Fine Resolution Topographic Mapping of the Jovian Moons: A Ka-band High Resolution Topographic Mapping Interferometric Synthetic Aperture Radar. S. N. Madsen[1] F. D. Carsey[1], E. P. Turtle[2] and , [1]Jet Propulsion Laboratory, MS 300-227, 4800 Oak Grove Dr., Pasadena, CA 91109, soren.n.madsen@jpl.nasa.gov, [2]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721 USA.

Introduction: The topographic data set obtained by MOLA has provided an unprecedented level of information about Mars' geologic features. The proposed flight of JIMO provides an opportunity to accomplish a similar mapping of and comparable scientific discovery for the Jovian moons through use of an interferometric imaging radar analogous to the Shuttle radar that recently generated a new topographic map of Earth. A Ka-band single pass across-track synthetic aperture radar (SAR) interferometer can provide very high resolution surface elevation maps. The concept would use two antennas mounted at the ends of a deployable boom (similar to the Shuttle Radar Topographic Mapper) extended orthogonal to the direction of flight. Assuming an orbit altitude of approximately 100 km and a ground velocity of approximately 1.5 km/sec, horizontal resolutions at the 10 meter level and vertical resolutions at the sub-meter level are possible.

Science applications:

High-resolution topographic data of the surfaces of the icy Galilean satellites would be immensely valuable to improving our understanding of the surface geology and geologic processes (both endogenic and exogenic) and of the subsurface structures of these bodies. Such a data set, in combination with theoretical models, would allow strong constraints to be placed on the satellites' interior structures and material and thermal properties. For example, quantifying the extent to which impact craters have undergone viscous relaxation [*e.g.*, 1-3] will constrain the rheology, and thus temperature, of the ice. Knowledge of the thermal structure of these satellites is essential for understanding the current states and evolution of their interiors. Topographic data would also provide a necessary tool for discriminating between different formation theories for geologic features that are unique to these bodies such as Europa's double ridges and chaoses [*e.g.*, 4-6] and Ganymede's grooved terrain [*e.g.*, 7-8].

Instrument Details: Synthetic Aperture Radar (SAR) imaging allows photo-like high resolution strip images to be generated from orbital height. The resolution mechanisms are ranging and antenna synthesis that provides a narrow antenna beam in the along-track dimension, on the order of half the physical antenna's length. Each pixel element of a one-look SAR image holds amplitude and phase information. By interfering two SAR images it is possible to measure displacements at the fractional wavelength level. If an interferometric SAR system (InSAR) uses two antennas displaced across the direction of motion and orthogonal to the look direction, it is possible to locate the radar return in three dimensions, a capability that has recently been used to generate the most accurate global digital elevation data for Earth [9]. A second way to utilize interferometric information is, if a given repeat pass geometry can be repeated at two different times, in which case InSAR can be used to measure deformation/displacements at the fractional wavelength scale.

The instrument that we are here suggesting will apply a 5 m long boom extended orthogonal to the direction of flight. The frequency applied would be 35 GHz (8 mm wavelength) and the peak transmit power would be 5 kW. The antennas at the tip of the boom would be 2 m long and 5 cm in width. The system would have the capability to look both right and left simultaneously, imaging swaths on the order of 30 km. The performance of the resulting data would be described by the equation:

$$dH \times dV \geq 10 \text{ m}^2$$

where dH is the linear horizontal resolution and dV the elevation accuracy, e.g. if a 1 m vertical resolution is required, the best horizontal resolution would be 10 m.

Calibration schemes: Measuring relative heights within the 30 km swaths on either side of the ground track, is relatively simple, achieving absolute height accuracy is more difficult. Other than system issues (delays, phase shifts etc.) the attitude of the spacecraft is needed with great accuracy. Mapping both to the right and left is critical in that regard. Unknown roll-angle of the spacecraft will impact the heights of the right and left swaths in opposite directions, thus orbit crossing analysis can be used to refine the roll and the height measurements to a level comparable to the height noise of the data.

References:

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