Select SBIR 2012-I

National Aeronautics and Space Administration

SMALL BUSINESS INNOVATION RESEARCH (SBIR) Select Program Solicitation

Opening Date: September 17, 2012
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The electronic version of this document is at: http://sbir.nasa.gov

relevant environments, enabling transition to stakeholders. The research will result in evaluations of integrated automation technologies and procedures designed to address the following technical challenges:

- Develop Tactical Automation Technologies for Complex Operational Choke Points Including Surface, Arrival/Departure, and Dense Terminal Operations.
- Establish the basis for air/ground functional allocation for separation assurance including safe, graceful degradation of performance in response to off-nominal conditions.
- Develop strategic automation technologies that integrate probabilistic weather information and flow management capabilities.
- Conduct seamless integration of automation applications in a resilient, end-to-end Trajectory-Based Operations system.
- For the highest levels of NextGen performance and beyond, develop concepts, technologies, and system-wide evaluation and validation approaches.

In support of these technical challenges, ASP is seeking specific SBIR proposals in these two areas of interest:

- Integrated arrival, departure, and surface traffic planning for reduced fuel consumption, noise, and emissions during congested flows through:
    - Balanced runway usage and runway configuration management.
    - Optimized taxi planning of departures and arrivals.
    - Precision departure release scheduling.
    - Reduced fuel/noise/emissions continuous descent arrivals with precision scheduling.
    - Maintaining safety in ground operations through the development of concepts and algorithms for both aircraft- and ground-based surface conflict detection and resolution (CD&R) and integration of the two approaches.
    - Developing pilot display requirements and technologies for 4D taxi clearance compliance, and taxi clearance conformance monitoring algorithms and procedures.
    - Dynamic wake vortex separation criteria. Environmental impacts will be considered as concepts are investigated.
- Develop a tool for air traffic management cost assessment:
    - Aircraft line of flight impact to the airline and the NAS;
    - Quantify user costs on equipage and training along with benefits delivered by the related new concepts and capabilities;
    - Economic impact of policy decisions for new procedures on given concepts and technologies

Science Mission Directorate Select Subtopics

E3.01 Laser Transmitters and Receivers for Targeted Earth Science Measurements
Lead Center: LaRC
Participating Center(s): GSFC, JPL
OCT Technology Area: TA08

Earth is a complex, dynamic system we do not yet fully understand. We need to understand the Earth's atmosphere, lithosphere, hydrosphere, cryosphere, and biosphere as a single connected system. The purpose of NASA's Earth science program is to develop a scientific understanding of Earth's system and its response to natural or human-induced changes, and to improve prediction of climate, weather, and natural hazards. A major component of NASA’s Earth Science Division is a coordinated series of satellite and airborne missions for long-term global observations of the land surface, biosphere, solid Earth, atmosphere, and oceans. This coordinated approach enables an improved understanding of the Earth as an integrated system. NASA is completing the development and launch of a set of Foundational missions, new Decadal Survey missions, and Climate Continuity missions.

This subtopic seeks innovative laser transmitters and receivers to allow accurate measurements of atmospheric parameters with high spatial resolution from ground and airborne platforms. These developments require advances in the state-of-the-art lidar technology with emphasis on compactness, efficiency, reliability, lifetime, and high performance. This subtopic is seeking only the innovative laser transmitter subsystem or complete receiver subsystem for the three listed areas, which upon delivery would be infused into a lidar system demonstration. (*Individual lidar components are NOT solicited in this subtopic but can be submitted under theS1.01 Lidar Remote Sensing Technologies*) With the larger funded effort, NASA seeks to have delivered a full transmitter or receiver subsystem with turnkey operation meeting the requirements of one of the three targeted areas below. The selected proposal(s) will be required to work closely with the NASA customers to understand performance requirements.

