NASA SBIR 2008 Phase I Solicitation

X4 Structures, Materials and Mechanisms

The SBIR topic area of Structures, Materials and Mechanisms centers on developing lightweight structures, advance materials technologies, and low-temperature mechanisms for enabling Exploration Vehicles and Lunar Surface Systems.

Lightweight structures and advanced materials have been identified as a critical need since the reduction of structural mass translates directly to additional up and down mass capability that would facilitate additional logistics capacity and increased science return for all mission phases. The major technology drivers of the lightweight structure technology development are to significantly enhance structural systems by 1) lowering mass and/or improving efficient volume for reduced launch costs, 2) improving performance to reduce risk and extend life, and 3) improving manufacturing and processing to reduce costs.Â Â The targeted application of the technology is the Ares V launch vehicle, Lunar Lander, and Lunar Surface Systems such as the crew habitats.

Low-temperature mechanism technology is being developed for reliable and efficient operation of mechanisms in lunar temperatures including operations in lunar shadows at -230Â°C and sustained surface operations thru varying lunar temperatures of -230Â°C to +120Â°C for lunar surface rovers, robotics, and mechanized operations. The technology drivers of the low temperature mechanism technology development are to significantly enhance operation of mechanized parts by 1) lowering the operating temperature for life of the component and 2) improving mechanism performance (torque output, actuation performance, lubrication state) at the lunar environment conditions of cold and vacuum over the required life of the mechanism.Â The targeted application of the technology is to provide for operation of motors and drive systems, lubricated mechanisms, and actuators of lunar rovers and mobility systems, ISRU machinery, robotic systems mechanisms, and surface operations machinery (i.e., cranes, deployment systems, airlocks) for lunar surface operations.

This topic area is to enhance and fill gaps in technology development programs in the Exploration Technology Exploration Program Structures, Materials, and Mechanisms Project.Â Areas of development included in the SMM project include: low temperature drive system, motor, and gearbox system, personal kit radiation shielding materials, low density parachute material systems, expandable structural systems, Friction stir welded spun-domes, and advance composite structures. This topic area is responsible for mid-level technology research, development, and testing through experimental and/or analytical validation.Â

Subtopics

X4.01 Low Temperature Mechanisms

Lead Center: GSFC

Participating Center(s): GRC, JPL, JSC, LaRC

This subtopic focuses on the development of selected hardware and lubricants to support technologies for motors and drive systems (e.g., gear boxes) that will operate in cryogenic temperature environments such as permanently shaded craters on the Moon, and/or on the lunar surface exposed to the day/night cycle. In the former situation such mechanisms may be exposed to, and will need to operate in, sink temperatures as low as approximately 25K. In the latter situation they will need to operate over a temperature sink range of approximately 83K to 403K (-190Â°C to +130Â°C). A five year lifetime is desired. The component technologies developed in this effort will be utilized for rovers, cranes, instruments, drills, crushers, and other such facilities. The nearer term focus for this effort is for lunar missions, but these technologies should ideally be translatable to applications on Mars. These components must operate in a hard vacuum and/or planetary environment, with partial gravity, abrasive dust, and full solar and cosmic radiation exposure. Additional requirements include high reliability, ease of maintenance, low-system volume, low mass, and minimal power requirements. Low out-gassing is desirable, as are modular design characteristics, fail-safe operation, and reliability for handling fluids, slurries, biomass, particulates, and solids. While dust mitigation is not specifically included in this subtopic, proposed concepts should be cognizant of the need for such technologies. Specific areas of interest include innovative long life, light weight wide low temperature motors (in the range of 100W to 5 kWatts), gear boxes, lubricants, and closely related components that are suitable for the environments discussed above. One lubrication technology of specific interest is ionic fluids. Proposals for ionic fluid lubricant improvement should identify and/or formulate low volatility, non-corrosive extreme pressure (EP) and anti-wear additives for ionic fluid space lubricant candidate materials. Lubricant proposals should also include a sufficient quantity of the formulated end product so as to allow standard STLE 4-ball evaluation testing, comparing neat (unformulated) base ionic fluid performance to formulated ionic fluid performance.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.

X4.02 Advanced Radiation Shielding Materials and Structures

Lead Center: LaRC

Participating Center(s): ARC, GSFC, MSFC

Advances in radiation shielding materials and structures technologies are needed to protect humans from the hazards of space radiation during NASA missions. The primary area of interest for this 2008 solicitation is radiation shielding materials and structures for protection from long-duration lunar surface galactic cosmic radiation (GCR). The particular radiation species of greatest concern are protons, light ions, heavy ions, and neutrons. Research should be conducted to demonstrate technical feasibility during Phase 1 and to show a path toward a Phase 2 technology demonstration. Specific areas in which SBIR-developed technologies can contribute to NASA's overall mission requirements for advanced radiation shielding materials and structures include the following:

- Innovative lightweight radiation shielding materials and structures to shield humans in crew exploration vehicles, landers, rovers, and habitats and during lunar surface operations.
- Physical, mechanical, structural, and other relevant characterization data to validate and qualify multifunctional radiation shielding materials and structures.
- Innovative processing methods to produce quality-controlled advanced radiation shielding materials of all forms - resins, fibers, fabrics, foams, composites, light alloys, and hybrid materials.

