AN ODYSSEY OF EXPLORATION

It's been a great year -- a very satisfying year for Mars Odyssey. We completed our primary mission after two years (over one full Mars year) of mapping, we've acquired a tremendous amount of data on the thermal properties, the radiation environment, and the composition of the surface.

We look at the planets to help understand our own, and where our place is in the universe and the solar system. We've been tantalized by the fact that life may have arose there. And if it arose, is it still there? And if it's not there, what happened to it and is there any remains of it?

When you consider all the other billions and billions of stars, there must be other planets out there that aren't too different from Earth. Maybe they do have life on it, maybe life didn't exist for very long -- we don't really know what's going on. Mars, of course, is very close to us and may help us answer some of those philosophical questions that we sometimes just dream about.

I got interested in Mars when I was a kid. My mom bought me a telescope when I was about 12 years old, and I've been looking at Mars ever since. I was fascinated just because it was this tiny little place a long way away, and people were trying to speculate what it was like. So all my life I've been trying to take better and better pictures and get closer and closer to help sort of imagine what it would be like to actually walk around on that planet.

BETTER AND BETTER PICTURES

The camera on Mars Odyssey is called THEMIS, and it actually is two cameras in one. It's a visible light camera, taking pictures like you would see with your eye, and it's also an infrared camera. So we're able to really learn a lot about the composition of the surface -- what minerals make up the surface. It's really a powerful tool, and we've created now two maps -- one in the daytime and one in the nighttime -- each of which is the highest-resolution global map ever acquired at Mars.

THEMIS is two cameras in one, and we have to actually figure out when to turn them on, so we built a targeting tool, called JMARS, and we use it for all of our THEMIS operations. And right now, our education group has a huge number of K-12 students that use this tool every day for remote learning about Mars. A large number of Mars scientists use it as well, because it tends to work for both.

A big part of the Mars program is that we bring current data, coming down from Mars, to students around the country. The Mars Student Imaging Project allows students from fifth grade, all the way up through community college to learn the process of science in a first-hand way. They get to propose a science question -- all science begins with a question. Their team gets to pick some place on Mars that they get to take a picture. We teach them how to use our targeting tool -- the real tool that our scientists

use. They get to target that image, they get that image back from the spacecraft, *they* get to do the analysis, and *they* get to tell NASA what they discovered. The same thing that our scientists are doing, these kids are doing in real time also.

One of the things we really wanted to do on the Odyssey mission is share some of the excitement we have for Mars, and to that end, we created this software, the THEMIS Image Scroller, and we ship this out to museums across the country. We have images of every Martian landform imaginable -- from canyons to craters, to polar ice caps and channels -- and we present them all literally only a few days after we've collected them. People can really do science, if you will, at the same time we are doing it.

BURIED TREASURE

Often I'm asked, "Why is it we're interested in studying Mars?" and of course one of the aspects is in comparison to the Earth. Really in a sense, it's like a laboratory where different processes have been going on, and we can study them to get a better understanding of the processes going on on Earth.

So, originally we decided to send a gamma ray spectrometer to Mars because it was going to map the different elements as they appear on the surface of the planet. So we could tell where iron was located, where silicon...different elements in the periodic table. One of the most interesting one that we were hopeful to find would be hydrogen. And that's because hydrogen, of course, is tied up mostly in different forms of water, and water is really an essential building block of life.

It turns out, after we got there we were very surprised -- we found far more water than we ever expected. It was all located in the polar regions, so it was very cold -- it was in the form of ice -- and people hadn't seen it before because it was buried just beneath the surface. But the gamma rays can actually ...they're somewhat like x-rays, that they can penetrate other materials so we can actually see right through the dust that's on top of it.

The key thing about this data set that's fantastic, is that for the first time we can actually see what's happening, in a sense, in the polar night. All of our other data has been visual, and we get limited information about what's going on.

