Solar Electric Power System for the Exploration of Mars. J. O. Elliott[1] [1]Jet Propulsion Laboratory, California Institute of Technology, M/S 301-165, 4800 Oak Grove Dr., Pasadena, CA, 91109, *jelliott@jpl.nasa.gov*.

Introduction: Paving the way for in-depth exploration of Mars by humans will require infrastructure development far beyond that included with past crewed surface missions. Where lunar missions lasted only a few days on the surface, the nature of missions to Mars would result in crews spending much longer times, up to 18 months for a conjunction-class mission. Resources brought from Earth would be precious indeed, requiring at minimum a robust sytem for in-situ production of power. With sufficient power it may also be feasible to perform reasonably large scale In-situ Resource Utilization (ISRU) to provide sustainable production of resources such as oxygen, water, and fuels for spacecraft surface exploration vehicles. This reliance on ISRU was the finding of a design trade in the latest Mars design reference architecture (DRA) study [1] which determined that in-situ production of O2 for crew consumption and ascent propellant would be *enabling* to the mission.

In the same study a trade was performed to identify the power source to be used to support both ISRU and crew for the mission. In this trade the major types of power production considered were nuclear fission and solar power. In the course of the trade a number of assumptions were made regarding the design of each type of system, as well as how they would be transported, deployed, and used. This trade benefitted from the considerable recent development work that had been carried out by the Prometheus program to develop a low cost, low risk fission surface power system (FSPS) for lunar and Mars applications. The size of the system under development (~40 kWe) was in the range required for the DRA, and detail was available regarding deployment, system mass, and cost.

This was not true, however, for the solar power system concept that was traded against the FSPS. While system designs had been evaluated a decade previous [2], these designs were the result of relatively limited studies and had not been kept up-to-date with respect to developments in related fields such as solar array and regenerative fuel cell designs. In fact, one of the recommendations called out in the report on this power trade brought attention to this issue,

"It is noted that while the FSPS design that was considered in this study was the product of a fairly detailed design study that was performed for the LAT, the solar power system did not benefit from such an effort. Any further consideration of solar power systems should begin with a design study that would develop a detailed implementation concept that is more fully tailored to this application."

The need: To properly evaluate the viability of human scale solar power systems for Mars exploration it is urgent that a systematic design concept study be undertaken. In the past decade ideas on the performance and robustness of solar power for Mars missions has been radically altered by the unprecedented and continuing success of the solar-powered MER project. Technology developments in solar cells, array configurations and deployables, as well as continued progress in development of regenerative fuel cells necessary to meet nighttime power needs should be evaluated.

Perhaps even more important in the consideration of a large scale solar power system are the unique issues associated with autonomous deployment and operation in the variable martian environment. The recent DRA found both of these issues to be major factors in the outcome of the design trade. First, the requirement for completely autonomous deployment of thousands of square meters of solar array area was considered to be a significant risk in light of earlier experience with large autonomous array deployments on Skylab and the ISS. Of even greater concern is the ability of a solar-based power system to maintain sufficient power during a martian dust storm. Options were briefly explored for temporary emergency arrays that could be rolled out by the crew, but the trades explored were by no means exhaustive, and this area is one which needs additional consideration in the development of robust system architecture. Dust and dust mitigation technologies should also be revisited to better understand the impact of recent developments and in-situ data.

With a fully developed, system-level design of a Mars solar/fuel cell power system it will be possible to perform a balanced trade for future mission architectures to determine optimal methods for supply of electrical power.

References:

[1] Mars Architecture Steering Group, Bret G. Drake, editor, (2009), NASA/SP-2009-566, Human Exploration of Mars Design Reference Architecture 5.0.

[2] Kerslake, T.W, and L.L. Kohout (1999) NASA/TM-1999-209288, Solar Electric Power System Analyses for Mars Surface Missions.