space surveillance: BMC has success developing arrays up to 4096 elements for astronomy which can be used for space-based systems. These programs are funded by Department of Defense administrations with classified agendas.

Optical communication: Lasercomm systems would benefit from this new architecture for long-range, secure communication. Also, fiber optic communications can take advantage of our devices in an optical switching capacity.

Microscopy: The capabilities of many non-adaptive optics-enabled microscopy modalities' devices have reached their limits. Increasing actuator count and reducing cost of fabrication will enable users to purchase higher-resolution equipment at a lower cost for use in detecting disease. Modalities affected include two-photon excitation fluorescence (TPEF), second- and/or third-harmonic generation (SHG/THG), and 4Pi microscopy, coherent anti-stokes Raman spectroscopy (CARS) and super-resolution localization microscopy techniques.

Pulse-Shaping: Laser science strives to create a better shaped pulse for applications such as laser marking and machining, and material ablation and characterization. The use of a higher-actuator count array for these purposes will enable new science and more refined techniques.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)
High-actuator-count deformable mirrors have a few astronomical NASA commercial applications. The following applications apply to all Boston Micromachines (BMC) mirrors that will benefit from new manufacturing processes developed for this program and from subsequent reduced cost.
Astronomy: Post applications in this category can be broken into two categories: space telescopes and ground-based telescopes. In the case of space telescopes, there are a number of missions/mission concepts that require the wavefront control provided by the proposed high actuator count deformable mirrors. These include the Large UV/Optical/Infrared Surveyor (LUVOIR) and Habitable Exoplanet Imaging Mission (HabEx) telescopes. For ground-based telescopes, BMC has already had success developing arrays up to 4096 actuators for the Gemini Planet Imager and multiple smaller devices for high contrast imaging testbeds at Nanjing University, Space Telescope Science Institute, and University of Nice. BMC can achieve similar results for larger arrays for other new and existing installations such as the planned Extremely Large Telescopes (Thirty Meter Telescope (TMT), European Extremely Large Telescope (E-ELT) and the Giant Magellan Telescope (GMT)).
TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)
Microelectromechanical Systems (MEMS) and smaller
Adaptive Optics
Mirrors
Microfabrication (and smaller; see also Electronics; Mechanical Systems; Photonics)

PROPOSAL NUMBER:	17-2 **S3.06-8949**
PHASE-I CONTRACT NUMBER:	NNX17CP34P
SUBTOPIC TITLE:	Thermal Control Systems
PROPOSAL TITLE:	A Two-Phase Pumped Loop Evaporator with Adaptive Flow Distribution for Large Area Cooling

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
Creare, LLC
16 Great Hollow Road
Hanover, NH 03755 -3116 (603) 643-3800
PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)
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16 Great Hollow Road
Hanover, NH 03755 -3116
(603) 640-2425

Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 3
End: 4

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

NASA's future remote sensing science missions require advanced thermal management technologies to maintain multiple instruments at very stable temperatures and utilize waste heat to keep other critical subsystems above minimum operational temperatures. Two-phase pumped loops are an ideal solution for these applications. A critical need for these pumped loops is a microgravity-compatible evaporator having a large cooling area to maintain the temperatures of multiple electronics and instruments. The evaporator must be able to accommodate multiple heat loads with a wide range of heat flux densities and allow heat loads to be mounted on any available locations of its cooling surfaces to facilitate vehicle-level system integration. To this end, Creare proposes to develop a lightweight, compact evaporator with innovative internal design features to adaptively distribute liquid refrigerant to heated areas, preventing dryout in areas with high heat flux. This advanced flow distribution feature reduces liquid recirculation flow in the pumped loop and thus the system power input. The design features also provide strong internal structural support for the evaporator, reducing the size and mass of the evaporator cover plates. In Phase I, we proved the feasibility of the evaporator by developing a preliminary evaporator design, predicting its overall performance, and demonstrating its key performance features and fabrication processes by testing. In Phase II, we will optimize the evaporator design, fabricate a 0.5 m x 0.5 m evaporator, demonstrate its steady state and transient performance in a representative pumped loop, and deliver it to NASA JPL for further performance evaluation.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

The evaporator technology has applications in advanced two-phase thermal management systems for commercial and military satellites, aircraft, terrestrial cooling systems for electronics and laser systems, hybrid vehicle power electronics, and computer servers.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

The proposed evaporator will enable reliable two-phase pumped loops for efficient and precision thermal control of critical instruments in remote sensing science satellites and exploration vehicles, including a future mission to Saturn's moon Enceladus and the Surface Water and Ocean Topography (SWOT) mission. The evaporator technology also has applications in future two-phase thermal management systems for rovers and habitats.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)
Active Systems

PROPOSAL NUMBER:	17-2 **Z8.01-9758**
PHASE-I CONTRACT NUMBER:	NNX17CP36P
SUBTOPIC TITLE:	Small Spacecraft Propulsion Systems
PROPOSAL TITLE:	Fiber-fed Advanced Pulsed Plasma Thruster (FPPT)

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
CU Aerospace, LLC
301 North Neil Street, Suite 502
Champaign, IL 61820 -3169 (217) 239-1703
PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)
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301 N. Neil St.-Suite 502
Champaign, IL 61820 -3169
(309) 255-8442
Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 5
End: 6
TECHNICAL ABSTRACT (LIMIT 200 WORDS)
CU Aerospace (CUA) proposes the continued development of a Fiber-fed Pulsed Plasma Thruster (FPPT) that will enable cis-lunar and deep space missions for small satellites. While classic PPT technology is mature, it has historically been limited by its propellant load to precision pointing and small delta-V applications. A recent thruster advancement by CUA, Monofilament Vaporization Propulsion (MVP), adapted extrusion 3D printing technology to feed polymer propellant fiber to a resistojet thrust chamber. FPPT leverages this advancement by feeding PTFE fiber to its discharge region, enabling class-leading PPT propellant throughput and variable exposed fuel area. An innovative, highly parallel ceramic capacitor bank dramatically lowers system specific mass. FPPT is inherently safe; its non-pressurized, non-toxic, inert propellant and construction materials minimize range safety concerns. The Phase I effort accumulated more than 582,000 pulses, with thrust-stand measured Ibits from 0.057 – 0.241 mN-s at 960 – 2400 s specific impulse, representing a dramatic enhancement from state-of-art PPT technology. A Phase II 1U FPPT thruster will provide 2200 – 4900 N-s total impulse, enabling 0.4 – 1.0 km/s delta-V for a 5 kg CubeSat. A 1U design variation with 590 g propellant enables as much as ~10,000 N-s and 2 km/s for a 5 kg CubeSat. Advancing the technology to a 2U form factor increases propellant mass to 1.4 kg and delta-V to 10.7 km/s for an 8 kg CubeSat. CUA anticipates delivering to NASA a life-tested flight-like > 2,000 N-s 1U integrated system by the end of Phase II including the advanced thruster head with igniter system, PTFE fiber feed system, power processing unit, and control electronics.
POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)
Commercial interest in very small satellites continues to grow. In the 1-50 kg satellite sector, launches have shifted from a fairly balanced distribution between civil, government, commercial, and defense (2009-2016) to a distribution dominated by commercial interests. Moving forward, it is more important than ever that these satellites have access to propulsion systems to extend their asset time on orbit. The proposed thruster offers CubeSats and other small satellites a significant propulsion capability with high impulse per unit volume. The FPPT thruster will provide a compact, light-weight, non-hazardous propulsion technology solution that will be made available in a family of sizes that can meet the differing needs of users in DOD, industry, and universities for CubeSat and small-satellite missions. FPPT will require no

safety equipment for storage, transportation, integration, and testing, and place no demanding requirements on the launch provider, making it an ideal low-cost solution for industry, research, and academic small-satellite propulsion needs.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

