

Mars Science Laboratory (MSL): Planetary Protection Lessons Learned

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MSL: PP Lessons Learned

- Purpose
 - To assess the MSL PP-related activities from a Headquarters perspective
 - The good
 - The bad
 - The ugly

In order to

- Preserve the good
- Correct the bad
- Eliminate the ugly

MSL: PP Lessons Learned (cont'd)

- Background
- MSL was originally classified a PP Category IVc mission, based on the mission description provided to the PPO (Planetary Protection Officer) at the time of the categorization request.
- Specifically, the categorization letter included the following:

MSL: PP Lessons Learned (cont'd)

- *As requested, the MSL mission is hereby assigned as Category IVc in accordance with NPR 8020.12C, with the following options for implementation (assuming an RPS is incorporated into the final design for the landed portion of the mission):*

1. Prepare the landing system to meet Viking post-sterilization cleanliness requirements (controlled cleaning and assembly as noted below, followed by a system-level dry heat microbial reduction step in accordance with NPR 8020.12C), with control of recontamination through launch and delivery to Mars:

Under this option no restrictions on landing sites would be imposed on the mission by my office.

MSL: PP Lessons Learned (cont'd)

or

2a. Prepare the landing system to meet Viking pre-sterilization cleanliness requirements in accordance with NPR 8020.12C, including the following top-level requirements:

The total bioburden for exposed exterior and interior spacecraft surfaces of the “landed system” shall not exceed 3×10^5 spores at launch, with the average bioburden not exceeding 300 spores per square meter, as measured by the NASA standard microbial assay.

MSL: PP Lessons Learned (cont'd)

2b. In addition, the portions of the sampling apparatus or any other portions of the spacecraft that will contact the martian subsurface must be subject to a sterilizing treatment providing no less than a four-order-of-magnitude reduction in the spore population measured by the NASA standard microbial assay. The required reduction is based on an initial bioburden of no more than 300 spores per square meter.

MSL: PP Lessons Learned (cont'd)

- 2c. The mission will be limited to landing sites not known to have extant water or water-ice within 1 m of the surface. One-sigma landing ellipses that address failure modes subsequent to parachute opening at Mars need to fall outside such areas. In addition, later access to martian special regions (as defined by NPR 8020.12C) will be permitted only by vertical mobility, through the use of sterilized sampling hardware, as detailed above. No horizontal access through mobility by an unsterilized rover will be allowed:

-Proposed landing sites will be reviewed by my office for compliance with this requirement pre-launch, and prior to the preparation and presentation of landing site options to the Science Mission Directorate Associate Administrator.

MSL: PP Lessons Learned (cont'd)

The Good

- In Curiosity, the mission landed a rover that square centimeter for square centimeter and cubic meter for cubic meter is the cleanest spacecraft that landed on another planet since the two Vikings in the summer of 1976.
 - The total of spores on accountable surfaces was 5.64×10^4 (36 spores/m²) and encapsulated in non-metallic material 1.81×10^5
- The cleanliness achieved by Curiosity is a testament to a job well done by the JPL Planetary Protection (PP) team and the engineers, scientists, and technicians throughout the long and involved ATLO operations at JPL, Denver, and KSC.

MSL: PP Lessons Learned (cont'd)

- The MSL PP team was a good mix of seasoned and younger professionals, whose expertise was appropriate to the task.
- They functioned well, they were dedicated to the effort, and they helped establish a healthy culture of responsible behavior among the ATLO personnel relative to hardware cleanliness.
- They monitored closely the spacecraft's bioburden through a large number of frequent assays, insisted on regular and thorough cleaning procedures, and took good advantage of the synergy with the contamination control requirements.

MSL: PP Lessons Learned (cont'd)

- They improved on the previous means of entering and manipulating the assay data by further automating the process and better streamlined the sample processing operation.
- The team worked well with the Headquarters PPO and her designees keeping them apprised of developments.

MSL: PP Lessons Learned (cont'd)

- Lessons Learned

The project PP implementation teams should include experienced professionals. Frequent and numerous assays are essential. They reinforce the criticality of proper clean room protocols, they identify and enable timely remedies of cleanliness anomalies, and they ultimately ensure compliance.

- Improvements

Training of management and ATLO personnel should be made mandatory for Category IV missions.

MSL: PP Lessons Learned (cont'd)

The Bad

- Despite some improvements in the efficiency of operations, the JPL PP team was short-staffed.
- Project budgetary pressures limited the team to four full time members.
- Previous projects of similar or lesser complexity (MER is an example) employed at least two more professionals and, in the case of Viking, up to six more.

MSL: PP Lessons Learned (cont'd)

- Limited staffing was also the case at Headquarters. The PPO and her senior advisor shared the monitoring duties on a part time basis, since both also addressed other programmatic needs.
- To cite the Viking example, involved in the monitoring activities were two full time contractor professionals (one literally embedded in the project team throughout ATLO operations at KSC), a half time contractor professional, as well as the PPO and his assistant.

MSL: PP Lessons Learned (cont'd)

As a consequence:

- Some critical details went unchecked:
 - the paperwork relating to the sterilization treatment and subsequent recontamination prevention measures for the drill bits and the rover wheels

MSL: PP Lessons Learned (cont'd)

- the late discovery of the fact that blankets were installed inside the heat shield. The addition of blankets was a change to the design. The change rendered a heat shield area of about 34 square meters no longer accessible for assays. After the fact, arrangements were made for taking verification samples of a small subset of the area through the installed blankets.
- The issues of the wheels and the drill bits will be further discussed in the “Ugly”.

