

A WHOLE
NEW WORLD AWAITS.

EDUCATOR'S GUIDE

WALT DISNEY PICTURES
INVITES YOU TO DISCOVER THE MYSTERY OF MARS

ROVING MARS

Presented as a Public Service by
LOCKHEED MARTIN 

ABOUT THE FILM

Dear Educator,

“ROVING MARS” is an exciting adventure that follows the journey of NASA’s Mars Exploration Rovers through the eyes of scientists and engineers at the Jet Propulsion Laboratory and Steve Squyres, the lead science investigator from Cornell University. Their collective dream of Mars exploration came true when two rovers landed on Mars and began their scientific quest to understand whether Mars ever could have been a habitat for life.

Since the 1960s, when humans began sending the first tentative interplanetary probes out into the solar system, two-thirds of all missions to Mars have failed. The technical challenges are tremendous: building robots that can withstand the tremendous shaking of launch; six months in the deep cold of space; a hurtling descent through the atmosphere (going from 10,000 miles per hour to 0 in only six minutes!); bouncing as high as a three-story building on the first touchdown; and then bouncing again and again to a gentle stop, safe on Mars.

It is no wonder that NASA decided to name the twin robot geologists, the Mars Exploration Rovers, Spirit and Opportunity. They represent the hopes and vision of men and women who worked against great odds to bring to life a mission in search of answers to the history of water on Mars, and whether the red planet ever could have sustained life.

This movie details the development of Spirit and Opportunity from their assembly through their fantastic discoveries, discoveries that have set the pace for a whole new era of Mars exploration: from the search for habitats to the search for past or present life... and maybe even to human exploration one day.

Having lasted many times longer than their original plan of 90 Martian days (sols), Spirit and Opportunity have confirmed that water persisted on Mars, and that a Martian habitat for life is a possibility. While they continue their studies, what lies ahead are NASA missions that not only “follow the water” on Mars, but also “follow the carbon,” a building block of life. In the next decade, precision landers and rovers may even search for evidence of life itself, either signs of past microbial life in the rock record or signs of past or present life where reserves of water ice lie beneath the Martian surface today.

It will take the next generation of explorers, those in classrooms today, to continue on this path of great discovery.

Walt Disney Pictures Presents “ROVING MARS”
Presented as a public service by Lockheed Martin.



Above: Rover 2 is driven over staggered ramps to test the suspension’s range of motion.

Below: The Mars Exploration Rover (MER) aeroshell is guided by workers as it moves to a rotation stand.



ROVING MARS

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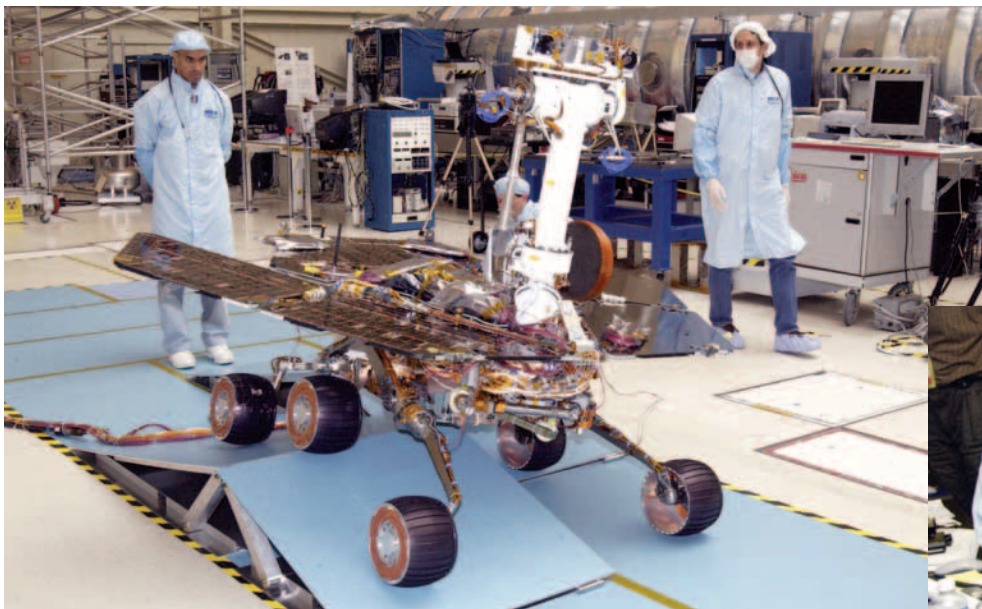
The activities in this Guide are designed for students in grades 5-9. The Guide may be used before or after viewing the film. Activities and material in this Guide may be reproduced for the classroom.



ABOUT THE MOVIE

MEET THE EXPLORERS

It takes all kinds of people to make a Mars mission happen: people with dreams, talent, persistence, and a love of adventure. NASA is looking for the next generation of engineers who will make Mars exploration possible, and your students might be among those to make history happen and discovery come alive. Here are stories from some of the people who are currently paving the way.



A key mechanical engineer on the Mars Exploration Rover Mission, Kobie Boykins carefully watches Spirit as it takes its first “steps” in the spacecraft assembly facility at JPL.

KOBIE BOYKINS

Kobie Boykins graduated from Rensselaer Polytechnic Institute before becoming a mechanical engineer at NASA’s Jet Propulsion Laboratory. Balancing a demanding career with outside interests is not always easy, but his versatile personality allows him to go from lab coat to leather motorcycle jacket with ease. His motto is: “I live to work. I don’t work to live.” When Kobie wakes up, he is always excited to go to work, where he gets to test rovers and other spacecraft, even throwing them out of helicopters to test their ability to survive.



Polly Estabrook, lead telecommunications system engineer for the Mars Exploration Rover Mission, reviews telemetry from Opportunity’s landing with the entry, descent and landing manager, Rob Manning.



Steve Squyres, principal investigator for the Mars Exploration Rover Mission points to the tracks the Opportunity rover made as it left its protective lander.

STEVE SQUYRES

Steve Squyres, the lead scientist on the Mars Exploration Rover mission, has wanted to explore Mars up close and personal ever since he was in college at Cornell University and viewed images from the Viking missions to Mars in the late 1970s. Like every scientist, he is an explorer at heart, seeking to voyage into the unknown. While it took him several decades and several NASA proposals, Steve has now achieved his dream of exploring an unmapped territory: Mars! His advice to young engineers and scientists is that there is no substitute for persistence. You must get all the training you need, but the most important thing to success is to not let setbacks stop you.



