# Mars Reconnaissance Orbiter

NASA launched a multipurpose spacecraft named Mars Reconnaissance Orbiter on Aug. 12, 2005 to advance our understanding of Mars through detailed observation, to examine potential landing sites for future surface missions and to provide a high-data-rate communications relay for those missions.

Scientists will use the spacecraft to study the surface, monitor the atmosphere, and probe underground, all to gain better knowledge of the distribution and history of Mars' water, whether frozen, liquid or vapor.

Carrying the most powerful telescopic camera ever flown to another planet, Mars Reconnaissance Orbiter will be able to show Martian landscape features as small as a kitchen table from the spacecraft's low orbital altitude. That camera and five other science instruments will produce copious data every day for a planned 24-month science phase. To pour the data back to Earth at more than 10 times the rate of any previous Mars mission, the spacecraft will use a wider antenna dish, a faster computer and an amplifier powered by a bigger solar-cell array.

**Mission Overview**

An Atlas V two-stage launch vehicle sent the spacecraft on its way to Mars from Cape Canaveral Air Force Station, Fla.

During the cruise phase of the mission, the flight team put the spacecraft through a series of checkout tests and science calibrations, in addition to conducting two maneuvers to fine-tune its trajectory.

The spacecraft will reach Mars on March 10, 2006. A multi-engine burn as the spacecraft first nears the planet will slow the craft enough for Mars' gravity to capture it. The first orbit will take about 35 hours and have an extremely elliptical shape, with its farthest point about 150 times farther from the planet than its closest point. The mission will use aerobraking for the next 6 months to modify the orbit to a rounder shape optimal for science operations. Aerobraking, used previously at Mars by NASA's Mars Global Surveyor and Mars Odyssey orbiters, relies on repeated, carefully calculated dips into the upper atmosphere, where friction with the atmosphere slows the spacecraft. This reduces the cost of the mission by reducing by about 450 kilograms (992 pounds) the amount of onboard fuel that had to be launched from Earth in order for the spacecraft to enter the desired orbit around Mars.

Mars Reconnaissance Orbiter's primary science phase will begin in November 2006 and operate for 2 Earth years, encompassing a full Mars year. Every 112 minutes, the spacecraft will make a complete circuit of Mars, flying a nearly circular orbit that will range from about 255 kilometers (160 miles) over the
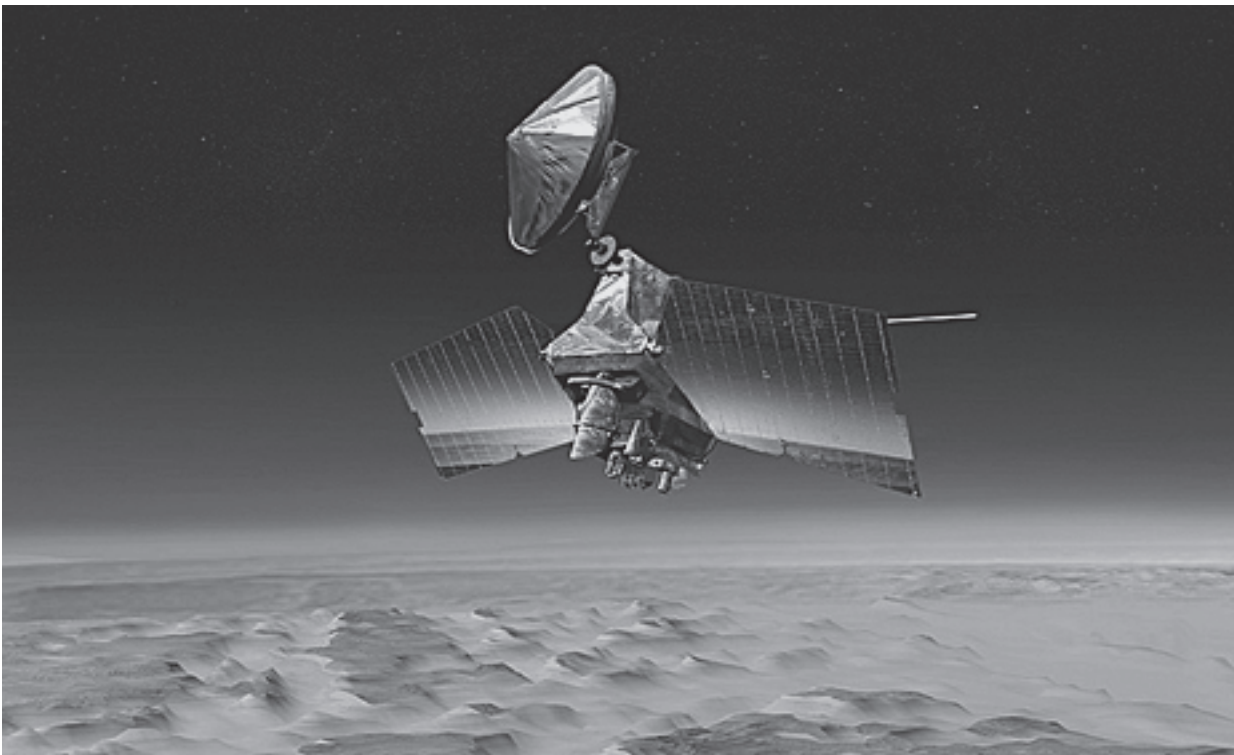
South Pole to 320 kilometers (200 miles) over the North Pole.

