MARS ISPP PRECURSOR [MIP]: THE FIRST FLIGHT DEMONSTRATION OF IN-SITU PROPELLANT PRODUCTION. David Kaplan, Code EX, NASA/Johnson Space Center, Houston Texas 77058, USA.

Strategic planning for human missions of exploration to Mars has conclusively identified in-situ propellant production (ISPP) as an enabling technology[1]. The Mars reference mission concept predeploys a robotic propellant production plant to the planet two years before the planned departure of the crew from Earth. The successful operation of this plant is necessary for the human journey to begin.

In response to a solicitation for flight demonstration projects from NASA Headquarters in June 1996, a team of engineers from the Johnson Space Center, Jet Propulsion Laboratory, and Lewis Research Center proposed — and subsequently was selected to fly — the Mars ISPP Precursor (MIP) Flight Demonstration. The objective of MIP is to characterize the performance of processes and hardware which are important to ISPP concepts and which interact with the Mars environment during operation. Because of uncertainties associated with the Mars environment and conditions that cannot be adequately simulated on Earth, operating this hardware in the actual Mars environment is extremely important. Failure to perform testing of this hardware in the actual Mars environment could lead to propellant production degradation or failure, and/or the need for overly-conservative designs which would increase system mass and cost.

The MIP Flight Demonstration will be the first ISRU[2] hardware ever deployed to a planet or moon. Its successful operation will pave the way for future robotic and human missions to use and rely on propellants produced using the Martian atmosphere as feedstock.

The MIP is comprised of seven distinctive demonstrations:

¨ Mars entry and landing environment characterization;
≠ Atmospheric dust filtration;
Æ Atmospheric carbon dioxide collection and conditioning;
Ø Radiator/thermal management demonstration;
∞ Advanced photovoltaic cell/array demonstration;
± Dust accumulation and removal tests; and
≤ Production of oxygen.

At the completion of this flight demonstration, the MIP Team will be able to:

- recommend preferred hardware configurations for the intake and adsorption of carbon dioxide from the Martian atmosphere;
- recommend preferred hardware configurations for innovative thermal management concepts of heat transfer between the components of the ISPP plant as well as to the outside environment;
- understand long-term performance degradation characteristics of advanced solar array concepts operated in the actual Mars environment;
- evaluate the functionality of electrostatically removing accumulated dust off the solar array; and
- understand the characteristics of zirconia cells to generate propellant-grade oxygen.

The MIP Flight Demonstration unit is to be flown as a payload on the MARS SURVEYOR 2001 Lander. Therefore, it will be designed to meet SURVEYOR Lander instrument and mission specifications. Standard vehicle power, data/communications, and mechanical interfaces will be used to integrate the MIP unit onto the SURVEYOR 2001 Lander.

As a MARS SURVEYOR payload, the MIP unit will be only one of several instruments competing for power, volume, and mass allocations. Therefore, the MIP package will be designed to be small and light weight. Initial design goals are for an overall maximum external envelope of 30.5 x 30.5 x 30.5 cm (12 x 12 x 12 inches) and a package mass of 3 to 5 kg (6.6 to 11 lbm). The actual package design limits will depend upon SURVEYOR Lander hardware limitations that will be defined as the 2001 mission matures. MIP power requirements have not yet been determined; however, preliminary analysis shows a power level in the 15 to 30 watts range.

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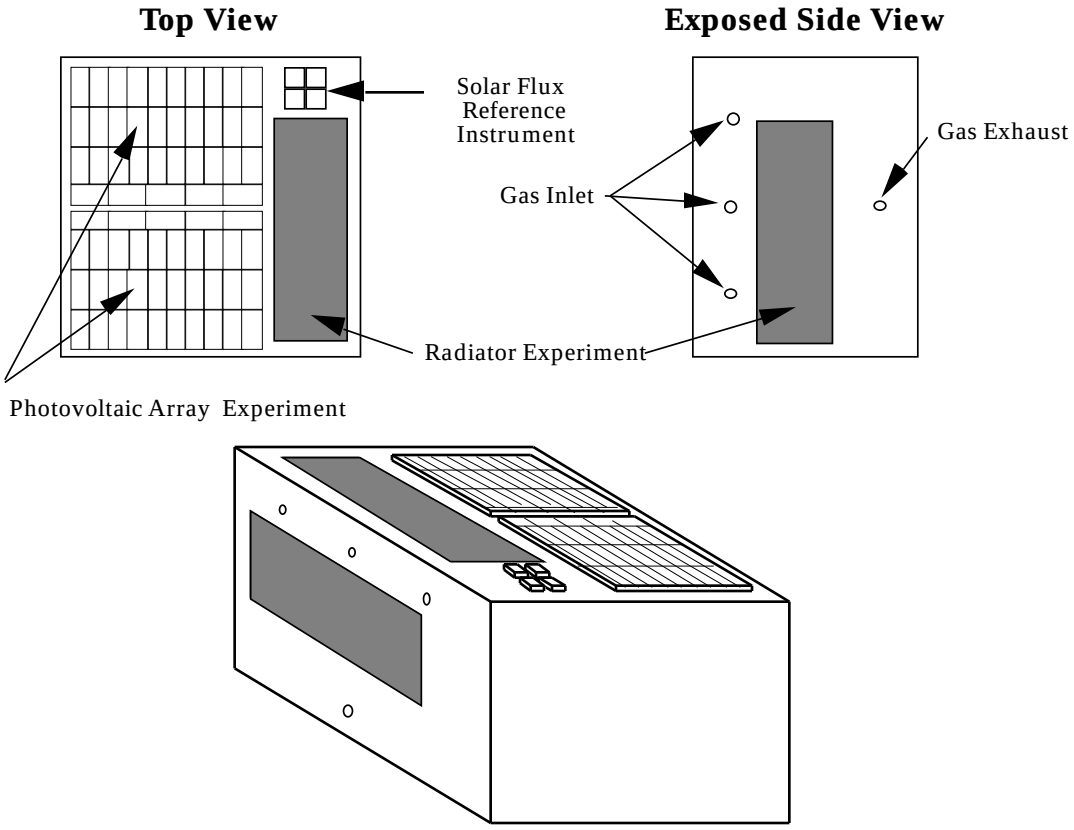
[1] "Mars Reference Mission," NASA SP-6107, February 1997.

[2] In-Situ Resource Utilization

The MIP unit will be designed to operate up to 500 days on the surface of Mars. This duration is comparable to the operation requirement for an ISPP plant incorporated into a robotic Mars Sample Return mission.



Preliminary Mars ISPP Precursor (MIP) Flight Demonstration design concept