Historically, pulsed plasma systems have targeted small delta-V applications such as ACS. With the demonstrated high performance of CUA's FPPT (Isp up to 2400 seconds) and its innovative propellant feed and storage system, FPPT exceeds the goals of the Z8.01 topic and outperforms previous state of the art PPT systems, as well as newer technologies. With an anticipated > 2,000 N-s total impulse from a 1U system, large orbit transfers and even inclination changes of tens of degrees are now available to smaller satellites. The intrinsic safety of FPPT and its inert, unpressurized PTFE propellant position it as a prime candidate for secondary payload missions where costs and logistics are dominated by range safety concerns. The solid propellant has no handling, storage, or operational restrictions. The ease of handling and storage for the solid propellant can extend operation to planetary missions with no additional monitoring or controls. FPPT system unit costs are anticipated to be significantly below competing CubeSat propulsion systems.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)

Ablative Propulsion
Fuels/Propellants
Maneuvering/Stationkeeping/Attitude Control Devices
Spacecraft Main Engine
Relative Navigation (Interception, Docking, Formation Flying; see also Control & Monitoring; Planetary Navigation, Tracking, & Telemetry)
Spacecraft Design, Construction, Testing, & Performance (see also Engineering; Testing & Evaluation)

PROPOSAL NUMBER:	17-2 **H9.04-8557**
PHASE-I CONTRACT NUMBER:	NNX17CP37P
SUBTOPIC TITLE:	Advanced RF Communications
PROPOSAL TITLE:	GaN MMIC Ka-Band Power Amplifier

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)

Custom MMIC Design Services, Inc.
300 Apollo Drive
Chelmsford, MA 01824 -3629 (978) 467-4290

PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)

James Moniz
moniz@custommmic.com
300 Apollo Drive

Chelmsford, MA 01824 -3629
(978) 467-4290 **Ext:** 119

Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 3
End: 4

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

NASA is seeking innovative Advanced RF Platform technologies at the physical level, specifically Ka-Band high efficiency high linearity 10 to 20 Watt solid state power amplifiers (SSPAs), to meet the needs of future space missions for communications and sensor applications. Space missions require small size, weight, and power (SWaP) among the hardware components. As a result, monolithic microwave integrated circuits (MMICs) are well suited to fill this need. In Phase I of this SBIR, Custom MMIC Design Services, Inc. (Custom MMIC) analyzed a number of commercially available Gallium Nitride (GaN) MMIC process technologies from domestic foundries based in the United States, and selected the optimum process for linear power amplifiers (PAs) - the 0.2 um GaN process as offered by Northrop Grumman Space and Technology (NGST). Custom MMIC's use of novel small- and large-signal linear power amplifier (PA) circuit design techniques led to circuit simulations exhibiting a large signal gain greater than 22 dB from 31.7 to 32.3 GHz, a linear output power of 13 W, input and output return losses of better than -20 dB, a PAE of 41% PAE, and an error vector magnitude (EVM) of 4.5% for 8PSK 500 MHz modulation. In addition, Custom MMIC's use of the balanced amplifier topology allowed the simultaneous independent optimization of input/output return losses and internal PA impedances for linearity and PAE. As a result, Custom MMIC has produced a design that represents a new industry state-of-the-art benchmark for linear Ka-Band GaN MMIC PAs. In Phase II, we will develop not only the MMIC hardware that represents this design for JPL at Ka-Band (31.8 - 32.3 GHz) but also a similar linear PA for GSFC at K-Band (25.5 - 27 GHz) and a saturated radar PA for JPL at 35 GHz.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

Linear GaN PA MMICs represent a new frontier in microwave research and development, though to date few manufacturers have been able to turn such efforts into viable commercial products. Custom MMIC is one such company that has made the successful transition from design to production on a number of GaN amplifiers, and so is well suited to bring an expanded portfolio of new GaN amplifiers to the market in a timely and efficient manner. Custom MMIC will use the follow-on Phase II SBIR contract to bring a number of new 10-20 W, Ka-band high power amplifiers to the commercial space.

The 25-27 GHz GaN 5 W linear amplifier is being well received in the commercial markets. A customer has already designed it into a new product and we are transitioning to production. We are in discussions with this customer as to whether the performance can be improved. It is likely that when this SBIR program transitions to Phase II we would also target this lower frequency band for a 10 W linear variant.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

The improvements and innovations achieved during the Phase I portion of this 10-20 W, KA-Band GaN MMIC PA and subsequently manufactured in a follow-on Phase II will allow us to develop other state-of-the-art, linear, high efficiency PAs for NASA at other frequency bands. Specifically, Custom MMIC can apply these Phase I results to improve the 5 W, 25 to 27 GHz

Power Amplifier as previously developed for NASA Goddard, and the 5 W, 35 GHz Power Amplifier for Radar Applications as previously developed for NASA JPL, such that both amplifiers can be increased to greater than 10 W output power with better PAE. Other NASA Applications could be 1) NASA deep space missions that require high data rate Ka-Band downlinks, 2) Mass, power and volume challenged surface missions to moons, asteroids and comets (such as Europa Lander), and 3) Future NASA instruments that require Ka-Band radars (such as Mars 2020).

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)
Radiometric
Sensor Nodes & Webs (see also Communications, Networking & Signal Transport)
Microwave
Ad-Hoc Networks (see also Sensors)
Amplifiers/Repeaters/Translators
Transmitters/Receivers
Circuits (including ICs; for specific applications, see e.g., Communications, Networking & Signal Transport; Control & Monitoring, Sensors)

PROPOSAL NUMBER:	17-2 **H9.01-8624**
PHASE-I CONTRACT NUMBER:	NNX17CP40P
SUBTOPIC TITLE:	Long Range Optical Telecommunications
PROPOSAL TITLE:	High Power (50W) WDM Space Lasercom 1.5um Fiber Laser Transmitter

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
Fibertek, Inc.
13605 Dulles Technology Drive
Herndon, VA 20171 -4603 (703) 471-7671

PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)
Doruk Engin
dengin@fibertek.com
13605 Dulles Technology Drive
Herndon, VA 20171 -4603
(703) 471-7671

Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 3
End: 5

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

Fibertek proposes to develop and demonstrate a spaceflight prototype of a wideband, high power 50W, 1.5-um fiber laser transmitter, supporting high data rate wavelength-division-multiplexed (WDM) operation for space optical communication links. The fiber laser transmitter will support up to 8x WDM channels with high power conversion efficiency. The proposed 10x scaling of the average and peak power performance for such a space-qualifiable WDM 1.5-um transmitter enables >100x data-rate scaling of current space laser communication links. In Phase 1 of the program all proposed performance objectives were exceeded or achieved. The successful outcome of Phase II will be to develop a prototype, space-qualifiable, high-efficiency, high-power (50W), 1.5-um WDM space lasercom transmitter. This advances the Technology Readiness Level (TRL) from 3 to 5.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

This effort supports the need for large data volume DoD and commercial GEO inter-satellite networks and high data volume downlink and LCRD (Lunar Communication Relay Demonstrator) style relay.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

1) Supports NASA SCaN (Space Communications and Navigation Program) roadmap to enable large science data volume returns from deep space missions. NASA exploration mission to Mars, planets and asteroid belts will benefit from much higher data rates and longer ranges than the current state of the art.

2) NASA SCaN office initiatives to support large 100G + core GEO networks.

