



# Mars Science Laboratory



NASA's Mars Science Laboratory mission is preparing to set down a large, mobile laboratory — the rover Curiosity — 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 will carry 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**

Plans for the Mars Science Laboratory call for launch from Cape Canaveral Air Force Station, Florida, between Nov. 25 and Dec. 18, 2011, and arrival at Mars in August 2012.

The spacecraft has been designed 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 slows its descent with a parachute, then uses retro rockets mounted around the rim of an upper stage. In the final seconds, the upper stage acts 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, Pasadena, Calif., builder of the Mars Science Laboratory, has 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 will be supplied by a U.S. Department of Energy radioisotope power generator. The multi-mission 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 will provide 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 has been designed to use 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.

More than 100 scientists participating in a series of open workshops since 2006 have compared merits of more than 30 Martian locations as potential landing sites for the rover. Evaluations of scientific appeal and safety factors led NASA to select four finalist candidate sites in 2008, with the final selection to be made in 2011. All four have exposures of minerals formed under wet conditions.

Selection of a landing site of prime scientific interest has 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. For example, the mission could go to the floor of a crater whose steep walls would make a less precise landing too risky.

Advancing the technologies for precision landing of a heavy payload will yield 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 conduct extensive surface exploration for Martian life.

## 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 will provide.

A suite of instruments named Sample Analysis at Mars will analyze 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 will also examine 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 will take extreme close-up pictures of rocks, soil and, if present, ice, revealing details smaller than the width of a human hair. It will also be able to 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 will determine 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 will be provided by the Canadian Space Agency.

The Mars Science Laboratory Mast Camera, mounted at about human-eye height, will image the rover's surroundings in high-resolution stereo and color, with the capability to take and store high-definition video sequences. It will 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 will use laser pulses to vaporize thin layers of material from Martian rocks or soil targets up to 7 meters (23 feet) away. It will include 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 will characterize 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.

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In the two minutes before landing, the Mars Descent Imager will capture 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. Michael Malin is principal investigator.

Spain's Ministry of Education and Science is providing 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 is providing the Dynamic Albedo of Neutrons instrument to measure subsurface hydrogen up to one meter (three 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 will contribute to scientific observations. Like the Mars Exploration Rovers, Curiosity will have 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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