- *Tunable laser system development for water vapor DIAL systems for high altitude aircraft platforms* - Need: climate, upper-troposphere, lower-stratosphere, cirrus cloud, and satellite validation studies. Application from high altitude platforms (35,000 to 65,000 ft). Water vapor in the high altitudes impacts climate, radiation, stratospheric /tropospheric exchange, and even impacts satellite validation activities. There is a critical need for high accuracy, high resolution water vapor measurement and its impact at the highest altitudes. The most critical unmet need for a high-altitude a water vapor DIAL system is a compact, rugged, and efficient tunable laser transmitter to operate on one of the strong H_2O absorptions lines near 934.55, 935.43 or 944.11 nm (H_2O line center). Tunability over the side of the line up to 100 pm is needed. Need to demonstrate the laser can operate locked at 0 pm, 25 pm, 50 pm, and 100 pm from line center position of the H_2O line at low pressure. Frequency stability of <0.1 pm and linewidths of <0.2 pm are required. High spectral purity >99.9% need to be demonstrated. Ability to switch between wavelengths within 300 micro second is needed. Pulse energies in the range 5 to 100 mJ with output power of 2-5 W (low pulse energies will require higher average power to overcome background and detector noise issues). (Note for later spacecraft application 50 mJ – 500 mJ and output power ~ 10 W would be needed).
- *Compact, rugged laser transmitter for advanced ozone DIAL lidar systems* - NASA and other agencies have a long-term interest in lidar profile measurements of atmospheric ozone from the ground and also from aircraft. A measurement goal would be ± 5 ppb ozone throughout the troposphere. Major technology advances are needed to allow multiple ozone lidar stations to make continuous ozone profile measurements over extended time intervals. Laser transmitters are needed that simultaneously (or interleaved) produce three eye-safe ultraviolet wavelengths (preferably tunable) between approximately 280 and 316 nm with approximately 1-nm linewidth. Laser pulses would typically be less than 100-nsec in pulsewidth with ~2 Watts power in each of 3 UV wavelengths. Both high (~1kHz) and low (~20Hz) repetition rate lasers will be considered. Such a system would be required to operate reliably for extended times with a minimum of expendable supplies and be easily transportable. The total instrument volume would be approximately one square meter. The laser system is targeted for infusion in a ground system demonstration.
- *Atmospheric Lidar with Cross-Track Coverage* - A key measurement capability for NASA Earth Science applications is lidar remote sensing of atmospheric clouds and aerosols and, increasingly, cloud-aerosol interactions. The vertical resolution possible with lidar systems provides accurate identification of cloud and aerosol layer heights and structure. However, a primary limitation of existing lidar instruments is lack of horizontal (e.g., cross-track) coverage. Technologies are solicited for transmitter, transceiver, or receiver technologies that enable airborne lidar measurements of clouds and aerosols having both vertical and horizontal extent. Technologies are sought that demonstrate a capability that can be mounted on a relevant high-altitude aircraft platform (specifically, ER-2, Global Hawk, or Proteus). The ability of any proposed technology to be scalable to spaceborne application is highly desirable. The focus is on cloud and aerosols (and cloud-aerosol interaction); proposals specific to scanning/mapping surface altimetry will be considered nonresponsive. Funds available permit development of instrument subsystems. Depending on the approach chosen, the subsystem might be a novel transmitter, transceiver, or a scanner/receiver subsystem. Regardless of the subsystem developed, it is essential that the proposer demonstrate how their subsystem can be integrated into a complete instrument. That is, developing a novel scanning technology that cannot be easily or affordably coupled to a transmitter would be of little use. The successful proposal(s) will demonstrate consideration of the end-to-end instrument design, including demonstration that the system envisioned would be capable of obtaining sufficient signal over required averaging volumes (e.g., demonstrate simulation capability sufficient to convince reviewers that the resultant measurement will be useful).

Although different approaches might be proposed, and different subsystems or types of subsystems are possible, general guidance on requirements include:

- Profiling of cloud and aerosol backscatter, with emphasis on multiple wavelengths and depolarization measurement capability, if possible.
- Horizontal coverage of at least ± 5 km, with horizontal resolution < 1 km. Therefore, the system design should have at least 10 cross-track points, and more if possible.
- Along-track resolution will be driven by the specific technology proposed, but in general, along-track integration times of < 2 seconds is preferred.
- Vertical resolution can be driven by the detector(s) and data system, but nominal vertical resolution of < 100 m is desirable. System designs should be sized appropriately to obtain sufficient signal over these vertical and horizontal resolutions.
- It is desirable to utilize solid-state (e.g., photon-counting) detection if possible. Data systems can be readily obtained to interface with photon-counting detectors, thereby lowering the cost and complexity of a completed instrument.
- Size, mass, power constraints need to be considered and should be commensurate with accommodations of the NASA ER-2, Global Hawk, or Proteus aircraft. In general, the airborne platforms will limit the transceiver aperture size. Thermal, pressure, and other environmental constraints of these high-altitude airborne platforms should also be considered.

Successful proposals will demonstrate an understanding of the relevant science need, and present a feasible plan to work with a NASA sponsor to use follow-on funding opportunities to develop a complete airborne instrument. Follow-on opportunities include, but are not limited to Instrument Incubator Program (IIP), Airborne Instrument Technology Transition (AITT), Earth Venture - Instrument (EV-I), or Phase III SBIR funding.

The Phase I research activity should demonstrate technical feasibility during and show a clear path to a Phase II prototype. The Phase II deliverable should be packaged in such a manner that it can be directly infused into follow-on opportunities to develop a complete lidar instrument.

E3.02 Advanced Technology Telescope for Balloon Mission
Lead Center: MSFC
Participating Center(s): GSFC, JPL
OCT Technology Area: TA08

The purpose of this sub-topic is to mature demonstrated component level technologies (TRL4) to demonstrated system level technologies (TRL6) by using them to manufacture complete telescope systems. Examples of desired technological advances relative to the current state of the art include, but are not limited to:

- Reduce the areal cost of telescope by 2X such that larger collecting areas can be produced for the same cost or current collecting areas can be produced for half the cost.
- Reduce the areal density of telescopes by 2X such that the same aperture telescopes have half the mass of current state of art telescope. Less mass enables longer duration flights.
- Improve thermal/mechanical wavefront stability and/or pointing stability by 2X to 10X.

Technological maturation will be demonstrated by building one or more complete telescope assemblies which can be flown on potential long duration balloon experiments to do high priority science. Potential missions can cover any spectral range from X-rays to far-infrared/sub-millimeter. Potential telescopes include, but are not limited to:

- High-Energy Telescope.
- Ultra-Stable 1-meter Class UVOIR Telescope.
- Low-Cost CMB Telescopes.
- Low-Cost Far-Infrared Telescopes.
- Cryogenic Far-Infrared Telescope.
- 5 to 10 meter Segmented Far-IR Telescope.
- Heliophysics UVOIR Telescope.

Deliverable for Phase I is a reviewed preliminary design demonstrating feasibility.

