

Ka-Band Atmospheric Noise Temperature Measurements at Goldstone, California Using a 34-meter Beam-Waveguide Antenna

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The NASA Deep Space Network (DSN) is evaluating the use of the Ka-band (32 GHz) downlink frequency band for deep space telecommunications. Ka-band (32 GHz) is 3.8 times higher in frequency than the DSN's operational X-band (8.4 GHz) frequency. Ka-band provides an advantage of 11.6 dB (ratio of 14.5) over X-band in the spacecraft EIRP when the same spacecraft transmitter output power and the same effective antenna size are used. In practice, the Ka-band downlink advantage over X-band is reduced to about 7 dB due to higher atmospheric noise, decreased ground station antenna efficiency, and increased weather susceptibility. This higher Ka-band advantage, relative to X-band, can be used to reduce cost, power, mass, or volume of future deep radio telecommunications systems on board spacecraft. It is important to statistically characterize Ka-band atmospheric effects at the specific DSN tracking sites in order to quantify the advantages of using Ka-band.

The SurfSat-1 link experiment provided spacecraft signal strength measurements using the NASA DSN R&D 34-meter beam waveguide antenna, DSS-13, at Goldstone, California. In addition to signal strength, total power radiometer (TPR) data were acquired for the purpose of noise calibration. X-band and Ka-band TPR data from 192 of these experiments, conducted between November 1995 and October 1996, were acquired over a wide range of elevation angles. The passes were typically 5 to 20 minutes in duration and occurred within 3 hours of sunrise and sunset.

The Ka-band TPR system operating noise temperature (Top) data were recorded and analyzed as a function of elevation angle. The data were used to solve for the equivalent atmospheric noise contribution (Tatm) and attenuation of one mass of atmosphere (antenna zenith or 90 degree elevation angle) at Ka-band. A least-squares solution for Tatm was fit through the Top data which were acquired as the antenna was moved through various elevation angles (antenna tipping curves). The antenna's field-of-view (beam) over the fitted data encountered one air mass at the zenith to 5.5 air masses at 10.5 degree antenna elevation angle. The statistics and cumulative distributions of these measurements will be presented along with intercomparisons of independent estimates derived from concurrent water vapor radiometer (WVR) data, and a surface model.