



# Mars Science Laboratory/Curiosity



NASA's Mars Science Laboratory mission set down a large, mobile laboratory — the rover Curiosity — at Gale Crater, using precision landing technology that makes many of Mars' most intriguing regions viable destinations for the first time. During the 23 months after landing, Curiosity will analyze dozens of samples drilled from rocks or scooped from the ground as it explores with greater range than any previous Mars rover.

Curiosity carries the most advanced payload of scientific gear ever used on Mars' surface, a payload more than 10 times as massive as those of earlier Mars rovers. Its assignment: Investigate whether conditions have been favorable for microbial life and for preserving clues in the rocks about possible past life.

## Mission Overview

The Mars Science Laboratory spacecraft launched from Cape Canaveral Air Force Station, Florida, on Nov. 26, 2011. Mars rover Curiosity landed successfully on the floor of Gale Crater on Aug. 6, 2012, Universal Time (evening of Aug. 5, Pacific Time).

Engineers designed the spacecraft to steer itself during descent through Mars' atmosphere with a series of S-curve maneuvers similar to those used by astronauts piloting NASA space shuttles. During the three minutes before touchdown, the spacecraft slowed its descent with a parachute, then used retrorockets mounted around the rim of an upper stage. In the final seconds, the upper stage acted as a sky crane, lowering the upright rover on a tether to the surface.

Curiosity is about twice as long (about 3 meters or 10 feet) and five times as heavy as NASA's twin Mars Exploration Rovers, Spirit and Opportunity, launched in 2003. It inherited many design elements from them, including six-wheel drive, a rocker-bogie suspension system and cameras mounted on a mast to help the mission's team on Earth select exploration targets and driving routes. Unlike earlier rovers, Curiosity carries equipment to gather samples of rocks and soil, process them and distribute them to onboard test chambers inside analytical instruments.

NASA's Jet Propulsion Laboratory (JPL), Pasadena, Calif., builder of the Mars Science Laboratory, engineered Curiosity to roll over obstacles up to 65 centimeters (25 inches) high and to travel up to about 200 meters (660 feet) per day on Martian terrain.

The rover's electrical power is supplied by a U.S. Department of Energy radioisotope power generator. The multimission radioisotope thermoelectric generator produces electricity from the heat of plutonium-238's radioactive decay. This long-lived power supply gives the mission an operating lifespan on Mars' surface of a full Mars year (687 Earth days) or more. At launch, the generator provided about 110 watts of electrical power to operate the rover's instruments, robotic arm, wheels, computers and radio. Warm fluids heated by the generator's excess heat are plumbed throughout the rover to keep electronics and other systems at acceptable operating temperatures.

The mission uses radio relays via Mars orbiters as the principal means of communication between Curiosity and the Deep Space Network of antennas on Earth.

The overarching science goal of the mission is to assess whether the landing area has ever had or still has environmental conditions favorable to microbial life, both its habitability and its preservation.

Curiosity landed near the foot of a layered mountain inside Gale Crater. Layers of this mountain contain minerals that form in water and may also preserve organics, the chemical building blocks of life. The portion of the crater floor where Curiosity landed has an alluvial fan likely formed by water-carried sediments. Selection of Gale Crater followed consideration of more than 30 Martian locations by more than 100 scientists participating in a series of open workshops.

Selection of a landing site of prime scientific interest benefited from examining candidate sites with NASA's Mars Reconnaissance Orbiter since 2006, from earlier orbiters' observations, and from a capability of landing within a target area only about 20 kilometers (12 miles) long. That precision, about a five-fold improvement on earlier Mars landings, makes feasible sites that would otherwise be excluded for encompassing nearby unsuitable terrain. The Gale Crater landing site is so close to the crater wall that it would not have been considered safe if the mission were not using this improved precision.

Advancing the technologies for precision landing of a heavy payload yields research benefits beyond the returns from Mars Science Laboratory itself. Those same capabilities would be important for later missions, both to pick up rocks on Mars and bring them back to Earth and to conduct extensive surface exploration for Martian life.

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## Science Payload

In April 2004, NASA solicited proposals for specific instruments and investigations to be carried by Mars Science Laboratory. The agency selected eight of the proposals later that year and also reached agreements with Russia and Spain for carrying instruments those nations provided.

A suite of instruments named Sample Analysis at Mars analyzes samples of material collected and delivered by the rover's arm, plus atmospheric samples. It includes a gas chromatograph, a mass spectrometer and a tunable laser spectrometer with combined capabilities to identify a wide range of organic (carbon-containing) compounds and determine the ratios of different isotopes of key elements. Isotope ratios are clues to understanding the history of Mars' atmosphere and water. The principal investigator is Paul Mahaffy of NASA's Goddard Space Flight Center, Greenbelt, Md.

