Out of this World RC!

A look under the hood of the Mars Exploration Rovers

by James Oberg

PHOTOS AND ILLUSTRATION PROVIDED BY JPL/NASA

The latest missions to Mars by the two Mars exploration Rovers Spirit and Opportunity have been a spectacular success. But what makes these interplanetary RC cars tick? Read on for a look under the hood of these amazing vehicles.

The Rover 'body' is called the WEB (Warm Electronics Box). Its gold-painted, insulated body walls keep heat in when the night temperatures on Mars can drop to -96 degrees Celsius (-140 degrees Fahrenheit)! The body contains a UHF (Ultra High Frequency) antenna, X-band telecommunications hardware, a navigation unit, a guidance computer, and a camera mast. Each Rover has a top speed on flat, hard ground of two inches per second. The Rover is programmed to drive for roughly 10 seconds, then stop to observe and understand the terrain it has driven into for 20 seconds, before moving safely onward for another 10 seconds.

IMAGE COURTESY: NASA/JPL/CORNELL

The Mars Exploration Rover has six wheels, each with its own individual motor. The two front and two rear wheels also have individual steering motors (1 each). These Rovers can turn a full 360 degrees, in place, and swerve and curve while driving.

One black-and-white Science Microscopic Imager is mounted on the robotic arm to take extreme close-up pictures of rocks and soil.

ROBOT ARM

At the end of the arm is a cross-shaped turret, a hand-like structure that holds various tools that can spin through a 350-degree turning range. Almost a third of the weight of the titanium robotic arm comes from the four instruments it holds at the end of the arm.

The Rock Abrasion Tool is a powerful grinder, able to create a hole 45 millimeters (about 2 inches) in diameter and 5 millimeters (0.2 inches) deep into a rock on the Martian surface. The forearm also holds a small brush so that the Rock Abrasion Tool can spin against it to "brush its teeth" and rid the grinding tool of any leftover pieces of rock before its next bite.

ENERGY AND BRAINS

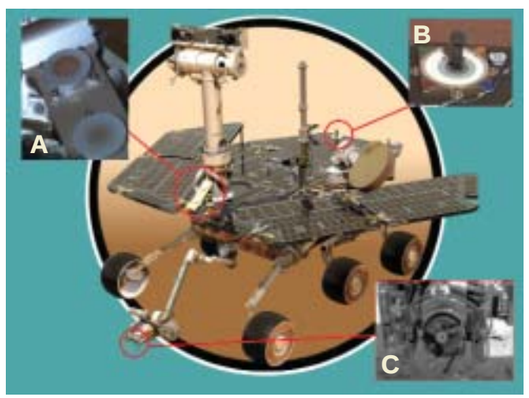
The Rover solar arrays can generate about 140 watts of power for up to four hours per Martian day. The Rover needs about 100 watts to drive. The power system for the Rover includes two rechargeable batteries that provide energy for the Rover at night.

NINE ONBOARD CAMS

There are a total of nine television cameras on each Rover: Four black-and-white Hazard Avoidance Cameras (Hazcams) are mounted on the lower portion of the front and rear of the Rover; they capture three-dimensional (3-D) imagery used by the Rover brain for steering. Two black-and-white Navigation Cameras (Navcams) are mounted on the mast gather panoramic, three-dimensional (3D) imagery to support ground navigation planning by scientists and engineers.

When one side of the Rover goes up (say, rolling over a rock), the rocker in the "rocker-bogie" suspension system automatically makes the wheels on the other side go down to even out the weight load. This system causes the Rover body to go through only half of the range of motion that the "legs" and wheels experience. The Rover can drive over obstacles (such as rocks) or through holes that are more than a wheel diameter (25 centimeters or 10 inches) in size. Each wheel also has cleats, providing grip for climbing in soft sand and scrambling over rocks.

Two color Science Panoramic Cameras (Pancams) are mounted on the Rover mast and deliver 3D panoramas of the Martian surface. The narrow field of view and height of the cameras basically mimic the resolution of the human eye. The cameras are small enough to fit in the palm of your hand (about 9 ounces), but can generate panoramic image mosaics as large as 4,000 pixels high and 24,000 pixels around.



The mast assembly acts as a periscope for the spectrometer science instrument that is housed inside the Rover body, and it provides height and a better point of view for the Panoramic Cameras and the Navigation Cameras. Motors can turn the cameras full circle, or tilt them straight up or down. Details: (A) dust collection magnets, (B) color calibration sheets with sundial (provided by Planetary Society) and (C) rock abrasion tool.

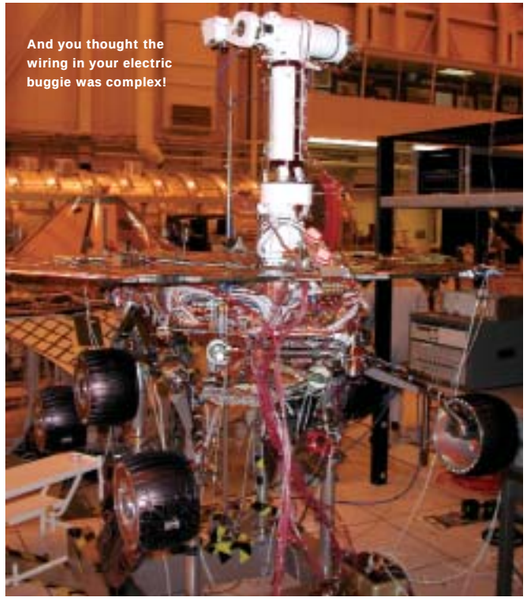
The Rover dwarfs the much smaller Pathfinder vehicle previously sent to Mars.

The Rover computer contains special memory to tolerate the extreme radiation environment from space and to safeguard against power-off cycles so that programs and data will not accidentally erase when the Rover shuts down at night. On-board memory is roughly the equivalent of that of a standard home PC (each Rover has 128 MB of DRAM and 3 MB of EEPROM).

ANTENNAS

The Rover has both a low-gain and high-gain antenna that serve as both its "voice" and its "ears". They are located on the Rover equipment deck (its "back"). The low-gain antenna sends and receives information in every direction; that is, it is "omni-directional." The antenna transmits radio waves at a low rate to the Deep Space Network (DSN) antennas on Earth. The high-gain antenna can send a "beam" of information in a specific direction, so the antenna can move to point itself directly to any antenna on Earth.

Not only can the Rovers send messages directly to Earth, but they can uplink information to other spacecraft orbiting Mars. The orbiters can also send messages to the Rovers. The data rate direct-to-Earth is roughly a third as fast as a standard home modem (3,500 to 12,000 bits per second). The data rate to the orbiters is four times faster than a typical dial-up home modem (128,000 bits per second).



And you thought the wiring in your electric buggie was complex!

A Mars Rover is checked out (a Pathfinder vehicle of the type used on an earlier mission to Mars precedes it).

What's in store for future missions? Plans include a possible nuclear-powered rover of still larger size. There may even be a chance to buy "RC time" and drive one of these rovers on another planet yourself! We will keep you posted. ◎

Another other-worldly car: the Lunar Rover used during the Apollo moon missions.

For great high-resolution images of the Mars Rovers and other spacecraft, checkout: http://photojournal.jpl.nasa.gov/PIADetQuery.html. On that site you can browse images by mission, spacecraft or science instrumentation. For the latest news on the Mars Rovers, see http://marsRovers.jpl-.nasa.gov/-home/index.html.
—the editors