Deliverable for Phase II is a fully integrated and tested telescope assembly, ready to be incorporated into a potential balloon mission payload.

In all cases, the telescopes must be designed to survive balloon environments, including 150K to 330K temperature range and 10G shock. The mass budgets for each telescope are nominal.

Successful proposals will demonstrate an understanding of how the engineering specifications of their telescope meets the performance requirements and operational envelop of a potential balloon science mission; and presents a credible plan to build the proposed telescope.

Please note, for this sub-topic a telescope is defined as a complete integrated system of optical and structural components which collects and concentrates electro-magnetic photons/waves for detection by a scientific imaging and/or spectroscopic instrument.

See Technical Challenges for baseline technical requirements for potential telescopes.

The 2010 National Academy Astro2010 Decadal Report recommended increased use of sub-orbital balloon-borne observatories. Two specific needs include:

- Far-IR telescope systems for Cosmic Microwave Background (CMB) studies.
- Optical/NIR telescope systems for Dark Matter and/or Exo-Planet studies.

Additionally, Astro2010 identifies optical components as key technologies needed to enable several different future missions, including:

- Light-weight X-ray imaging mirrors for future very large advanced X-ray observatories.
- Large aperture, light-weight mirrors for future UV/Optical telescopes.

The 2012 National Academy report "NASA Space Technology Roadmaps and Priorities" states that one of the top technical challenges in which NASA should invest over the next 5 years is developing a new generation of larger effective aperture, lower-cost astronomical telescopes that enable discovery of habitable planets, facilitate advances in solar physics, and enable the study of faint structures around bright objects. To enable this capability requires low-cost, ultra-stable, large-aperture, normal and grazing incidence mirrors with low mass-to-collecting area ratios. To enable these new astronomical telescopes, the report identifies three specific optical systems technologies:

- Active align/control of grazing-incidence imaging systems to achieve < 1 arc-second angular resolution.
- Active align/control of normal-incidence imaging systems to achieve 500 nm diffraction limit (40 nm rmswavefront error, WFE) performance.
- Normal incidence 4-meter (or larger) diameter 5 nm rms WFE (300 nm system diffraction limit) mirrors.

Technical Challenges

Technological developments at the telescope system level are required to enable higher capability measurements, longer duration flights and more affordable missions. The purpose of this sub-topic is to mature demonstrated component level technologies (TRL4) to demonstrated system level technologies (TRL6) by using them to manufacture complete telescope systems. Examples of desired technological advances relative to the current state of the art include, but are not limited to:

- Reduce the areal cost of telescope by 2X such that larger collecting areas can be produced for the same cost or current collecting areas can be produced for half the cost.
- Reduce the areal density of telescopes by 2X such that the same aperture telescopes have half the mass of current state of art telescope. Less mass enables longer duration flights.
- Improve thermal/mechanical wavefront stability and/or pointing stability by 2X to 10X.

Successful proposals shall provide a credible plan to deliver for the allocated budget a fully assembled and tested telescope assembly which can be integrated into a potential balloon mission to meet a high-priority NASA science objective. Successful proposals will demonstrate an understanding of how the engineering specifications of their telescope meets the performance requirements and operational envelop of a potential balloon science mission. Phase I delivery shall be a reviewed design and manufacturing plan which demonstrates feasibility. While detailed analysis will be conducted in Phase II, the preliminary design should address how optical, mechanical (static and dynamic) and thermal designs and performance analysis will be done to show compliance with all requirements. Past experience or technology demonstrations which support the design and manufacturing plans will be given appropriate weight in the evaluation. Phase II delivery shall be a completely assembled and tested optical telescope assembly ready to be integrated into a potential balloon mission. Testing shall confirm compliance of the telescope assembly with its requirements.

High Energy Telescope

A high-energy telescope is desired which includes the collecting optic, the structure which connects the collecting optic to the detecting instrument, and any mechanisms needed to maintain alignment and pointing stability of the collecting optic relative to the detecting instrument. Collecting optic should be able to collect and concentrate high-energy photons (above 10 keV). Collecting optics can be grazing incidence reflective, refractive or diffractive with a potential focal length ranging from 4 to 10 meters. Other ‘optical’ elements such as coded apertures can be considered. Angular resolutions should be significantly less than 1 arcminute for grazing-incidence optics, and ideally in the arcsecond range. Active control of the optic figure may be necessary. For refractive /diffractive optics, lower resolutions are acceptable, depending on energy. Effective collecting area should be greater than 10’s cm^2 at 10 keV to enable useful data from typical balloon observing times. Higher energy ‘optics’ should provide enough area for a significant signal during flight. Optical assemblies must ideally be light weight to satisfy future mission demands. Total telescope mass budget goal is 200 kg.

Ultra-Stable 1-meter Class UVOIR Telescope

Potential Exoplanet balloon studies require a complete optical telescope system with 1 meter or larger of collecting aperture to characterize exoplanets and dust disks over the range of wavelengths from 300 to 1100 nm, and ideally as long as 1600 nm. The telescope should be diffraction limited at 500 nm (< 36 nm transmitted wavefront) over a total field of view subtending at least 10 arc-seconds and over a field of regard extending from 20 to 70 ° elevation angle with respect to the gravity vector. The wavefront error power spectral density should monotonically decrease with increasing spatial frequency i.e., have no strong harmonics, from 0 to 30 cycles per aperture.