In the mission control room at JPL, Julie Townsend discusses rover data with her co-worker.

JULIE TOWNSEND

After getting a bachelor's and a master's degree in aerospace engineering, Julie came to NASA's JPL to work on the Mars Exploration Rover mission. She was involved in nearly every phase of the mission, from assembly to surface operations. As a member of the mission-critical rover systems team, Julie and her co-workers monitored the health of the rovers as they landed on Mars. Julie now works on building robots that will assist with missions to the moon, repair future spacecraft carrying astronauts, and assemble large structures in orbit like future space stations or maybe even large ships traveling to Mars or beyond.

POLLY ESTABROOK

After working on various space exploration missions and commercial satellite projects, Polly became the lead telecommunications system engineer for the rovers. The Mars Exploration Rovers' communication system had to function as soon as the spacecraft was jettisoned by the rocket delivering it to Mars. One of the tensest moments for Polly was when the communication link had to tell how the spacecraft functioned during the "six minutes of terror" when the rovers plunged into the atmosphere and descended to the surface of Mars.



Wayne Lee, systems manager for entry, descent and landing, waves a broom, indicating a clean sweep as the team went two for two with the successful landings of both Spirit and Opportunity.

ROB MANNING

A self-described mediocre student, Rob Manning knew he wanted to be an engineer because he liked knowing how things work, but was intimidated



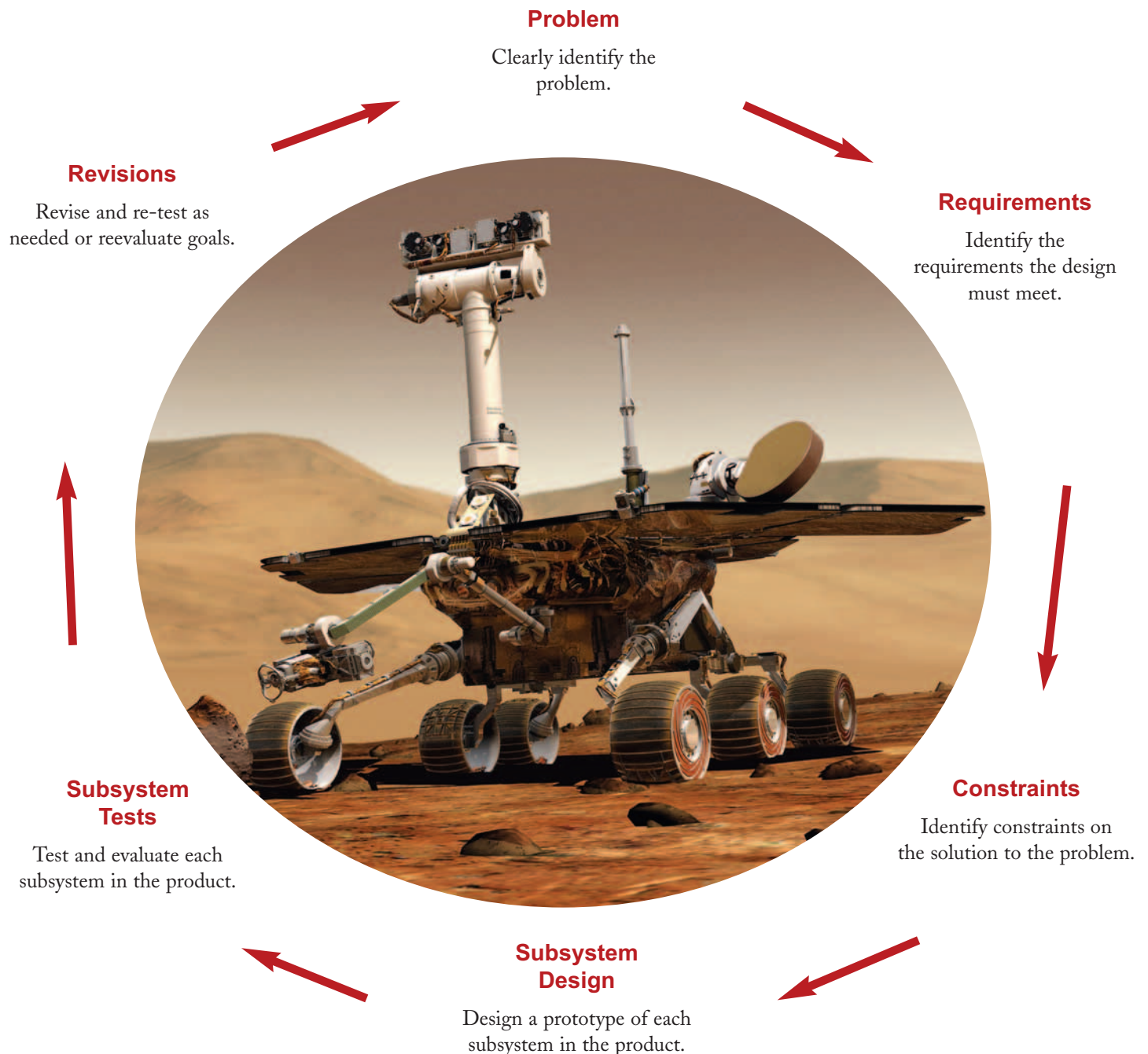
by the thought of applying for college. With a lot of hard work and dedication, Rob earned bachelor's degrees from Whitman College and Caltech. Today, he is one of the most valued Mars team members. He was the entry, descent and landing manager for the Rover mission; he was in charge of getting the rovers safely to the surface of Mars. He is now the chief engineer for the whole Mars program.

WAYNE LEE

In the summer of 1993, just before entering orbit, the Mars Observer spacecraft, like two-thirds of all spacecraft sent to Mars, was lost. Almost immediately, JPL and NASA planners decided to fly the mission again, on the highly successful Mars Global Surveyor orbiter. They needed an extra person to work on it and Wayne got the job. He then signed on to work on the rovers' landing systems. An aerospace engineer by training, Wayne likes the excitement of the job most. When the spacecraft flies through the atmosphere at more than 25 times the speed of sound, there's no margin of error. You've got to get it right the first time. For some, that pressure would be awful, but not for Wayne, who gets a thrill from high-velocity travel.

