Exploring the Rover

Suggested Grade Level: 3–9

Summary

- Students will identify the component parts of the MER rovers.
- Students will describe and understand the functions of the component parts of the MER rovers.

Standards

- NM Science Content Standards: Strand I, Scientific Thinking and Practice; Strand III, Science and Society
- National Science Education Standard: Standard E, Abilities of Technological Design

Background Information

In January 2004, the two Mars Exploration rovers (MER), Spirit and Opportunity, landed at two very different sites on Mars. Each rover carried nine cameras and seven scientific instruments and was designed to do the work of a field geologist. The instruments carried by the each rover were specifically selected to include instruments that could examine rocks beneath their weathered rind (see How the RAT Works activity), instruments that could obtain a chemical analysis of the elements or minerals in the rock (the spectrometers), and instruments that could see the rock close-up (see Getting a Closer Look activity). Rover design is very difficult. The engineers and designers have to plan for durability and mobility, but they also must balance weight with the number and type of instruments (scientific payload) requested by the science team. The MER rovers have a large number of cameras and instruments and some of them do double duty. For example, the PanCam is the primary camera and it is also an instrument of science used to observe and analyze the landscape. The microscopic imager is both a microscope and a camera.

Materials

MER Rover Component Data Sheet (Exploring the Rover booklet) included in this activity. Teacher's answer keys are at the end of the activity instructions. Table 3, List and Description of MER Rover Components, included in this activity and designed to be used as background information for the teacher.

Preparation

1. Print and photocopy the Exploring the Rover booklet for each student or team. Assemble the booklet by printing or copying Pages 4 and 5 of this activity in double-sided format or printing the pages separately and taping or stapling them together. Then fold in half. Print Table 3 and note the Teacher's Answer Key for your background information.

2. Direct the students to the Mars Rover web site in order to research information about the MER mission and rover components. Abundant information can be found at http://marsrovers.jpl.nasa.gov/home/ (click on the Mission and then Rovers). Students can also select a few MER web site addresses from the list included in this CD to research more information. If it is difficult to find information about the rover components, Table 3 may be printed and used as a reference by the students.

Introduction for Students

The two MER rovers, Spirit and Opportunity, landed at two very different sites on Mars. Both rovers carried identical cameras and scientific instruments and were designed to be lightweight enough to be launched to Mars, survive on Mars, and do the work of a field geologist exploring Mars. The scientific instruments carried by each rover were specifically selected to enable the rovers to examine the rocks of Mars. The rovers also needed to be able to travel over rough terrain, communicate with Earth, and solve some of their own problems. Every component of the rovers had a special function or task. See if you can match component and function.

Procedure

1. Students can work individually or as teams and research information about the MER rovers on web sites or in the Making Tracks on Mars exhibit at New Mexico Museum of Natural History and Science in Albuquerque, NM, (if field trips are available) or by using Table 3 as a reference source in the classroom.

2. After completing the Exploring the Rover booklet, each student or team should choose one of the component parts and become an expert on that part in order to present the information about this component to the class.

Process/Closure

Why were certain instruments and other parts designed for the MER rovers? Do you think that the design was based on the main scientific focus of the rovers? What instrument or part do you think was the most useful on the MER rovers? What instrument or part was the most unusual or unique? What instruments and parts do you think are necessary to make a good rover? What instruments and capabilities do you think should be designed and built for the next rover mission to Mars and why?

Extension/Enrichment

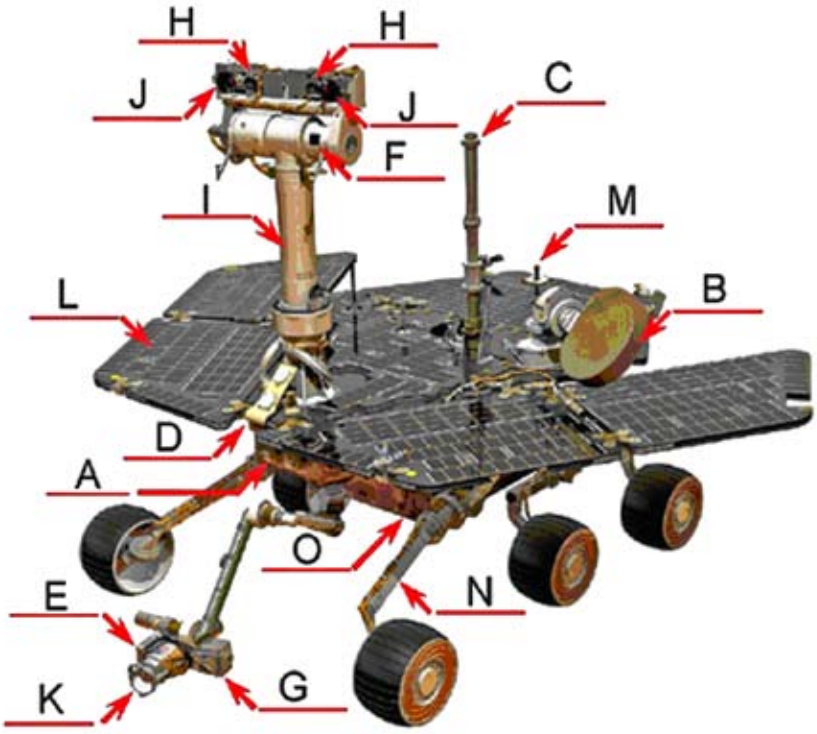
This activity can be linked to a visit to the exhibit Making Tracks on Mars at the New Mexico Museum of Natural History and Science. The Exploring the Rover booklet can be completed during the field trip with the students examining the rover replica and working with the interactive "rover" kiosk. This activity also can be presented in association with any of the other Rover Activities in this curriculum guide.