3) Space laser communication transmitter for ISS/LEO/GEO platforms, similar to NASA technology demonstrator missions

4) High-data rate, multi-channel laser transmitters, as an adjunct high-volume data link for Earth Science missions, such as for hyper-spectral imaging, JPSS (Joint Polar Satellite System), Landsat, and radar/lidar missions where large data volumes are needed.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)

Fiber (see also Communications, Networking & Signal Transport; Photonics)
Filtering
Gratings
Lasers (Communication)
Spacecraft Instrumentation & Astrionics (see also Communications; Control & Monitoring; Information Systems)
Multiplexers/Demultiplexers
Transmitters/Receivers
Waveguides/Optical Fiber (see also Optics)
Models & Simulations (see also Testing & Evaluation)

PROPOSAL NUMBER:	17-2 **Z6.01-8732**
PHASE-I CONTRACT NUMBER:	NNX17CP47P
SUBTOPIC TITLE:	High Performance Space Computing Technology

PROPOSAL TITLE: FLASHRAD: A Non-Volatile 3D Rad Hard Memory Module for High Performance Space Computers

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
Irvine Sensors Corporation
3001 Red Hill Avenue, B3-108
Costa Mesa, CA 92626 -4506 (714) 444-8700
PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)
James Yamaguchi
jyamaguchi@irvine-sensors.com
3001 Red Hill Avenue, B3-108
Costa Mesa, CA 92626 -4506
(714) 444-8785

Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 3
End: 4

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

The computing capabilities of onboard spacecraft are a major limiting factor for accomplishing many classes of future missions. Although technology development efforts are underway that will provide improvements to spacecraft CPUs, they do not address the limitations of current onboard memory systems. In addition to CPU upgrades, effective execution of data-intensive operations such as terrain relative navigation, hazard detection and avoidance, autonomous planning and scheduling, and onboard science data processing and analysis require high-bandwidth, high-capacity memory systems to maximize data storage and provide rapid access to observational data captured by high-data-rate instruments (e.g., Hyperspectral Infrared Imager, Interferometric Synthetic Aperture Radar).

Three-dimensional ICs, after a long wait, are now a reality. The first mainstream products are 3D memory cubes that offer manifold improvements in size, capacity, speed, and power. Unfortunately, none of these are ready for space. The purpose of this research and development is to pursue a non-volatile, 3D memory module that can meet the high-reliability requirements of space and interface to the High Performance Space Computer (HPSC) using a high-speed serial interface. Development will include fabricating a 3D memory cube and RTL for a FPGA based memory controller which will eventually be migrated to a rad-hard ASIC. The FPGA based platform will integrate a 3D memory cube to produce a 3D memory module prototype that will validate and demonstrate the features, reliability, and performance of the envisioned 3D module.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

Optimization of the logic base of a memory cube has not been available for any application. Development of the design tools to achieve better optimization of these logic bases will in turn lead to a broader application base which will benefit not only the users for space applications, but will benefit terrestrial users to help improve the efficiency of their electronics by addressing SWaP issues.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)
The computing capabilities of onboard spacecraft are a major limiting factor for accomplishing many classes of future missions. Although technology development efforts are underway that will provide improvements to spacecraft CPUs, they do not address the limitations of current onboard memory systems. In addition to CPU upgrades, effective execution of data-intensive operations such as terrain relative navigation, hazard detection and avoidance, autonomous planning and scheduling, and onboard science data processing and analysis require high-bandwidth, high-capacity memory systems to maximize data storage and provide rapid access to observational data captured by high-data-rate instruments (e.g., Hyperspectral Infrared Imager, Interferometric Synthetic Aperture Radar).Three-dimensional ICs, after a long wait, are now a reality. The first mainstream products are 3D memory cubes that offer manifold improvements in size, capacity, speed, and power. Unfortunately, none of these are ready for space. The purpose of this research and development is to pursue a non-volatile, 3D memory module that can meet the high-reliability requirements of space and interface to the High Performance Space Computer (HPSC) using a high-speed serial interface. Development will include fabricating a 3D memory cube and RTL for a FPGA based memory controller which will eventually be migrated to a rad-hard ASIC. The FPGA based platform will integrate a 3D memory cube to produce a 3D memory module prototype

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)
Metallics
Spacecraft Instrumentation & Astrionics (see also Communications; Control & Monitoring; Information Systems)
Circuits (including ICs; for specific applications, see e.g., Communications, Networking & Signal Transport; Control & Monitoring, Sensors)
Manufacturing Methods
Materials (Insulator, Semiconductor, Substrate)
Models & Simulations (see also Testing & Evaluation)
Software Tools (Analysis, Design)
Processing Methods

PROPOSAL NUMBER:	17-2 **S1.11-8595**
PHASE-I CONTRACT NUMBER:	NNX17CP48P
SUBTOPIC TITLE:	In Situ Instruments/Technologies for Ocean Worlds Life Detection
PROPOSAL TITLE:	WOLFEChip: Wholly-Integrated Optofluidic Laser-Induced Fluorescence Electrophoresis Chip

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
Leiden Measurement Technology
1230 Mountain View Alviso Road, Suite A
Sunnyvale, CA 94089 -9408 (650) 605-3046

PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)
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Sunnyvale, CA 94089 -9408
(510) 301-8980

Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 4
End: 6

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

In this Small Business Innovative Research (SBIR) effort, Leiden Measurement Technology LLC (LMT) proposes to design and build the Wholly-integrated Optofluidic Laser-induced Fluorescence Electrophoresis Chip (WOLFEChip) System, a microchip capillary electrophoresis (MCE) system using a miniaturized optofluidic approach for packaging all critical optical elements necessary for laser-induced fluorescence (LIF) on-chip. WOLFEChip uses cutting-edge laser micromachining to fabricate fully-three-dimensional optical elements that focus excitation laser light into a MCE microchannel to excite fluorescence. The fluorescence emission is collected using custom-designed high-numerical aperture collection optics immune to misalignment of the chip up to 1-mm. This improves on current and past implementations of MCE-LIF by (1) greatly miniaturizing the optical elements which comprise a significant amount of space in MCE-LIF systems; (2) making the entire LIF optical system monolithic and immune to misalignment which greatly enhances the vibration-resistance of the entire system; (3) making the system immune to operator-to-operator variations caused by the periodic need to carefully align traditional MCE-LIF systems; and (4) greatly reducing measured stray light and thereby potentially increasing the signal-to-noise ratio (SNR) of the MCE-LIF system by employing right-angle excitation/emission optical geometries and through the use of high-quality fluorescence-free fused silica. LMT will deliver a complete MCE-LIF system featuring a refined WOLFEChip design created in Phase I.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

WOLFECHip technology allows MCE-LIF systems to be ruggedized and maintained by less-skilled personnel and so has many uses outside of NASA. Due to its sensitivity, specificity, portability (both in terms of mass and ruggedness), and flexibility it can be used in many different situations including (1) environmental research of terrestrial and marine waters (e.g., detecting important biomarkers or nutrient sources); (2) process control and monitoring of closed water systems (e.g., Naval shipboard water monitoring, water treatment centers); (3) pharmaceutical research; (4) monitoring and identification of organic pollution in water, soils, and sediments (e.g., pesticides, fuels, drugs); (5) the detection of biological and chemical weapons. Advantages of WOLFEChip over existing electrophoresis technologies are its portability (enabled by its size and its rugged optofluidic implementation of LIF), resolution (MCE-LIF is inherently higher-resolution than CE due to the injected plug size), and operator-to-operator invariance (other MCE-LIF systems require an operator to manually align optics into a MCE chip, leading to LIF efficiencies varying based on the skill of the operator; WOLFEChip uses integrated optics to avoid this). In Phase III, LMT will seek to establish commercial relationships with vendors of

MCE-LIF systems for marketing commercial-implementations of WOLFEChip to environmental scientists, water-quality monitoring authorities, and the United States Navy.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

WOLFECHip is especially well-suited for detecting life on Ocean Worlds in the solar system (e.g., Europa, Titan, Enceladus) as well as other smaller bodies (e.g., asteroids, comets) and rocky planets (e.g., Mars). For the detection of life, an unambiguous, highly-sensitive, definitive approach is required and MCE-LIF is an ideal technique for detecting life by measuring the relative abundance and chirality of amino acids and other important biomarkers. Key benefits of MCE-LIF for space exploration include: (1) its levels of detection are orders-of-magnitude lower than more traditional high-TRL gas chromatography approaches; (2) the technique uses minute volumes of reagents; (3) the instrumentation inherently requires very little power and mass; and (4) MCE-LIF is highly-suitable for dealing with liquid samples. WOLFEChip will be a great stride towards further miniaturizing and ruggedizing MCE-LIF hardware for upcoming mission opportunities by fully integrating the critical LIF optics on-chip thereby reducing mass, size, and the need for mechanical stability/alignment of external optical systems to micro-scale features.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)

