A PRELIMINARY STUDY OF THE POTENTIAL FOR HIGH RESOLUTION PARAMETRIC RADAR IMAGING OF MARS BY GROUND-BASED RADAR; R.F. Jurgens, S.D. Howard, M.A. Slade, L. Robinett and D. Strobert, Jet Propulsion Laboratory

Radar imaging of Mars presents a difficult problem because the product of its delay dispersion and Doppler frequency spread is a number much greater than one for all radar frequencies for which ground-based facilities could be used. As a result, delay-Doppler radar imaging techniques are troubled with multiple ambiguities. Despite this problem, a number of techniques have provided useful imagery since the first CW observations made by Goldstein and Gillmore [1] revealed the highly radar variable surface of Mars.

Downs et al. [2] and Pettengill, Shapiro and Rogers [3] demonstrated that moderate resolution images of altimetry and scattering parameters could be built up using the apparent equatorial edge which is free of the two-fold ambiguity associated with the entire delay-Doppler image. This technique was further refined by Downs, Reichley and Green [4] and provides altimetry, Fresnel reflectivity, and Hagfor's C parameter values for each pixel (8x100 km) in the image. Unfortunately, only a small portion of the planet has been mapped, and most of the delay-Doppler echo remains tantalizing. These stand as the highest resolution radar imagery available.

Most recently, low resolution full disk images have been made by Muhleman et. al. [5] using the Goldstone/VLA unfilled aperture to resolve the disk (a procedure immune to the multiple ambiguities but somewhat limited by grating lobes), by Thompson and Moore [6] using forward modeling of geological units, by Hudson and Ostro [7] using direct inversion modeling. The latter two techniques rely on acquiring a large number of CW spectra for all longitudes and as many latitudes as possible. The former is capable of nearly continuous imaging as the planet rotates revealing the scattering properties of surface units. These techniques are able to provide global coverage at resolutions on the order of a hundred km. Currently, the procedures are useful only with the SC (same sense circular) polarization data, since the scattering law of the OC (opposite sense circular) polarization shows the strong and highly variable quasi-specular scattering that either greatly complicates the modeling or reveals the grating lobes.

During the 1988 opposition of Mars, the first radar interferometer experiment using DSS-14 on two successive and nearly over-lapping tracks failed due to hardware difficulties. Such overlaps are infrequent, and only a small amount of coverage can be obtained. For that reason, we have implemented a bistatic interferometer to resolve the two-fold ambiguity of the conventional delay-Doppler image. The technique is not useful for the SC polarization as it relies on the strong quasi-specular scattering to minimize the range ambiguities. Test data were acquired during four tracks of the 1990 opposition of Mars. Full imaging capability can not be achieved until algorithms are developed that do 3D surface modeling. However, we have created a preliminary video animation that provides convincing evidence that images of altimetry, Fresnel reflectivity, and Hagfor's C parameter could be deriived for each pixel (roughly 8x8 km) in the image. An intensive radar survey could provide coverage of 40% of the Martian surface in the equatorial region. Thus, maps equivalent to the Pioneer-Venus radar imagery (see Masursky et.al. [8]) but with roughly 300 times higher areal resolution seem possible over most of the surface.

Figures 1 and 2 show the relative radar sensitivity for various Martian oppositions since 1970 to 2000 for monostatic and bistatic experiments at Goldstone respectively. The lower curve (squares) indicates the sensitivity at 12.5 cm had no up-grades been made since 1970. The upper curve (+'s) shows the 3.54 cm sensitivity which became available in 1975. This curve, however, shows substantial increases due to the 70m antenna development in 1986, the 0.5 MW transmitter up-grade in 1991, and finally the full 1.0 MW up-grade in 1995. The center curve beginning in 1986 shows the 12.5 cm improvement due entirely to the 70 m antenna up-grade. Figure 2 show the sensitivity of an interferometer formed from DSS-13 and DSS-14. Substantial improvement arrives in 1991 as the new 34 m DSS-13 antenna comes on line and later with a super-cooled Maser augmented by the improvements shown in Figure 1 to DSS-14. These curves demonstrate that any experiment that could be performed at the times of the best oppositions (for example 1971-73) can now be performed at any opposition, for longer periods of time, and with better signal to noise ratio. Obviously, the close oppositions near the year 2000 could provide phenomenal data sets.

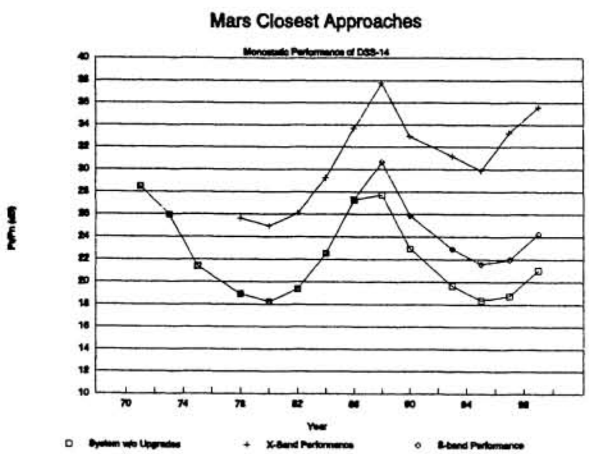

Figure 1

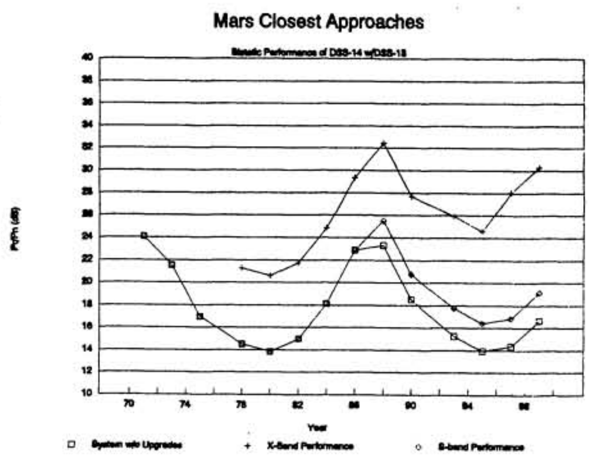

Figure 2

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