Dynamic wavefront stability must be < 0.3 nm rms over timescales of 100s seconds and < 1 nm rms over timescales of 100s minutes. Sources of wavefront instability include thermal variations with boresight angle, thermal drift, coupling of residual vibration from reaction/momentum wheels, residual wind effects above 100,000 ft, and pointing induced beam shear. The telescope can achieve the stability requirement via either passive design or an actively controlled mirror (i.e., secondary mirror, fine steering mirror, deformable mirror, etc.).

Possible telescope configurations include, but are not limited to, two mirror Cassegrain and Gregorian configurations, and 3 mirror anastigmat designs. Ideally the telescope is an unobscured off-axis system that can function with several different types of coronagraphs. But on-axis systems with simple secondary support spiders are allowed for a subset of possible high-contrast instruments. The telescope should form a centimeter scale real pupil image after the primary mirror vertex. The total telescope mass budget goal is 300 kg.

Low-Cost CMB Telescopes

Potential balloon measurements of CMB linear polarization desire complete 3 to 4 meter class off-axis telescope systems which are 2X lower areal cost and 2X lower areal mass than the current 2 meter class state of the art (as represented by the BLAST telescope) with the following optical, mechanical and operational requirements.

Optical requirements:

- 3 meter to 4 meter diameter primary mirror.

- Diffraction-limited performance at 500 micron wavelength at 250 K.
- Wavefront stability of 15 micrometers rms per K.
- F/1 to F/1.5 primary mirror.
- 70 arc-minute field of view at 500 micron wavelength.
- Strehl ratio > 0.95 at edge of field of view.

Mechanical and operational requirements:

- Telescope to operate at ambient temperature 250 K (200 to 300K range).
- Telescope and mount to survive 10G shock (vertical).
- Telescope and mount to survive 5G shock (tilted 45 °).
- Mass of telescope to be 200 kg or less.
- Recurring production cost < $200 K per telescope.

Successful proposals will deliver a complete preliminary design for the telescope at the end of Phase I and two to four complete telescope systems at the end of Phase II.

Low-Cost Far-Infrared Telescopes

Potential balloon Far-Infrared missions desire complete off-axis telescope systems which are 2X lower areal cost and 2X lower areal mass than the current state of the art with the following optical, mechanical and operational requirements.

Optical requirements:

- 2.5 meter to 4 meter diameter primary mirror.
- Diffraction-limited performance at 100 micron wavelength at 250 K.
- Wavefront stability of 2.5 micrometers rms per K.
- F/1 to F/1.5 primary mirror.
- 15 arc-minute field of view at 100 micron wavelength.
- Strehl ratio > 0.95 at edge of field of view.

Mechanical and operational requirements:

- Telescope to operate at ambient temperature 250 K (200 to 300K range).
- Telescope and mount to survive 10G shock (vertical).
- Telescope and mount to survive 5G shock (tilted 45 °).
- Mass of telescope to be 200 kg or less.
- Recurring production cost < $200 K per telescope.

Successful proposals will deliver a complete preliminary design for the telescope at the end of Phase I and two to four complete telescope systems at the end of Phase II.

Cryogenic Far-Infrared Telescope

Potential Far-Infrared balloon missions achieve significant improvements in sensitivity using cryogenic optics. Anticipated missions require a complete telescope system with larger collecting apertures and lower areal mass than the current state of the art. A cryogenic telescope is desired with 3 meter on-axis collecting aperture maintained at temperatures below 20 K. Low mass and long cryogenic hold time are particularly important.

Optical requirements:

- Diffraction-limited performance at 300 micron wavelength at 20 K.
- F/1 to F/1.5 primary mirror.

- Field of view 20 arc-minutes minimum, 40 arc-min desired.
- Strehl ratio > 0.95 at edge of field of view.

Cryogenic requirements:

- Maintain entire telescope at 20 K or colder.
- Hold time 48 hours or longer, with goal of 21 days.

Mechanical requirements:

- Telescope and cryostat to survive 10G shock (vertical).
- Telescope and cryostat to survive 5G shock (tilted 45 °).
- Mass of telescope + cryostat to be < 1000 kg (goal 500 kg).

Successful proposals will deliver a preliminary design for the complete telescope and cryostat at the end of Phase I. Successful proposals will deliver the complete telescope and cryostat at the end of Phase II.

5 to 10 meter Segmented Far-IR Telescope

Potential Far-IR balloon studies required a complete optical telescope system with a 5 to 10 meter segmented aperture; 250 to 500 micrometer diffraction limited performance; wavefront stability of less than 10 micrometers rms; and a total mass of 400 (5m) to 800 kg (10m).

Heliophysics UVOIR Telescope

Potential Heliophysics studied require a complete optical telescope and/or camera system with: 1 to 2 meter collecting aperture, 20 ° field of view, 0.001 ° angular resolution and UV to Visible (120 to 700 nm) spectral range.

E3.03 Extreme Environments Technology
Lead Center: JPL
Participating Center(s): ARC, GRC, GSFC, LaRC, MSFC
OCT Technology Area: TA08

The present state of practice for building space systems for exploring our solar system planets is based on the placing space craft subsystems into environmentally protected housings that are power inefficient and bulky. The goal of the subtopic is to develop technologies that dramatically change this practice resulting in the development of highly power efficient and light weight space subsystems by developing space subsystems that would be capable of operating directly in the extreme environment of the planets of our solar systems.