THE ENGINEERING DESIGN PROCESS

These activities will help your students gain a better understanding of the process engineers use to design and build robots, such as the Mars rovers. Engineers complete the design process long before they shape the first piece of metal. The design process involves the following steps, which ensure that the goals of the project are balanced with the constraints (limitations) placed on the design. It also ensures that the necessary testing and revisions take place in order to yield a fully functioning machine.



VOCABULARY

Acceleration: The rate at which a body's velocity changes with time; the change in velocity may be in magnitude or direction or both.

Calibration: The act of checking or adjusting (by comparison with standards) the accuracy of an instrument.

Drift Correction: An adjustment made to correct a gradual change in direction or position.

Force: Any push or pull that can cause a body to be accelerated.

Mass: The quantity of matter in a body.

Newton: The standard unit of force that will accelerate a mass of 1 kilogram 1 meter per second squared.

Newton's First Law of Motion (also known as the Law of Inertia): Every body continues in its state of rest, or of uniform motion in a straight line, unless acted upon by an outside force.

Newton's Second Law of Motion: The acceleration of a body is directly proportional to the net force acting on the body and inversely proportional to the mass of the body.

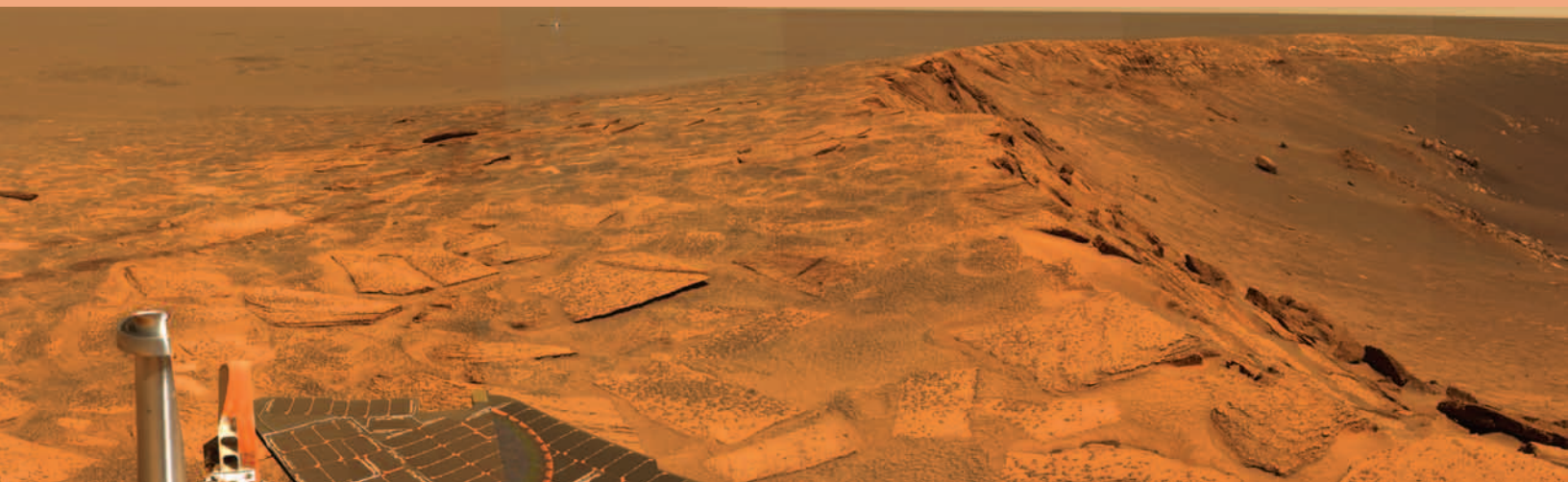
Subsystem: A system that is part of the operation of a larger, more complex system.

Trajectory: The path of a projectile or other moving body through space.

Velocity: The speed of a body and its direction of motion.

Work: The product of the force exerted and the distance through which the force moves.

$W = Fd$ (where W =work, F = force, d = distance)



This is the Spirit panoramic camera's "Lookout" panorama. The panorama spans 360 degrees and consists of images obtained in 108 individual pointings and five filters at each pointing. Image credit: NASA/JPL/Cornell

STANDARDS AND CORRELATIONS

All lessons correlate to national standards taken from the National Science Education Standards (NSES) and the National Council of Teachers of Mathematics (NCTM).

	Out of This World Launch	Command and Control: Getting from Here to There	Rover Races	Descent into Endurance Crater	Bringing Mars Home: Launch Platform
NSES					
Science as Inquiry	✓	✓	✓	✓	✓
Physical Science	✓	✓			✓
NCTM					
Numbers/Operations				✓	✓
Data Analysis/Probability	✓	✓		✓	
Measurement				✓	
Geometry				✓	

"OUT OF THIS WORLD" LAUNCH

Grade Level: 5-9

National Standards: NSES: Motions and Forces, Abilities of Technological Design, Understanding about Science and Technology

Materials (per team of four students): Rubber bands, wooden dowels, craft sticks, small ball, target, measuring tape, protractor, white glue, graph paper

Duration: Two to three forty-five-minute class periods

Objective:

Using the results of their experiments, students will create graphs of physical variables and use these graphs to successfully hit a pre-determined target with a projectile propelled by launchers.

Activity:

This activity introduces students to the energy and guidance problems faced by NASA engineers every time they send a rocket into space. The task is to launch a payload using a rubber band powered launcher from a starting base and having the payload successfully land at a predetermined landing site. Students must carefully adjust the energy imparted to their "spacecraft" and also have to consider how they will control the craft so that it arrives on target.



The rocket must be on the correct trajectory from the moment of launch.
Credit: NASA

Classroom Discussion:

Discuss the reasons scientists choose particular locations for the landing sites of Mars rovers. Explain that NASA engineers must design a launcher that will allow it to escape Earth's gravity, proceed on a predetermined path through space, protect the payload as it descends to the surface of Mars and land in the desired location. Ask students to brainstorm possible challenges involved with launching a rocket so that each rover lands on target. List these challenges on the chalkboard.

