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Paper Title: Mars Exploration Rover: Thermal Design is a System Engineering Activity

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ABSTRACT –

The Mars Exploration Rovers (MER), were launched in June and July of 2003, respectively, and will land on Mars in early and late January of 2004, respectively. The flight system architecture implements many successful features of the Mars Pathfinder (MPF) system: A cruise stage that transports an entry vehicle that houses the Lander, which in turn, uses airbags to cushion the Rover during the landing event. The initial thermal design approach focused on adopting the MPF design wherever possible, and then concentrating on the totally new Rover thermal design. Despite a fundamentally sound approach, there were several salient lessons learned. Some were due to differences from MPF, while others were caused by other means. These lessons sent a clear message: thermal design continues to be a system engineering activity. In each major flight system assembly, there are excellent examples of this recurring theme. From the cruise stage, the cascading impact of a propulsion fill and drain valve thermal design change after system level test is described. In addition, we present the interesting resolution of the sun sensor head thermal design (bare metal versus white paint). The final implementation went against best thermal engineering practices. For the entry vehicle consisting of the aeroshell and equipment mounted to it, the inertial measurement unit mounted on a shock-isolation fixture presented a particularly difficult design challenge. We initially believed that its operating time would be limited due to its relatively low mass and high power dissipation. The primary batteries located on the Lander appeared to be a similar challenge, and fortunately, the cell chemistry was changed to obviate this challenge. We conclude with the evolution of the Rover actuator thermal design where the single-string warm-up heaters are employed. In this instance, fault protection requirements drove the final thermal design implementation.