Performance Projections for Solar Array Power Options on the Lunar Surface

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Abstract

In NASA's ambitious vision for space exploration, the NASA Lunar Architecture Team has concluded that the first objective is to build an outpost on the rim of the Shackleton Crater at the South Pole. One reason for this selection is the high amount of sunlight over the year (greater than 70%), allowing solar power to become the major power source.

Lunar solar 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 may 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 from an orbiting satellite may also be applicable to providing power over the nighttime.

Figure 1: Full scale SLASR module

This study will discuss the capability of the Stretched Lens Array on the SquareRigger platform (SLASR) as the basis for a lunar surface power system. The Stretched Lens Array (SLA), developed by ENTECH, Inc., uses refractive concentrator technology to collect and convert solar energy into useful electricity. 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 is 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.

The array operating temperature is dependent upon the lunar surface location and will affect the performance projections. Although a polar region seems certain for the first outpost, this study will take into account the wide temperature swings on the equator, shown in figure 2, and demonstrate that solar power is applicable for all lunar outpost sites. For equatorial sites, the orientation of the solar array and the need to reduce the surface background temperature will be included in this study. Several surface treatments have been described in the past to ameliorate this problem.

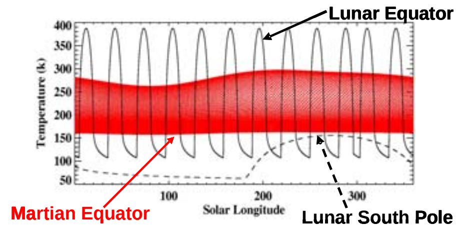

Figure 2: Lunar and Mars surface temperatures (Courtesy MIT & Draper)

The projected performance of a 25-30 kW lightweight, high efficiency SLASR array using the 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.

Energy storage options will also be discussed and are critically dependent upon lunar surface location. Because the lightweight SLA can be packaged into small volumes with low mass, the amount of power that can be delivered to the lunar surface is substantial. Results based on several lander cargo scenarios will be presented and a detailed plan for incremental build-up a lunar base power system will be presented. These power projections will show that the SLA is a lightweight, reliable, and cost effective power option for all locations on the lunar surface.