Students can list, draw, and describe six components (from the MER rovers or new components) that they would include if designing their own future rover, and discuss why they would select those components for a future rover mission.

Students can sketch a new design for a Mars rover on the back of the booklet.

Credits

This activity was created by Amy Grochowski and Jayne Aubele, New Mexico Museum of Natural History & Science.



Teacher's Answer Key to the Components Data Sheet:

1-O, 2-L, 3-N, 4-I, 5-J, 6-A/H, 7-F, 8-K, 9-E, 10-C, 11-B, 12-d, 13-M, 14-G

Design Your Own Rover!

Which components would you include when designing your own rover? Why? List them below.

Component	Reason to Include It

Mars Exploration Rover Mission Investigation Log

Exploring the Rover

Name(s) _____

_____

Date _____

Name(s) _____ Date _____

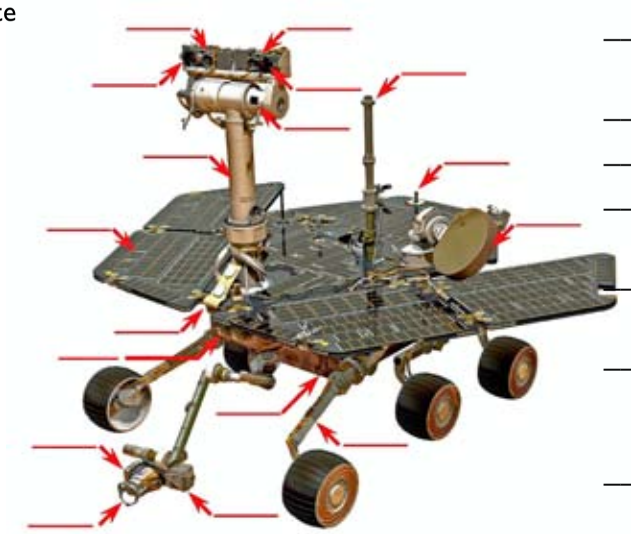
_____

Exploring the Rover

MER Rover Component Data Sheet

Match the components (parts) of the rover listed below with the functions of the rover and fill in the sheet on the facing page. Then label the appropriate locations on the rover drawing.

A. HazCams
B. high-gain antennae
C. low-gain antennae
D. magnets
E. microscopic imager
F. mini TES: thermal emission spectrometer
G. Mossbauer spectrometer
H. NavCams
I. PMA: PanCam mast assembly
J. PanCams
K. RAT: rock abrasion tool
L. solar panels
M. sundial
N. suspension
O. WEB: warm electronics box



The Functions

Match the functions with the components listed on the left.

___ 1. Contains all the electronics, batteries, on-board computer and other components.

___ 2. Generate energy to charge the on-board lithium-ion batteries.

___ 3. Allows rolling over rocks bigger than the wheels and enables the rover to tilt up to 45 degrees in any direction without overturning.

___ 4. Holds the PanCam, NavCam, and mini TES.

___ 5. Provides color stereo images of the rover's surroundings.

___ 6. Provides black and white stereo images of the rover's surroundings.

___ 7. Sees infrared radiation (heat) emitted by rocks and soil.

___ 8. Can grind away a rock's dust-covered and weathered surface.

___ 9. A microscope and a camera can provide extreme close-up views.

___ 10. Receives and sends commands and images to and from the rover at a low rate of transmission.

___ 11. Sends and receives images, engineering data, and science commands to and from the rover at a high rate of transmission.

___ 12. Collects airborne dust and separates magnetic particles from non-magnetic ones.

___ 13. A calibration target, allowing scientists to adjust the color and brightness of images received from Mars.

___ 14. Can determine the composition and abundance of iron-bearing minerals in rocks or soil.

Table 3. Description of MER Rover Components

Alpha Particle X-Ray Spectrometer. This instrument, built by German scientists, accurately determines the chemical elements that make up rocks and soil.Analyzing the elements that make up the Martian surface will provide scientists with information about Mars crust, weather¬ing processes, and potential past water.