What our data are telling us is that water is in sufficient abundance on Mars that what we see, which is the upper meter of the surface -- which is something like that -- contains enough water if you sum over the whole planet to make a layer of water, covering the whole planet, that's about ankle-high. And that seems like a small amount of water, but it's going to pool in places and it can exist below the surface. And if it is below the surface, then there's considerably more water than what we see.

In the future, when we get to the point of human exploration, we're going to have to choose locations where there is water that can be extracted. It's a long way to get to Mars, and there's no possible way to take the quantities of water that you would need for

the duration of your visit. It's definitely going to be a driving factor in terms of where human exploration would start.

PREPARING FOR HUMAN EXPLORATION

When people go to Mars, or other places in deep space, they're going to be exposed to significantly more radiation than we get here on the surface of the Earth. So we need to understand exactly what radiation dose people are going to get.

We're using Mars Odyssey to monitor the hazards that astronauts might experience on a trip to Mars.

We got a year-and-a-half worth of good data out of MARIE, and we were able to make the determination that the radiation levels were about as expected, two to three times greater that in Earth orbit. On Earth, we've got a very thick atmosphere, and that stops a great deal of the radiation that comes in. We've also got a magnetic field, and that causes particles to be deflected toward the poles. If you had the MARIE instrument in Earth orbit -- and we do, in a sense, because we've got a very similar instrument on the space station -- it records levels that are about half as high as what MARIE saw.

["Radiation console...yes..."]

What we're doing here is basically monitoring the radiation environment at the International Space Station. We do that a couple of different ways: we're monitoring output from the sun, and then also sort of the natural galactic background. For example, if you look here, you see this green and blue set of lines. This represents a solar event, and if levels reach certain values, then we ask the crew to seek more sheltered areas in the space station, or we can change the timing of what they're going to do and when -- maybe not do an EVA or go outside the vehicle, depending on what's going on.

In order to go to Mars -- to put people on the Martian soil -- then all of these kinds of technologies and all of the things we do here are going to have to be probably expanded significantly and then adapted to that kind of arena.

As we move towards expanding the number of places that we go in the solar system, we'll be going places where the Earth-bound satellites don't give us the information we need. So what we'll have to have is a network of monitors all around the solar system so that people can be on the other side of the Sun from where Earth is, and we'll still have monitoring capability, and warning capability, most importantly, to tell them "Yes, a big event is headed your way. You'd better take shelter."

I came into working on the MARIE project under kind of sad circumstances, because Gautam Badhwar, who worked in space radiation for his entire, distinguished career, unfortunately died shortly after Odyssey was on its way to Mars.

We are sorry we lost Dr. Badhwar on the way to Mars. He was a very humble man, and we definitely learned -- every day working with him was a learning experience. The one thing I remember the most about him is that he always made us feel like equals. He saw MARIE function during the cruise phase, but never during orbit, and this is his brainchild. We were hoping he'd be around to see it, but we have great scientists right now that are working on the team and filling his shoes, and it took...this was a truly a team effort between science and engineering in many organizations. It can be used as an example of cooperation between cities, states and different organizations -- a good lesson to learn from and apply on other projects and other tasks.

Having a successful mission like Mars Odyssey requires the efforts of literally hundreds of people. A lot of people who you never see, behind the scenes, are doing just a great job to get the commands up to the spacecraft, ["copy that...thanks"] to do the data handling, to monitor the health of the instruments and all the systems on board ["Data Control...Odyssey Ace..."]. These people don't get the credit, but they really deserve it, because on our project we have just had a fantastic team. They've done a great job for us, and it's really a tribute to their efforts that we've been so successful.

The Odyssey project looks like it's going to be a long term project. Serving the role as landing site scout, and now lander relay platform...

The highlight of our operations over the past year really has been our support for the Mars Exploration Rovers. Almost all of the data that has come the rovers on the surface has come through Odyssey, and we're very proud to have provided that type of support for the rovers.

Our performance to date has been just wonderful, and we believe that the spacecraft will be sort of a cornerstone in the infrastructure of the Mars Exploration Program for a long, long, time.