

High-Powered Radar Sounders for the Investigation of Jupiter's Icy Moons. A. Safaeinili, E. Rodriguez, and Wendy Edelstein, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, e-mail: ali.safaeinili@jpl.nasa.gov.

Introduction: Radar sounders provide the unique capability of investigating the interior of planetary and small bodies. In mono-static configuration, a radar sounder (generally nadir-pointing) transmits radio waves and receives returned echo from both surface and subsurface of the body. The radar echoes can be analyzed on-board or on the ground to reveal the complex dielectric distribution of the subsurface that will reveal the internal stratigraphy and other geological features. For planetary applications, radar sounders can be used to provide details about the subsurface of planets such as the existence of liquid water under the surface, thickness of ice in polar caps and other regions (e.g. application to Mars) or detection of liquid water under icy crust of Europa. An entirely different application is possible for small bodies (asteroid and comets) where radio reflection tomography can provide 3-D volumetric structure (e.g. Kofman et al., 1998, Safaeinili et al., 2002).

Currently, there are two radar sounders planned for Mars. The first is MARSIS (Picardi et al., 2002) that is planned to start operation at Mars in early 2004. MARSIS is designed with a high relative bandwidth over a frequency range extending from 0.1 MHz to 5.5 MHz. In the subsurface sounding mode, MARSIS has four distinct 1-MHz centered at 1.8, 3, 4 and 5 MHz. The second is SHARAD (Seu et al.) planned to arrive at Mars in 2005. SHARAD has a bandwidth of 10-MHz centered at 20 MHz.

Investigation of Jupiter's Icy Moons: If liquid water is present under the icy surfaces of Europa, Ganymede, and Callisto, a HF/VHF radar sounder has the potential of detecting the depth of such interface and the stratigraphy that may exist in the ice shell. In 1999, a study was carried (Blankenship *et al.*) that defined a radar sounder instrument mission to detect Europa's ice/water interface. This study recommended a 50-MHz radar with a 100 m depth resolution with ice/water interface detection capability up to a depth of 20 km under nominal scenarios achieved by a radiated power of 20 W. The proposed design by this team was driven by factors such as Jupiter background noise, and expected subsurface attenuation in the icy medium. This design may need to be modified to take advantage of the high level of power and data rate provided by the new generation of spacecraft considered for the JIMO mission.

High-Power Radar: A radar sounder's performance depends on its ability to penetrate deep in the subsurface. Deep penetration is especially critical for

the detection of water/ice interface in Europa whose depth is uncertain. The ability to penetrate in the subsurface is directly dependent on the radiated power by the radar. MARSIS and SHARAD's dynamic range is limited to ~ 50 db dictated by the galactic background noise and radar's radiated power. One method to increase the dynamic range further is to increase the radiated power. Both MARSIS and SHARAD have a radiated power in the order of 10 W. An increase of this radiated power to 1-10 kW will increase the dynamic range by 20-30 db.

Technology Readiness: The technology to implement a high-power radar sounder is well within reach. A considerable amount of heritage for radar sounding already exists. Airborne ice-sounders have been used successfully since 1960s (e.g. Gudmandsen, 1971). MARSIS on ESA's Mars Express spacecraft (Launch May 2003), and SHARAD on NASA's MRO spacecraft (Launch 2005) will demonstrate the orbital measurement techniques. During the study phase for the Europa Orbital Radar Sounder, two independent antenna studies were completed. Both concepts consisted of a 3-element Yagi array excited with a low power (100W) transmitter. Also a 100W high-efficiency transmitter has been prototyped. High power (KW) HF/VHF SSPA technology is mature. The Technology Readiness Level (TRL) of the instrument is 3-5.

This talk will address the main drivers in the design of a radar sounder for the JIMO mission and provide a potential solution that will optimize the chances of success in the detection of ice/water interface and subsurface stratigraphy.

References:

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