Natural Radio Source and Spacecraft Signal Measurements at Ka-band (32.0 GHz) and X-band (8.4 GHz) Using a 34-Meter Beam-Waveguide Antenna

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Several telecommunications studies performed by the NASA Deep Space Network (DSN) have shown that by utilizing K_a-band (31.8 to 32.3 GHz) frequencies over X-band (8.40 to 8.45 GHz) frequencies on a spacecraft-to-ground communications link, a potential advantage of 6 to 8 dB (factor of 4 to 6 improvement) can be realized for equivalent spacecraft radio system configurations. The increased advantage comes from increased antenna gain at the shorter wavelengths and can be used to increase data volume, decrease transmission time, decrease transmitter power on the spacecraft, decrease spacecraft antenna size, or allow for a smaller antenna on the ground. However, the advantage can be reduced by higher atmospheric noise, decreased ground station antenna efficiency, and weather susceptibility at K_a-band.

The concept of conducting a K_a-band link experiment to verify these studies and to better understand any difficulties that could deter this performance gain from being realized became reality with the Mars Observer Project's KaBLE (Ka-Band Link Experiment). KaBLE utilized data acquired by the DSS-13 34-meter beam-waveguide (BWG) antenna in Goldstone, California while tracking Mars observer's Ka-band beacon (33.7 GHz) and X-band signal (8.4 GHz) between January and August, 1993.

With the loss of Mars Observer, it became important to continue the study of the link advantage until another spacecraft with Ka-band capability became available. The KaAP (K_a-band Antenna Performance Experiment) project was initiated in December 1993 to evaluate antenna efficiency by observing natural radio sources at both Ka-band and X-band. These ongoing evaluations allowed the antenna efficiency and weather effects at each frequency band to be measured as incremental performance improvements and configuration changes were realized at the ground station. The ground station advantage of K_a-band relative to X-band is quantified using the acquired efficiency data from both bands. This information benefits the DSN and future flight projects considering Ka-band. The knowledge gained about the temporal variability of the K_a-band advantage due to weather effects will allow planners of future flight projects to develop robust, efficient telecommunication strategies at Ka-band. The effort also facilitates the demonstration and development of optimal operational strategies for BWG antennas.

Two spacecraft with Ka-band equipment will be available during the next two years. Surfsat-1, launched on November 4, 1995, is a DSN Technology Program flight experiment. Surfsat-1 tracking data are currently being acquired and analyzed for the purpose of characterizing the link advantage. Mars Global Surveyor (MGS), scheduled for launch in November 1996, will carry KaBLE-II, another DSN Technology Program experiment. These missions allow Ka-band link advantage studies to continue using X-band and K_a-band spacecraft signal sources.

This paper will focus on the KaAP antenna efficiency characterization of the DSS-13 BWG antenna using natural radio source observations as well as weather statistics gathered at Ka-band. Current status of the Surfsat-1 measurements as well as plans for KaBLE-II experiments will also be discussed.

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