Lenses
Biological (see also Biological Health/Life Support)
Biological Signature (i.e., Signs Of Life)
Chemical/Environmental (see also Biological Health/Life Support)
Optical/Photonic (see also Photonics)
Analytical Instruments (Solid, Liquid, Gas, Plasma, Energy; see also Sensors)
Analytical Methods
Prototyping

PROPOSAL NUMBER:	17-2 **S1.04-9669**
PHASE-I CONTRACT NUMBER:	NNX17CP49P
SUBTOPIC TITLE:	Sensor and Detector Technology for Visible, IR, Far IR and Submillimeter
PROPOSAL TITLE:	Tunable, High-Power Terahertz Quantum Cascade Laser Local Oscillator

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)

LongWave Photonics
958 San Leandro Avenue
Mountain View, CA 94043 -1996 (617) 399-6405

PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)

Tsungyu Kao

wilt_kao@longwavephotonics.com
958 San Leandro Avenue
Mountain View, CA 94043 -1996
(617) 399-6405

Estimated Technology Readiness Level (TRL) at beginning and end of contract:

Begin: 3
End: 5

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

NASA and NASA funded missions/instruments such as Aura/MLS (Microwave Limb Sounder), SOFIA/GREAT and STO/STO-2 have demonstrated the need for local oscillator (LO) sources between 30 and 300 um (1 and 10 THz). For observations >2 THz, technologically mature microwave sources typically have microwatt power levels which are insufficient to act as LOs for a heterodyne receivers. LongWave Photonics is proposing to develop a high power, frequency tunable, phase/frequency-locked, single mode, External Cavity THz quantum cascade laser (ECT-QCL) system with >2 mW average power output and a clear path to increase the power to >10 mW. The system includes a THz QC gain chip based on SISP or metal-metal waveguide with an integrated horn or lens structure to reduce facet reflectivity. Frequency selective external feedback will be tunable over 100's of GHz, with center frequencies ranging from 2 to 5 THz. The gain chip will be packaged in a high-reliability Stirling cycle cooler with all external component integrated under the same enclosure.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

Initial applications for this technology are mainly research markets for low-pressure gas spectroscopy. The narrow line width and the ability to provide real-time frequency information and frequency tunability of THz radiation also has great appeal. Another potential application is to replace THz gas laser used for THz detector power calibration. Long-term applications include industrial uses for trace gas detection. For industrial applications, the use of high-reliability, compact Stirling cycle coolers would greatly increase the usability of these QCL devices, which have traditionally required liquid nitrogen cooling or larger cryocooling systems.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

NASA applications include the use of the QCL as an LO for >2 THz receivers for future missions. Here the narrow linewidth (<100 kHz) of the QCLs can be used to resolve Doppler-limited low-pressure gasses (~MHz linewidth). The external cavity QCL LO will be a frequency tunable, compact replacement for any gas-laser LO. The resulting source will be a compact, reliable, table-top sized THz high power with narrow linewidth. It will be an easy-to-use platform for NASA researchers to study the performance of other key components in the receiver such as Schottky or HEB mixers. THz QC gain chip can also be used as the power amplifier providing gain for solid-state frequency multiplier or as the low noise preamplifier in the heterodyne receiver to reduce overall noise temperature.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)

Detectors (see also Sensors)
Lasers (Measuring/Sensing)
Chemical/Environmental (see also Biological Health/Life Support)

Electromagnetic
Optical/Photonic (see also Photonics)
Radiometric
Terahertz (Sub-millimeter)
Analytical Instruments (Solid, Liquid, Gas, Plasma, Energy; see also Sensors)

PROPOSAL NUMBER:	17-2 **S2.01-9655**
PHASE-I CONTRACT NUMBER:	NNX17CP52P
SUBTOPIC TITLE:	Proximity Glare Suppression for Astronomical Coronagraphy
PROPOSAL TITLE:	Next-Generation Deformable Mirrors for Astronomical Coronagraphy by Utilizing PMN-PT Single Crystal Stack Actuators in integration with Driver ASIC

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
Microscale, Inc.
800 West Cummings Park, Suite 3350
Woburn, MA 01801 -6377 (781) 995-2245
PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)
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xwu@microscaleinc.com
800 West Cummings Park, Suite 3350
Woburn, MA 01801 -6377
(339) 927-1996
Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 3
End: 4
TECHNICAL ABSTRACT (LIMIT 200 WORDS)
This SBIR Phase II project aims to develop innovative manufacturing methods for batch fabrication of single crystal PMN-PT stack actuator deformable mirrors (DM) at low cost of up to one order of magnitude reduction to those offered by the state-of-the-art manufacturing techniques. The methods, being applicable to produce high-performance deformable mirrors with a large variety of pixel densities and actuator counts, are also proposed to seamlessly integrate the DM manufacturing process with a novel large-scale driver ASIC, hence an enhancement of the proposed batch manufacturing process by reliably packaging DMs with high yield, zero failure pixel, and with high optical qualities, and on top of these offering the demanded high-resolution mirror surface control. Low payload, high performance, low cost, and low power, are the four keys that can lead a DM to successful implementation into NASA's high-performance systems. For lab testing, concept inspiration, and concept validation, the AO

communities need high-performance but low-cost DMs to study wide variety of AO concepts on a tight budget and in a timely fashion; on the other hand, once an AO concept is approved, a space-based adaptive optics system will additionally demand low payload and low power dissipation for space-based deployment. The proposed DM manufacturing and ASIC integration aims to develop DMs to meet the two staged needs through one joint DM-ASIC development program.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

Non-NASA applications include laser beam shaping, ophthalmology and other microscope applications. In particular, for the Department of Defense, if needed, the prototype adaptive optical systems based on the Phase II results can be applied to military seekers, FLIRs, optical communications, and other adaptive optics systems for military operations. For optical computing, the VLSI circuit could be combined with piston-only micromirror structure for a phase-only spatial light modulator. Commercial markets for these systems also include retinal imaging, supernormal human vision, and amateur telescopes. The research is also expected to lead to a family of compact, low-cost, high performance spatial light modulators for direct retinal display, head mount display, and large-screen projection display applications.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

In general, future high-performance systems for: (1) correction of aberrations in large-aperture, space-deployed optical interferometers and telescopes, (2) high-resolution imaging and communication through atmospheric turbulence, (3) laser beam steering, and (4) optical path alignment, (5) propagation of directed laser energy through atmospheric turbulence, will require deformable mirror (DM) wavefront correctors with several hundred to millions of elements. More specifically, NASA missions and instruments that would benefit from the proposed DM manufacturing/packaging technology are WFIRST (near future), Visible Nulling Coronagraph (VNC), single aperture far-infrared observatory (SAFIR), Extrasolar Planetary Imaging Coronagraph (EPIC), and the Terrestrial Planet Finder (TPF). Other NASA projects that would benefit from the proposed TTP mirror technology include the Submillimeter Probe of the Evolutionary Cosmic Structure (SPECS), the Stellar Imager (SI) and the Earth Atmospheric Solar Occultation Imager (EASI).

