ENTRY, DESCENT, AND LANDING COMMUNICATIONS FOR THE 2011 MARS SCIENCE LABORATORY

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ABSTRACT

The Mars Science Laboratory (MSL), established as the most advanced rover to land on the surface of Mars to date, launched on November 26th, 2011 and will arrive to the Martian Gale Crater during the night of August 5th, 2012 (PDT). MSL will investigate whether the landing region was ever suitable to support carbon-based life, and examine rocks, soil, and the atmosphere with a sophisticated suite of tools. This paper addresses the flight system requirement by which the vehicle will transmit indications of the following events using both X-band tones and UHF telemetry to allow identification of probable root causes should a mission anomaly occur: Heat-Rejection System (HRS) venting, completion of the cruise stage separation, turn to entry attitude, atmospheric deceleration, bank angle reversal commanded (each discrete reversal), parachute deployment, heatshield separation, radar ground acquisition, powered descent initiation, rover separation from the descent stage, and rover release. During Entry, Descent, and Landing (EDL), the flight system will transmit a UHF telemetry stream adequate to determine the state of the spacecraft (including the presence of faults) at 8 kbps initiating from cruise stage separation through at least one minute after positive indication of rover release on the surface of Mars. The flight system will also transmit X-band semaphore tones from Entry to landing plus one minute although since MSL will be occulted by Mars as seen from the Earth, Direct-To-Earth (DTE) communications will be interrupted at approximately 308 s after Entry (~120 prior to Landing). The primary data return paths are through the Deep Space Network (DSN) for DTE and the existing Mars network of orbiting assets for UHF, which include the Mars Reconnaissance Orbiter (MRO), Mars Odyssey (ODY), and Mars Express (MEX) elements. These orbiters will record the telemetry data stream and return it back to Earth via the DSN.

The paper will introduce the EDL communication strategies adopted by previous lander missions (Viking, Mars Pathfinder, Mars Polar Lander, Mars Exploration Rovers, and Mars Phoenix), and compare them to the current MSL strategy for EDL communications support. It will also describe how maintaining EDL communications became a critical driver during the selection of the final launch/arrival strategy. A description of the telecommunications system and the different MSL spacecraft configurations will be presented as well as a detailed EDL timeline showing what radios will be enabled during the different EDL events.

Another important aspect of EDL communications is the coordination between the MSL and the MRO/ODY/MEX Navigation teams as well as the DSN ground support team. This coordination involves generation and delivery of EDL relay targets, and exchange of trajectory predicts and attitude profile information. Preparation for EDL communications during cruise has been very successful and the orbiters have nearly completed their on-orbit phasing in order to achieve the EDL relay targets at the Entry Interface Point (EIP) as requested by the MSL project. During the next several months, the MSL, MRO, ODY, and MEX Navigation teams will continue their joint effort in order to ensure EDL communications, and complete the last set of maneuver(s) to achieve the correct orbiter geometry at MSL arrival.

Multiple Monte Carlo runs designed to evaluate the expected total power received during the different EDL events show that MRO will lock up on the MSL signal before Entry through several minutes after landing. ODY bent-pipe communications, allowing for near real-time receipt of MSL telemetry information minus the one-way light time delay, will also be available shortly after Entry through a few minutes after landing. Mars Express will record on open loop, canister mode, providing a third asset to the UHF link. MEX will set at approximately one minute before landing. Even though, X-band communications will be lost due to MSL's arrival geometry, this will occur during the last part of EDL when both MRO and ODY have optimal visibility. Orbiter teams are expected to achieve their EDL relay targets within ± 30 s of the on-orbit phasing target (which is consistent with their spacecraft on-orbit phasing control). Additional Monte Carlo runs show that even if the orbiters achieve off-nominal phasings, the probability of lockup is still high for on-orbit phasing errors up to ± 180 s for MRO and up to ± 60 s to ODY which adds even more robustness to the EDL communications strategy.