NASA SBIR 2017 Phase I Solicitation

H5.01 Mars Surface Solar Array Structures

Lead Center: LaRC

Participating Center(s): GRC

Technology Area: TA12 Materials, Structures, Mechanical Systems and Manufacturing

Initial manned missions to the Mars surface may use large photovoltaic (PV) solar arrays to generate power for habitats, ISRU, science investigations, and battery charging. Nominal overall size of the solar array "farm" is 2500 m^2. Because of the critical nature of electrical power, this equipment may be prepositioned and validated prior to human landings. Modular solar array designs could be based on individual deployable structures with 50-150 m^2 of area each. Another approach could be a single monolithic structure. Regardless of the configuration, autonomous deployment/assembly is assumed to be required.

This subtopic seeks innovations in lightweight structures, robust deployment/retraction mechanisms, and autonomous assembly focusing on the process of post-landing deployment and erection of a large solar power system on the surface of Mars. Each lander might have its own modular power system that could be relocated closer to the loads to reduce cabling lengths and grow available power as the human Mars base grows.

Design guidelines for these autonomously deployed Mars solar array structures are:

- 2500 m^2 total solar cell area; < 5000 kg total mass including all mechanical and electrical components; and < 20 m^3 total launch volume.
- Loads: 5 g axial, 2 g lateral, 145 dB OASPL for launch and 50 m/s Mars surface winds. Ideally > 1 g deployed strength to allow unconstrained Earth deployment qualification.
- Capable of being optionally deployed on lander, offloaded and transported to another site, and then optionally interfaced with other power units.
- Deployable/retractable at -50° C on terrain with up to 0.5 m obstacles and 15 deg slopes. Operating height > 1 m to avoid wind-blown sand collection.
- Integrated dust mitigation and abatement methods. Dust accumulation is the #1 design risk issue for sustained PV power production on Mars.
- Tolerant of daily thermal cycling from -100° C to 25° C over a lifetime of 10 years.
- Concept of operations (ConOps) including transportation and robotic assembly aids and all design assumptions must be clearly defined.

This subtopic seeks innovations in the following areas for Mars solar array structures:

- Novel packaging, deployment, retraction, dust-abatement, or in-situ manufacturing concepts.
- Lightweight, compact components including booms, ribs, substrates, and mechanisms.
- Optimized use of advanced ultra-lightweight materials (but not materials development).

- Validated modeling, analysis, and simulation techniques.
- High-fidelity, functioning laboratory models and test methods.

Proposals should emphasize mechanical design innovations, not PV, electrical, or energy storage innovations, although a complete solar array systems analysis is encouraged. If solar concentrators or solar tracking are proposed, strong arguments must be developed to justify why this approach is better from technical, cost, and risk points of view over fixed planar solar arrays. Of special interest are modular designs that are self-supporting in 1 g and can be autonomously deployed, retracted, relocated, and optionally interfaced with other power sources at least twice after months of operation on the Mars surface. Sharing of conceptual CAD models and analyses with NASA for mission studies, and delivery of prototype hardware to NASA at the end of Phase II for independent testing, are highly encouraged.

In Phase I, contractors should prove the feasibility of proposed innovations using suitable analyses and tests. In Phase II, significant hardware or software capabilities that can be tested at NASA should be developed to advance their Technology Readiness Level (TRL). TRLs at the end of Phase II of 3-4 or higher are desired.

References:

- Tom Kerslake, "Solar Electric Power System Analyses for Mars Surface Missions," 1999, http://ntrs.nasa.gov/search.jsp?R=19990063893.
- Robert Cataldo, "Power Requirements for NASA Mars Design Reference Architecture 5.0," 2009, http://ntrs.nasa.gov/search.jsp?R=20120012929.
- Mars landing site concept animation, "Mars Exploration Zones," 2015, https://www.youtube.com/watch?v=94bIW7e1Otg&sns=em.