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)

Composites
Smart/Multifunctional Materials
Actuators & Motors
Microelectromechanical Systems (MEMS) and smaller
Adaptive Optics
Lasers (Communication)
Visible
Infrared
Microfabrication (and smaller; see also Electronics; Mechanical Systems; Photonics)
Processing Methods

PROPOSAL NUMBER:	17-2 **S1.02-9973**
PHASE-I CONTRACT NUMBER:	NNX17CP53P
SUBTOPIC TITLE:	Technologies for Active Microwave Remote Sensing
PROPOSAL TITLE:	Deployable Ku/Ka/W Tri-Band Cylindrical Parabolic Antenna

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
MMA Design, LLC
P.O. Box 7804
Loveland, CO 80537 -0804 (970) 290-6426
PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)
Christopher Pelzmann
capelzmann@mmadesigmllc.com
2555 55th St. Suite 104
Boulder, CO 80301 -5729
(720) 728-8491

Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 3
End: 6

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

MMA has proposed a technical approach creates a highly simplistic antenna architecture by taking advantage of natural mechanics of high-strain composite materials to create a 1D parabolic reflector surface. At smaller scales (1-2 m2), the architecture allows continuous reflector surfaces for ESPA-class spacecraft, while at larger scales a modular architecture is taken advantage of to produce much larger apertures without requiring comparatively large spacecraft. The effort will develop a large aperture at Ku, Ka, and W frequencies using rollable shell surfaces that combine the surface accuracy of rigid reflectors with the packaging advantages of flexible reflectors. Developing a stowable, “morphing”, high-strain composite reflector surface with sufficient surface roughness and position knowledge for frequencies up to 94 GHz will enable large apertures with reduced stowed envelope and can dramatically reduce the hardware, instrument and mission implementation costs. Originally inspired by the shape of a beam being deflected under load, MMA is using analysis and lab testing to determine the prescribed loading configuration capable of deflecting a semi-rigid member into a parabolic curve. By using the mechanics of bending rather than molding and manufacturing to prescribe the reflector’s shape, the system provides a repeatable method of forming a parabolic surface. This architecture lends itself to a structurally simple system, providing high reliability and low complexity. Phase I efforts demonstrated through analysis and prototyping that loading conditions exist for isotropic beams to form a surface closely matching a parabola, while RF performance simulations verified the reflector’s ability to perform with minimal gain losses up to 95 GHz. The phase II effort will build upon this early development to design, build, and test a deployable tri-band antenna system.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

The same economic drivers that support NASA commercialization of this technology apply to

non-NASA markets. The DoD, foreign countries, and commercial interests are all in need of improved, timely weather data.
The U.S. military has expressed interest in smaller, lower cost, dis-aggregated satellite system architectures that support rapid upgrades and replacements. This technology can support such efforts in precipitation measurement, hurricanes, ocean surface winds and many more weather needs with more accurate and timely data availability from low earth orbits.
Many countries suffer the negative effects of typhoons and hurricanes and actively fund low cost weather satellite missions that can be greatly enhanced by this antenna technology.
Commercial entities are also potential data consumers for such efforts as disaster relief and assessments of weather damage, agricultural impacts, etc.
As mentioned above, the wide band capability of this technology also supports a wide range of other RF applications that will also drive commercialization of this antenna/reflector technology.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

NASA utilizes multi-band radar for precipitation and moisture related weather monitoring instruments. Recent missions have incorporated large, expensive antenna systems that drive large mission costs such as the Global Precipitation Measurement Mission ($1B). The availability of a relatively large aperture (2 square meters) that performs at Ku/Ka/W frequencies but can stow in a small volume (~.001 cubic meters) enables missions to be conducted on much smaller, less expensive satellite platforms (300-400 kg ESPA/ESPA Grande) that can be launched as secondary payloads on larger rockets, or utilize many of the emerging lower cost rockets for a dedicated launch. This approach supports rapid deployment of experimental missions as well a mission which utilizes multiple satellites in a constellation to provide faster revisit times and also enables instrument upgrades and rapid, low cost replacement/replenishment.
The broad frequency capabilities of this antenna technology also support commercialization into other RF applications required by NASA including communications, other applications of RF remote sensing and imaging, etc.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)

Electromagnetic
Microwave
Radio

PROPOSAL NUMBER:	17-2 **S1.03-9385**
PHASE-I CONTRACT NUMBER:	NNX17CP60P
SUBTOPIC TITLE:	Technologies for Passive Microwave Remote Sensing
PROPOSAL TITLE:	Correlation Radiometer ASIC

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)

Pacific Microchip Corporation
3916 Sepulveda Boulevard, #108
Culver City, CA 90230 -4650 (310) 683-2628

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Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 3
End: 5

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

The proposed project aims to develop an application specific integrated circuit (ASIC) for the NASA's microwave correlation radiometers required for space and airborne Earth sensing applications. The radiometer instrumentation installed on CubeSats and SmallSats is required to have small volume, low weight and consume low power. Currently used correlating radiometers rely on analog signal processing, thus are bulky, power hungry and cannot be reprogrammed. Analog filter parameters tend to be unstable over temperature, power supply voltage, may degrade over time, and need tuning.

The proposed low-power, rad-hard ASIC will operate with microwave correlation radiometer front ends down-converting the RF to up to 10GHz IF quadrature signals. The ASIC will include digitizers, bandpass filters, cross-correlators, totalizers, serializers, an output data interface, and an I2C interface for the ASIC's programming. Bandpass filters will split up the digitized quadrature IF input signals into bands (up to 16), will cross-correlate the signals within each band, and will ship out the resultant data in a convenient format. Instead of analog signal processing performing a strictly defined function, the ASIC will employ a digital signal processing which can be reprogrammed to adopt specific parameters of the filter block such as the number of bands, each filter's corner frequency, bandwidth and filter's order. A number of innovations will be introduced to the ASIC in order to combine programmability, low power consumption and radiation tolerance.

The project's Phase I will provide the proof of feasibility of implementing the proposed ASIC. Phase II will include finishing the design, chip fabrication, testing and delivering the ADC prototypes which will be ready for commercialization in Phase III.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

In addition to its primary application in the NASA's correlation radiometry systems, the proposed ASIC is targeted for other commercial and military related systems which require small size, low power, radiation hardened radiometers. Commercial applications include radiometers employed on communication, remote sensing and navigation satellites. With the increasing deployment of small size satellites, compact radiometer based positioning is essential as well as it is crucial for swarms of satellites that should maintain certain formation. Possible military applications include satellites used for communication and surveillance. Another area of application includes synthetic aperture radar receiver modules. In case of the Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA), both space and ground based remote sensing instruments require high precision radiometers for temperature, water vapor, pollutant, ozone and other exploration.

Radiometers used for thermal imaging in security systems is yet another application area for the proposed ASIC.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

The proposed correlation radiometer back end ASIC combining signal normalization, digitizing, programmable digital bandpass filtering and cross-correlation functions is expected to greatly reduce the size, complexity, power consumption and reliability of radiometer instruments. These radiometers are required for the current and future NASA's passive remote sensing instruments within Earth, planet and sun exploration missions. In addition, the proposed ASIC can find application in radiometers required for radio astronomy for measurements of the properties of the Cosmic Microwave Background (CMB). Distributed Spacecraft Missions (DSM) including Constellations, Formation Flying missions, or Fractionated missions using CubeSats or SmallSats require precise position synchronization between satellites which can be implemented by using correlation radiometers tracking a common radiation source.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)

Infrared

Circuits (including ICs; for specific applications, see e.g., Communications, Networking & Signal Transport; Control & Monitoring, Sensors)

PROPOSAL NUMBER:	17-2 **S1.04-8763**
PHASE-I CONTRACT NUMBER:	NNX17CP61P
SUBTOPIC TITLE:	Sensor and Detector Technology for Visible, IR, Far IR and Submillimeter
PROPOSAL TITLE:	A Low Power Rad-Hard ADC for the KID Readout Electronics

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
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Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 2
End: 4

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

The proposal aims to develop an analog-to-digital converter (ADC) required for the Kinetic Inductance Detector (KID) readout electronics. KIDs are developed for photometers and spectrometers for astrophysics focal planes, and earth or planetary remote sensing instruments. ADCs employed in space based KIDs are required to combine several features: radiation hardness, low power consumption, high resolution and high-sampling rate to facilitate increase in the number of the readout tones and to reduce the size of the electronics.

