

Mars Exploration Rover (MER) Surface Mission Tactical Uplink Concepts, Processes, and Tools

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In January 2004 the Mars Exploration Rover (MER) Mission will land two rovers on Mars three weeks apart, in two geologically distinct regions. Executing the uplink processes required to efficiently develop plans, sequences, and commands on a daily basis for these two "rolling rockhounds" will be very challenging. Among these challenges for MER operations are rapid command turnaround, sustained operations on a rotating "Mars Time" schedule, commanding of multiple spacecraft within a single mission and non-deterministic rover drive times.

To operate these rovers, the MER Mission Operations System has designed a two-pronged process consisting of a "strategic" element, which maintains and derives plans across longer mission timescales, and a "tactical" element, which is responsible for operations one "sol" (a Mars diurnal cycle, 24.6 hours in length) at a time. This paper concentrates on the tactical element.

MER tactical operations are driven by the need to complete the downlink-to-uplink cycle in 19 hours or less. The rover plan for each sol is highly dependent on the results of the prior sol's activities, requiring the completion of the end-of-sol downlink before the uplink planning process can begin. Once the downlink is received, the telemetry is analyzed sufficiently to characterize the spacecraft state and mission results. With this information in hand, a set of science requests is generated, based on a resource envelope and a series of engineering needs. The requests in the science activity plan each have a priority level assigned so that later changes can be accomplished with the original scientific goals in mind. The science activity plan is then combined with additional engineering activities to generate an integrated science and engineering plan that optimizes available resources. Tools to model resources at the activity level facilitate this step.

In the next step in the process, the objective is to generate sequences of commands that implement the approved activity plan. Because turnaround time requirements do not permit complete execution of all command sequences through the Flight Operations testbed, alternative means of command load validation--using pre-validated sequence templates, sequencing rules, and software simulation--must be employed. Software tools provide approved command formats and flight rule checking, as well as higher-fidelity resource-checking and traverse simulation. The last steps in the process involve command load approval, radiation and activation.

Overall, surface uplink operations are qualitatively similar to those of Mars Pathfinder (MPF), but differ considerably in detail. MER has two rovers as opposed to MPF's one. Those MER rovers must be operated intensively over 90 sols each, whereas the MPF lander and rover were only required to last 30 and 7 days respectively. MER will place a much greater emphasis on achieving the best possible science mission return than the MPF engineering demonstration mission. Important MPF lessons learned are being incorporated where applicable. Such lessons include the importance of front-loading the uplink process to develop realistic plans to keep surprises out of the later sequence generation steps, building an operations team with enough personnel to sustain operations, and use of ground tools with self-documenting capabilities.

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