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MARS GLOBAL SUBSURFACE SOUNDER

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Abstract

The MARSIS and SHARAD orbital radar sounders have given tantalizing glimpses of sub-surface fof Mars [1,2]. Unfortunately, to accommodate these investigations aboard spacecraft with a number of other high-level investigations, MARSIS and SHARAD had to accept some compromises in instrument design and operation that have limited their potential capabilities. Here we describe a proposal for a new Mars orbital radar mission that would be solely dedicated to sub-surface sounding, to achieve maximum spatial resolution and penetration depth through an optimized orbit, antenna design, increased power and significantly improved signal to noise ratio..

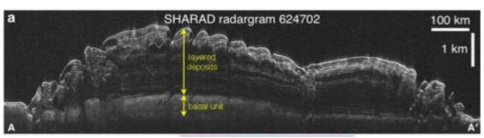

Figure 1. Sharad Radargram ((Image credit: NASA/JPL-Caltech/University of Rome/Southwest Research Institute/University of Arizona)

1. Science Goals

The chief science goals of this mission are to investigate the stratigraphic and structural evolution of the Martian subsurface and polar layered deposits (PLD), as well as the distribution and state of subsurface water (whether present as a liquid or as massive ice deposits) through the acquisition of a 3-D radar map to depths in excess of 1 km in predominantly lihic environments and 4 km within the PLD.

The MARSIS and SHARAD radar investigations have provided clear demonstrations of the capabilities of deep-sounding radar to conduct such investigations of the PLD [3-5], mid-latitude lobate debris aprons [6, 7], pedestal craters [8], the Medussa Fossea Formation [9. 10], the frozen 'sea' in Athbasca Vallis [11], as well as map the variation in global surface dielectric properties to ~100 m depth [12] The Mars Global Subsurface Sounder (MGSS) is expected to significantly improve on this performance by taking advantage a spacecraft and mission optimized for radar sounding.

2. Methodology

Over a mission duration of 2 years, the MGSS will be able to compile a global 3-D map of local variations in dielectric properties at a spatial resolution of H: ~1 km V: ~10-20 m in top 1 km, with a maximum potential sounding depth in excess of 4 km in the PLD. The identification of structural, lithologic, and volatile signatures will be aided by comparisons between the radar and other remote sensing data.

3. Mission Approach

MGSS is a dual-band radar sounder that operates at 1-6 MHz and 15-25 MHz. 2-D SAR processing is used to maximize both along and cross track resolution and clutter suppression, while onboard along track processing minimizes the downlink data rate. The spacecraft has sufficient mass margin to incorporate sufficient shielding minimize signal degradation by electromagnetic interference and maximize the signal to noise ratio.

The orbit of MGSS is is similar to that of the Mars Reconnaissance Orbiter, being nearly sun synch-ronous at 92.6° at an altitude 300 km. This orbit results in the acquisition of 13 complete ground tracks across the planet each solar day, with an orbital precession rate of about 500 m/day. Thus, a full global survey can be completed in two Martian years.

A synthetic aperture and cross-track array proces-sing minimize the effects of surface clutter and improve the effective depth of sounding.

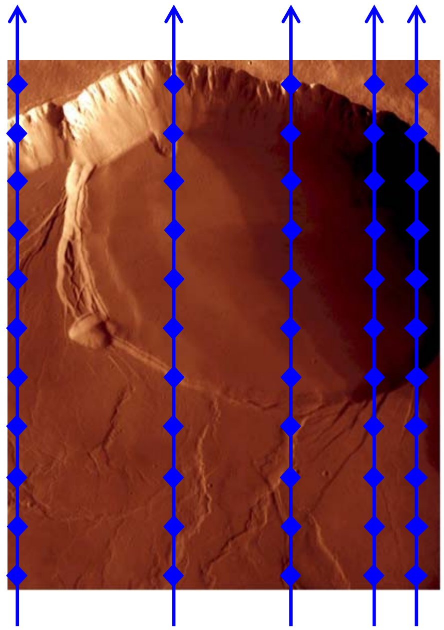

Figure 2: Orbits produce 2-D Synthetic Array

Our large synthetic aperture in cross track is formed by sequential orbital passes. The orbits are sufficiently random to eliminate grating lobes. Array processing techniques, such as constrained optimization, can then be used to steer nulls in the direction of the surface clutter.

The spacecraft's computer has sufficient processing and memory for on-board signal processing, thus reducing the output data rate needed for downlink. A data rate of 280Kbps is sufficient to return data for building up a global radar map over two Martian years.

4. Summary and Conclusions

This mission proposal is an evolution of one that was originally developed in response to NASA's request for Mars Scout Mission Concepts in 2001 [13]. In light of the lessons learned from the MARSIS and SHARAD investigations, it appears that significant improvements can be made in an orbital radar sounder's performance and coverage when the spacecraft and mission are optimized for this purpose. This is particularly true of the low-frequency investigations conducted by MARSIS, which were seriously constrained by the highly eccentric orbit of Mars Express. A dedicated radar sounding mission, such as MGSS, offers the opportunity to greatly expand our understanding of the geologic and volatile evolution of Mars.

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