Voyager Mission Support

N. Fanelli and H. Nance
Deep Space Network Operations Section

This is a continuation of the Deep Space Network report on tracking and data acquisition for Project Voyager. This report covers the postencounter period for Voyager 2 and the Saturn cruise period for Voyager 1, August-September 1979.

I. Introduction

Voyager 1 continued in its Saturn Cruise phase with solar conjunction activities during the period of August 8 through 20, 1979. Voyager 2 completed the Post Encounter activities on August 28, 1979 and entered the Saturn Cruise phase. Solar conjunction activities were observed during the period August 8 through 29, 1979.

II. DSN Operations

A. Radio Science

One of the primary activities supported by the DSN during July and August was the special radio science activity conducted during the solar conjunction of both Voyager spacecraft and Pioneer spacecraft.

1. **Experiment objective.** The solar conjunction provided the Voyager Project with the unique opportunity to perform observations of the solar wind and solar corona as the ray paths from the Voyager spacecraft passed near the Sun. The observations greatly enhanced the knowledge of variations of the solar wind and corona in the region of the Sun. When combined with observations taken nearly simultaneously from Pioneer 11 and Pioneer Venus orbiter, the data are expected to yield important new information related to the plasma distribution near the disc of the Sun and over its north pole. The listing below outlines representative dates and changes in the Sun-Earth-probe (SEP) angle during the solar conjunction.

Date, 1979	Voyager 1, deg	Voyager 2, deg
August 2	14	8
August 8	11	5
August 12	7	2
August 14	6	1
August 16	4	2
August 18	3	3
August 20	2	4
August 21	1	5
August 24	2	7
August 26	3	8
August 28	4	9
August 29	5	10
September 1	7	12

Forty seven passes were scheduled for support of the solar conjunction activity; 24 passes were scheduled for Goldstone, Calif., 9 passes for Canberra, Australia, and 14 passes for Madrid, Spain. Each of the Voyager 2 passes required four hours of occultation data assembly (ODA) recording, and Voyager 1 passes required three hours of ODA recording. Data collection began on July 24, 1979, from Madrid, on July 31 from Goldstone and on August 8 from Canberra.

2. **Station configuration.** Special configuration, and in some cases extra equipment, was required during the support recording period. The extra equipment comprised an open loop receiver (OLR) and a multi-mission receiver (MMR) used to provide data to the ODA recorder. The standard closed loop receiver configuration for S-band and X-band radio metric data was used with selected doppler sample rates as specified for the particular pass.

The MMR/ODA equipment was used for the open loop data at Goldstone and Madrid, and the OLR/ODA equipment was used at Canberra. Filters, sample rates, and record number were changed during the activity based on experience gained and modified requirements. 1-kHz S-band and 3-kHz X-band filters were selected initially with 2000 sample/second and 8 bits quantization sample rate. Later, after special installation, 100-Hz filters were used with 200 sample/second and 8 bits quantization for S/X-band.

With the 1/3-kHz filters, Goldstone and Madrid calibrated the MMR output/ODA input power level for S/X-band at plus 16 dBm. Canberra OLR output/ODA input power level for the S/X-band was set at plus 12 dbm. With the 100-Hz filter used at all stations for S/X-band, the ODA input power level was set at plus 20 dBm.

Special ODA predicts were generated and made available from JPL for one- and two-way spacecraft modes. To minimize tape usage, the number of ODA records was initially set at 29,000 records or a record time per tape of 4.1 hours, but later changed to 25,000 records or 3.5 hours of data to insure that all data was included on one tape.

As the SEP became smaller, it was found that the solar plasma exceeded prediction and the 100-Hz bandwidth was exceeded. The stations were instructed to return to the 1/3-kHz filters and the 2000 sample/second and 8 bits quantization sample rate. The signal noise temperature (SNT) also increased with the decrease in SEP, and it became necessary to reduce the MMR/OLR output power to the ODA to prevent saturation. Solar activity was more intense than expected; therefore, a table of SNT vs MMR/OLR output power reduction was required. The resultant values were:

SNT, K	Reduction in MMR/OLR output, dB
40	1
80	2
125	3
200	4
500	5
800	6
1260	7

However, in no case was the output power reduced to less than plus 13 dBm.

To compensate for this changing calibration requirement, the stations were required to obtain the S/X-band SNT from the strip chart recorders for each pass. The SNTs were recorded for future reference. When time permitted, the current SNT was used to update the MMR/OLR output power levels for the pass; if time did not permit, the data obtained from the previous pass was used. The station equipment and personnel responded effectively under these changing and varying conditions, and the total data requirement was met by the DSN.

B. Command Capability

Up to the time of the Voyager solar conjunction, there were no quantitative data on command link performance degradation at small SEP angles. As a result, each flight project was forced to adopt a conservative command policy as it approached a solar conjunction. The Voyager Project used the opportunity during the solar conjunction period to collect such data. Command capability demonstration tests were conducted on selected Voyager 1 passes when the SEP angle was 5 degrees or less. The tests consisted of four dummy commands transmitted to Voyager 1 four separate times during the test period. Each series of commands was transmitted at a different uplink power level. The four uplink power levels were obtained by using different levels of transmitter power and modulation suppression of the uplink.

