The Rotation and Interior Structure Experiment (RISE) for the InSight mission to Mars. W. M. Folkner[1] , S. W. Asmar[1,] V. Dehant[2] and R. W. Warwick[3], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, [2]Royal Observatory of Belgium, Brussels, Belgium, [3]Lockheed Martin Space Systems, Denver, CO 80201.

Introduction: The InSight mission goals are to improve knowledge of the interior structure of Mars. The goals of the Rotation and Interior Structure Experiment (RISE) are to deduce the size and density of the martian core through estimation of the precession and nutation of the spin axis. The precession and nutation estimates will be based on measurements of the relative velocity of the InSight lander and tracking stations on Earth. The velocity is related to the Doppler shift of radio signals transmitted from the tracking stations to the lander where they are detected and re-transmitted back to Earth. Doppler measurements are crucially important for navigation of the spacecraft from launch to arrival on Mars. The RISE measurement requirements can be met without any additional equipment but do place constraints on the locations of antennas on the lander.

Previous and expected results from Doppler measurements: The precession rate of the Mars spin axis was estimated originally using Doppler measurements from the Viking and Mars Pathfinder landers [1]. The estimated precession rate clearly established that Mars is differentiated and gave constraints on the diameter of the core. Subsequently, Doppler observations of Mars Global Surveyor, Mars Odyssey, and Mars Reconnaissance Orbiter over more than a decade have allowed estimation of the precession rate through the effect of the martian gravity field on the spacecraft orbits [2]. The precession rate combined with estimates of the second order gravity field harmonic provide the total polar moment of inertia.

If the martian core is fluid, as indicated from estimates of the k2 Love number, then the nutation of the spin axis will show a signature that gives information on the polar moment of inertia of the core and the free-core nutation period, which depends on the size and shape of the core (i.e. the core flattening). Detection of the nutation signatures is not expected to be possible from further orbiter Doppler measurements. The RISE observations over one martian year should provide clear detection of the nutation signature. RISE will also provide improved estimates of rotation-rate variation, which are caused by seasonal exchange of CO_2 between the atmosphere and the ice caps.

RISE instrumentation: The RISE measurements will be made using X-band (8 GHz) radio signals transmitted between the Earth and the spacecraft. The radio equipment includes multiple antennas, a transponder for detection of signals from Earth and generation of signals coherent with the received signals, and a solid-state power amplifier for generating the signals transmitted back to Earth. The radio equipment will be largely the same as used for the Mars Exploration Rover mission [3].

For RISE, Doppler measurements will be made at times when the Earth is at low elevation, when the Doppler signature due to the rotation of Mars is largest. Two fixed medium-gain antennas, one pointed to the east and one pointed to the west, will be used to provide adequate gain for RISE.

Most of the data from the other InSight instruments (seismometer and heat-flow probe) will be transmitted to one or more Mars orbiters using a UHF radio. The orbiters will then relay the data to Earth. The relay of data through an orbiter allows more data to be sent for a given amount of electrical power on the lander than direct transmission to Earth. The use of two medium-gain antennas used for RISE will also allow a moderate amount of data to be transmitted directly to Earth in case of some problems with relay through an orbiter.

The UHF radio on InSight and on the orbiters do support Doppler measurements. These measurements will not be useful for geodesy purposes because of the large amount of multi-path errors experienced with the long wavelength (~0.75 m) and wide-bandwidth antennas used.

The accuracy for the RISE Doppler measurements is expected to be comparable with that achieved with Mars Pathfinder and the MER rovers. The longer duration and fixed location of the InSight lander will provide the capability needed to resolve the effects of the martian core on the nutation of the spin axis.

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