An X-ray diffraction and fluorescence instrument called CheMin also examines samples gathered by the robotic arm. It is designed to identify and quantify the minerals in rocks and soils, and to measure bulk composition. The principal investigator is David Blake of NASA's Ames Research Center, Moffett Field, Calif.

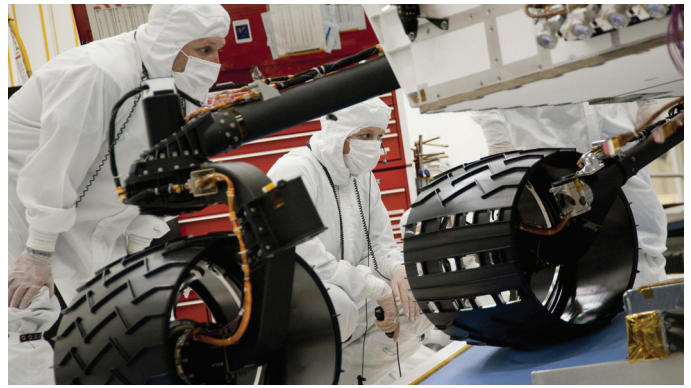
Mounted on the arm, the Mars Hand Lens Imager takes extreme close-up pictures of rocks, soil and, if present, ice, revealing details smaller than the width of a human hair. It can also focus on hard-to-reach objects more than an arm's length away. The principal investigator is Kenneth Edgett of Malin Space Science Systems, San Diego.

Also on the arm, the Alpha Particle X-ray Spectrometer for Mars Science Laboratory determines the relative abundances of different elements in rocks and soils. Dr. Ralf Gellert of the University of Guelph, Ontario, Canada, is principal investigator for this instrument, which was provided by the Canadian Space Agency.

The Mars Science Laboratory Mast Camera, mounted at about human-eye height, images the rover's surroundings in high-resolution stereo and color, with the capability to take and store high-definition video sequences. It can also be used for viewing materials collected or treated by the arm. The principal investigator is Michael Malin of Malin Space Science Systems.

An instrument named ChemCam uses laser pulses to vaporize thin layers of material from Martian rocks or soil targets up to 7 meters (23 feet) away. It includes both a spectrometer to identify the types of atoms excited by the beam, and a telescope to capture detailed images of the area illuminated by the beam. The laser and telescope sit on the rover's mast and share with the Mast Camera the role of informing researchers' choices about which objects in the area make the best targets for approaching to examine with other instruments. Roger Wiens of Los Alamos National Laboratory, Los Alamos, N.M., is the principal investigator.

The rover's Radiation Assessment Detector characterizes the radiation environment at the surface of Mars. This information is necessary for planning human exploration of Mars and is relevant to assessing the planet's ability to harbor life. The principal investigator is Donald Hassler of Southwest Research Institute, Boulder, Colo.



In the two minutes before landing, the Mars Descent Imager captured color, high-definition video of the landing region to provide geological context for the investigations on the ground and to aid precise determination of the landing site. Pointed toward the ground, it can also be used for surface imaging as the rover explores. Michael Malin is principal investigator.

Spain's Ministry of Education and Science provided the Rover Environmental Monitoring Station to measure atmospheric pressure, temperature, humidity, winds, plus ultraviolet radiation levels. The principal investigator is Javier Gómez-Elvira of the Center for Astrobiology, Madrid, an international partner of the NASA Astrobiology Institute.

Russia's Federal Space Agency provided the Dynamic Albedo of Neutrons instrument to measure subsurface hydrogen up to 1 meter (3 feet) below the surface. Detections of hydrogen may indicate the presence of water in the form of ice or bound in minerals. Igor Mitrofanov of the Space Research Institute, Moscow, is the principal investigator.

In addition to the science payload, equipment of the rover's engineering infrastructure contributes to scientific observations. Like the Mars Exploration Rovers, Curiosity has a stereo navigation camera on its mast and low-slung, stereo hazard-avoidance cameras. Equipment called the Sample Acquisition/Sample Preparation and Handling System includes tools to remove dust from rock surfaces, scoop up soil, drill into rocks and collect powdered samples from rocks' interiors, sort samples by particle size with sieves, and deliver samples to laboratory instruments.

The Mars Science Laboratory Entry, Descent and Landing Instrument Suite is a set of engineering sensors designed to measure atmospheric conditions and performance of the spacecraft during the arrival-day plunge through the atmosphere, to aid in design of future missions.

## Program/Project Management

The Mars Science Laboratory is managed for NASA's Science Mission Directorate, Washington, D.C., by JPL, a division of the California Institute of Technology in Pasadena. At NASA Headquarters, David Lavery is the Mars Science Laboratory program executive and Michael Meyer is program scientist. In Pasadena, Peter Theisinger of JPL is project manager and John Grotzinger of Caltech is project scientist.

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