THE 2009 MARS TELECOMMUNICATIONS ORBITER. G.R. Wilson[1], R. DePaula[2], R.E. Diehl[1], C.D. Edwards[1], R.J. Fitzgerald[3], S.F. Franklin[1], S.A. Kerridge[1], T.A. Komarek[1], and G.K. Noreen[1], [1]Jet Propulsion Laboratory, 4800 Oak Grove Drive, MS 183-501, Pasadena, CA, 91109, USA (gwilson@jpl.nasa.gov) [2]NASA Headquarters, Washington DC [3]NASA Goddard Space Flight Center, Greenbelt, MD

Introduction

The first spacecraft with a primary function of providing communication links while orbiting a foreign planet has begun development for a launch in 2009. NASA's Mars Telecommunications Orbiter would use three radio bands to magnify the benefits of other future Mars missions and enable some types of missions otherwise impractical. It would serve as the Mars hub for a growing interplanetary Internet. And it would pioneer the use of planet-to-planet laser communications to demonstrate the possibility for even greater networking capabilities in the future.

With Mars Telecommunications Orbiter overhead in the martian sky, the Mars Science Laboratory rover scheduled to follow the orbiter to Mars by about a month could send to Earth more than 100 times as much data per day as it could otherwise send. The orbiter will be designed for the capability of relaying up to 15 gigabits per day from the rover, equivalent to more than three full compact discs each day. The same benefits would accrue to other future major Mars missions from any nation.

Relay service by the orbiter would also relieve designers of smaller future Mars landers, and perhaps aircraft, from needing to equip those missions with the ability to communicate directly with Earth. That would reduce launch weight and free up payload capacity for more science equipment.

During its nearly 10-year mission in orbit, Mars Telecommunications Orbiter would aid navigation of arriving spacecraft to their martian landing sites and monitor critical events during landings and orbit insertions. In addition, it would enable data-transmission volumes great enough to bring a virtual Mars presence to the public through a range of Internet and video features.

Mission Overview

This communications mission has been designed to orbit Mars about 20 times farther from the planet's surface than current spacecraft designed primarily for science, such as Mars Global Surveyor, Mars Odyssey and Mars Reconnaissance Orbiter. To make radio contact with a surface mission, an orbiter must be above Mars' horizon. From its altitude of nearly 5,000 kilometers (3,000 miles) Mars Telecommunications Orbiter would remain above the horizon from the perspective of a landed spacecraft for several hours every day, allowing much greater data-relay capability than lower-altitude orbiters.

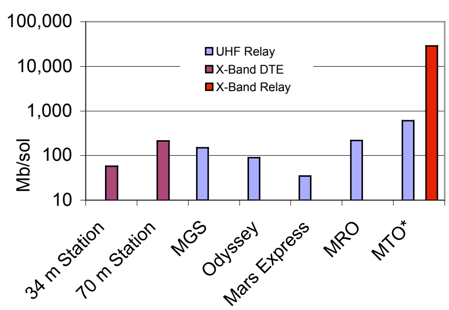

Figure 1. Data volumes (Mbit/Sol) from the surface of Mars for various communications strategies.

Approximately 10 months after launch from central Florida's Cape Canaveral Air Force Station, Mars Telecommunications Orbiter would fire its main engine three times to brake into a nearly circular orbit when it arrives at the planet in August 2010. Standard chemical propulsion will be used for braking because getting into the final high-altitude orbit limits the usefulness of aerobraking -- a fuel-saving technique employed by recent Mars orbiters to shape their orbits by repeatedly dipping into Mars' upper atmosphere.

The spacecraft is being designed for a prime mission of 6 years after it reaches Mars, with the capability to serve for an additional 4 years if its mission is extended. Over that period, it could support an assortment of spacecraft studying Mars from orbit, as well as at or near the surface, including landers, rovers, aircraft or dispersed ground stations.