Assessment:

Students will be able to use the graphed information from their experimental trials to determine the position and energy needed to successfully hit the predetermined target.

Science Background:

Getting from Earth to Mars isn't easy! We must give the spacecraft enough energy to leave the influence of the Earth's gravity. When the spacecraft arrives at Mars, it needs even more energy to slow it down for a safe landing on the surface of the planet. We also have to ensure that the spacecraft manages to hit its target. The slightest error in launch trajectory turns into a spectacular miss at the end of the spacecraft's journey. Energy to lift the spacecraft and guidance to make sure the spacecraft arrives on-target are the two biggest challenges in getting to Mars.

Currently, the only way to provide a spacecraft with enough energy to reach Mars is to use chemical-fueled rocket boosters like the Atlas, Titan and Delta launch vehicles that NASA has used for all its missions to Mars. For the rover missions, NASA used the Delta II launch vehicle, a forty-meter (131 feet) long rocket capable of generating 485,700 newtons (109,135 pounds) of thrust. Sophisticated on-board and ground-based computers monitor the spacecraft's trajectory to ensure that the spacecraft arrives safely at Mars. The rocket's sensors take in data that allows its processor to determine the rocket's current position. If a course correction is necessary, ground controllers on Earth can instruct the rocket's processor to fire its thrusters to make the change. Because of fuel limitations, however, only very small corrections can be made in the trajectory of the spacecraft. It is critical that the rocket be on the correct path right from launch.

“OUT OF THIS WORLD” LAUNCH

Name _____

Date _____

Follow these steps to fill out your Data Log:

1. Plan a design with your teammates and construct your launcher using only craft sticks and/or wooden dowel, white glue and rubber bands. Be creative!
2. At the “test range” (the area your teacher has set aside for testing) place your “spacecraft” projectile (small, light ball) in your launcher.
3. Measure the distance you pull the launching mechanism using the tape measure.
4. Measure the angle (degrees to the left or right of straight ahead) at which your launcher is pointing with the protractor.
5. Launch your spacecraft!
6. Measure the distance from the launcher to the point of first touchdown.
7. Measure the angle from the launcher to the point of first touchdown.
8. Repeat steps 3-7 for several launcher angles and pull-back distances.
9. Graph your results!

LAUNCHER ANGLE (degrees from straight ahead)	LAUNCHER PULL-BACK (cm)	DISTANCE TO TOUCHDOWN POINT (m)	ANGLE TO TOUCHDOWN POINT (degrees from straight ahead)

COMMAND AND CONTROL: GETTING FROM HERE TO THERE

Grade Level: 5-9

National Standards: NSES: Motions and Forces, Abilities of Technological Design, Understandings about Science and Technology

Materials (per team of four students): Toy "pull-back and release" car, measuring tape, protractor, graph paper

Duration: One forty-five-minute class period

Objective:

For a "pull-back and release" toy car (or Pennyracer), students will plot energy (in units of pull-back distance) vs. distance of travel and distance of travel vs. course deviation. They will use these graphs to exactly hit a pre-determined target with their simulated rover.

Activity:

Students will perform a simple calibration of a toy car and use that calibration to navigate to a target point on the floor. Students begin to see that every system, from the robotic arm to the mobility system, needs to be calibrated. This calibration is performed in similar ways in every case.

Classroom Discussion:

Arriving at Mars is only the first step in achieving the goals of a mission to Mars. Engineers also must ensure that when the spacecraft is on the surface of the planet it is able to precisely move where and how it is told to move. Spacecraft on the surface of Mars, such as the Mars Exploration Rovers, have no way of directly determining where they are on the surface. There is no Global Positioning System (GPS) on Mars!

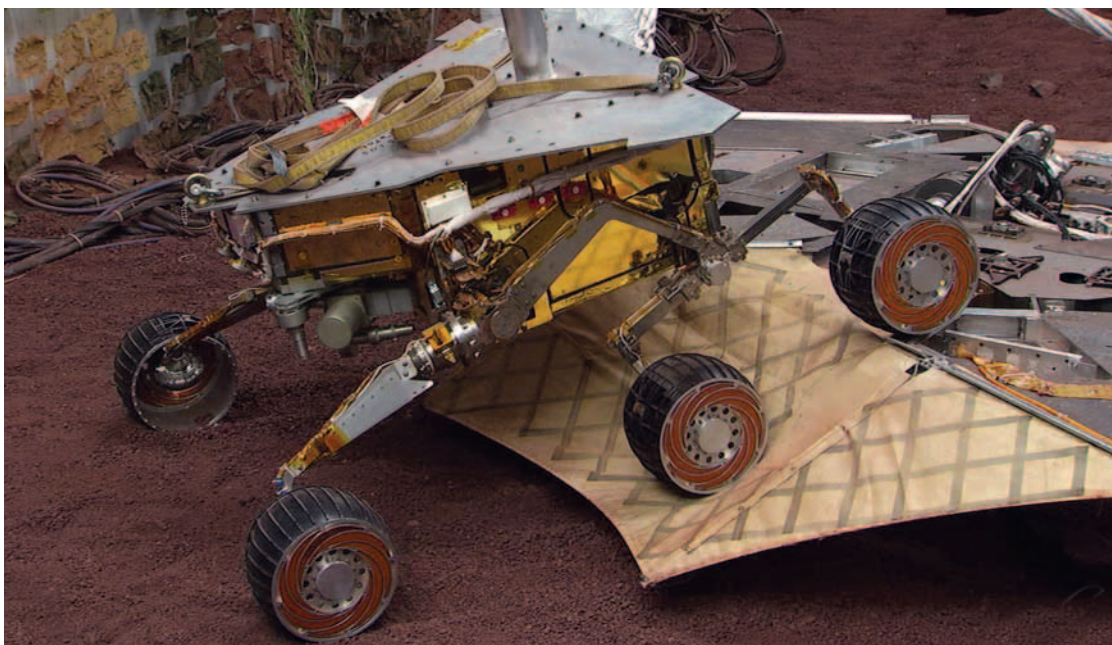
Engineers must know precisely how far and in what direction the rover has traveled from its starting point. In order to do this, they must know how far the rover will travel at a particular power level in a particular amount of time, as well as how much the rover deviates from a straight-line course in that same amount of time. The process of measuring these characteristics is called calibration.

