Mission Design for a Nuclear Reactor-Powered Mars Cryobot Lander

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The planning of Mars surface missions has progressed in recent years in the direction of increasing capability and science return with an attendant need for increased power and longevity. The Viking missions demonstrated longevity at low power levels (~ 70We per lander) and current planning includes plans for radioisotope-powered missions in the 100 to 200 We range. Beyond levels of about 1 kWe radioisotope sources begin to be prohibitively massive, especially for a landed system. At levels of about 3 kWe, the use of a fission power system for surface applications becomes attractive from a number of standpoints.

This paper describes a study carried out by a team from JPL and the DoE to investigate the utility of a 3 kWe surface fission power system for Mars missions. The team was originally tasked to perform a study to evaluate the usefulness and feasibility of incorporation of such a power system into a landed mission. In the course of the study it became clear that the application of such a power system was enabling to a wide variety of potential missions. Of these, two mission concepts were developed, one for a stationary lander and one for a reactor-powered rover. This paper discusses the design of the lander mission, which was developed around the concept of landing a cryobot on the Mars north polar ice cap. The cryobot is designed to bore through the entire 2 km thickness of the ice cap, providing a picture of the Martian climate spanning more than a million years of Martian history. The high sustained power available from the reactor system proves to be an ideal match for this mission design enabling a level of science return unavailable from an alternative power sources. The lander design is based on a minimum extrapolation of technology, drawing heavily on the existing concepts in development at JPL for the 2009 Mars Science Laboratory (MSL) lander and EDL systems. This paper describes the unique design challenges encountered in the development of this mission architecture and incorporation of the fission power system in the lander, and presents a detailed description of the final design of this trailblazing science mission.