MSL: PP Lessons Learned (cont'd)

- While staffing issues contributed to the problem, the main cause of it was the lack of effective communication among the program and project management, engineers, contamination control personnel, and the project PP team.

MSL: PP Lessons Learned (cont'd)

- Lessons Learned

Staffing of a Category IV project's PP team must be better scrutinized. The team must include enough members to account for both planned activities and schedules and contingencies. The latter tend to be the rule more than the exception. To ensure effective communications with other project teams and management, a member of the team should be assigned the responsibility to participate daily in all related meetings, and to maintain regular liaison with the contamination control team and the cognizant engineers. As more experienced PP practitioners are lost to retirement, it is imperative that newer members receive thorough training, preferably before their seasoned colleagues leave.

MSL: PP Lessons Learned (cont'd)

At NASA Headquarters, it is essential to afford the PPO the ability to hire more staff. Two FTE's is a minimum. The PPO's senior advisor will retire in the next two years making it an urgent need indeed. For Category IV missions, and most especially for IVb , IVc and restricted sample return, it is critical to have a PPO designee embedded in the project's PP team throughout the ATLO operations. Monitoring all PP-related activities should be the full time activity of this designee.

MSL: PP Lessons Learned (cont'd)

- *Steps should be taken to establish better coordination between the PP team and the QA/QC personnel.*

MSL: PP Lessons Learned (cont'd)

The Ugly

- Throughout the history of Planetary Protection, one requirement of the PPO's project monitoring activities that was universally recognized and unchallenged has been access to facilities and events that are critical to this function.
- This typically includes verification assays, observation of operations that could affect PP compliance, attendance at selected project meetings and tag-ups, and review of pertinent documentation. All Program Executives and Project Managers have understood the need for, and freely granted that access.

MSL: PP Lessons Learned (cont'd)

- This, however, was not always the case with MSL.
- The project tried to impose arbitrary limitations on the number of PPO personnel involved in verification assays
- It restricted viewing of important operations
- It did not facilitate attendance at launch and landing
- Less than cooperative in addressing issues that came up

MSL: PP Lessons Learned (cont'd)

- Even for routine requests, well within the right of the PPO to make, and provided for in the PP NPR and in project documentation there were unprecedented resistance and bureaucratic obstacles.
- The Program Executive did not prove helpful in mediating conflict. Instead, another layer of complexity was added by limiting the PPO's traditionally direct access to project management, access that in the case of every previous flight project proved the best way to resolve issues.

MSL: PP Lessons Learned (cont'd)

- The issues of preventing recontamination of the drill bits and the rover wheels were mishandled and could have caused delays in the launch of MSL.
- The wheels which were originally bagged after sterilization were taken out of containment with only the tread subsequently covered.
- The previously sterilized drill bits were removed from their containment, re-assayed for contamination control, and put back into containment, while one bit was placed in the drill (a clear violation of the PP requirements).

MSL: PP Lessons Learned (cont'd)

- This latter example, discovered less than three months before launch, led to a Request for Deviation by the project and the subsequent decision by the PPO, in consultation with the PPS, to re-categorize the mission just two weeks before launch, an unprecedented action in the long history of Planetary Protection.
- Fortunately, the re-categorization (from Category IVc to Category IVa) was made possible by the fortuitous choice of landing site. The re-categorization letter included the following conditions:

MSL: PP Lessons Learned (cont'd)

“Prelaunch cleanliness requirements shall remain as described in the approved MSL Planetary Protection Plan, for hardware not intended to access the Martian subsurface.

▫ *Landing site restrictions, as detailed in the original MSL Categorization Letter and Planetary Protection Plan, shall apply. A review by the NAC Planetary Protection Subcommittee found minimal potential for the presence of water ice within a meter of the surface at Gale Crater, and identified this landing site as the most desirable of available options from the standpoint of planetary protection.*

MSL: PP Lessons Learned (cont'd)

□ *The project is prohibited from introducing any hardware into a Mars Special Region, as defined in NASA Procedural Requirements document NPR 8020.12D. Fluid-formed features such as Recurring Slope Lineae are included in this prohibition. Any evidence suggesting the presence of Special Regions or flowing liquid at the actual MSL landing site shall be communicated to the Planetary Protection Officer immediately, and physical contact by the lander with such features shall be entirely avoided.”*

MSL: PP Lessons Learned (cont'd)

- Another important consequence of the re-categorization and the corresponding limited contamination control measures taken on MSL , is the integrity of the rover science relating to the search for evidence of life on Mars.
- In particular, the SAM instrument's potential discovery of organics will be made more difficult to defend adequately given the lack of effective sterilization and recontamination prevention.
- This brings into focus the issue of what constitutes a “life detection” experiment and who is responsible for making the determination.

MSL: PP Lessons Learned (cont'd)

Utilize the lessons learned for “Bad” to gain better access to project information and to ensure more effective and frequent communication.

MSL: PP Lessons Learned (cont'd)

- Lessons Learned

It is important to safeguard the right of access of the PPO and her/his team to spacecraft facilities and operations. To this end, more detailed language should be included in the NPR and flight projects' PP Plans that makes abundantly clear what the scope of the access should be, what facilities are included, what operations are involved, and what milestones are covered.

MSL: PP Lessons Learned (cont'd)

The right of the PPO to interface directly with the project management should remain unchallenged. Therefore, all appropriate documentation should include language to protect it. The SMD should take steps to encourage and promote team building and synergistic relationships among PE's, Program Scientists, and the PPO.

The PPO should be directly involved in the determination of what constitutes a "life detection" experiment for all missions.

MSL: PP Lessons Learned (cont'd)

QUESTIONS?