In addition to its own science, Mars Reconnaissance Orbiter will serve as a communications relay satellite for missions that land on Mars. The first to use this capability, according to current plans, will be Phoenix, the first mission in NASA's competitively selected Mars Scout program. Phoenix is a stationary lander for studying Mars' north polar region in 2008. Data from Mars Reconnaissance Orbiter will also help in selection of landing sites for future missions. Among the first planned for using this capability is a highly sophisticated rover called Mars Science Laboratory, now in development and slated to begin surface operations in 2010.

## Science Objectives

The science objectives for the Mars Reconnaissance Orbiter mission make it the critical next step in the NASA Mars Exploration Program of "following the water" as a multi-mission strategy for learning about Mars' changing climate, geologic history and potential ability to harbor life. Key objectives for this mission are to:

❑ Characterize the present climate of Mars and how the climate changes from season-to-season and year-to-year.

❑ Characterize Mars' global atmosphere and monitor its weather.

❑ Investigate complex terrain on Mars and identify water-related landforms.

❑ Search for sites showing stratigraphic or compositional evidence of water or hydrothermal activity.

❑ Probe beneath the surface for evidence of subsurface layering, water and ice, and profile the internal structure of the polar ice caps.

❑ Identify and characterize sites with the highest potential for future missions that will land on Mars' surface, including possible missions to collect samples for returning to Earth.

❑ Relay scientific information to Earth from Mars surface missions.

## Spacecraft

Mars Reconnaissance Orbiter has a height of 6.5 meters (21 feet) topped by a 3-meter (10-foot) radio antenna dish. Its width from the tip of one solar panel to the tip of the other is about 13.6 meters (45 feet). The solar panels have about 20 square meters (220 square feet) of solar cells. The spacecraft weighed about 2,180 kilograms (4,800 pounds) at launch, with fuel for 20 onboard thrusters making up about half of that mass.

Lockheed Martin Space Systems, Denver, Colo., built the spacecraft.

For handling large amounts of data, Mars Reconnaissance Or-

biter has 160 gigabits of solid-state memory and a processor operating at up to 46 million instructions per second.

The orbiter carries six science instruments for examining the planet in various parts of the electromagnetic spectrum from ultraviolet to radio waves. Two other investigations will use the spacecraft itself as a tool.

❑ **High Resolution Imaging Science Experiment** will photograph many areas totaling about 1 percent of Mars' surface in unprecedented detail, revealing features as small as 1 meter (3 feet) across. Ball Aerospace, Boulder, Colo., built the camera for the University of Arizona, Tucson.

