Crossing Mars: Past and Future Missions to a Cold, Dry Desert

Dr. Geoffrey A. Landis of the Photovoltaics and Space Environment Effects Branch presented an overview of recent discoveries about the environment of Mars. He covered missions from the 1966 Mariner IV that returned those first grainy close-up pictures of Mars showing an ancient cratered terrain to the Mars Odyssey mission with its tantalizing evidence of recent water flows on Mars.

Mars is one of the most interesting planets in the solar system, featuring enormous canyons, giant volcanoes, and indications that, early in its history, it might have had rivers and perhaps even oceans. Five years ago, in July of 1997, the Pathfinder mission landed on Mars, bringing with it the microwave-oven sized Sojourner rover to wander around on the surface and analyze rocks. Pathfinder is only the first of an armada of spacecraft that will examine Mars from the pole to the equator in the next decade, culminating (someday, we hope!) with a mission to bring humans to Mars.

Mars is the next planet out from the Sun, so it gets a little bit less sunlight than we do, and so it is a cool planet. Mars is a bit smaller than the Earth. The first thing you notice when you look at it is that it's a very red planet -actually more of a muddy orange color, but it's much redder than the Earth, which is why they call it the red planet.

The fact that we think of it as being a small planet is a little bit misleading. In fact, the land area of Mars is greater than the entire land area of the planet Earth. It's really a big place. There's a lot to explore on the planet Mars.

You can see Mars from the Earth, and even from here, about fifty million kilometers at the closest, with a telescope we can see a lot things about Mars. It has clear dark and light features; you can see it has a polar cap. Like the Earth, Mars has an axis that's tilted, and therefore it has seasons, winter and summer, and the polar caps grow in the winter and shrink in the summer. It also has clouds, so you can tell that it has an atmosphere.

But to really get a good look at Mars, you need a spacecraft. You need to get up close, and now we can see really interesting things about Mars. The first thing that spacecraft learned when they visited Mars in 1964 was that it has a lot of craters. It's a lot like the Moon. It's been heavily bombarded, which is reasonable because it's closer to the asteroid belt than we are, so you do get asteroids that hit the planet Mars. From these first spacecraft to visit Mars we also learned that its atmosphere is very thin-- less than 1% as thick as Earth's atmosphere.

After the first spacecraft, which just flew past the planet, we put spacecraft into orbit. Viking looked at it more carefully and saw that Mars has what appears to be dry river beds. These look like dry rivers. So Mars once had water. Today, Mars is a very cold and dry world, so what happened to the water? Where is it now? As we know, water is very important. It's important for life - all of us drink it. We also know that as soon as the planet Earth has a surface cool enough that water could condense on it, life formed on Earth. That was a few billion years ago. But once, perhaps several billion years ago, Mars also had water. So it seems very probable that it might once have had life. We do have a pretty good guess that underneath the soil on Mars, there is still water in the form of permafrost.-- the Mars Odyssey mission will tell us about this.

Mars is the planet of extremes. It has the largest canyon the solar system, the Valles Marineris, a canyon that extends almost a third of the way across Mars. They named it Valles

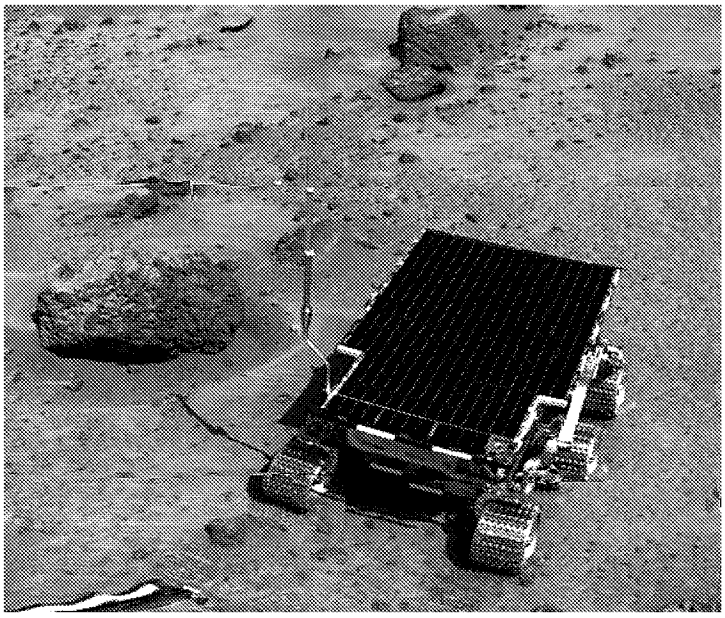
Marineris, the "Canyon of the Mariner", because it was discovered by the Mariner spacecraft. This is a canyon four thousand kilometers long, and in places nearly ten kilometers deep. (In my novel, my characters spend much of their time exploring and climbing through Valles Marineris.)