Assessment:

Students will submit their graphs detailing the results of their tests on their car and demonstrating their mastery of the measurement processes required. They will demonstrate their understanding of these graphs by using them to determine the energy (pull-back distance) and drift correction needed to reach their exact predetermined target.

Science Background:

Every mechanical system needs to be calibrated in order to run smoothly, but in the case of Mars robots, it is critical. We cannot simply tell a rover to "go forward three meters," since the robot has no way of measuring the distance of three meters on the surface of Mars. Instead, we can tell the rover to "turn your motors on for ten seconds," and if we know from our calibration that the rover travels at a velocity of 0.3 meters per second, then we know that the rover will travel three meters. Similarly, if our calibration tells us that the rover drifts 50 cm to the left of straight in that three-meter distance, we know that we need to aim for a spot 50 cm to the right of the actual target point. Calibration allows the rover to navigate safely and accurately even when we are millions of kilometers away from it.



Long before launch, engineers test the route by which the Mars Exploration Rover Opportunity will roll off its lander.
Credit: NASA/JPL

COMMAND AND CONTROL: GETTING FROM HERE TO THERE

Name _____

Date _____

Follow these steps to fill out your Data Log:

1. Select a car to represent your rover.
2. At the “test range” (the area your teacher has set aside for testing) measure the distance you pull back the rover.
3. Measure the angle (degrees to the left or right of straight ahead) at which your rover is pointing.
4. Release your rover!
5. Measure the distance from the starting point to the stopping point.
6. Measure the angle from the starting point to the stopping point.
7. Repeat steps 3-7 for several starting angles and pull-back distances.
8. Graph your results!

STARTING ANGLE (degrees from straight ahead)	PULL-BACK DISTANCE (cm)	DISTANCE TO STOPPING POINT (m)	ANGLE TO STOPPING POINT (degrees from straight ahead)

ROVER RACES

Grade Level: 5-9

National Standards: NSES: Abilities of Technological Design

Materials (per team of four students): Simple blindfolds (3), obstacles (such as construction paper squares so the students won't trip over them when blindfolded), small plastic soccer cones (to use as sample rocks), stopwatch, rover command worksheet, two clipboards (one for driver and one for judge)

Duration: One forty-five-minute class period

Objective:

Students will apply their understanding of robotic programming and teleoperation of a robotic vehicle to simulate a rover that must race other rovers across the Martian surface.

Activity:

Students will simulate the teleoperation (remotely commanding a rover on the Martian surface). The task requires a rover on the Martian surface to move from its lander (starting point), navigate an obstacle course that represents a Martian surface (construction paper), pick up rock samples (soccer cones), and complete its traverse to the finish line. All instructions must be written in advance on the worksheet prior to the start of the simulation. Each team will have an official timekeeper and judge for the race. After the first trial, the students will realize that calibration of the rover (size of steps) will play a big part of the success of their attempt to navigate. Repeat the simulation at least twice.

Procedure:

Each team will consist of a rover driver, a rover (3 students linked hand to shoulder and blindfolded = 1 rover), a timer, and a judge. A simulated Martian surface is laid out on the floor in any symmetrical pattern, leaving pathways for the rover to make turns and pick its way through. The timer keeps track of the elapsed time as the driver reads the instructions that were prepared prior to the driving of the rover, and the judge keeps track every time the front person on the rover steps on a rock (paper). When possible, the rover driver can command the blindfolded rover to pick up a rock (cone) for collection.

Classroom Discussion:

Teleoperation, controlling a robot from a distance, is no easy task. Rovers that are operating on Mars cannot be driven in real time because the time required for a signal to travel from Earth to Mars can be up to 20 minutes, one way, at the speed of light. How well do your students think they can do driving a rover on Mars?

Assessment:

Students are able to demonstrate an understanding of teleoperation by successfully executing a sequence of rover commands that maneuver the rover along a simulated Mars terrain. The winning rover is the one that hits the least number of rocks, has the best time and collects the most rocks.

Science Background:

Because of the large distance between Earth and Mars, the rovers on Mars cannot be commanded in real time. The science team must agree on the commands in advance (daily) and send them up to Mars to drive the rover.



Two images of rocky Mars terrain taken by the panoramic camera onboard the Mars Exploration Rover Spirit. Image credit: NASA/JPL/Cornell



ROVER RACES

Name _____

Date _____

1. Walk the simulated Martian terrain (avoiding the rocks) and record your rover commands on this worksheet, making certain to include every step the rover will have to perform. Commands include: forward, right turn, left turn, back-up, and stop.
2. Number each instruction with the order in which it is to be carried out. You will not be allowed to change the commands once written. Test your program with the “rover”!
3. Discuss the results of your rover test.
4. What changes would you make before another rover test?

COMMAND NUMBER	ACTION TO BE PERFORMED

DESCENT INTO ENDURANCE CRATER

Grade Level: 5-9

National Standards:

NSES: Use Mathematics in All Aspects of Scientific Inquiry, Forces and Motion

NCTM: Use ratios and proportions to represent quantitative data; Use appropriate graphical representations of data; Solve simple problems involving rates and derived measurements for such attributes as velocity; Use geometric models to represent and explain numerical and algebraic relationships

Materials: Small, fast-rolling toy car (as friction-free as possible), stiff cardboard to serve as a sloping crater wall, blocks or other supports to raise slope angle, tape measure with metric markings, stopwatch, graph paper, protractor, masking tape

Duration: One forty-five-minute class period

Objective:

Students will learn how an object's motion can be described by its position and velocity and how forces can cause a change in the object's motion.

Activity:

As navigators for the Opportunity rover, your students are tasked to discover the steepest slope the rover can roll down without exceeding its maximum safe speed, which for this experiment will be one meter per second. (This speed was chosen arbitrarily for the purposes of this simulation. It does not represent the actual speeds attainable by the Opportunity rover.) A small toy car will simulate Opportunity; the sloping crater wall will be simulated by an inclined plane constructed from stiff cardboard and blocks.

