MARS OCCULTATION MICROMISSION

Concept Description

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Summary

The goal of the Mars Occultation Micromission is to provide daily vertical profiles of the pressure and temperature of the Martian atmosphere at more than 30 locations distributed over the Martian surface. These data will be used to provide the inputs to detailed Martian climate models.

The mission will consist of two microsatellites launched as piggyback payloads on an Ariane 5. The microsatellites will be placed in an elliptical orbit with the two satellites going in opposite directions in the orbit.

During each orbit, the radio signal between the satellites will be lost twice as Mars comes between the two satellites, and acquired twice as the satellites reemerge from behind Mars. During each Martian occultation, the radio signal traverses the Martian atmosphere. Accurate measurements of the Doppler shift due to the refractive index of the atmosphere will enable determination of the vertical pressure and temperature.

The mission can take advantage of other Martian orbiters. Most Mars orbiters will be able to transmit at a 8.4 GHz (X-band) through a low-gain antenna. The MOM microsatellites will be able to receive the radio signal from other Mars orbiters. These auxiliary orbiters would not have to be specifically pointed. With just one auxiliary orbiter available to transmit to either microsatellite, the number of possible occultation measurements approximately triples. The actual number of occultation measurements depends on the orbits of the auxiliary orbiters and on the orbits chosen for the microsatellites.

The two microsatellites can also be used to support landers and rovers on the Martian surface. Each microsatellite can include a light UHF radio system for transmission of commands and reception of telemetry from landers and rovers, and relaying the telemetry to Earth through the X-band radio system. The two microsatellites can greatly increase the number of possible contacts per day to Martian landers or rovers.

radioscience

Mission Description

The two MOM microsatellites will be launched as piggyback passengers on an Ariane 5 rocket used to place communication satellites into geosynchronous transfer orbit (GTO). From GTO the microsatellite propulsion system will be used to place the microsatellites onto Mars approach trajectory after a lunar flyby. At Mars the microsatellites will be placed in an elliptical orbit with the two satellites going in opposite directions in the orbit.

The payload of each microsatellite will consist of only a sophisticated radio system. The radio system will be used for navigation and for communication to the Earth during approach to Mars and after reaching Martian orbit, and for transmission of radio signals to each other. During each orbit, the signal between the satellites will be lost twice as Mars comes between the two satellites, and acquired twice as the satellites reemerge from behind Mars. During each Martian occultation, the radio signal traverses the Martian atmosphere. Accurate measurements of the Doppler shift due to the refractive index of the atmosphere will enable determination of the vertical pressure and temperature. If the orbital period is 3 hours, with four occultations per orbit, there will be about 32 vertical profiles determinations per day.

In addition, it will probably be possible for the microsatellites to perform measurements using other Martian orbiters. For example it might be arranged to have Mars Global Surveyor, Mars Climate Surveyor, or other Martian orbiter to transmit at 8.4 GHz through the low-gain antenna used for these orbiters. These auxiliary orbiters would not have to be specifically pointed. If the auxiliary satellite does not have an ultra-stable oscillator that can be used as a frequency reference, then it will often be possible for the auxiliary orbiter to lock onto an uplinked signal from the DSN and transmit at 8.4 GHz coherent with the DSN signal. This capability for the microsatellites to receive signals from other Mars orbiters geometrically increases the number of possible occultation measurements and global coverage. With just one auxiliary orbiter available to transmit to either microsatellite, the number of possible occultation measurements approximately triples. The actual number of occultation measurements depends on the orbits of the auxiliary orbiters and on the orbits which can be achieved given the severe mass constraints associated with the micromission launch using the Ariane 5 piggyback capability.

During each occultation, one satellite will receive the signal transmitted by the other satellite. The Doppler shift of the received signal will be precisely measured by the receiving satellite. The science data consists of the time series of Doppler measurements during the few seconds that the signal is traversing through the Martian atmosphere. Each occultation will provide a few tens of kilobytes of information for later transmission to Earth using the microsatellite's radio communications link to the NASA Deep Space Network (DSN).

Radio System Description

Recent spacecraft sent to Mars include a radio system for communication with the Earth, that receives signals from the DSN at 7.4 GHz and transmits to the Earth at 8.4 GHz (X-band). The MOM microsatellites will use the same basic radio system. The radio system will include a high-gain antenna for communication to the Earth and a low-gain (omnidirectional) antenna for satellite-satellite measurements and for emergency communication to the Earth. To support the satellite-satellite measurements, the MOM orbiters will include a second receiver for reception of signals at 8.4 GHz. Each satellite will also include an ultrastable oscillator (USO) and a Doppler measurement system.

During an occultation, the first satellite will transmit at 8.4 GHz through a low-gain antenna, with the signal phase-coherent with its USO. The second satellite will point its high-gain antenna at the first satellite and receive the 8.4 GHz signal and measure its Doppler shift. After the occultation, the second satellite will transmit the Doppler data to Earth while transmitting at 8.4 GHz. A switch will be used on the high gain antenna feed to alternate between transmission and reception at 8.4 GHz. The satellite will never transmit while receiving an 8.4 GHz occultation signal. During occultation, the 7.4 GHz receiver will remain active for reception of commands from the DSN through a low-gain antenna.

Using 8.4 GHz as the occultation signal frequency allows each satellite to use only one high-power radio transmitter, and allows for the reception of signals from other Mars orbiters that will be able to transmit 8.4 GHz. Using 8.4 GHz as the signal frequency prevents the use of two-way signals during occultations, requiring the use of a USO on each spacecraft.

Besides the X-band radio system, the MOM microsatellites can also include a radio system for communication with Mars landers. These landers use UHF (~400 MHz) for transmitting and receiving radio signals. The Netlanders may also transmit at 2 GHz (S-band) for measurement of the ionosphere. The MOM microsatellites can use the Doppler measurement system used for occultation measurements to record the Doppler shift of the Netlander radio signals to support the Netlander Geodesy Experiment, which requires high-precision Doppler measurements to determine properties of Mars from variations in the Martian rotation.