Mars has the largest mountains in the solar system as well. Olympus Mons, the largest, rises up twenty-five kilometers. It's a volcano so tall that the top of it is in vacuum and outside the atmosphere. It is far taller than Mount Everest.

The Pathfinder Mission and Landing on Mars

Pathfinder was a solar-powered spacecraft. Before Pathfinder nobody had used solar power on Mars before; Pathfinder was a first. Analyzing the operation of solar power systems on Mars was a project that I worked on, and I am very proud that some of my work helped in the design of the power system for this spacecraft.

Pathfinder came down in a parachute, and then the airbags inflated. It bounced on the surface, as high as a five story building, and at least eighteen times. That was just as many as they counted; it probably bounced more than that. Then it opened up, like a flower unfolds, and the blue solar petals on the inside were revealed, and we got to see the Sojourner rover.

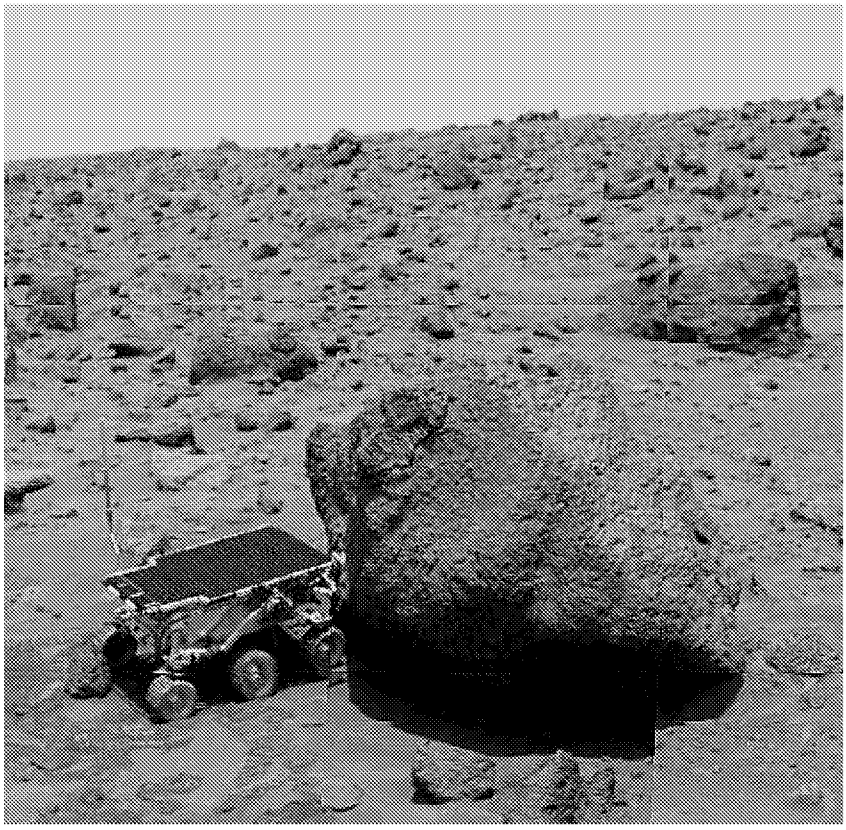


Six Wheels on Soil!

The Sojourner rover really was the real star of the show. This is the first time that anybody has operated a wheeled vehicle on another planet, and I'm pleased to tell you that it set a world speed record for the fastest vehicle ever to go on the world of Mars. The speed record was a little bit under half a meter per minute--that's about one-fiftieth of a mile per hour--but that is faster than anybody has ever gone on Mars before. It has six wheels that enable it to run over different kinds of terrain, and walk over rocks. The suspension is articulated to allow it to crawl over very large rocks. If a car had the same sort of wheel systems, it could drive over something

a rock a meter and a half tall, as tall as a dining room table. So it gives it a good amount of ability to go over very rough terrain.

