Planetary Protection for Mars Science Laboratory

NASA takes strict precautions to avoid the possible introduction of microbes from Earth when sending robotic spacecraft to any solar system body with the potential for past or current biological activity.

For the Mars Science Laboratory mission's Curiosity rover, this includes requirements for the cleanliness of flight hardware before launch and specific criteria for its landing site and areas it will explore.

What is planetary protection?

"Planetary protection" is the term given to the practice of protecting solar system bodies from contamination by Earth life, and protecting Earth from possible life forms that may be returned from other solar system bodies. NASA has a planetary protection officer responsible for establishing and enforcing planetary protection requirements consistent with agency policy and the obligations of the United States under the 1967 Outer Space Treaty. Article IX of that treaty stipulates that the exploration of space be conducted in a manner that preserves the pristine biological conditions of celestial bodies.

In a clean room at NASA's Kennedy Space Center, Mars Science Laboratory personnel sample the inboard side of the spacecraft's heat shield to confirm its cleanliness before final assembly for launch.

NASA requires that each spacecraft project be responsible for implementing measures to comply with the agency's planetary protection requirements for the project. In general, this results in specific planetary protection considerations during the design, assembly, test and transport of mission hardware to keep it biologically clean before flight.

How is planetary protection being handled with Mars Science Laboratory?

For Curiosity, compliance with NASA planetary protection requirements was accomplished mainly through the careful maintenance of clean room protocols, periodic cleaning of spacecraft surfaces with alcohol wipes, and dry heat treatment of some spacecraft parts.

Technicians and engineers assembling the components of the rover and preparing it for launch routinely cleaned surfaces by wiping them with alcohol. In addition, rover components tolerant of high temperature were treated using dry heat techniques to reduce the number of bacterial spores. Selected components were heated to temperatures ranging from 110 to 146 degrees Celsius (230 to 295 degrees Fahrenheit) for durations up to 144 hours. Tools and other equipment that could come into contact with rover hardware were also cleaned routinely with alcohol wipes.

Spore-forming bacteria have been the focus of planetary protection standards because these bacteria can survive harsh conditions for many years as inactive spores. Planetary protection requirements called for the entire Mars Science Laboratory flight system to launch with no more than 500,000 bacterial spores — about one tenth as many as in a typical teaspoon of seawater.

In addition, the exposed interior and exterior surfaces of the landed system, including the rover, parachute and back shell, were limited to carrying no more than 300,000 spores, with the average spore density not exceeding 300 spores per square meter (about 11 square feet). This ensures that any biological load is not concentrated in one place.

The heat shield and descent stage will hit the ground hard enough that hardware could break open. The number of spores inside this hardware that could be exposed was included in the final spore count.

The NASA planetary protection team carefully sampled the surfaces of Mars Science Laboratory flight hardware and performed microbiological tests to demonstrate that the spacecraft meets these requirements. The team found Mars Science Laboratory to be extremely clean: the final bioassays found a total of 278,000 spores on the entire flight system, with 56,400 spores on the surfaces of rover hardware.

What could happen now that Curiosity has been launched?

It is unavoidable that portions of the flight hardware will impact the surface of Mars as part of a normal landing event. This impact may cause the hardware to split open and potentially release spores trapped inside the hardware during manufacturing processes. To ensure Mars Science Laboratory does not exceed the spore allocation, studies were conducted on various materials, including paint, propellants and adhesives, to determine the number of spores in a given volume.

In many cases, the parts of the spacecraft containing these and other materials were treated with dry heat to reduce the number of spores. For hardware expected to impact Mars, such as the cruise stage after its separation from the aeroshell, a detailed thermal analysis was conducted to make sure that plunging through the Mars atmosphere gets the hardware sufficiently hot that few spores survive.

Curiosity uses heat from a Multi-Mission Radioisotope Thermoelectric Generator (MMRTG) to produce electricity and keep the rover's internal systems at proper operating temperatures. Because of heat produced by the generator, the Mars Science Laboratory project is also complying with a planetary protection requirement to avoid going to any site on Mars known to have water or water ice within 1 meter (about 3 feet) of the surface.

This is a precaution against any landing-day accident that could introduce unsterilized hardware into an environment where heat from the mission's MMRTG and a source of Martian ice or water could provide conditions favorable for terrestrial microbes to grow on Mars.

The MMRTG is expressly designed to contain its fuel in accident environments that could occur on Earth, including its atmosphere. While atmospheric conditions at Mars would have different effects on the MMRTG in a failed entry/descent, the construction of the generator still affords significant capability to contain the fuel in several potential contingency scenarios.

It is possible, but not likely, that any microbes that remained on the flight hardware could come to rest near a warm element of the power source. However, given Mars' intense environmental conditions—including sterilizing radiation from the sun and extremely cold temperatures—it is highly unlikely that Earth-based life could survive for any significant length of time.

Another way of helping make sure the Mars Science Laboratory mission does not transport Earth life to Mars is to ensure that any hardware that was not cleaned for planetary protection purposes, such as the upper-stage propulsion system, does not encounter Mars accidentally. When Curiosity lifted off on November 26, 2011, the initial flight path for the spacecraft and the Centaur upper stage of its Atlas V launch vehicle was selected so that the flight system's trajectory would miss Mars without further spacecraft maneuvers during cruise to the red planet.

This trajectory correction strategy occurred as planned, thus confirming that the spacecraft was put on target for landing but the Atlas upper stage will not impact on Mars.

For more information on the Mars Science Laboratory mission and the Curiosity rover, visit **mars.jpl.nasa.gov**

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