Classroom Discussion:

In June of 2004, NASA scientists decided to send the Mars Exploration Rover, Opportunity, over the edge of Endurance Crater, a huge, deep impact crater on the surface of Mars in the Meridiani Planum region. The science team knew that the rover might not be able to make it out of the crater, but decided that the potential science benefit outweighed the risk of getting stuck in the crater. The problem, however, was how to get the rover down the side of the crater and safely back out without tipping it over. If Opportunity did not make it safely to its science site on the crater wall, they would lose the rover without gaining any science information at all. In order to find a safe route to the site, Opportunity's navigators had to consider a variety of factors, but each of these factors was essentially a force that would change the rover's motion as it descended the crater wall. As they do the activity, ask students to think about how their results would be different had they performed the experiment on Mars.

Assessment:

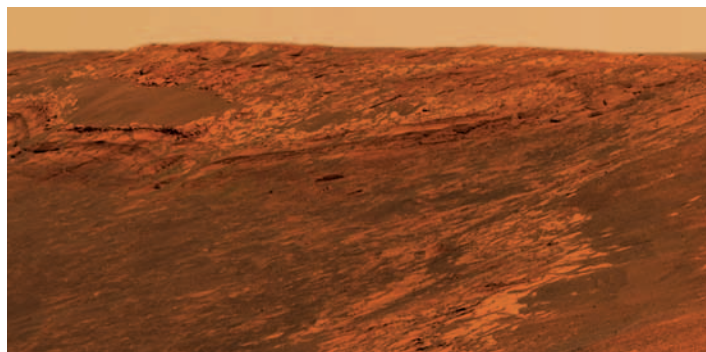
The students will be able to plot velocity vs. force (ramp angle) and identify the resulting linear relationship between force and changes in motion and predict how the velocity of the car will change as a result of different ramp angles.



A rover test drives up a manmade slope at JPL to simulate conditions it will face in "Endurance Crater." The test rover successfully descended and climbed the platform, adding confidence that Opportunity could cross a similar hurdle in Endurance Crater. Image credit: NASA/JPL

Science Background:

All physics begins with the study of forces and motion. Newton's Three Laws of Motion describe how forces affect the motion of an object. They form the basis of most of physics and of robotics. Newton's Laws are just as valid on Mars as they are on Earth, but because Mars has one-third the gravity of Earth, rovers, and everything else, will fall (or roll, in this case) much more slowly on the Red Planet. This activity demonstrates to students that when a force (gravity in this case) is applied to a stationary object, it will experience acceleration; that is, a change in velocity.



This image shows the "Karatepe" ingress, where the rover began its traverse down into Endurance Crater. Image credit: NASA/JPL

DESCENT INTO ENDURANCE CRATER

Name _____

Date _____

Follow these steps to fill out your Data Log:

- Measure the angle of the crater wall with a protractor and record it in the box.
- Release the car (your model rover) from the top of the incline.
Start the clock when the front wheels of the car pass the bottom of the incline.
- Stop the clock when the front wheels of the car have traveled one meter.
Record the time in the second box.
- Record the final velocity (distance traveled – 1 meter – divided by time elapsed) in the last box.
- Plot the crater wall angle versus the final velocity on the graph paper.
- Extend your plot from 0 degrees to 90 degrees and use this graph to predict the maximum crater wall angle your Opportunity model can travel down without exceeding its maximum safe speed (given by your teacher).

WALL ANGLES (degrees)	TIME ELAPSED (seconds)	FINAL VELOCITY (maximum speed)	OBSERVATIONS

BRINGING MARS HOME: MARS LAUNCH PLATFORM

Grade Level: 5-9

National Standards: NSES: Abilities of Technological Design

Materials (per groups of four students): Toothpicks (approximately 100-200 per team), two sticks of firm modeling clay per team, weights (can use rocks or large metal washers), balance (if weights are unlabeled), and a meter stick

Duration: Forty-five-minute to sixty-minute class period

Objective:

Students will learn how the “test, evaluation, and revision” process ensures that a finished design will meet its design goals and engineering constraints.

Activity:

In this activity, students will discover the “test, evaluation and revision” process firsthand. Students will be given toothpicks and clay and will be asked to build a structure that can support the greatest gravitational potential. The students are encouraged to try different forms of structures (cross beams, suspensions, triangles or other geometric shapes, etc.), and test each type to see which can support the most weight. While there is a competitive nature in this activity, it is important that students get as many chances as they wish to experiment with different designs. In the interest of time, students should be encouraged to test small, representative portions of a given type of structure before attempting to build the final tower. The goal is for students to experience the iterative nature of the engineering design process.

Classroom Discussion:

Scientists hope someday to collect Mars rock samples and bring them back to study on Earth. The return spacecraft that would be used for such a mission will need a platform to support its launch from the Martian surface. The launch platform will need to meet two requirements: first, it must be able to support as large a mass as possible to allow it to support the return spacecraft and second, it must be as tall as possible to prevent damaging equipment still on the surface. Discuss these requirements with the students at the beginning of this activity.

Assessment:

The students should demonstrate that they have experimented with a number of different designs by building and sketching small prototypes of different platform designs before they construct and test the final platform that they think will perform the best. They should be able to determine the gravitational potential energy of their final design.

Science Background:

As discussed previously, the launch platform will need to meet two requirements: support a large mass and be as tall as possible. The gravitational potential energy is defined as the energy stored in an object due to the fact that it has been lifted off the ground. This potential energy can be easily converted into kinetic energy (energy of motion) by simply dropping the object! Mathematically, the gravitational potential energy of an object can be found from:

$$\text{Potential Energy} = m \times h \times g = \text{mass of object (kg)} \\ \times \text{height of object (meters)} \times \text{acceleration of gravity} \\ (9.81 \text{ m/sec}^2 \text{ on Earth, } 3.71 \text{ m/sec}^2 \text{ on Mars})$$

As you can see, the potential energy combines both requirements for the launch platform: mass and height. Therefore, your students will be tasked to build a platform that can give the spacecraft the greatest gravitational potential energy.



Ready for launch. Credit: NASA

BRINGING MARS HOME: MARS LAUNCH PLATFORM

Name _____

Date _____

Scientists hope someday to collect Mars rock samples and bring them back to study here on Earth. The return spacecraft that would be used for such a mission will need a platform for its launch from the Martian surface. The launch platform will need to meet two requirements: first, it must be able to support as large a mass as possible (to allow it to support the return spacecraft), and second, it must be as tall as possible (to prevent damaging equipment still on the surface).

