NASA SBIR 2018 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

Human missions to the Mars surface will require tens of kilowatts of electrical power for life support, science, in-situ resource utilization (ISRU), and other equipment. Possible power sources include nuclear reactors and solar arrays with batteries or regenerative fuel cells. Solar arrays are a mature, reliable technology used on most spacecraft and increasingly for Earth terrestrial power, and also at small sizes up to ~3 m^2 for several successful Mars landers and rovers. However, human missions will need thousands of square meters of solar cells to generate the required power. Furthermore, the solar arrays must survive inevitable dust storms and possibly months of dormancy before and between crew visits.Â

This subtopic seeks structural and mechanical innovations for solar arrays with at least 1000 m^2 of total area that autonomously deploy from Mars landers. Design guidelines for these large deployable solar arrays are:Â

- Solar arrays must self-deploy.
- Total area: 1000 m^2. Extensibility to 1500+ m^2 is desirable.
- Mass goal: < 1.5 kg/m^2 including all mechanical and electrical components. Packaging goal: < 10 m^3 per 1000 m^2 of deployed area.
- Launch loads: 5 g axial, 2 g lateral, 145 dB OASPL.
- Lander may not have azimuth control (i.e., guaranteed landing clocking angle). State all assumptions concerning array orientation and sun pointing.
- Solar arrays deploy in Mars 0.38 gravity and low winds (use 0.5 g for preliminary design). Solar arrays operate in Mars 0.38 gravity and wind gusts (use 1.0 g for preliminary design).
- Must survive peak winds of 50-100 m/s and simultaneous upward winds of 25-50 m/s (dust devils) with maximum air density of 0.023 kg/m^3.
- Deployable on terrain with up to 0.5 m obstacles/depressions, 15 degree slopes, and potentially hidden hazards (e.g., sand-filled holes). Operating height > 0.5 m to avoid wind-blown sand collection.
- Time to deploy: < 8 hrs.
- Deployed strength: Ideally > 1 g to allow unconstrained Earth deployment qualification.
- Integrated dust abatement or removal methods. Dust accumulation is the #1 design risk issue for sustained solar power production on Mars.
- Tolerant of daily thermal cycling from -100Â° C to 25Â° C over a lifetime of 10-15 years.
- Describe the concept of operations (ConOps) including all packaging, deployment, and operating assumptions.Â Â

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

- Novel packaging, deployment, retraction, terrain-following ground supports, or in-situ assembly or manufacturing concepts.
- Lightweight, compact components including booms, ribs, substrates, and mechanisms.
- Load-limiting devices to avoid damage during extreme winds.
- 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.Â

Proposals should emphasize structural and mechanical innovations, not photovoltaics, 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 design innovations that improve NASAâ€™s proposed solar array concepts using multiple Compact Telescoping Arrays (CTAs) as depicted on Charts 16-19Â of Reference 2.Â Load alleviation methods to avoid damage during extreme winds are also of high interest.Â

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.Â

*References:*Â

1. Joseph Appelbaum and Geoff Landis, â€œPhotovoltaic Array for Martian Surface Power,â€ 43rd Congress of the International Astronautical Federation, NASA TM-105827, August 28, 1992, https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19920024655.pdf.Â

2. Richard Pappa and Tom Kerslake, â€œMars Surface Solar Arrays,â€ FISO telecon seminar with recorded audio, June 7, 2017, http://spirit.as.utexas.edu/~fiso/telecon/Pappa-Kerslake_6-7-17/.Â

3. Lee Mason, â€œMars Surface Powerâ€ panel, AIAA Propulsion and Energy Forum with recorded video, July 12, 2017, https://livestream.com/AIAAvideo/PropEnergy2017/videos/159709334.