To meet this requirement, the stations were required to perform special calibrations. Additional pretrack preparation time was included in the schedule to support this requirement. The 64-meter stations were required to calibrate their transmitters for 10 kW, 6 kW and 4 kW. 26-meter stations calibrated their transmitters at 18 kW, 12 kW and 8 kW. Range modulation suppression was calibrated at the 64-meter stations for 3 dB, 4 dB and 16 dB, while the calibration at the

26-meter stations was for 3 and 10 dB. All stations verified that command modulation suppression values were calibrated with 3 dB and 0.54 dB.

The tests were successfully supported by the scheduled stations. The activity was highly successful in providing capability data. The results for the period of August 9-29 are contained in Table 1. The levels at which commands were and were not processed is contained in Fig. 1.

C. Other

During the period the stations routinely supported the various spacecraft activities and tests, such as radio frequency subsystem automatic gain control, command detector unit signal-to-noise ratio, antenna and sun sensor calibration, periodic engineering and science calibration, plasma calibration, magnetometer calibration, low energy charged particles, tracking loop capacitor, etc. These efforts all required special preparation and tracking activities by the stations. The resulting support provided by the DSN was excellent.

III. DSN Status

A. DSS 61 – Madrid

On August 9, 1979, the Madrid station was decommitted from project support operations and began an upgrade that will convert the station from a 26- to a 34-meter capability. This upgrade primarily increases the antenna size and included receivers for the reception of X-band signals. The station will return to an operational status on March 9, 1980.

B. DSS 62 – Madrid

The programmed oscillator control assembly was moved from DSS 61 to DSS 62 for the period of upgrade activities so that the capability would be available to uplink Voyager 2. With the loss of the radio frequency tracking loop capacitor in Receiver 2 and complete loss of Receiver 1 (see *Deep Space Network Progress Report 42-49*) it is necessary for the Voyager 2 uplink to be continually tuned to maintain the uplink. This equipment relocation allows a combination of a 26- and 64-m station coverage for both Voyagers during the viewperiod over the Spanish sector.

Table 1. Voyager 1 command capability demonstration test information

Test number	GMT DOY	SEP angle in, deg	First set of 4 commands: S/C RCVR AGC, dBm	First set: Predicted uplink, dBm	First set: dB above command threshold	Second set of 4 commands: S/C RCVR AGC, dBm	Second set: Predicted uplink, dBm	Second set: dB above command threshold	Third set of 4 commands: S/C RCVR AGC, dBm	Third set: Predicted uplink, dBm	Third set: dB above command threshold	Fourth set of 4 commands: S/C RCVR AGC, dBm	Fourth set: Predicted uplink, dBm	Fourth set: dB above command threshold	Total number of commands processed	
1	221	10	-124	-123	17	-135	-134	6	-137	-136	4	-137	-138	2	16	
2	229	4.4	-121 -129	-123	17	-133 -138	-134	6	-134 -145	-136	4	-137 -142	-138	2	16	Command No. 13 had 1 error corrected by CCS.
3	230	4.2	-122 -126	-123	17	-131 -135	-134	6	-133 -139	-136	4	-135 -141	-138	2	14	CMD 14 and 16 not processed. All lock changes were counted by CCS.
4	232	2.6	a	-123	17	a	-134	6	a	-136	4	a	-136	4	13	Confirmed by CCS hr summary on next day; due to bad D/L data.
5	234	1.4	a	-122	18	a	-125	15	a	-128	12	a	-131	9	15	One of the last 3 commands was not processed.
6	235	1.2	a	-123	17	a	-128	12	a	-132	8	a	-138	2	13	Confirmed next day by CCS hourly summary.
7	236	1.3	a	-123	17	a	-134	6	a	-136	4	a	-138	2	15	Confirmed next day by CCS hourly summary.
8	239	3.0	a	-123	17	a	-134	6	a	-136	4	a	-138	2	13	Confirmed next day by CCS hourly summary.
9	240	3.7	-120 -130	-123	17	-133 -139	-134	6	-131 -147	-136	4	-138 -150	-138	2	14	2 of the last 4 commands were not processed.
10	241	4.4	-122 -130	-123	17	-135 -138	-134	6	-137 -142	-136	4	-139 -140	-138	2	16	CMD 7 and 10 each had 1 error corrected by CCS.

[a]No usable downlink data.

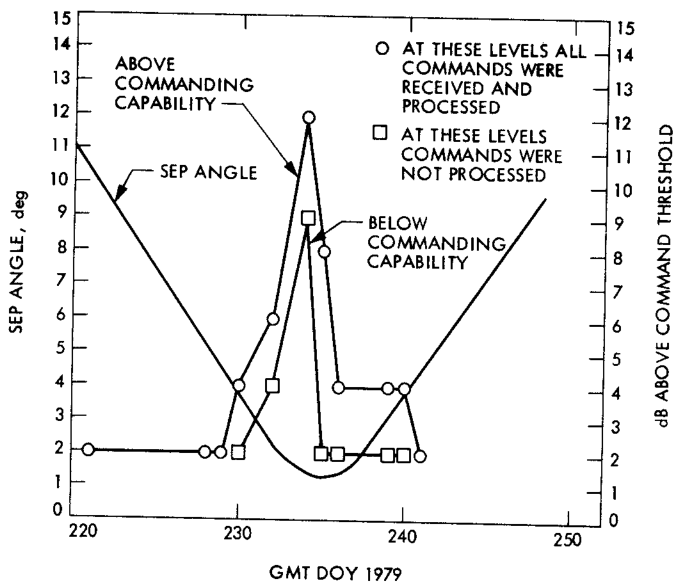

Fig. 1. Command threshold vs SEP angle