- Innovative concepts to reuse, recycle, and reprocess materials and structures in space for use as radiation shielding materials and structures.

X4.03 Expandable Structures

Lead Center: LaRC

Participating Center(s): JPL, JSC, MSFC

X4.04 Composite Structures - NDE/Structures Health Monitoring

Lead Center: JSC

Participating Center(s): ARC, JSC, LaRC

Monitoring systems for advanced composite structures on the Exploration Program vehicles and systems lack sensors that are practically deployable. Monitoring is needed for improved robustness and reliability of composite structures or the mass advantage and performance of composites may not be realized. Adding sensors efficiently at any point in the vehicle lifetime is a necessity since some monitoring is needed for troubleshooting, validation of the loads, strain and thermal environment.

Sensors and their acquisition systems are needed that require a reduced wire infrastructure. Acoustic Emissions (AE) sensors have been shown to receive indications well out ahead of failure. Since propagation distance varies with each configuration and expected fault, many sensors will be needed to ensure composite health. The amount of wiring needed with standard approaches can offset much of the weight savings from composites and increase costs.

New AE sensor mounting methods and flexible sensors are needed that accommodate sometimes highly curved surfaces, don't fail or unbond at cryogenic tank temperatures and withstand high G loading. Very small sensors will need to be embedded at times to accommodate cases where attaching is impractical or the phenomenon can best be measured from within the composite structure.

Wireless sensors and wireless data acquisition systems with local processing of the composite structures events are needed to reduce the wiring and total data handling needs. Totally passive wireless sensor-tags can have advantages in certain applications.

Applications include: Advanced composite structures such as cryotanks, large area composites such as launch vehicle fairings, hard to access/inspect composite members, as well as metallic pressurized structures of all kinds. Interior as well as exterior measurements of the pressure vessel are needed.

Technologies: Flexible, highly efficient piezo materials for sensors, passive sensor-tags for communication, compact sensor data systems for modularity. Versions may be adaptable for acceleration, displacement/strain monitoring CEV parachutes as well for inflatable habitats.

TRL-3 should be achievable by the end of Phase 1.

TRL-6 should be achievable by the end of Phase 2.

X4.05 Composite Structures - Cryotanks

Lead Center: LaRC

Participating Center(s): GRC, GSFC, JSC, LaRC, MSFC

While Aluminum-lithium may be adequate for cryotanks (for immediate use and long-term storage) the use of composite materials offers the potential of significant weight savings. Composite cryotank technology would be applicable to EDS propellant tanks, Altair propellant tanks, lunar cryogenic storage tanks and Ares V tanks.

A material system (resin + fiber) which displays high resistance to microcracking at cryogenic temperatures is necessary for linerless cryotanks which provide the most weight-saving potential. This SBIR will focus on development of toughened, high strength composite materials because the literature indicates that they have the highest microcrack resistance at cryogenic temperatures.

Greatest interest is in novel approaches to increase resin strength and/or reduce resin CTE, thereby increasing resistance to microcracking at cryogenic temperature. Possible topics could include use of toughening agents, novel surface treatments for carbon fibers, reduced-temperature curing methods that reduce residual thermal stresses, etc.

Performance enhancements would be evaluated by a characterization program, which would ideally generate temperature-dependent material properties including strength, modulus, and CTE as functions of temperature. Additionally, notch sensitivity, plain strain fracture toughness, and microcracking fracture toughness as functions of temperature are desirable.

Tests will need to be performed at temperatures between -273Â°C and 23Â°C to fully characterize any nonlinearity in material properties with changes in temperature.

Initial property characterization would be done at the coupon level in Phase 1. Generation of design allowables, characterization of long-term material durability, and fabrication of larger panels would be part of follow-on efforts.

X4.06 Composite Structures - Manufacturing

Lead Center: MSFC

Participating Center(s): ARC, GRC, GSFC, LaRC

This subtopic solicits innovative research for advanced composite materials processing and characterization concepts that support the development of lightweight structures technologies that should be applicable for space transportation vehicle systems. Interests are in advanced composite structures, which can be tailored for strength, stiffness, weight and temperature capabilities with high performance at a lower cost. Reduction in structural mass translates directly to additional up-and-down mass capability that would facilitate logistics and increase science return for future missions. Advanced composites are targeted that could be implemented into launch vehicles, lunar landers, and habitats. Innovations in technology are needed for manufacturing, processing and bonded joints for structural and cryogenic applications. Manufacturing processes of interest are automated composite fiber/tape placement, non-autoclave curing, and bonding of composite joints. Development of concepts can include material system characterization, proof-of-concept demonstrations for lightweight structures, enabling performance, and affordability (including life cycle costs) enhancement.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 prototype demonstration. Demonstrate manufacturing technology that can be scaled up for very large structures.