To pick a name for the Pathfinder rover, they held a contest for schoolchildren. The name was chosen by Valerie Ambroise, a school girl from Connecticut. "Sojourner" means "wanderer," and the Sojourner rover wanders around on Mars, so it's a very appropriate name. The Sojourner rover is stowed on one of the petals covered with solar panels. To drive off the petal and onto the surface, they have to deploy rolled-up ramps. These ramps to get the rover to the surface are spring-loaded, so they deploy with an enthusiastic bing.



The Sojourner rover and the rock "Yogi," viewed by the Pathfinder lander. (This image is a mosaic of several dozen individual frames taken by the Pathfinder "IMP" camera; close inspection reveals many seams where individual frames do not perfectly overlap.)

Most of the scientists on the mission were geologists, and geologists love to talk about rocks. They decided to name all the rocks that they can see, so that when they talk about rocks, they remember which one is which. So the first thing they did when they got the pictures down was to make a mural of the surface of Mars as seen by the lander camera. They stuck the mural on the wall of the conference room and said anybody could name a rock. So if you have a name for a rock, you just write it on a little yellow piece of paper, and stick it on to the picture. If everybody likes it, they'll leave it up, and if they don't like it, some body else will name the rock. I'm very proud of one rock, "Yogi," which I named, and which was featured very prominently in the news coverage! Pathfinder mission had other instruments on it as well, including the APXS

("Alpha Proton X-ray Spectrometer") that could actually sniff the rocks and find out what they are made out of. It was a very capable instrument.

The Pathfinder lander, surrounded by deflated airbags, as viewed by the Sojourner rover's camera.

Future Missions to Mars

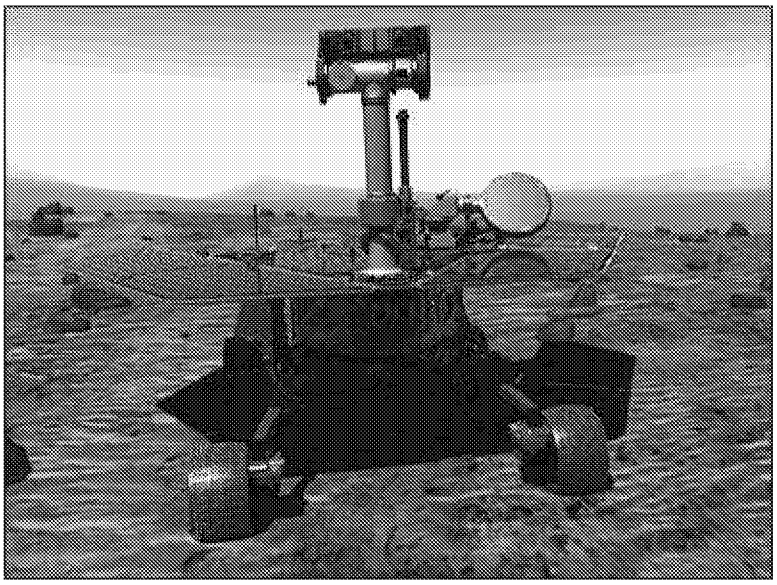
Pathfinder is not the end of Mars exploration. We have a whole armada of spacecraft going to the red planet. The Mars Global Surveyor is in orbit around Mars right now and has a mapping camera that shows very detailed close-up pictures of the surface of Mars from orbit.

I worked on another mission, which was intended to launch in 2001, called the 2001 Surveyor lander. Unfortunately in 1999 two missions to Mars both failed, and because of those failures, the 2001 lander mission was postponed and then cancelled. We were all very disappointed. Another mission did launch to Mars in 2001, an orbiter, the Mars "Odyssey" mission. The Odyssey spacecraft is in orbit around Mars right now, and taking measurements of Mars from orbit.