High Temperature, High Pressure, and Chemically Corrosive Environments - NASA is interested in expanding its ability to explore the deep atmosphere and surface of Venus through the use of long-lived (days or weeks) balloons and landers. Survivability in extreme high temperatures and high pressures is also required for deep atmospheric probes to giant planets. Proposals are sought for technologies that enable the in situ exploration of the surface and deep atmosphere of Venus and the deep atmospheres of Jupiter or Saturn for future NASA missions. Venus features a dense, CO_2 atmosphere completely covered by sulfuric acid clouds at about 55 km above the surface, a surface temperature of about 486 degrees Centigrade and a surface pressure of about 90 bars. Technologies of interest include high temperature and acid resistant high strength-to-weight textile materials for landing systems (balloons, parachutes, tethers, bridles, airbags), high temperature electronics components, high temperature energy storage systems, light mass refrigeration systems, high-temperature actuators and gear boxes for robotic arms and other mechanisms, high temperature drills, phase change materials for short term thermal maintenance, low conductivity and high-compressive strength insulation materials, high temperature optical window systems (that are transparent in IR, visible and UV wavelengths) and advanced materials with high specific heat capacity and strength for pressure vessel construction, and pressure vessel components compatible with materials such as steal, titanium and beryllium such as low leak rate wide temperature (-50 degrees Centigrade to 500 degrees Centigrade) seals capable of operating between 0 and 90 bars.

Low Temperature Environments - Low temperature survivability is required for surface missions to Titan (-180 degrees Centigrade), Europa surface (-220 degrees Centigrade), Ganymede (-200 degrees Centigrade), near earth objects and comets. Also the Earth's Moon equatorial regions experience wide temperature swings from -180 degrees Centigrade to +130 degrees Centigrade during the lunar day/night cycle, and the sustained temperature at the shadowed regions of lunar poles can be as low as -230 degrees Centigrade. Mars diurnal temperature changes from about -120 degrees Centigrade to +20 degrees Centigrade. Also for the baseline concept for Europa Jupiter System Mission (EJSM), with a mission life of 10 years, the radiation environment is estimated at 2.9 Mega-rad total ionizing dose (TID) behind 100 mil thick aluminum. Proposals are sought for technologies that enable NASA's long duration missions to low temperature and wide temperature environments. Technologies of interests include low-temperature resistant high strength-weight textiles for landing systems (parachutes, air bags), low-power and wide-operating-temperature radiation-tolerant /radiation hardened RF electronics, radiation-tolerant/radiation-hardened low-power/ultra-low-power wide-operating-temperature low-noise mixed-signal electronics for space-borne system such as guidance and navigation avionics and instruments, radiation-tolerant /radiation-hardened power electronics, radiation-tolerant/ radiation-hardened high-speed fiber optic transceivers, radiation-tolerant/ radiation-hardened electronic packaging (including, shielding, passives, connectors, wiring harness and materials used in advanced electronics assembly), low to medium power actuators, gear boxes, lubricants and energy storage sources capable of operating across an ultra-wide temperature range from -230 degrees Centigrade to 200 degrees Centigrade and Computer Aided Design (CAD) tools for modeling and predicting the electrical performance, reliability, and life cycle for low-temperature electronic/ electro-mechanical systems and components.

Research should be conducted to demonstrate technical feasibility during Phase I and show a path toward a Phase II hardware/software demonstration, and when possible, deliver a demonstration unit at TRL 5 or higher upon the completion of the Phase II contract.

Appendices

Appendix A: Sample Briefing Chart

All briefing charts are done electronically and are created using the "Briefing Chart" form that is linked in the Activity Worksheet of the Proposal Submission EHB. Each section should be completed and the "Submit" button selected to save changes.

Input: Below is a sample form of the required input:

Proposal Title:
PI Name: Firm Name: City, State:

Image:
Upload Image: Select Image Type (BMP, GIF, JPEG, TIF) : Browse Images:

Note: The uploaded image will be scaled 340x200 pixel size in the generated briefing chart.

Identification and Significance of Innovation: (Limit 1,000 characters or 15 lines, whichever is less)
Enter brief and concise text here related to the identification and significance of the innovation.

Technical Objectives and Work Plan: (Limit 1,500 characters or 20 lines, whichever is less)
Enter brief and concise text here related to the technical objectives and work plan.

NASA Applications: (Limit 500 characters or 6 lines, whichever is less)
Enter text here related to the technology's NASA applications.

Non-NASA Application: (Limit 400 characters or 6 lines, whichever is less)
Enter text here related to the technology's non-NASA applications.

Firm Contact: (Please check the main firm contact for the technology)
__ Business Contact __ Principle Investigator __ Other, Specify Name: ____________________

Output: Once the input has been completed submitted online, a PDF version of the briefing chart is created automatically and is available for download. A sample of the electronic output is shown below:

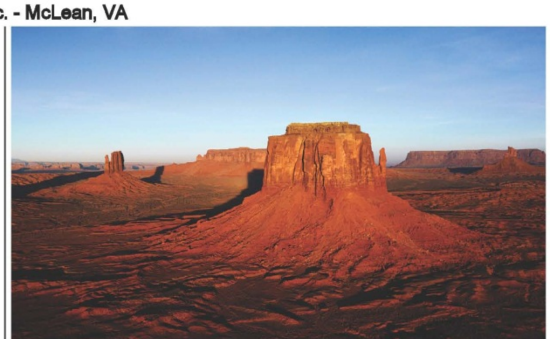
NASA SBIR/STTR Technologies
A1.01-9999 - Test Proposal for R*E*I

PI: NASA SBIR
TESTREI Systems Inc. - McLean, VA

Identification and Significance of Innovation

Enter text here related to the identification and significance of the innovation.