❑ **Compact Reconnaissance Imaging Spectrometer for Mars** will extend the search for water-related minerals on Mars by providing spectral information that could identify key minerals in patches as small as a swimming pool at a few thousand carefully chosen sites, while covering the whole planet at a resolution of 200 meters (650 feet). Johns Hopkins University's Applied Physics Laboratory, Laurel, Md., provided this instrument.

❑ **Context Camera** will take wider-swath pictures to provide a simultaneous visual context for smaller-area observations by other instruments. Over the primary science phase, this imager could cover 15 percent or more of the Mars surface. The supplier is Malin Space Science Systems, San Diego, Calif.

❑ **Mars Climate Sounder** will look both down and horizontally through the atmosphere in order to quantify the global atmosphere's vertical variations of water vapor, dust and temperature. This instrument, supplied by NASA's Jet Propulsion Laboratory, Pasadena, Calif., utilizes recent technological advances to achieve the measurement objectives of a heavier, less compact instrument originally developed at JPL for the 1992 Mars Observer and 1998 Mars Climate Orbiter missions.

❑ **Mars Color Imager** will produce global images daily to track changes in Martian weather. In addition, it will use ultraviolet filters to examine variations in ozone. Ozone serves as a reverse indicator about water in Mars' atmosphere. Where there's more water, there's less ozone, and vice versa. The camera is essentially a copy of a Mars Climate Orbiter instrument. However, the Mars Reconnaissance Orbiter instrument has a wider fish-eye lens to compensate for the spacecraft rolls needed to target specific locales on Mars. The new Mars Color Imager is also supplied by Malin Space Science Systems.

❑ **Shallow Subsurface Radar** will penetrate to roughly half a kilometer (a third of a mile) below Mars' surface for information about underground layers of ice, rock and, perhaps, melted water that might be accessible from the surface. This radar, which will also probe the internal structure of the Martian ice caps, is provided by the Italian Space Agency (ASI) through a bilateral agreement.

❑ The **Gravity Investigation** will track variations in the orbiter's movement in order to map Mars' gravity by its effect on the spacecraft. Previous orbiters have mapped regional

variations in the planet's gravity that result from differences in crustal thickness and other factors. This spacecraft's lower altitude will allow higher-resolution data. Researchers will use gravity measurements to assess how much the mass of Mars' polar ice caps changes with the seasons.

❑ The Atmospheric Structure Investigation will use data collected from the orbiter's accelerometers during each dip into the upper atmosphere throughout the aerobraking phase of the mission. The upper atmosphere's effect on the spacecraft's velocity will be analyzed for information about changes in the density of the atmosphere at known altitudes. Quick analysis will help guide calculations about how deep to plan the next dip. The accumulated data will also improve understanding of atmospheric dynamics.

**Additional Payload**

The payload for the mission also includes a relay telecommunications package and two technology demonstrations.

❑ **Electra** is an ultra-high-frequency (UHF) radio for relaying commands from Earth to landers on the Mars surface and for returning science and engineering data back to Earth using the orbiter's more powerful direct-to- Earth telecommunications system.

❑ The **Optical Navigation Camera** compares the predicted positions of Mars' two moons, Phobos and Deimos, with the camera's observations as the spacecraft approaches Mars. Once demonstrated by Mars Reconnaissance Orbiter, this navigation technique can be used by future Mars landers to enter the atmosphere more precisely and thus land closer to the intended site.

❑ Another technology demonstration adds a higher-frequency (Ka band) radio transmitter to the standard (X band) package. The Ka band package uses less power than its X band counterpart to send the same amount of data. However, the Ka band signal is more attenuated by water in Earth's atmosphere. A comparison of Ka band and X band performance will provide information to support planning future use of the telecommunications systems.

**For More Information**

The official Web site of the Mars Reconnaissance Orbiter project is at http://mars.jpl.nasa.gov/mro