The proposed SAR ADC aims to achieve a 12-bit resolution and the lowest to date reported figure of merit (FOM) at the 1GSps rate. A number of innovations will be introduced to the ADC in order to combine low power consumption (below 100mW) with the signal to noise and distortion ratio (SINAD) of at least 65dB. Tolerance to at least 100Krads of total ionizing dose (TID) radiation will be achieved through application of ultra-thin gate oxide CMOS technology. A novel calibration technique for the capacitor mismatch will be introduced to improve linearity and increase the sampling rate. The proposed calibration technique introduced to the sub-ranging architecture with application of the asynchronous SAR logic will facilitate reduction of switching power.

Phase I work provided the proof of feasibility of implementing the proposed ADC. Phase II will result in the silicon proven ADC prototypes being ready for commercialization in Phase III.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)
The potential commercial applications for the proposed low power ADC include electronic systems employed in communication and scientific satellites, high-energy physics instruments, and medical X-ray imaging equipment. The proposed ADC can also find application in instruments and devices which require low power consumption, such as portable devices employing wireless data transmission based on WiFi, WiMAX and WiGig specifications.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)
The proposed ADC is primarily targeted for application in the Kinetic Inductance Detector and will meet the NASA's expectations for the radiation hardened low power ADC required for the detector's readout electronics. The ADC will also be applicable for other NASA missions since it offers a flexible solution for meeting the stringent radiation tolerance and power consumption requirements that are essential in L-band and P-band radars, an advanced synthetic aperture radar (SAR), an interferometer for surface monitoring, ice topography, hydrology, oceanography.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)
Sensor Nodes & Webs (see also Communications, Networking & Signal Transport)
Circuits (including ICs; for specific applications, see e.g., Communications, Networking & Signal Transport; Control & Monitoring, Sensors)

PROPOSAL NUMBER:	17-2 **S2.01-9936**
PHASE-I CONTRACT NUMBER:	NNX17CP62P
SUBTOPIC TITLE:	Proximity Glare Suppression for Astronomical Coronagraphy
PROPOSAL TITLE:	Polymer Coating-Based Contaminant Control/Elimination for Exo-S Starshade Probe

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
Photonic Cleaning Technologies, LLC
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Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 4
End: 7

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

Our First Contact Polymer (FCP) is an easy-to-apply, residue-less, peelable strip coat that protects and cleans optics, detectors, and other sensitive surfaces, restoring them to a pristine condition. Using FCP is as simple as spraying or brushing it on a surface of interest, allowing it to dry for 15 minutes, and stripping off the rugged coating when desired. Multiple measurements, including at NASA's Goddard Space Flight Center, show that FCP cleans better than any existing method, including the complicated, expensive, and hazardous CO2 snow, leaving no detectible residue. FCP is used to clean telescope optics at the Keck Observatory, GTC in the Canary Islands, Vandenberg Airforce Base, etc. The polymer was used by LIGO to clean the optics that enabled its breakthrough discovery of gravitational waves and enables the THAAD missile interceptor by protecting and cleaning its optics. FCP was even used at the Smithsonian Institute to clean irreplaceable gems such as the Hope Diamond, demonstrating potential uses far beyond optics. Our technology is a crosscutting solution enabling the demanding cleanliness requirements of the Exo-S Starshade probe's occulter, reducing the duration and cost of meeting Planetary Protection requirements without damaging sensitive components, and providing cleanroom-level cleanliness without the cleanroom, including for semiconductor manufacturing. Since our Red FCP exhibits anomalously high adhesion to certain metals and the amorphous metallic glass of Starshade petal edges, we developed in Phase I a variant with lower adhesion to metals. While the resulting adhesion was too low to be optimal, it demonstrated the adhesion tunability of our product. In Phase II, we produce 18 variants, identifying the lowest-cost one that provides optimal adhesion to protect, clean, and minimize

the contribution of peeling to a mission’s alignment error budget. We also develop Standard Operation Procedures and training for application and removal.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

Post-SBIR commercialization will focus on photonics markets and markets where surface sterility is of interest. These include medical & scientific research, pharmaceutical & food productions, or any manufacturing currently using clean rooms to maintain sterility. Surface radiation contamination removal would interest government & commercial operators within the nuclear/defense industries.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

Our surface-specific stripcoatings will provide superior cleaning & protection from recontamination. In Phase I , we began developing a truly enabling, crosscutting technology that fills needs for multiple NASA missions, successfully developing the ability to prepare space-ready, contamination-free surfaces at unprecedented levels. Our strippable, surface-tunable, and residue-less polymer solutions can be a critical and key enabling technology required to meet mission objectives. For example, the LIGO experiment used our FCP to clean the optics that enabled its breakthrough gravitational-wave discoveries. As in LIGO, the contamination control requirements for the Starshade and the Large Interferometer Space Antenna (LISA) missions are so demanding that without the performance level of our technology, we believe those missions will not launch. LISA was recently selected by the European Space Agency (ESA) for its third large Cosmic Vision mission, while Starshades are seen as a key technology for the HabEx mission, currently under study. A starshade is also under consideration in support of the Wide-Field InfraRed Survey Telescope (WFIRST) and the Large UV/Optical/IR (LUVOIR) Surveyor. Potential future applications include creating/maintaining sterile & biological contamination-free surfaces enhancing NASA's Planetary Protection Mission, and nanotube doped, ESD controlled films for CCD and IRFPA sensor cleaning.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)

Coatings/Surface Treatments
Polymers
Adaptive Optics
Detectors (see also Sensors)
Lasers (Weapons)
Optical
Microfabrication (and smaller; see also Electronics; Mechanical Systems; Photonics)

PROPOSAL NUMBER:	17-2 **Z7.01-8404**
PHASE-I CONTRACT NUMBER:	NNX17CP64P
SUBTOPIC TITLE:	Supersonic Parachute Inflation Materials Testing, And Instrumentation

PROPOSAL TITLE: Weaved Distributed Plastic Optical Fiber Sensor (DIFOS) SHM system

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Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 3
End: 7

TECHNICAL ABSTRACT (LIMIT 200 WORDS)

ROI with the support of a strategic partners from the decelerator vehicle business will complete the engineering development, produce, extensively laboratory test, environmentally qualify on a relevant parachute platform, and deliver to NASA a low power lightweight, small form factor, weaved DIFOS SHM system. At the end of the Phase II program, ROI will identify a relevant parachute platform an instrumented with a large array of POF sensors weaved within the textile fabrics of the parachute. The instrumented parachute demonstration platform will be laboratory and airborne tested under simulated load test conditions encountered by NASAs decelerator systems, and it will evaluate the time synchronize data collection and wireless data transferring fidelity and quality of the DIFOS SHM system. ROI will also develop am airworthiness qualification plan, including compliance with environmental, vibration, shock, pressure, and water immersion.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

The DIFOS SHM system represents a new, innovative, and reliable solution for the in-flight time synchronized distributed monitoring of the passive and dynamic structural state (load/stress/strain) levels of trailing body deployable supersonic decelerator technologies. Its, lightweight, compact package, self-power efficient, wireless communication, distributed and embedded DIFOS SHM network system provide unique cost affordable solution for many SHM/NDE applications. In the parachute market, the major share is controlled by the military sector, which uses them extensively on its aircraft and for use by the paratroopers. Growing conflicts and wartime scenario across world is a major factor driving the employment of parachutes in military. Further, sales of unmanned aerial vehicles have been experiencing high growth around the world. This is one major booster for the global parachute market. The DIFOS technology addresses the global SHM/NDE aerospace and avionics market expected to grow to over 6.8-billion in 2020 and with the potential to instrument over 6000 space flight vehicles, military, and commercial airplanes, and peripheral structural monitoring system with additional markets in wind turbines, energy power plants, oil & gas, pipelines, petrochemical and geothermal exploration, civil infrastructures, health-care, and security.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

