MARS PATHFINDER MICROROVER
A SMALL, LOW-COST, LOW-POWER SPACECRAFT

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On December 5, 1996, NASA will launch its first Discovery Class Mission, the Mars Pathfinder. The Mars Pathfinder spacecraft includes a 450 kg lander and a 11 Kg, 6 wheeled microrover. The microrover will be deployed from the lander shortly after the spacecraft has landed on July 4, 1997 and will perform a wide range of science and technology experiments. The significance of the microrover is that although it is formally part of the mission's instrument payload, it is in reality a small spacecraft. It performs all the functions that a typical spacecraft performs including: navigation; command and data handling (command execution, data acquisition, telemetry packetization); power generation, distribution, and control; thermal control; telecommunications; and, instrument, sensor, and actuator control.[1] The Mars Pathfinder Microrover is also quite unique in that its total cost of development as well as support for mission operations is a mere $25.5M. This is more than an order of magnitude less than the cost of any previously flown interplanetary spacecraft. The microrover is also being developed an built in only 3 years which includes conceptual design on up to delivery of the flight article and launch.

The design of the microrover has been influenced by a wide range of mission, environmental, and programmatic constraints. These have included severe limitations upon mass and volume, the need to survive the launch and landing loads, the desire to be as independent from the lander as possible, and the need to operate on the surface of M ars. However, once it was decided that the rover must fit within a bread box and weigh no more than - 12 kg, perhaps none of these constraints has had a greater impact upon the microrover's overall design than that of power.

During the mission, the microrover's 0.22 m2 gallium arsenide solar panel will be capable of producing a maximum of only 16 watts at high noon. At 10:00 am (LST) it will produce only 11.0 watts and by about 2:30 pm (LST) it is again back down to 11.0 watts 2 As a result, the microrover simply cannot "walk and chew gum" at the same time. For example, there is not enough power to simultaneously operate the RF modem and run all six wheel motors, to operate the modem and take images, to run all four steering motors and the six drive motors, or to run the six drive motors and operate the camera/laser-based obstacle detection system. The implications of this upon the design of the microrover's control system arc far reaching.

This paper will provide an overview of the design of the Mars Pathfinder Microrover with emphasis upon how it functions as a complete, self-contained spacecraft. It will also present a discussion of the major impact that the above mentioned power limitations have had upon the design of the microrover's control system. The latter is believed to be particularly relevant to the design of future, small, low-cost spacecraft.

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[1] The navigation functions, albeit different from interplanetary trajectory control, arc no less complicated and involve the use of numerous sensors to measure vehicle position and orientation as well as sensors to detect for the presence of hazards (i.e., obstacles) a.. the vehicle autonomously drives across the surface of the Mars,

2 While the microrover also contains primary (i.e., non-rechargeablc) batteries, they serve primarily as a backup to the solar panel and could provide enough energy to perform a several day contingency mission.