# Mars Science Laboratory: Curiosity Rover Mission Description

## Mission Overview

Development of the Mars Science Laboratory project began in 2003. On November 26 2011, the Mars Science Laboratory mission launched a spacecraft on a trajectory to Mars, and on August 6, 2012 (UTC), it landed a mobile science vehicle named Curiosity at a landing site in Gale Crater. During the trip to Mars, instrument health checks were performed and the Radiation Assessment Detector (RAD) instrument collected science data. For the primary mission of one Mars year duration on the surface of Mars, the rover will explore the landing site and gather imaging, spectroscopy, composition data, and other measurements for selected Martian soils, rocks, and the atmosphere. These data will allow the science team to quantitatively assess the habitability and environmental history. If the mission can continue beyond one Mars year, an extended surface mission will follow. The mission's primary objectives are to assess the biological potential of the landing site, characterize the geology of the landing region, investigate planetary processes that influence habitability, and characterize the broad spectrum of surface radiation.

The science instruments, with an acronym or abbreviation and Principal Investigator (PI) are listed below:

Science Instrument PI

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Alpha Particle X-ray Spectrometer (APXS) Ralf Gellert

Chemical Camera (ChemCam) Roger Wiens

Chemistry & Mineralogy (CheMin) David Blake

Dynamic Albedo of Neutrons (DAN) Igor Mitrofanov

Mast Camera (Mastcam) Michael Malin

Mars Hand Lens Imager (MAHLI) Kenneth Edgett

Mars Descent Imager (MARDI) Michael Malin

Radiation Assessment Detector (RAD) Don Hassler

Rover Environmental Monitoring Station (REMS) Javier Gomez-Elvira

Sample Analysis at Mars (SAM) Paul Mahaffy

## Mission Phases

The Mars Science Laboratory Mission is divided in time into six phases: (1) Development; (2) Launch; (3) Cruise and Approach; (4) Entry, Descent, and Landing (EDL); (5) Primary Surface Mission; and (6) Extended Surface Mission.

Development

Development of the Mars Science Laboratory mission began in October 2003 with concept and technology development, followed by preliminary design and technology development completion from March 2006 through September 2006, final design and fabrication from September 2006 through January 2008, and system assembly, integration, and test from late January 2008 until launch on November 26, 2011.

Spacecraft Id : MSL

Target Name : MARS

Mission Phase Start Time : 2003-10-01

Mission Phase Stop Time : 2011-11-26

Spacecraft Operations Type : ROVER

Launch

The launch phase began when the spacecraft switched to internal power prior to launch and ended when the spacecraft reached a thermally stable commandable configuration after separation from the launch vehicle upper stage. MSL was launched on an ATLAS V 541 launch vehicle on November 26 2011 at 15:02 UTC (10:02 EST) from Cape Canaveral Air Force Station, Florida.

Spacecraft Id : MSL

Target Name : MARS

Mission Phase Start Time : 2011-11-26

Mission Phase Stop Time : 2011-11-26

Spacecraft Operations Type : ROVER

Cruise and Approach

The cruise and approach phase began when the launch phase ended, and ended 30 minutes prior to entry into the Mars atmosphere. The MSL spacecraft used a ballistic Type 1 interplanetary transfer during cruise from Earth to Mars. The major activities during cruise included: checkout and maintenance of the spacecraft in its flight configuration; monitoring, characterization, and calibration of the spacecraft and payload systems; software parameter updates; attitude correction turns; navigation activities for determining and correcting the vehicle's flight path; and preparation for EDL and surface operations. Three Trajectory Correction Maneuvers (TCMs) were conducted during cruise. The only science investigation during cruise was radiation monitoring by the RAD instrument.

Approach began 45 days before entry into the Martian atmosphere and ended 30 minutes before entry. During approach, the focus of operations was primarily on navigation activities (including a fourth and final TCM eight days before landing), and preparation for entry, descent, and landing.

Spacecraft Id : MSL

Target Name : MARS

Mission Phase Start Time : 2011-11-26

Mission Phase Stop Time : 2012-08-06

Spacecraft Operations Type : ROVER

Entry, Descent, and Landing

The entry, descent, and landing (EDL) phase began when the Cruise and Approach Phase was over (30 minutes before atmospheric entry), and ended when the rover reached a thermally stable, positive energy balance, commandable configuration on the surface of Mars. During this phase, a series of events was self-triggered on the spacecraft. Before entry, the thermal loop was vented and the cruise stage was jettisoned. The entry vehicle, consisting of the backshell, heat shield, descent stage, and rover, performed a series of guided maneuvers. Cruise balance masses separated to adjust the center of mass of the entry vehicle. At 3522.2 km from the center of Mars, the vehicle entered the atmosphere. This was followed by peak heating, peak deceleration, supersonic parachute deploy, and heat shield separation. At the appropriate time, the descent stage engines started, the backshell and parachute separated, and the MARs Descent Imager (MARDI) started recording video. As the descent stage approached the surface using powered descent, at an altitude of about 18.6 m, the rover was lowered on a descent rate limiter and bridle umbilical device to 7.5 m below the descent stage, and its wheels were deployed into the touchdown configuration. The descent stage continued descending until the rover touched down on the surface of Mars. The rover landed in Gale Crater at the latitude of 4.5895 degrees South, and longitude of 137.4417 degrees East, in late southern winter (Solar Longitude L=150.7), at 15:03 Local Mean Solar Time on Mars (August 6, 2012, 05:18 UTC Spacecraft Event Time). Upon successful touchdown, the descent rate limiter and bridle umbilical device were cut. The descent stage flew away and impacted the surface 650 meters away from the rover.

