An Analysis of System Performance Under the Severe Weather Conditions at Goldstone, December 1971

M. S. Reid
Communications Elements Research Section

Adverse weather conditions, unusual for the area in their severity, were experienced at Goldstone in December 1971. This article presents a summary of the analysis of the system performance under these conditions, and subsequent conclusions. The results of a brief study of cloud cover characteristics in the southwestern United States to a distance of several hundred miles from Goldstone, California, are also presented.

I. Introduction

Adverse weather conditions which were unusual for the area in their severity were experienced at Goldstone in December 1971. S-, X-, and K-band system sensitivity was degraded to a greater extent than has ever been recorded before at Goldstone. Some S-band tracking time was lost during this period. This article presents a summary of the analysis of the system performance and subsequent conclusions.

II. System Performance Analysis

Figure 1 shows S-, X-, and K-band system temperatures as a function of time for the period of December 27 through 30, 1971. Spacecraft tracking times are shown as well as S-band ground received signal loss computed from recorded automatic gain control (AGC) voltages. Weather conditions, antenna snow cover, and outside ambient air temperatures are also presented for this period. Snow started falling at approximately 1800 GMT, December 27, and again at approximately 2100 GMT, December 28. The two snowfalls stopped at about 0400 GMT, December 28, and 0900 GMT, December 29, respectively. Intermittent light rain preceded the first snowfall on December 27. Ambient air temperatures at DSS 14 dropped from December 25 to 29, when a low of $-8°C$ was recorded and the temperature was less than $-5°C$ for 4½ h.

The signal loss section of the figure shows that the received signal loss reached a peak of -5.5 and -7 dB in two of the three tracking periods covered.

In the lowest section of the figure, excess system temperatures are plotted for S-, X-, and K-bands. Excess system temperature is defined as that portion of the measured system temperature which is in excess of the system temperature to be expected in clear, dry weather at the given antenna elevation angle. S-band data are shown dotted, X-band solid, and K-band dashed. Data gaps, due to equipment malfunction or other problems, are shown by breaks in the lines. The S- and X-band data were reduced from analog records. The K-band

data were recorded in digital form. This recording system was limited in dynamic range, although it was more reliable than the analog system and capable of providing greater resolution. The limited dynamic range of the recording system is clearly shown in the figure when the system is saturated. S-band and X-band data were derived from total power radiometers. Gain stability and additional reliability were achieved at K-band by the use of a noise-adding radiometer (Ref. 1).

III. Conclusions

As a result of the experience gained by operation of the station during these severe environmental conditions, it was concluded that the primary effect of dry snow is not the snowfall itself in the atmosphere but rather the accumulation of snow on the antenna surface. This can reduce antenna efficiency and increase the operating noise temperature. The effect of severe environmental conditions, however, can be minimized by proper procedures modified by mission requirements. In the case of the December 1971 snowfall, the snow was wet and the ambient temperature below zero for many hours, with the result that the wet snow froze on the antenna surface. This made the removal of the snow and ice very difficult. Of the several methods used, the only successful one was tracking the sun when the weather cleared, which melted off the accumulated snow and ice.

The accumulation of snow or ice on the antenna surface must be avoided in as large a measure as possible by judicious stowing and dumping decisions. Real-time discussion between the project or experimenter and the station manager is necessary so that such decisions can be made effectively. Station procedures for operating under severe environmental conditions have been modified in the light of this experience. Furthermore, it is recommended that an investigation be made to consider the possibility of developing a reliable method to maintain the horn covers free of moisture and ice in all weather conditions. This is particularly important for the X- and K-band horns.