All of NASA's current and future space vehicle programs will benefit significantly from this project, wherein the key technological challenge is to develop methodologies for monitoring load, stress, strain, flaws, fatigue, and degradation in large complex structures. NASA's Robotic Exploration Program has a critical need for advanced sensor systems to enhance and expands NASA's current SHM. Specific NASA applications of the DIFOS SHM system include un-attended inspections on large and complex composite structures, i.e., decelerator systems parachutes and ballutes, honeycomb structures, multi-wall pressure vessels, thermal blankets, meteoroid shields, batteries, etc., commonly found in spacecraft, and habitats, and support infrastructures.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)

Structures
Entry, Descent, & Landing (see also Astronautics)
Nondestructive Evaluation (NDE; NDT)
Diagnostics/Prognostics
Aerodynamics
Entry, Descent, & Landing (see also Planetary Navigation, Tracking, & Telemetry)

PROPOSAL NUMBER:	17-2 **S4.01-8340**
PHASE-I CONTRACT NUMBER:	NNX17CP65P
SUBTOPIC TITLE:	Planetary Entry, Descent and Landing and Small Body Proximity Operation Technology
PROPOSAL TITLE:	An Enhanced Modular Terminal Descent Sensor for Landing on Planetary Bodies

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)

Remote Sensing Solutions, Inc.
3179 Main Street, Unit 3, P.O. Box 1092
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PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)

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Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 3
End: 6
TECHNICAL ABSTRACT (LIMIT 200 WORDS)
Remote Sensing Solutions (RSS) proposes the development of a modular, small, high performance terrain relative Terminal Descent Radar (TDR) for range and velocity sensing of planetary landing and vehicles engaging in proximity operations. The innovation builds off of and improves upon the highly successful Curiosity / Mars Science Laboratory sky crane Terminal Descent Sensor. Our improvements include significant improvements to the size, weight, and reproducibility of the design; a modular design; and improvement in the ability to detect and remove the effects of airborne debris.
In this effort we propose to realize prototypes of our recurring, reproducible designs at Ka-band and W-band. We also propose to develop, implement, and validate through field demonstration new measurement algorithms that can mitigate issues of false velocity measurements due to moving dust and sand, particularly at low altitudes where thruster fire can cause movement of surface particles. Such algorithms mitigate that concern for planetary bodies where dust or sand are a concern (i.e. the Moon, Mars, comets, asteroids, and even Europa), and, by extending measurements closer to the surface, save mission cost and complexity by decoupling the landing problem from errors in the inertial measurement unit.
POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)
The TDR developed by RSS would be broadly applicable to the commercial space sector as well as NASA. Beyond space applications, the sensors & algorithms that yield robust, independent range and velocity measurements have broad applicability to autonomous vehicles, including autonomous underwater vehicles (AUVs) and unmanned aerial vehicles (UAVs). As evidenced from the letters included in this proposal, RSS has already begun working with several companies on the development and marketing of small, lightweight radars and sonars for UAVs and AUVs, respectively.
POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)
Every major landing mission since Surveyor has used radar as the key component for delivering range and velocity information. The JPL TDS proved highly successful but was not designed to be reproducible. Rebuilding TDS beyond Mars 2020 is likely cost prohibitive, as well as size prohibitive for smaller class missions. A reproducible, low-cost landing radar system would fill an immediate need for upcoming landing missions, including Discovery class through flagship concepts like a Europa lander, also including lunar landing, due to its ability to operate independent of sun illumination, lack of need for coherent surface features (required for an incoherent imaging system to measure horizontal velocity), and far superior performance compared to lidar in the presence of dust and other particulates. Such a sensor thus solves a key, critical long-term NASA need post-Mars 2020, enabling numerous classes of planned and future robotic and crewed missions.
TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)
Entry, Descent, & Landing (see also Astronautics)
Positioning (Attitude Determination, Location X-Y-Z)

Air Transportation & Safety
Entry, Descent, & Landing (see also Planetary Navigation, Tracking, & Telemetry)
Navigation & Guidance
Relative Navigation (Interception, Docking, Formation Flying; see also Control & Monitoring; Planetary Navigation, Tracking, & Telemetry)
Spacecraft Instrumentation & Astrionics (see also Communications; Control & Monitoring; Information Systems)
Space Transportation & Safety
Autonomous Control (see also Control & Monitoring)
Perception/Vision

PROPOSAL NUMBER:	17-2 **Z3.02-8909**
PHASE-I CONTRACT NUMBER:	NNX17CP68P
SUBTOPIC TITLE:	Advanced Metallic Materials and Processes Innovation
PROPOSAL TITLE:	Thermoplastic Forming of Bulk Metallic Glasses for Precision Robotics Components

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
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PRINCIPAL INVESTIGATOR/PROJECT MANAGER: (Name, E-mail, Mail Address, City/State/ZIP, Phone)
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Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 3
End: 4
TECHNICAL ABSTRACT (LIMIT 200 WORDS)
Demand for novel manufacturing methods for space systems brings unique properties of bulk metallic glasses (BMG) into the spotlight. In addition to superior mechanical properties associated with enhanced reliability, BMG technology can offer new manufacturing processes that result in components with higher precision and complexity, eliminating machining and minimizing final assembly. In this project, we propose to utilize the unique thermoplastic forming (TPF) ability of BMGs to net shape high precision robotic gears. Within Phase I, we have proven feasibility of this technology. The technical objectives for Phase II is to further advance the technology to a level that allows NASA to test and use BMG gears in NASA missions. This requires high precision, repeatability, robustness, and consistency of fabricated parts. In

addition, a technical focus will be on expanding the versatility of TPF-based fabrication process in terms of the range of geometries and sizes of flexsplines and the range of BMG alloys that can be used with TPF processes. Identifying the suite of BMG alloys that can be used for TPF-based molding would provide NASA with an option to select the best property combinations in terms of specific strength, ductility, wear, friction, and costs. An additional technical objective is to develop strategies to reduce friction and wear through surface finish of the molded flexsplines and fabrication of surface composites in a one processing step. The outcome of the project will be manufacturing capabilities for precision robotic components and ready-to-test flexspline gear parts with complex thin walled geometries, improved properties and dimensions suitable for Europa Lander and Kennedy Space Center and other NASA's locations. Beyond space applications, the use of versatile thermoplastic forming processes for precision gears has a strong potential to bring cost savings for a wide range of industries that use robotic mechanisms.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

Combining the properties of best structural metals with the processability of thermoplastics brings unique opportunities to robotics, aerospace, defense, automotive and biomedical industries. Specific applications that we are addressing in this NASA Phase II project include precision robotics components that outside space can be used for industrial and consumer applications. Miniaturization of robotics equipment is an important trend in medical and defense applications and thermoplastic forming of BMGs is uniquely suited for this.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

Development of novel manufacturing processes for structures with superior mechanical properties has long been identified as one of the critical needs for NASA. In this project, we focus on forming precise robotics components with thin walled structures and high dimensional accuracy using bulk metallic glasses (BMGs). BMG robotics components are highly attractive for use at low temperature and harsh environments, such as Europa mission, due to improved mechanical properties and ability to operate unlubricated. Such BMG gears can also be used in robotics arms at Kennedy Space center, Goddard Space Flight Center and other NASA's locations. Beyond robotics, BMG technology is also attractive for small satellites and pressure vessels and other structural space applications.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)

Metallics
Structures
Robotics (see also Control & Monitoring; Sensors)
Prototyping
Processing Methods

PROPOSAL NUMBER:	17-2 **S1.02-9250**
PHASE-I CONTRACT NUMBER:	NNX17CP70P
SUBTOPIC TITLE:	Technologies for Active Microwave Remote Sensing
PROPOSAL TITLE:	Enabling Larger Deployable Ka-Band Antenna Apertures with Novel Rib

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
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Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 4
End: 6

