NASA SBIR/STTR — Small Business Innovation Research / Small Business Technology Transfer

NASA SBIR 2019 Phase I Solicitation

H5.01 Lunar Surface Solar Array Structures

Lead Center: LaRC

Participating Center(s): GRC, MSFC

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

NASA intends to start delivering small payloads to the lunar surface in 2019, moving to larger mid-size payloads by 2022 and eventually to human exploration [Ref. 1]. These missions will be powered by some combination of solar arrays with energy storage (e.g., batteries or regenerative fuel cells), radioisotope power converters, and nuclear fission depending on mission location and length, technology maturity, safety, and cost. Power estimates range from hundreds of watts initially to hundreds of kilowatts for an expansive human settlement [Ref. 2]. Mission plans are evolving and are mostly notional today but fault-tolerant power generation systems are critical in all cases.

An identified need for the initial human lander is a vertically deployed, retractable, sun-tracking solar array that generates ~4 kW of average and 6Â kW of peak power. This lander would shuttle at least 5 times between the orbiting Lunar Gateway and elevated sites near the poles where the sun shines almost continuously, the temperature remains near -50Â° C, and frozen water exists in nearby craters [Ref. 3]. The solar array will be deployed and operated in zero gravity on the Gateway and during the initial descent, retract for final descent and landing, deploy again on the lunar surface for a 7-30 day mission, retract again for ascent, and then deploy again for transfer back to the Gateway.

Ideally, the solar array technology developed for this initial human lander can be reconfigured for follow-on habitats, rovers, and in-situ resource processing, and adapted for later use on Mars. For an eventual permanent polar outpost, vertically deployed tracking solar arrays that generate up to 100 kW each (~300 m^2) are imagined. These arrays would be similar in size to the flight-proven solar array wings on the ISS and would provide a centralized and high-efficiency power generation capability.

This subtopic seeks structural and mechanical innovations for lightweight solar arrays that can deploy and retract at least 10 times in both zero-g and lunar gravity from landers, rovers, habitats, and other surface equipment at the lunar poles. Full or possibly partial retraction will minimize rocket plume loads and dust accumulation, and allow valuable solar array hardware to be reused, repurposed, or reconfigured. Because most spacecraft solar arrays do not self-retract, this technology is not well developed. Mechanized, fault-tolerant retraction of lightweight solar arrays would be a valuable design option to have available, and suitable innovations and variations of existing array concepts [e.g.,

Ref. 4] are of special interest.

Design guidelines for these deployable/retractable solar arrays are:

- Vertical orientation (solar cells pointed at the horizon).
- Sun tracking with dust-resistant mechanisms and motors.
- Deployed area: 30 m^{2}Â initially; up to 300 m^{2}Â eventually per unit.
- Specific mass: >150Â W/kg at 30 m^2; >100 W/kg at 300 m^2.
- Specific packing volume: >60 kW/m^{3}Â at 30 m^2; >40 kW/m^{3}Â at 300 m^2.
- Deployment/operation in both zero and lunar gravity.
- Number of mechanized deploy/retract cycles: at least 10; stretch goal >20 (in service).
- Lifetime: >10 years.
- Power generation: State assumptions.

Â Suggested areas of innovation include:

- Novel packaging, deployment, retraction, and modularity concepts.
- Lightweight, compact components including booms, ribs, substrates, and mechanisms.
- Load-limiting devices to avoid damage during deployment, retraction, and solar tracking.
- Optimized use of advanced lightweight materials (but not materials development).
- Validated modeling, analysis, and simulation techniques.
- High-fidelity, functioning laboratory models and test methods.
- Flight hardware for demonstration on a small or mid-size lander (multiple motorized retractions required).
- Completely new solar array concepts; e.g., thinned "rigidÂ panel" solar arrays.

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 are proposed, strong arguments must be developed to justify why this approach is better from technical, cost, and risk points of view over unconcentrated planar solar arrays.

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). TRL at the end of Phase II of 4 or higher is desired.Â

An identified need for the initial lunar human lander is a vertically deployed, retractable, sun-tracking solar array that generates ~3-4 kW of power. This lander would shuttle at least 5 times between the orbiting Lunar Gateway and elevated sites near the poles where the sun shines almost continuously, the temperature remains near -50Â° C, and frozen water exists in nearby craters. The solar array will be deployed and operated in zero gravity on the Gateway and during the initial descent, retract for final descent and landing, deploy again on the lunar surface for a 7-30 day mission, retract again for ascent, and then deploy again for transfer back to the Gateway.Â

NASA has plans to purchase services for delivery of payloads to the Moon through the Commercial Lunar Payload Services (CLPS) contract. Â Under this subtopic, proposals may include efforts to develop payloads for flight demonstration of relevant technologies in the lunar environment. Â The CLPS payload accommodations are yet to be precisely defined, however at least for early missions, proposed payloads should not exceed 15 kilograms in mass and not require more than 8 watts of continuous power. Smaller, simpler, and more self-sufficient payloads are more likely to be accommodated. Commercial payload delivery services may begin as early as 2020. Selection for award under this solicitation will not guarantee selection for a lunar flight opportunity.Â

References:Â

- â€œNASA Seeks Ideas to Advance Toward Human-Class Lunar Landers,â€ March 2018,Â https://www.nasa.gov/feature/nasa-seeks-ideas-to-advance-toward-human-class-lunar-landers.
- Petri, D., Cataldo, R., and Bozek, J., â€œPower System Requirements and Definition for Lunar and Mars Outposts,â€ AIAA Paper 2006-4103, June 2006,Â https://doi.org/10.2514/6.2006-4103.
- Burke, J., "Merits of a Lunar Pole Base Location," in Lunar Base and Space Activities of the 21st Century, Mendell, W. (editor), 1985,Â https://www.lpi.usra.edu/publications/books/lunar_bases/.
- McEachen, M., â€œCompact Telescoping Array: Advancement from Concept to Reality,â€ AIAA Paper 2018-1945, January 2018,Â https://doi.org/10.2514/6.2018-1945.