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



Technical Objectives and Work Plan

Enter text here related to the technical objectives and work plan.

NASA Applications

Enter text here on NASA applications.

Non-NASA Applications

Enter text here on Non-NASA applications.

Firm Contacts
Test User
TESTREI Systems Inc.
P.O. Box 9183
McLean, VA, 20171-1111
PHONE: (703) 480-9100

NON-PROPRIETARY DATA

Appendix B: Technology Readiness Level (TRL) Descriptions

The Technology Readiness Level (TRL) describes the stage of maturity in the development process from observation of basic principals through final product operation. The exit criteria for each level documents that principles, concepts, applications or performance have been satisfactorily demonstrated in the appropriate environment required for that level. A relevant environment is a subset of the operational environment that is expected to have a dominant impact on operational performance. Thus, reduced-gravity may be only one of the operational environments in which the technology must be demonstrated or validated in order to advance to the next TRL.

TRL	Definition	Hardware Description	Software Description	Exit Criteria
1	Basic principles observed and reported.	Scientific knowledge generated underpinning hardware technology concepts/applications.	Scientific knowledge generated underpinning basic properties of software architecture and mathematical formulation.	Peer reviewed publication of research underlying the proposed concept/application.
2	Technology concept and/or application formulated.	Invention begins, practical application is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture.	Practical application is identified but is speculative, no experimental proof or detailed analysis is available to support the conjecture. Basic properties of algorithms, representations and concepts defined. Basic principles coded. Experiments performed with synthetic data.	Documented description of the application/concept that addresses feasibility and benefit.
3	Analytical and experimental critical function and/or characteristic proof of concept.	Analytical studies place the technology in an appropriate context and laboratory demonstrations, modeling and simulation validate analytical prediction.	Development of limited functionality to validate critical properties and predictions using non-integrated software components.	Documented analytical/experi-mental results validating predictions of key parameters.
4	Component and/or breadboard validation in laboratory environment.	A low fidelity system/component breadboard is built and operated to demonstrate basic functionality and critical test environments, and associated performance predictions are defined relative to the final operating environment.	Key, functionally critical, software components are integrated, and functionally validated, to establish interoperability and begin architecture development. Relevant Environments defined and performance in this environment predicted.	Documented test performance demonstrating agreement with analytical predictions. Documented definition of relevant environment.
5	Component and/or breadboard validation in relevant environment.	A medium fidelity system/component brassboard is built and operated to demonstrate overall performance in a simulated operational environment with realistic support elements that demonstrates overall performance in critical areas. Performance predictions are made for subsequent development phases.	End-to-end software elements implemented and interfaced with existing systems/simulations conforming to target environment. End-to-end software system, tested in relevant environment, meeting predicted performance. Operational environment performance predicted. Prototype implementations developed.	Documented test performance demonstrating agreement with analytical predictions. Documented definition of scaling requirements.
6	System/sub-	A high fidelity	Prototype implementations of	Documented test

	system model or prototype demonstration in a relevant environment.	system/component prototype that adequately addresses all critical scaling issues is built and operated in a relevant environment to demonstrate operations under critical environmental conditions.	the software demonstrated on full-scale realistic problems. Partially integrate with existing hardware/software systems. Limited documentation available. Engineering feasibility fully demonstrated.	performance demonstrating agreement with analytical predictions.
7	System prototype demonstration in an operational environment.	A high fidelity engineering unit that adequately addresses all critical scaling issues is built and operated in a relevant environment to demonstrate performance in the actual operational environment and platform (ground, airborne, or space).	Prototype software exists having all key functionality available for demonstration and test. Well integrated with operational hardware/software systems demonstrating operational feasibility. Most software bugs removed. Limited documentation available.	Documented test performance demonstrating agreement with analytical predictions.
8	Actual system completed and "flight qualified" through test and demonstration.	The final product in its final configuration is successfully demonstrated through test and analysis for its intended operational environment and platform (ground, airborne, or space).	All software has been thoroughly debugged and fully integrated with all operational hardware and software systems. All user documentation, training documentation, and maintenance documentation completed. All functionality successfully demonstrated in simulated operational scenarios. Verification and Validation (V&V) completed.	Documented test performance verifying analytical predictions.
9	Actual system flight proven through successful mission operations.	The final product is successfully operated in an actual mission.	All software has been thoroughly debugged and fully integrated with all operational hardware/software systems. All documentation has been completed. Sustaining software engineering support is in place. System has been successfully operated in the operational environment.	Documented mission operational results.

Definitions

Proof of Concept: Analytical and experimental demonstration of hardware/software concepts that may or may not be incorporated into subsequent development and/or operational units.

Breadboard: A low fidelity unit that demonstrates function only, without respect to form or fit in the case of hardware, or platform in the case of software. It often uses commercial and/or ad hoc components and is not intended to provide definitive information regarding operational performance.

Brassboard: A medium fidelity functional unit that typically tries to make use of as much operational hardware/software as possible and begins to address scaling issues associated with the operational system. It does not have the engineering pedigree in all aspects, but is structured to be able to operate in simulated operational environments in order to assess performance of critical functions.