TECHNICAL ABSTRACT (LIMIT 200 WORDS)
The significance and relevance of the proposed innovation is to design and develop a novel rib that will enable 2-6m aperture parabolic reflectors and antennas for smallsats. The rib will be rollable and allow 100: 1 compaction ratios. It will provide deployment authority and deployed structural integrity meeting Ka-band precision requirements. Higher communication data rates, longer transmission distances, increased sensor capacity for active radar and radiometers are all directly related to larger aperture sizes.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)
There is strong market growth in CubeSat up to smallsat size satellites in the commercial arena. Numerous communications, data transfer and Earth observation constellations are planned. Many of them would benefit from a lightweight, small packaged volume, high gain antenna. In the terrestrial market, the U.S. Military is seeking man-packable high gain antennas for forward operating Warfighters.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)
The proposed innovation relative to NASA needs will be focused on small to medium aperture antennas up to Ka-band and used for Earth observing science missions (RainCube radar, radiometers), deep space communications, and any mission needing high data rate down links. The rib technology would enable larger apertures for any higher gain mission needs.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)
Composites

Metallics
Deployment
Machines/Mechanical Subsystems
Structures
Analytical Methods
Antennas
Command & Control
Characterization
Prototyping

PROPOSAL NUMBER:	17-2 **S2.02-8520**
PHASE-I CONTRACT NUMBER:	NNX17CP71P
SUBTOPIC TITLE:	Precision Deployable Optical Structures and Metrology
PROPOSAL TITLE:	Redundant StarShade Truss Deployment Motor/Cable Assembly

SMALL BUSINESS CONCERN: (Firm Name, Mail Address, City/State/ZIP, Phone)
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Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 3
End: 5
TECHNICAL ABSTRACT (LIMIT 200 WORDS)
The proposed innovations are as follows: 1) A fully redundant electrical and mechanical motor/cable deployment assembly 2) A redundant motor/cable deployment assembly that is integrated and deploys a perimeter truss for a starshade 3) A truss strut mechanism that allows petal and truss deployment and provides a stiff and repeatable support 4) A truss node light seal the suppresses all sun and starlight through a truss node with articulating truss elements and inner disk and petal interfaces. The significance and relevance of the proposed innovations is to meet the technical challenges of deploying a large scale perimeter truss (10-30m diameter) for a starshade. The STDT's "Exo-S Final Report" identified an open issue to "Mature perimeter truss technology readiness." This is part of a defined starshade technology gap S-5 that is titled "Demonstrate inner disk deployment with optical shield." In the NASA JPL starshade design the

petals are placed into their precise position by the deploying truss and truss strut. The truss also deploys the spiral wrapped inner disk and at the end tensions the precision spokes. If the truss was not able to fully deploy or meet the on-orbit load (deployment and deployed) and positioning requirements then the mission would fail. Obviously, the truss deployment mechanism needs to be a robust and reliable system.

POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)

Large scale deployable perimeter trusses could also be used for large solar arrays for SEP applications or planetary surface operations that would need a robust architecture that can withstand high accelerations. In addition, the technology developed through this SBIR would apply to any cable driven deployment that would benefit from the reliability of a fully redundant electrical and mechanical system. Cable spoolers are used for deploying articulating booms, trusses, thermal blankets, solar arrays as well as deploying and controlling guys and stays.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)

Technology developed during this SBIR program will be directly applied to any NASA telescope program involved with exoplanet discovery and
characterization that needs an external occulter, or Starshade. NASA has identified a potential rendezvous mission with WFIRST/AFTA because it
is a large astrophysics telescope capable of supporting direct imaging with a starshade. Beyond starshades, the technology developed through this SBIR would apply to any cable driven deployment that would benefit from the reliability of a fully redundant electrical and mechanical system. Cable spoolers are used for deploying articulating booms, trusses, thermal blankets, solar arrays as well as deploying and controlling guys and stays.

TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)

Actuators & Motors
Deployment
Structures
Hardware-in-the-Loop Testing
Simulation & Modeling
Autonomous Control (see also Control & Monitoring)
Command & Control

PROPOSAL NUMBER:	17-2 **S4.03-8399**
PHASE-I CONTRACT NUMBER:	NNX17CP73P
SUBTOPIC TITLE:	Spacecraft Technology for Sample Return Missions
PROPOSAL TITLE:	Advanced Ignition System for Hybrid Rockets for Mars Sample Return, Phase II

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Estimated Technology Readiness Level (TRL) at beginning and end of contract:
Begin: 3
End: 6
TECHNICAL ABSTRACT (LIMIT 200 WORDS)
To return a sample from the surface of Mars or any of the larger moons in the solar system will require a propulsion system with a comparatively large delta-V capability. Consequently, significant propellant mass will be required. While it is technically feasible to generate O_2 and CO propellants by electrolysis of CO_2 from the Martian atmosphere, it will only work on bodies where there is significant CO_2 in the atmosphere, and the mass of the required infrastructure (electrolyzer, batteries, solar panels) is substantial. A recent study showed that a hybrid rocket with multi-start capability trades more favorably than either a CO_2 electrolysis system or a bipropellant system where the propellants are generated on Earth. Using a high-performance hybrid propellant combination and being able to restart the hybrid rocket are the keys. In previous and ongoing work, Ultramet has demonstrated that electrically heated open-cell silicon carbide foam can be used as an igniter for both monopropellant and bipropellant rocket engines. Due to its low mass, excellent oxidation resistance, and favorable electrical characteristics, the foam can be heated to 1300°C in just seconds, which enables it to quickly ignite any propellant flowing through it. The Phase I project demonstrated that a foam heater could be turned on and off any number of times and that it was capable of heating oxygen and igniting paraffin. Applied to a portion of the oxidizer stream in a hybrid rocket engine, this will provide multi-start capability. In Phase II, Ultramet will team with Parabilis Space Technologies to design, fabricate, and test a hybrid rocket ignition system suitable for use with O_2, NTO, or MON-25 on a Mars ascent vehicle.
POTENTIAL NASA COMMERCIAL APPLICATION(S) (LIMIT 150 WORDS)
This technology can be used for igniting non-hypergolic bipropellants, ionic liquid monopropellants, and hydrazine in main and attitude control engines on commercial and military spacecraft, as well as main and reaction control engines on commercial and military boosters. Other aerospace applications include ignition systems and catalyst preheaters for aeropropulsion turbine engines and air heaters for hypersonic wind tunnels similar to the Aerodynamic and Propulsion Test Unit at Arnold Engineering Development Center (AEDC). Non-aerospace applications include ignition systems and catalyst heaters for turbine engines used for terrestrial power generation, and gas and water heaters where high efficiency is critical.

POTENTIAL NON-NASA APPLICATION(S) (LIMIT 150 WORDS)
This technology will initially be targeted at hybrid rockets, and the near-term application will be hybrid rockets for a Mars sample return mission. More generally, foam-based heaters that are amenable to use at high temperatures in highly oxidizing environments can be used as igniters for virtually any non-hypergolic propellant combination. These include O2/CO, LOX/CH4, LOX/ethanol, and LOX/RP-1 among others. They can also be used to ignite hydrazine, as well as ionic liquid monopropellants such as LMP-103S and the E, Q, and A blends of AF-M315. This makes the technology applicable to engines of virtually any thrust class, from large booster engines to small attitude control engines. Specific missions of interest to NASA include ascent/descent engines for missions to Mars, the Moon, other planetary moons, and asteroids.
TECHNOLOGY TAXONOMY MAPPING (NASA's technology taxonomy has been developed by the SBIR-STTR program to disseminate awareness of proposed and awarded R/R&D in the agency. It is a listing of over 100 technologies, sorted into broad categories, of interest to NASA.)
Ceramics
Coatings/Surface Treatments
Metallics
Exciters/Igniters
Fuels/Propellants
Launch Engine/Booster
Spacecraft Main Engine
Simulation & Modeling
Models & Simulations (see also Testing & Evaluation)