Spacecraft

The spacecraft design concept is currently being studied. At launch, the spacecraft is expected to weigh about 2 tons, most of which would be propellant to be expended getting into Mars orbit. On orbit, the spacecraft would span more than 7 meters (23 feet) across. Its most prominent feature, besides the large solar arrays required to power it, would be a large dish antenna with a diameter in the range of 2 to 3 meters (7 to10 feet). From Mars orbit, that narrow-beam antenna would communicate with Earth-based antennas in NASA's Deep Space Network in both the X-band and the Ka-band of radio frequencies.

Other antennas with broader beams will be mounted on an independently pointable platform. These antennas will cover the ultra-high-frequency band and the X-band of radio frequencies. They are designed for the other leg of the relay job, communicating with other craft on or near Mars' surface.

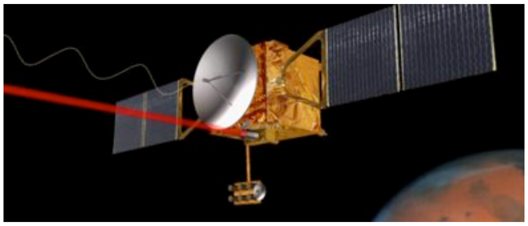

Figure 2. Artist concept for the Mars Telecommunications Orbiter at Mars. (Note: Radio and Optical beams simulated.)

As part of a technology demonstration project, Mars Telecommunications Orbiter would carry an optical communications terminal with a 30-centimeter-diameter (12-inch) telescope to communicate with a terminal on Earth using a highly focused laser beam. The Earth terminal will use a telescope with an effective aperture of about 5 meters (16 feet). This Mars Laser Communication Demonstration Project will demonstrate a capacity of 10 megabits per second, with a goal of 30 megabits per second, making it the first high-rate, deep space optical communications experiment. The high data-rate potential of optical communications makes the technology appealing for extensive use in future planetary missions. This demonstration project is intended to build experience for weighing the speed advantage of optical communications against the susceptibility of having the communications channel blocked by clouds.

Mars Telecommunications Orbiter would also demonstrate a key technology for orbital rendezvous by taking to Mars a sphere about the size of a soccer ball. It would release the sphere, then track its location from separation distances of up to about 6,000 kilometers (3,600 miles). This task would be a test run of technology that could be needed to support a possible future Mars sample-return mission to collect rocks from Mars and bring them back to Earth. Such a mission would likely launch a sealed sample-return capsule from Mars' surface for retrieval by a spacecraft temporarily orbiting Mars but capable of returning to Earth. Precise knowledge of the capsule's location would be needed for the retrieval to succeed. The sphere to be tracked by Mars Telecommunications Orbiter would mimic the physical properties of a sample-return capsule, providing a demonstration of systems for locating it from a great distance.

Project/Program Management

NASA's Jet Propulsion Laboratory, a division of the California Institute of Technology, Pasadena, manages the Mars Telecommunications Orbiter project for the NASA Office of Space Science, Washington, D.C.

The Mars Laser Communications Demonstration Project is being provided by NASA's Goddard Space Flight Center, Greenbelt, Md. The Massachusetts Institute of Technology's Lincoln Laboratories, Lexington, Mass., is providing the flight terminal for the demonstration. JPL is developing the ground station.

The spacecraft will be constructed by an industry contractor. NASA plans to issue an industry wide request for proposals for that contract in late 2004. Conceptual studies for the spacecraft design have already been completed by four aerospace companies: Ball Aerospace, Boulder, Colo.; Lockheed Martin Space Systems, Denver, Colo.; Northrop Grumman Space Technology, Redondo Beach, Calif.; and Spectrum Astro, Gilbert, Ariz.

For Mars Telecommunications Orbiter, Dr. Ramon DePaula at NASA Headquarters is program executive and Tom Komarek at JPL is project manager. For the Laser Communication Demonstration, Richard Fitzgerald at Goddard is project manager and Dr. Steve Townes at JPL is acting principal investigator.