Proto-type Unit: The proto-type unit demonstrates form, fit, and function at a scale deemed to be representative of the final product operating in its operational environment. A subscale test article provides fidelity sufficient to permit validation of analytical models capable of predicting the behavior of full-scale systems in an operational environment

Engineering Unit: A high fidelity unit that demonstrates critical aspects of the engineering processes involved in the development of the operational unit. Engineering test units are intended to closely resemble the final product (hardware/software) to the maximum extent possible and are built and tested so as to establish confidence that the design will function in the expected environments. In some cases, the engineering unit will become the final product, assuming proper traceability has been exercised over the components and hardware handling.

Mission Configuration: The final architecture/system design of the product that will be used in the operational environment. If the product is a subsystem/component, then it is embedded in the actual system in the actual configuration used in operation.

Laboratory Environment: An environment that does not address in any manner the environment to be encountered by the system, subsystem, or component (hardware or software) during its intended operation. Tests in a laboratory environment are solely for the purpose of demonstrating the underlying principles of technical performance (functions), without respect to the impact of environment.

Relevant Environment: Not all systems, subsystems, and/or components need to be operated in the operational environment in order to satisfactorily address performance margin requirements. Consequently, the relevant environment is the specific subset of the operational environment that is required to demonstrate critical "at risk" aspects of the final product performance in an operational environment. It is an environment that focuses specifically on "stressing" the technology advance in question.

Operational Environment: The environment in which the final product will be operated. In the case of space flight hardware/software, it is space. In the case of ground-based or airborne systems that are not directed toward space flight, it will be the environments defined by the scope of operations. For software, the environment will be defined by the operational platform.

Appendix C: NASA SBIR/STTR Technology Taxonomy

Aeronautics/Atmospheric Vehicles
Aerodynamics
Air Transportation & Safety
Airship/Lighter-than-Air Craft
Avionics (see also Control and Monitoring)
Analysis
Analytical Instruments (Solid, Liquid, Gas, Plasma, Energy; see also Sensors)
Analytical Methods
Astronautics
Aerobraking/Aerocapture
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)
Space Transportation & Safety
Spacecraft Design, Construction, Testing, & Performance (see also Engineering; Testing & Evaluation)
Spacecraft Instrumentation & Astrionics (see also Communications; Control & Monitoring; Information Systems)
Tools/EVA Tools
Autonomous Systems
Autonomous Control (see also Control & Monitoring)
Intelligence
Man-Machine Interaction
Perception/Vision
Recovery (see also Vehicle Health Management)
Robotics (see also Control & Monitoring; Sensors)
Biological Health/Life Support
Biomass Growth
Essential Life Resources (Oxygen, Water, Nutrients)
Fire Protection
Food (Preservation, Packaging, Preparation)
Health Monitoring & Sensing (see also Sensors)
Isolation/Protection/Radiation Shielding (see also Mechanical Systems)
Medical
Physiological/Psychological Countermeasures
Protective Clothing/Space Suits/Breathing Apparatus
Remediation/Purification
Waste Storage/Treatment
Communications, Networking & Signal Transport
Ad-Hoc Networks (see also Sensors)
Amplifiers/Repeaters/Translators
Antennas

Architecture/Framework/Protocols
Cables/Fittings
Coding & Compression
Multiplexers/Demultiplexers
Network Integration
Power Combiners/Splitters
Routers, Switches
Transmitters/Receivers
Waveguides/Optical Fiber (see also Optics)
Control & Monitoring
Algorithms/Control Software & Systems (see also Autonomous Systems)
Attitude Determination & Control
Command & Control
Condition Monitoring (see also Sensors)
Process Monitoring & Control
Sequencing & Scheduling
Telemetry/Tracking (Cooperative/Noncooperative; see also Planetary Navigation, Tracking, & Telemetry)
Teleoperation
Education & Training
Mission Training
Outreach
Training Concepts & Architectures
Electronics
Circuits (including ICs; for specific applications, see e.g., Communications, Networking & Signal Transport; Control & Monitoring, Sensors)
Manufacturing Methods
Materials (Insulator, Semiconductor, Substrate)
Superconductance/Magnetics
Energy
Conversion
Distribution/Management
Generation
Sources (Renewable, Nonrenewable)
Storage
Engineering
Characterization
Models & Simulations (see also Testing & Evaluation)
Project Management
Prototyping
Quality/Reliability
Software Tools (Analysis, Design)
Support
Imaging

3D Imaging
Display
Image Analysis
Image Capture (Stills/Motion)
Image Processing
Radiography
Thermal Imaging (see also Testing & Evaluation)
Information Systems
Computer System Architectures
Data Acquisition (see also Sensors)
Data Fusion
Data Input/Output Devices (Displays, Storage)
Data Modeling (see also Testing & Evaluation)
Data Processing
Knowledge Management
Logistics
Inventory Management/Warehousing
Material Handing & Packaging
Transport/Traffic Control
Manufacturing
Crop Production (see also Biological Health/Life Support)
In Situ Manufacturing
Microfabrication (and smaller; see also Electronics; Mechanical Systems; Photonics)
Processing Methods
Resource Extraction
Materials & Compositions
Aerogels
Ceramics
Coatings/Surface Treatments
Composites
Fluids
Joining (Adhesion, Welding)
Metallics
Minerals
Nanomaterials
Nonspecified
Organics/Biomaterials/Hybrids
Polymers
Smart/Multifunctional Materials
Textiles
Mechanical Systems
Actuators & Motors
Deployment

