PLANETARY NEWS: MARS (2006)

MARS RECONNAISSANCE ORBITER APPROACHES RED PLANET

By A.J.S. Rayl
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The Mars Reconnaissance Orbiter (MRO) is scheduled to arrive on time at the Red Planet in two weeks, NASA officials announced today at a press conference held at agency headquarters in Washington D.C.

"The journey from Earth to Mars takes 300 million miles. We are about 15 million miles away, so we're 95% there and we are right on the money now heading toward our encounter with Mars on March 10," said Jim Graf, MRO project manager at the Jet Propulsion Laboratory (JPL).

MRO, which will look at the Red Planet in unprecedented detail, will join a fleet of five other "distinguished" spacecraft at the planet: three orbiters -- Mars Global Surveyor, which arrived in 1997; Mars Odyssey, which arrived in 2001; and Mars Express, which arrived in 2003, and two rovers -- Spirit and Opportunity, which landed in January 2004 and are still roving strong. MRO launched on August 12, 2005 from Cape Canaveral, Florida.

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Mars Reconnaissance Orbiter (MRO) approaches Mars
Artist's depiction of the Mars Reconnaissance Orbiter (MRO) ariving at Mars Created: 24 February 2006. Credit: NASA / JPL

After its arrival, MRO will spend six months gradually adjusting the shape of its orbit by aerobraking before it begins its science phase this fall. Once it is in proper science orbit, though, this spacecraft is expected to yield more data than all previous Mars missions combined. Scientists will analyze the information to gain a better understanding of changes in Mars' atmosphere and the processes that have formed and modified the planet's surface. "We're especially interested in water, whether it's ice, liquid or vapor," according to JPL's Richard Zurek, project scientist for the orbiter. "Learning more about where the water is today and where it was in the past will also guide future studies about whether Mars has ever supported life."

As it nears Mars on March 10, MRO will point its main thrusters forward, then fire them to slow itself enough for the planet's gravity to grab it into orbit. Although getting MRO into orbit may seem like a cakewalk compared to getting both Spirit and Opportunity down on the planet two years ago, in fact, it is more difficult. "Orbiters seem to be the easiest thing to do, but in reality we only have about a 65% success rate of getting orbiters into orbit; whereas, landers we have about an 80% success rate," noted Doug McCuistion, director of NASA's Mars Exploration Program. "Mars is hard. Mars can be unpredictable."

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"We are getting into the dangerous part of the mission," added Graf. "We have accomplished an awful lot during cruise [phase], but now we're starting to enter the realm where we have lost two spacecraft in 15 years."

Here is what is supposed to happen for Mars orbit insertion (MOI):

MRO will approach the southern pole of Mars pointing as it goes directly to Earth. "We will rotate the spacecraft

about 120-degrees to keep the low-gain antenna pointed in a manner that we can continue to communicate with Earth," explained Graf. "Then we fire the thrusters for about 27 minutes – we have about 260 pounds of force. If we don't succeed in firing the thrusters, we will fly right by the [planet], so this is obviously the critical maneuver. We have to decrease our speed by 18% during this phase."

The MOI burn is set to begin at 1:25 pm Pacific Standard Time (9:25 pm UTC) and the team expects a signal shortly after this mission-critical engine burn has begun," said Graf. The "burn" will end during a suspenseful half-hour when the spacecraft is out of radio contact. About 21 minutes into the thrusters firing, MRO will disappear behind the planet. "We will have a loss of signal and we will be out of touch for the next 30 minutes, so we will not see the end of the burn itself."

MRO will continue on and will automatically terminate the burn. "We will come out of occultation at 2:16 pm PST (10:16 pm UTC)," noted Graf. "We will slew back to an attitude so that we can view back to Earth the minute we come out from behind Mars," he added. "We will get a signal back at that particular point in time, but we will not know whether we have been captured for another half an hour or so." The team must collect data from the spacecraft and make calculations to determine if MRO is in Mars' orbit.