Spacecraft Id : MSL

Target Name : MARS

Mission Phase Start Time : 2012-08-06

Mission Phase Stop Time : 2012-08-06

Spacecraft Operations Type : ROVER

Primary Surface Mission

The surface phase began when the EDL phase ended and will end when the mission is declared complete. The flight mission was designed to provide for a surface mission phase duration of at least one Mars year (687 days, or 669 sols), which is the primary or 'prime' surface mission.

Following touchdown, a combination of automated rover sequences and planned checkouts was executed in order to bring the rover up to a basic level of functionality and to verify that the rover systems and payload were all operating as expected. A surface initial checkout period was defined as starting at successful rover touchdown on Mars with descent stage separation/fly-away, and concluded with a transition to normal tactical operations.

Spacecraft Id : MSL

Target Name : MARS

Mission Phase Start Time : 2012-08-06

Mission Phase Stop Time : 2014-06-26

Spacecraft Operations Type : ROVER

Extended Surface Mission 1

The extended surface phase, if there is one, will begin on Sol 670.

Spacecraft Id : MSL

Target Name : MARS

Mission Phase Start Time : 2014-06-26

Mission Phase Stop Time : 2016-09-30

Spacecraft Operations Type : ROVER

Extended Surface Mission 2

Spacecraft Id : MSL

Target Name : MARS

Mission Phase Start Time : 2016-10-01

Mission Phase Stop Time : 2019-09-30

Spacecraft Operations Type : ROVER

Extended Surface Mission 3

Spacecraft Id : MSL

Target Name : MARS

Mission Phase Start Time : 2019-10-01

Mission Phase Stop Time : 2022-09

Spacecraft Operations Type : ROVER

Extended Surface Mission 4

Spacecraft Id : MSL

Target Name : MARS

Mission Phase Start Time : 2022-10-01

Mission Phase Stop Time : Present

Spacecraft Operations Type : ROVER

## Mission Objectives Summary

The Mars Science Laboratory began surface operations soon after landing and will continue for at least one Mars year (approximately two Earth years). The overall scientific goal of the mission is to explore and quantitatively assess a local region on Mars as a potential habitat for life, past or present. The MSL rover carries ten scientific instruments and a sample acquisition, processing, and distribution system. The various payload elements will be used as an integrated suite to detect and study potential sampling targets with remote and in situ measurements; to acquire samples of rock, soil, and atmosphere and analyze them in onboard analytical instruments; and to observe the environment around the rover. An overview of the science mission is provided in (Grotzinger et al., 2012).

MSL will investigate a site that shows clear evidence for ancient aqueous processes based on orbital data and undertake the search for past and present habitable environments. Assessment of present habitability requires an evaluation of the characteristics of the environment and the processes that influence it from microscopic to regional scales and a comparison of those characteristics with what is known about the capacity of life, as we know it, to exist in such environments. Determination of past habitability has the added requirement of inferring environments and processes in the past from observation in the present. Such assessments require the integration of a wide variety of chemical, physical, and geological observations.

MSL is not a life detection mission and is not designed to detect extant vital processes that would betray present-day microbial metabolism. Nor does it have the ability to image microorganisms or their fossil equivalents. MSL does have, however, the capability to detect complex organic molecules in rocks and soils. If present, these might be of biological origin, but could also reflect the influx of carbonaceous meteorites. More indirectly, MSL will have the analytical capability to probe other less unique biosignatures, specifically, the isotopic composition of inorganic and organic carbon in rocks and soils, particular elemental and mineralogical concentrations and abundances, and the attributes of unusual rock textures. The main challenge in establishment of a biosignature is finding patterns, either chemical or textural, that are not easily explained by physical processes. MSL will also be able to evaluate the concentration and isotopic composition of potentially biogenic atmospheric gases such as methane, which has recently been detected in the modern atmosphere. But compared to the current and past missions that have all been targeted to find evidence for past or present water, the task of searching for habitable environments is significantly more challenging (e.g., Grotzinger, 2009). Primarily, this is because the degree to which organic carbon would be preserved on the Martian surface - even if it were produced in abundance - is unknown.

The MSL mission has four primary science objectives to meet the overall habitability assessment goal. The first is to assess the biological potential of at least one target environment by determining the nature and inventory of organic carbon compounds, searching for the chemical building blocks of life, and identifying features that may record the actions of biologically relevant processes. The second objective is to characterize the geology of the landing region at all appropriate spatial scales by investigating the chemical, isotopic, and mineralogical composition of surface and near- surface materials, and interpreting the processes that have formed rocks and soils. The third objective is to investigate planetary processes of relevance to past habitability (including the role of water) by assessing the long timescale atmospheric evolution and determining the present state, distribution, and cycling of water and CO2. The fourth objective is to characterize the broad spectrum of surface radiation, including galactic cosmic radiation, solar proton events, and secondary neutrons."

References

Grotzinger, J., Beyond water on Mars, Nature Geoscience 2:231-233, 2009. https://doi.org/10.1038/ngeo480

Grotzinger, J.P., J. Crisp, A.R. Vasavada, R.C. Anderson, C.J. Baker, R. Barry, D.F. Blake, P. Conrad, K.S. Edgett, B. Ferdowsi, R. Gellert, J.B. Gilbert, M. Golombek, J.Gómez-Elvira, D.M. Hassler, L. Jandura, M. Litvak, P. Mahaffy, J. Maki, M. Meyer, M.C. Malin, I. Mitrofanov, J.J. Simmonds, D. Vaniman, R.V. Welch, and R.C. Wiens, Mars Science Laboratory mission and science investigation, Space Science Reviews, 170:5-56, 2012. https://doi.org/10.1007/s11214-012-9892-2