Exciters/Igniters
Fasteners/Decouplers
Isolation/Protection/Shielding (Acoustic, Ballistic, Dust, Radiation, Thermal)
Machines/Mechanical Subsystems
Microelectromechanical Systems (MEMS) and smaller
Pressure & Vacuum Systems
Structures
Tribology
Vehicles (see also Autonomous Systems)
Microgravity
Biophysical Utilization
Optics
Adaptive Optics
Fiber (see also Communications, Networking & Signal Transport; Photonics)
Filtering
Gratings
Lenses
Mirrors
Telescope Arrays
Photonics
Detectors (see also Sensors)
Emitters
Lasers (Communication)
Lasers (Cutting & Welding)
Lasers (Guidance & Tracking)
Lasers (Ignition)
Lasers (Ladar/Lidar)
Lasers (Machining/Materials Processing)
Lasers (Measuring/Sensing)
Lasers (Medical Imaging)
Lasers (Surgical)
Lasers (Weapons)
Materials & Structures (including Optoelectronics)
Planetary Navigation, Tracking, & Telemetry
Entry, Descent, & Landing (see also Astronautics)
GPS/Radiometric (see also Sensors)
Inertial (see also Sensors)
Optical
Ranging/Tracking
Telemetry (see also Control & Monitoring)
Propulsion
Ablative Propulsion
Atmospheric Propulsion

Extravehicular Activity (EVA) Propulsion
Fuels/Propellants
Launch Engine/Booster
Maneuvering/Stationkeeping/Attitude Control Devices
Photon Sails (Solar; Laser)
Spacecraft Main Engine
Surface Propulsion
Tethers
Sensors/Transducers
Acoustic/Vibration
Biological (see also Biological Health/Life Support)
Biological Signature (i.e., Signs Of Life)
Chemical/Environmental (see also Biological Health/Life Support)
Contact/Mechanical
Electromagnetic
Inertial
Interferometric (see also Analysis)
Ionizing Radiation
Optical/Photonic (see also Photonics)
Positioning (Attitude Determination, Location X-Y-Z)
Pressure/Vacuum
Radiometric
Sensor Nodes & Webs (see also Communications, Networking & Signal Transport)
Thermal
Software Development
Development Environments
Operating Systems
Programming Languages
Verification/Validation Tools
Spectral Measurement, Imaging & Analysis (including Telescopes)
Infrared
Long
Microwave
Multispectral/Hyperspectral
Non-Electromagnetic
Radio
Terahertz (Sub-millimeter)
Ultraviolet
Visible
X-rays/Gamma Rays
Testing & Evaluation
Destructive Testing
Hardware-in-the-Loop Testing

Lifetime Testing
Nondestructive Evaluation (NDE; NDT)
Simulation & Modeling
Thermal Management & Control
Active Systems
Cryogenic/Fluid Systems
Heat Exchange
Passive Systems
Vehicle Health Management
Diagnostics/Prognostics
Recovery (see also Autonomous Systems)

Appendix D: SBIR/STTR and the Space Technology Roadmaps

Research and technology topics/subtopics for the SBIR Program are identified annually by Mission Directorates and Center Programs. The Directorates identify high priority research and technology needs for respective programs and projects. The SBIR Program supports a range of technologies defined by a list of topics and subtopics that vary in content within each annual solicitation.

The following table relates the Select SBIR topics and subtopics to the Technology Area Breakdown Structure (TABS) in the Space Technology Roadmaps (STR). The table is organized by the OCT Technology Area (first column), with the related SBIR/STTR topics (third column) and subtopics (fourth column) listed as well. The Aeronautics area is included for completeness, though this is beyond the scope of the STR.

TA	STR Technology Area (TA) Level 1 Description	Select Topic	Select Subtopic Description	Select Subtopic
TA01	Launch Propulsion Systems	Human Exploration and Operations Mission Directorate Select Subtopics	Nano/Micro Satellite Launch Vehicle Technology	E1.02
TA02	In-Space Propulsion Technologies	Human Exploration and Operations Mission Directorate Select Subtopics	High Power Electric Propulsion Systems	E1.01
TA03	Space Power and Energy Storage	N/A	N/A	N/A
TA04	Robotics, Telerobotics and Autonomous Systems	N/A	N/A	N/A
TA05	Communication and Navigation	N/A	N/A	N/A
TA06	Human Health, Life Support and Habitation Systems	N/A	N/A	N/A
TA07	Human Exploration Destination-Systems	Human Exploration and Operations Mission Directorate Select Subtopics	International Space Station Utilization	E1.03
TA08	Science Instruments, Observatories and Sensor Systems	Science Mission Directorate Select Subtopics	Laser Transmitters and Receivers for Targeted Earth Science Measurements	E3.01
			Advanced Technology Telescope for Balloon Mission	E3.02
			Extreme Environments Technology	E3.03
TA09	Entry, Descent and Landing Systems	N/A	N/A	N/A
TA10	Nanotechnology	N/A	N/A	N/A
TA11	Modeling, Simulation, Information Technology and Processing	N/A	N/A	N/A

TA12	Materials, Structures, Mechanical Systems and Manufacturing	N/A	N/A	N/A
TA13	Ground and Launch Systems Processing	N/A	N/A	N/A
TA14	Thermal Management Systems	N/A	N/A	N/A
		Aeronautics Research Mission Directorate Select Subtopics	Air Traffic Management Research and Development	E2.01

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