Provided everything happens as it is designed to, this initial capture by Mars' gravity will put the spacecraft into a very elongated, 35-hour orbit. The planned orbit for science observations, however, is a low-altitude, nearly circular, two-hour loop. Therefore, after MRO completes MOI and before it can begin its main science assignments, it will have to adjust the shape of its orbit. "We have to bring our furthest point from planet down to a point from 35,000 miles to under 200 miles," explained Graf. "We do this by grazing the atmosphere each orbit and allowing the friction of the atmosphere against the spacecraft to slow ourselves down," a technique known as aerobraking.

By utilizing hundreds of carefully calculated 'dips' into the upper atmosphere -- deep enough to slow the spacecraft by atmospheric drag but not deep enough to overheat the orbiter, aerobraking is "like a high-wire act in open air," as Graf described it. "Mars' atmosphere can swell rapidly, so we need to monitor it closely to keep the orbiter at an altitude that is effective but safe." The orbiters already at Mars will provide a daily watch of the lower atmosphere, an important example of the cooperative activities between missions at Mars.

Theoretically, MRO could have gone directly into its circular science orbit on arrival, but it would have had to carry a lot more fuel for the main thrusters, and thus be sent aloft by a larger and more expensive launch vehicle. That would have left less payload weight for science instruments. "Aerobraking saves us [more than] 500 kilograms [of fuel] at launch and so we were able to go with a smaller launch," Graf explained.

Once it settles into its final orbit, MRO will begin the science phase of its primary mission, studying Mars in exacting detail from low orbit. The orbiter's suite of six instruments will serve to illuminate every level of Mars from underground layers to the top of the atmosphere. An infrared sounder will monitor atmospheric temperatures and the movement of water vapor. The most powerful telescopic camera ever sent to a foreign planet will reveal rocks the size of a small desk. An advanced mineral-mapper will be able to identify water-related deposits in areas as small as a baseball infield. The radar – which is supplied by the Italian Space Agency -- will probe for buried ice and water. And a weather camera will monitor the entire planet daily.

The instruments will produce torrents of data and if all goes as planned, MRO will return more data about Mars than all previous missions combined. The orbiter can send data to Earth at about 10 times the rate of any previous Mars mission, using a dish antenna 3 meters (10 feet) in diameter and a transmitter powered by 9.5 square meters (102 square feet) of solar cells.

MRO will also support future missions to Mars by examining potential landing sites and by providing a high-data-rate relay for communications back to Earth. Actually, the spacecraft has already set a record transmission rate for an interplanetary mission, successfully returning data at 6 megabits per second, fast enough to fill a CD-ROM every 16

minutes.

During its planned five-year prime mission, MRO will support the Phoenix Mars Scout, which is being built to land on icy soils near the northern polar ice cap in 2008, and the Mars Science Laboratory (MSL), an advanced rover under development for launch in 2009.

"Not only will Mars Science Laboratory's landing and research areas be determined by the Mars Reconnaissance Orbiter, but the first boots on Mars will probably get dusty at one of the many potential landing sites this orbiter will inspect all over the planet," said McCuistion.

"MRO truly is the next generation Mars explorer," offered Bob Berry, director of Space Exploration Systems, Lockheed Martin Space Systems, which with JPL designed and built the spacecraft. "The MRO bus design represents a 4th generation evolution started with MGS. MRO had a launch mass of 4,800 pounds and 215 square feet of solar array, stretching tip-to-tip about 46 feet, and is carrying consumables to last 10 years. And MRO is designed to return 34 terabits of data – equivalent to the content of a video store – and many times more than the previous planetary mission we have flown."

So far, for both spacecraft and the team, the flight has been a pleasant one. Soon it will be white-knuckle time, but the press conference panel agreed all systems are go for MRO. "The spacecraft team has used cruise to get the feel of the spacecraft to drive down risks through extensive risk reduction testing of the software and sequences necessary for MOI, the mapping mission, and aerobraking, to optimize our operational processes through training and characterization of spacecraft system," said Berry.

"During the cruise phase, we performed two trajectory correction maneuvers (TCMs)," Berry continued. "Because of the targeting and precision of those maneuvers, we have been able to cancel the last two planned TCMs. Cruise has demonstrated that we have very robust spacecraft margin. In summary, the spacecraft and spacecraft team are ready. The team is trained and confident. The spacecraft systems are healthy and performing as expected and we're looking forward to adding MRO to the constellation at Mars."