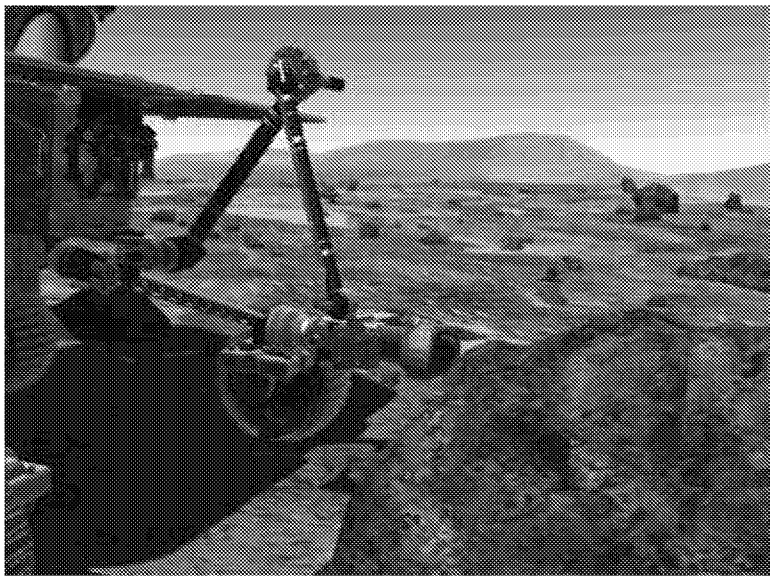
Many future missions are now being planned. The next mission to land on Mars is the Mars Exploration Rovers, two rovers each one much larger than the Sojourner rover, to launch in the summer of next year. 2003. At the same time, the British are heading to Mars with a small lander named the Beagle-2, a spacecraft which "hitchhike" to Mars with the ESA "Mars Express" orbiter. And then in 1005, the "Mars Reconaissance Orbiter" is going to fly.

Further in the future, in 2007 we will fly the Mars "Scout" missions. This is a solicitation for new concepts in Mars exploration, and several new ideas have been proposed. Some people that I work with would like to fly an airplane in the atmosphere of Mars. This is very difficult, because the atmosphere is so thin. Some people have suggested flying a balloon, and other people have suggested landing a spacecraft on the ice of the polar cap, and melting down through

the ice to see the layers under the ice. Another group is proposing a long-range rover to drive across the fascinating layered terrain around the polar cap.



The Mars Exploration Rover. Two of these rovers will launch to Mars in the summer of 2003.



Rock drilling tool on the 2003 Mars Exploration Rover

We would like to actually get samples back to Earth in a future mission, probably in the year 2015, which is only thirteen years from now, and blast them all home so we can take a look at them and look for fossils and for other interesting things.

All of these robotic flights are precursors to the most important future exploration: a mission to Mars with people on board. But right now there is no mission planned, so this is more science fiction than science.

In my science fiction novel, Mars Crossing, I picture such an expedition to Mars—in fact, several expeditions. The difficult part of sending people to Mars is not how to send them to Mars—the difficult part is bringing them home. (And most of my novel is about how the characters work at coming home). In the novel, the expeditions to Mars manufacture rocket fuel from resources found on Mars to bring the expedition home. One of the expeditions lands on the polar cap, and makes rocket fuel out of the carbon dioxide and water ice in the cap, and the other expeditions lands near the equator, and manufactures fuel out of the atmospheric carbon dioxide. I think that this is very realistic, and that when we do send humans to Mars, that this is the logical way to do it—we should make the rocket fuel on Mars, instead of bringing it from Earth. Of course, in my story, the characters have tremendous difficulties, and are in great danger. I hope that in the real world, they will not have so many problems! The best expedition is one that is not very exciting. But perhaps this is one of the functions of science fiction, to show what the problems might be.

I do think that eventually people will go to Mars. It is our sister planet, and we should go explore it!

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Robots in the Planetary Cold

Dr. William (Red) Whittaker, director of the Field Robotics Center of the Robotics Institute at Carnegie Mellon University, discussed operation of robotic explorers in challenging environments, including the Moon and Mercury. He gave historical background from the Russian Lunokhod tele-operated rover, the American Apollo manned rover vehicle and terrestrial robots including Nomad, which found meteorites in Antarctic and Pioneer, the robot that explored the damaged Chernobyl nuclear plant in Russia.

The main emphasis of the presentation was on autonomously controlled, sun-synchronous robots that are continuously operated by solar power. These are practical on slowly rotating bodies such as the Moon (28 days rotation) and Mercury (187 days) or on bodies with a tilted axis that allow continuous sunshine at polar regions during summer, such as Earth and Mars. Issues impacting sun synchrony are shown in the charts reproduced below.