COLD ROVER FOR MARS. Mohammad M. Mojarradi[1], Raphael Some[1], Alan Sirota[1], Kobe Boykins[1], John Cressler[2], Benjamin Blalock[3]. [1] Jet Propulsin Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, California 91109-8099, USA. [2] School of Electrical and Computer Engineering 777 Atlantic Drive, N.W., Georgia Institute of Technology, Atlanta, Georgia 30332-0250, USA, [3] Department of Electrical and Computer Engineering University of Tennessee, Knoxville, Tennessee 37916, USA

Introduction:

The surface temperature of Mars changes from 20C during the day to -120C at nights. This temperature range is significantly wider than the operating temperature range of commercial and military components (120C to -55C) [1]. To compensate for this temperature mismatch, the Mars Science Laboratory (MSL) and Mars Exploration Rovers (MER) place their electronic components in thermally protected systems and deploy survival heaters on their electromechanical components and sensors. The thermal protection systems for MSL and MER are shown in Figures 1 and 2 and are often referred to as the warm electronics box or WEB [2, 3, 4, 5]. The use of survival heaters significantly increases the power required by the rover. In addition, the warm electronics box is power inefficient, adds significant mass to the rover, and requires a jungle of wires to connect to loads and actuators located at the extremities of the spacecraft. Figure 3 shows the wiring between the MER WEB and the actuators and sensors placed in the extremities of the MER. The jungle of wires significantly complicates the tasks of assembly, debug, and integration of the rover.

We propose to build a Cold Rover that eliminates the need for the warm electronics box and survival heaters. The cold rover would use combination of electronic components and electronics packaging that have the ability to directly operate at the low temperatures of the Martian surface [1, 6, 7] plus low temperature capable electromechanical components, bearings, and gear boxes [8,9]. The use of low temperature electronics components would also enable the Cold Rover to have a significantly simplified wiring tree. Instead of a jungle of wire used in concert with a centrally located warm electronics box, the Cold Rover would deploy a standard communication bus between its computer and loads located in its extremities. This type of distributed architecture would allow multiply-redundant, highly integrated, modular loads consisting of cold-capable electronics, and electromechanical elements (actuators, sensors,…) to be easily connected to the same bus making the Cold Rover highly reliable, modular, and expandable.

The Cold Rover concept represents a revolutionary departure from the state of practice in Mars rovers. It offers significant savings in mass, power, size, and complexity for next generation Martian surface missions. It also has a very affordable development cost, as much of the required infrastructure has already been established. Recent low temperature characterization results at JPL indicate that many currently available electronic components operate well at the low temperatures of the Martian surface [1]. NASA's Exploration Technology Development Program (ETDP) previously established the infrastructure for the design of custom radiation hard, low temperature capable SiGe electronics [10, 11] on commercial foundry lines, allowing us to augment the extensive list of commercially available components with low cost ASICS that meet radiation and temperature requirements. This ETDP-initiated technology has been flight qualified and is currently employed on the MSL rover in the cold capable motor position encoder module [12].

For the Mars Cold Rover concept, all required components are readily available or attainable at reasonable cost, schedule and risk levels. NASA ETDP has also demonstrated low temperature mechanisms which consist of actuators and bearings (Figure 4) capable of operating at Martian surface temperatures without the use of survival heaters [6, 7]. Application of these NASA sponsored and developed technologies to the Cold Rover would dramatically reduce power, mass, size and complexity of future rovers for Mars as well as other destinations.

Figure 1 MSL WEB

Figures 2 and 3 MER WEB and the MER jungle of wires connecting the WEB to loads located at the extremities of the rover.

Figure 4 Low Temperature MSL Class Motor, Gearbox combination capable of operating at temperatures as low as -240C developed by NASA ETDP.

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