Ultralight, Compact, Deployable, High-Performance Solar Concentrator Array for Lunar Surface Power

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Abstract

In NASA's ambitious vision for space exploration, return visits to the moon are the initial focus. While these missions are not well defined other than in contractor system study reports, a common theme is to return to the lunar polar regions to search for primordial ice deposits initially, then expand the landings across the lunar surface including the rear side of the moon. In the early stages the missions will last from four to fourteen days, to avoid the challenge of energy storage over the nighttime. While these early missions anticipate the use of fuel cells to provide electrical energy to the landers and crew, it is likely that solar arrays will also become a major power source as well.

These arrays should have the following characteristics: high efficiency, light weight, high packaging density and be able to withstand the broad temperature swings on the moon. In addition, for those robotic missions that will explore the permanently dark polar craters, it is possible that beamed laser power may be an option to radioisotope powered rovers. Of course beamed laser power may also be applicable to providing power over the nighttime.

In this study, we will use the Stretched Lens Array on the SquareRigger platform as the basis (SLASR). At the present time this design has the following characteristics: specific power – 300 W/kg, areal power density – 300 W/m^2, stowed power – 80 kW/m^3 and capable of high voltage (>600 V) operation. Figure 1 shows a 2.5 x 5 m full scale building block module of the SLASR. This module is sized to produce 3.75 kW and weighs only about 10 kg.

Figure 1: Full scale SLASR module

These current benchmarks will be projected to the 2015 time frame with known improvements in cell and array technologies for a 25-30 kW array. Specific power will increase beyond 500 W/kg and similar improvements will be shown in the other parameters. One critical aspect of the study is the operating temperature on the moon.

The wide temperature swings on the equator over one year shown in figure 2 do not compare to the frigid temperature within the craters at the pole where the temperatures may reach as low as 50 K. Thus the orientation of the solar array and the possible need to reduce the surface background must all be included. Several surface treatments have been described in the past and will be used in this study.

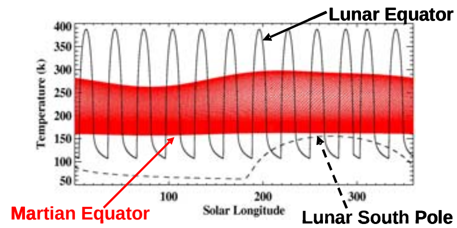

Figure 2: Lunar and Mars surface temperatures (Courtesy MIT & Draper)

The projected performance of a 25-30 kW lightweight, high efficiency SLASR array using multijunction solar cells expected to be available in 2010 time frame will be determined for a lunar polar region with high daylight during the year, an equatorial location during the day and an array in a permanently shadowed crater relying on laser illumination. The latter array will have GaAs solar cells matched to a nominal 800 nm wavelength laser and be sized for about 500 W. Temperature effects will be included.