IV. Cloud Cover Characteristics Study

A brief study was commissioned from a contractor of cloud cover characteristics in the southwestern United States (Ref. 2). The purpose of the study was to obtain preliminary information, to a distance of several hundred miles from Goldstone, on the frequency of possible microwave attenuation and system degradation at various locations in the Southwest. Simultaneous observations of cloud cover were examined in pairs for six locations in California and Arizona. One member of each pair was a Goldstone reference in each case. The reference station was Edwards Air Force Base, which is one of the closest meteorological stations to Goldstone. The simultaneous occurrence of nearly-clear sky conditions at one of the locations was considered to be of primary interest. Data used in the study consisted of cloud cover observations taken four times per day at each location over an extended period of time.

The results of this preliminary study indicated that the probability of experiencing nearly-clear skies at one and/or the other of the paired stations increases when the second station is beyond George Air Force Base. On the other hand, an increase from approximately 100 miles to 200 miles from Goldstone does not significantly increase the probability. Furthermore, the characteristic storm tracks, which generally lie to the north of Goldstone, should also be taken into consideration. It may be concluded from the study that areas to the east and southeast represent the most favorable direction for improvement in overall cloud conditions.

References

1. Batelaan, P. D., Goldstein, R. M., Stelzried, C. T., "A Noise Adding Radiometer for use in the DSN," *The Deep Space Network*, Space Programs Summary 37-65, Vol. II, p. 66, Jet Propulsion Laboratory, Pasadena, Calif., 1970.
2. Smith, T. B., *Study of Cloud Cover Relationships*, Internal Document, Contract 953564, prepared for the Jet Propulsion Laboratory by Meteorology Research, Inc., Altadena, Calif., October 1972.

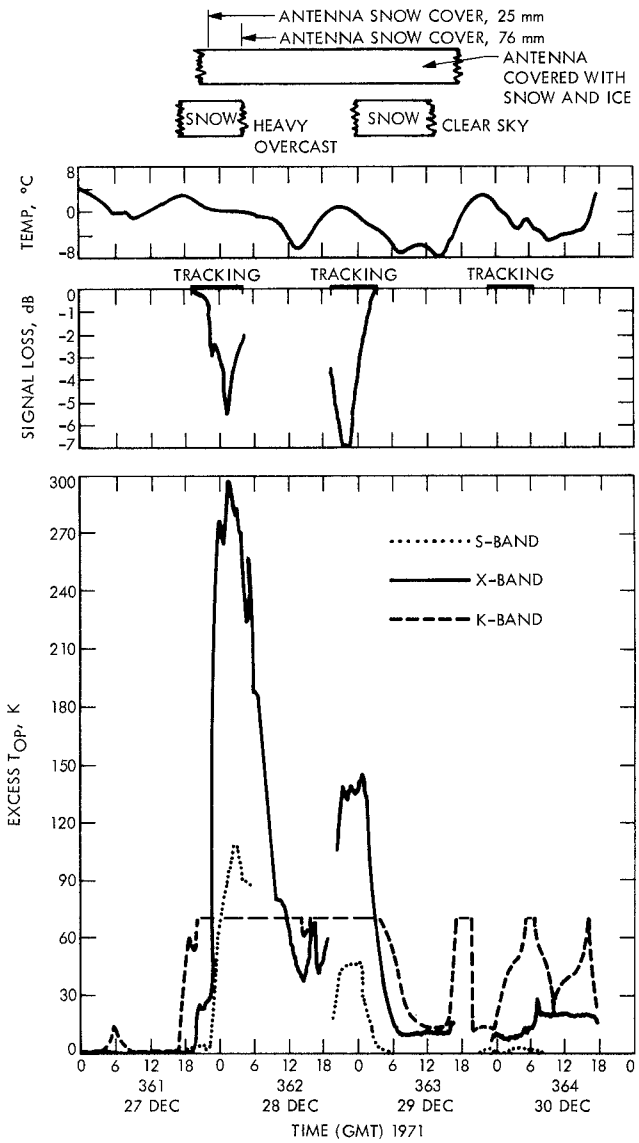

Fig. 1. Microwave and meteorological data, December 27–30, 1971