Atmospheric-Induced Effects Observed on Deep Space Ka-band Carrier Signals

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Atmospheric loss fluctuations due to water vapor and liquid water contribute to fluctuations in 32 GHz (Ka-band) signals. Signal degradation due to the weather, principally rain fades, is a major concern for Earth orbiting satellites, which operate at high microwave frequencies such as Ka-band. One program initiated to quantify the rain fade problem, was the Advanced Communications Technology Satellite (ACTS), whose propagation experiments included statistical measurements on fade depths and fade durations. Since NASA deep-space missions operate at much weaker received signal levels, and hence tend to operate at lower margins, it becomes more important to characterize propagation effects at these high microwave frequencies, in order to develop optimum telemetry data return strategies. During weather characterized by high atmospheric liquid water content and varying wind speeds, there will be significant variations in a received spacecraft's signal strength, and thus will have an impact on spacecraft telemetry data return. The dominant effect of severe (cloudy/rainy) weather on received Ka-band signals will be fading on received spacecraft signal strength (amplitude or SNR). The contributions due to liquid water are expected to have a lesser effect on path delay rate (frequency). In addition to rain fading, other atmospheric-induced effects on a spacecraft signal's SNR include scintillation and increased thermal noise.

This paper will report on atmospheric induced effects observed on received Ka-band carrier signals of deep-space missions, which were recorded on open-loop receivers. Signal amplitude and phase were extracted from the open-loop data samples acquired during worst-case and nominal weather passes. These data were analyzed in order to extract fluctuation information at the various time scales of interest and compared against model predictions. It is important to characterize these fluctuation effects at Ka-band on short time scales (~ 1 sec) that are comparable to that of telemetry data frames, in order to develop strategies that maximize data return at high data rates. This work will be useful to prepare for and plan future Ka-band experiments and operations on spacecraft that will have Ka-band telemetry links. The research described in this paper was carrier out by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

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