Procedure:

- Using the toothpicks and clay provided, make a platform structure that will provide the greatest gravitational energy. Then use this formula to calculate the gravitational potential energy given by your structure:

Potential Energy = $m \times h \times g$ = mass of object (kg)
 \times height of object (meters) \times acceleration of gravity
 (9.81 m/sec² on Earth, 3.71 m/sec² on Mars)

- You should think about and answer the following questions as you conduct your tests:

- What type of structural units (triangles, squares, etc.) will support the most weight?
- Do you want to build a short and sturdy structure that supports a heavy weight, or a tall structure that can only support a small weight, or some combination of the two?
- What data should you gather to prove that your structures will stand? Remember, the most successful design winner will be the team with a structure that can give a rock the greatest gravitational potential energy.

- Use a separate sheet of paper to sketch your design prototypes as you brainstorm designs.

- Use this sheet to record your observations during your test, evaluation, and revision process. Using the weights and meter stick, calculate the gravitational potential energy. Record your data in the next column.

RESOURCES

Books about Mars

Squyres, Steve. *Roving Mars*. Hyperion, NY. 2005. Spirit, Opportunity and the exploration of the Red Planet; get the behind the scenes story behind these remarkable rovers.

Hartmann, William K. *A Traveler's Guide to Mars*. Workman Publishing, NY. 2003. Live out Mars' geological history through the writings of a Mars Global Surveyor team member.

Hanlon, Michael. *The Real Mars*. Carroll and Graf Publishers, NY. 2004. Spirit, Opportunity, Mars Express and the quest to explore the Red Planet.

Croswell, Ken. *Magnificent Mars*. Free Press, NY. 2003. Join in a virtual tour of Mars by exploring four themes: Earth, air, fire and water.

Mishkin, Andrew. *Sojourner: An Insider's View of the Mars Pathfinder Mission*. Berkeley Publishing Co. NY. 2003. Travel with the six-wheeled Sojourner rover as she explores the rough, red terrain of Mars.

Morton, Oliver. *Mapping Mars: Science, Imagination, and the Birth of a World*. Picador, NY. 2002. Well-known British science writer Morton traces scientists' efforts to map and understand the surface of Mars.

Wethered, Peggy, Edgett, Ken, and Chesworth, Michael. *Touchdown Mars!* G. P. Putnam's Sons, NY. 2000. Imagine you are an Astronaut on your way to Mars. First you Board your rocket. Then you wait for the Countdown and Liftoff! This unique Mars ABC book is for young and old alike! Great Mars science!

Sumners, Carolyn and Rawlings, Pat. *An Earthling's Guide to Mars*. McGraw-Hill, NY. 1999. Travel to Mars with the Mars Pathfinder mission and plan your next vacation!

Ride, Sally and O'Shaughnessy, Tam. *The Mystery of Mars*. Crown Publishers, Inc. NY. 1999. Mars, with its thin atmosphere, rocky canyons, extinct volcanoes, and icy polar regions has a lot in common with Earth. The authors compare the two planets' evolution, geology, and geography to help explain about what we know about Mars today, in hopes of helping us understand more about Mars in the future.

Raeburn, Paul and Golombek, Matthew. *Mars: Uncovering the Secrets of the Red Planet*. National Geographic Society, Washington, DC. 1998. Humankind has always been fascinated by Mars, one of the planets closest to us — and seemingly most like us. Explore Mars in 3-D and through dramatic images from the Pathfinder mission and those that came before.

Websites:

Mars

<http://www.nasa.gov>

NASA's website provides information about all space missions, with classroom activities on its "For Educators" pages.

<http://mars.jpl.nasa.gov>

NASA's Mars Exploration Program site describes all Mars missions, the science strategy for "following the water," and information about the red planet.

<http://marsrovers.jpl.nasa.gov>

The official NASA Mars Exploration Rover site provides current images and discoveries from Spirit and Opportunity.

<http://athena.cornell.edu>

Lead scientist Steve Squyres maintains a site for information about the rovers' science instruments.

Mars Education

<http://mars.jpl.nasa.gov/classroom>

K-12 educators can find standards-aligned, inquiry-based classroom activities and other resources.