Body (also called the Warm Electronics Box or WEB). The rover body is made of composite honeycomb material insulated with a high-tech material called aerogel.The WEB contains all of the electronics, batteries, on-board computer, and other components that are not designed to survive the cold Martian nights.

HazCam (Hazard Cameras). These cameras take stereo snapshots of the terrain directly in front of (and behind) the rover. HazCam images are used by the rover to auto-navigate around obstacles such as big rocks, and they are also useful to the mission controllers and science team.

High Gain Antenna (also called the DTE or Direct to Earth antenna). This antenna directly sends and receives images, engineering data, and science commands to and from the rover at a high rate of transmission.

Low-Gain Antenna (also called OMNI Antenna). This antenna receives and sends commands and images to and from the rover at a low rate of transmission; and it can be used to communicate with the spacecraft currently in orbit around Mars such as Mars Global Surveyor and Mars Odyssey.

Magnets. There are three sets of magnets in various locations on the rover. The most obvious set is at the base of the PMA.The magnets will collect airborne dust and separate magnetic particles from non-magnetic ones in order to help the science team understand the composition of the dust of Mars.

Microscopic Imager. This tool is a combination of a microscope and a camera and will zoom in on a fresh rock surface produced by the RAT (rock abrasion tool) to produce extreme closeup views of its minerals, layers, or other small-scale features. This instrument can also determine the shape and size of particles making up the Martian soil.

Mini-TES (Thermal Emission Spectrometer). This instrument sees infrared radiation (heat) emitted by rocks and soil. Using this information, it can determine basic mineral compositions and allow the science team to select specific rocks and soils to examine in more detail.

Mossbauer Spectrometer. This instrument, also designed and built by German scientists, can specifically determine the composition and abundance of iron-bearing minerals in rocks or soil. This is very important because many of the most important minerals on Mars are known to contain iron and may provide clues to early Martian environmental conditions.

NavCam (Navigation Cameras). These cameras take black and white stereo images of the rover's surroundings.They are used by the mission controllers and science team to decide where the rover should go.

On-board Computer. The computer in each rover runs with a space-approved version of a PowerPC chip used in Macintosh computers, operating at a speed of 20 million instructions per second. On-board memory includes 128 megabytes of random access memory, augmented by 256 megabytes of flash memory and other non-volatile memory, which allows the system to retain data even without power.

PanCam (Panoramic Cameras). This is the first camera system to be sent to Mars with 20/20 vision (the resolution of the human eye), and it will provide panoramas of the surface at detail three times higher than that of Pathfinder. The camera takes color, stereo images of the rover's surroundings—the next best thing to being there yourself!

PMA (PanCam Mast Assembly). This mast holds the PanCam and NavCam and the mini-TES instrument. It holds the PanCams about 1.5 m (about 5 ft) above the ground and rotates to point the cameras and instruments.

Robotic Arm (also know as the Instrument Deployment Device or IDD). The rover's robotic arm can be called the "geologist's toolkit." It can move a variety of scientific instruments toward target rocks or soil surfaces in order to examine and analyze them. The instruments on the arm are the rock abrasion tool (RAT), the microscopic imager, the Mossbauer spectrometer, and the alpha particle x-ray spectrometer.

Rock Abrasion Tool (RAT). This tool acts as the rover's equivalent to the geologist's rock hammer. The RAT can grind away a circular portion of a rock's outer dust-covered and weathered surface in order to expose a fresh surface. This "ratted" or fresh surface can then be used by the other instruments on the arm to determine the chemical composition or the mineralogy of the rock.

Solar Panels. The solar panels generate the energy used to charge the on-board lithium-ion batteries that provide 140 watts and provide power for all of the operations of the rover. If the solar panels pick up too much dust and cannot generate enough energy to fully recharge the batteries, the rover will run out of power and the mission will end.

Sundial. This serves as the PanCam's calibration target, allowing scientists to make adjustments to the color and brightness of the images they receive from Mars. But it is also an educational tool! It will function as a true sundial, showing the local time on Mars. School children on Earth can make their own version and keep track of Earth local time and Mars local time at each landing site.

Suspension. Better than an SUV! Each rover is equipped with six-wheel drive.A rocker-bogie suspension system, which bends at its joints rather than using any springs, allows rolling over rocks bigger than the wheel diameter and enables the rover to tilt up to 45 degrees in any direction without overturning. Independent steering of the front and rear wheels allows the rover to turn in place or drive in gradual arcs.

Wheels. The spiral design of the six wheels, each 26 cm (10 in) in diameter, may look like a fancy decoration, but it is really designed to be a spring-like device allowing the wheel to flex. The orange parts are flexible foam inserted into the wheels to keep small rocks from being caught in the metal and damaging the wheel.