Radio science opportunities on Mars with an orbiter and lander(s).

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In the absence of a network of geophysical observatories on Mars, experiments in Martian geodesy have to be conducted by analyzing radio science data from space probes. The orbit of a spacecraft is usually determined from a radio link with the Earth but can be improved to a much higher precision from the radio link with a lander on the Martian surface. A radio science package is included in the future Martian lander GEP (Geophysical Experiment Package), which might take part in the future ExoMars mission. A mission to Mars with an orbiter and a lander will thus provide us with radio science data of very high quality, which can be applied to geophysics in several ways. On the one hand radio science tracking data can be applied to the study of the gravity field of Mars, especially the time-variable gravity, which yields insight into the deep interior and the atmosphere dynamics. Tracking more than one orbiter simultaneously can serve to improve the determination of the lowest-degree time-variable zonal coefficients of the gravity field (J_2, J_3, J_4, and J_5) and the tidal response of Mars (the tidal Love number k_2). Spacecrafts around Mars have been mostly in high inclination orbits (Mars Global Surveyor, Mars Odyssey and Mars Reconnaissance Orbiter are at inclination I=93 degree, Mars Express at I=87 degree), limiting the ability to properly separate the contribution of each coefficient J_i. A new mission with a low orbital eccentricity and a favorable orbital inclination would allow decorrelating J_2 and J_3 from the higher-degree harmonic coefficients of the gravity field. Such an orbit will therefore better extract time-variable gravity and improve our knowledge of the atmosphere and interior of Mars. Furthermore, an orbiter reaching a low altitude at pericenter (below 200 km) will improve our knowledge of the local structure of the crust and lithosphere, by way of the study of static gravity anomalies. On the other hand the orbiter can be used to determine the rotation variations of Mars. The combination orbiter-lander offers a more interesting geometry with three radio links (lander-Earth, lander-orbiter, orbiter-Earth) than with an orbiter (or lander) alone, so that more accurate values of the Martian rotation parameters can be obtained. Since rotation parameters (precession, nutation, polar motion, and length-of-day variations) are directly linked to the state and dynamics of the core and deep mantle, radio science with an orbiter and a lander offers a wonderful opportunity to elucidate unresolved questions about the deep interior of Mars as well as its atmosphere. The combined analysis of radio science data from the orbiter and from the lander will allow us to go beyond the objectives of these experiments taken separately. Simulation results will be shown.