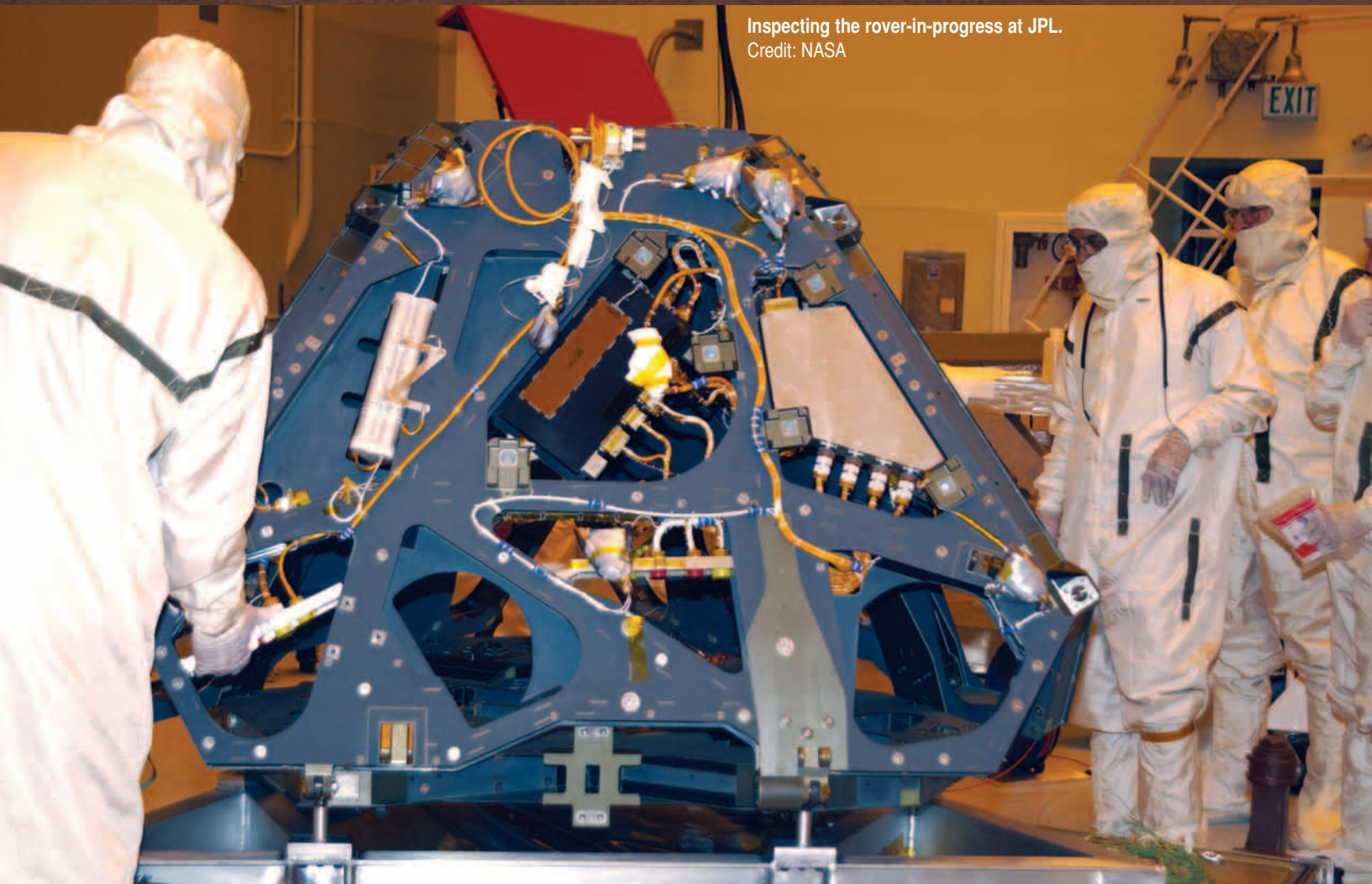
<http://msip.asu.edu>

Student teams explore Mars for real! Learn how to become part of the Mars Student Imaging Project and target and analyze an image of Mars using the THEMIS camera onboard the Mars Odyssey spacecraft.

This image taken by the panoramic camera onboard the Mars Exploration Rover Opportunity shows the rover's now-empty lander at Meridiani Planum, Mars.
Credit: NASA/JPL/Cornell



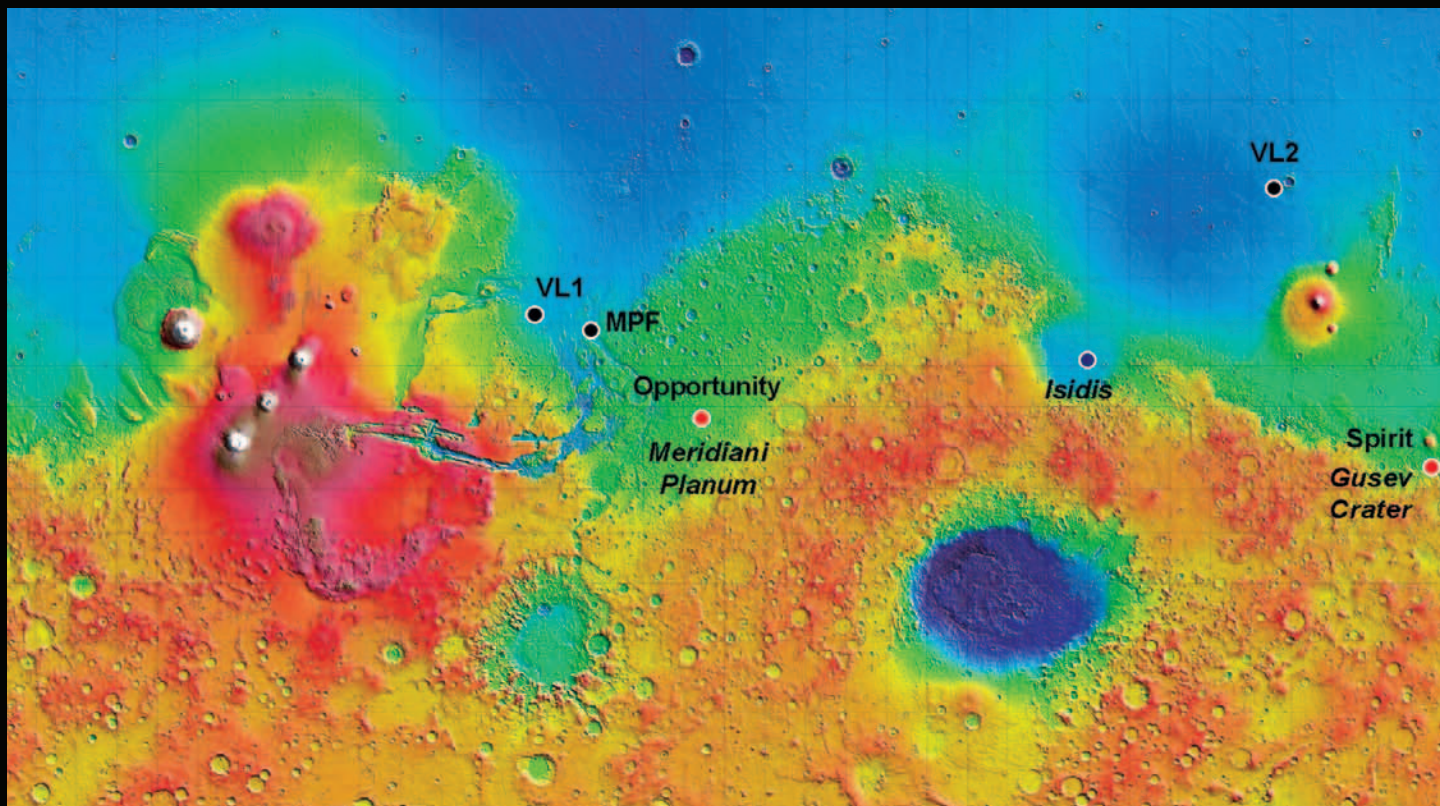
Inspecting the rover-in-progress at JPL.
Credit: NASA



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A map of Mars showing the landing sites of Spirit and Opportunity rovers. Credit: NASA/JPL

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