Voyager Mission Support

N. Fanelli and H. Nance
Control Center Operations

This is a continuation of the Deep Space Network report on tracking and data acquisition for Project Voyager. This article covers the period of April through June 1981.

I. Introduction

During this reporting period (April through June 1981), Voyager 1 was in the extended mission phase of operations. Voyager 2 completed the cruise phase of its operations and on 5 June entered the Observatory Phase of the Saturn Encounter operations.

II. DSN Support

A. Voyager 1

With the completion of the prime mission phase of Voyager 1 in December 1980, the emphasis was shifted to Voyager 2 and preparation for its Saturn Encounter. A reduced tracking support schedule was implemented. However, navigation cycles, command detector unit/signal noise ratio (CDU/SNR), periodic engineering and science calibration (PESCAL), Radio Frequency Subsystem/automatic gain control (RFS/AGC), tracking loop capacitor (TLC), high-gain antenna and sun sensor calibration (ASCAL) and ultrastable oscillator (USO) activities were routinely scheduled to maintain a check on the spacecraft's health.

On 13-14 May, a special cruise science maneuver was exercised by the spacecraft. The purpose of the maneuver was to allow a full-sky survey by the body-fixed instruments. The maneuver consisted of 10 complete yaw revolutions and 25 roll turns. During the maneuver, the spacecraft antenna was off earth-point for 18 hours and 47 minutes with no downlink for this period of time. DSS 63 (Madrid) successfully supported the activity at the start of the maneuver and the next day for the scheduled re-establishment of the downlink.

On 19 May the spacecraft was used for a dual uplink command test supported by DSS 12 (Goldstone) and 63 (Madrid). The uplink command capability for Voyager 1, using a single 64-meter-diameter antenna station with an output power level of 80 kW into the spacecraft low gain antenna, will be lost in mid-1982. A concept was developed to use dual uplink commanding via two 64-meter stations.

The concept consists of two 64-m simultaneous uplinks. The first part of the test has one 64-meter station uplink as a single sideband sine wave subcarrier. This is accomplished by off-setting the carrier by 512 Hz at S-band. For test purposes, the uplink was modulated plus/minus 90 degrees with a 16-Hz square wave to simulate command bits. During the second part of the test, the uplink was set to the same frequency at both 64-meter stations. The one uplink was modulated plus/minus 90 degrees with a 512-Hz square wave subcarrier to produce a double sideband suppressed carrier command signal. High precision ramps are required by both stations, with a maximum allowable frequency error of 0.1 Hz at S-band to ensure acceptable operation. The test was not completely successful. However, the Project assessment of the test was that uncorrected frequency variation between the two stations precludes the use of the noncoherent single-sideband sine wave subcarrier technique. The technique of combining two uplinks at the same frequency with one signal suppressed 20 dB with command modulation looks promising. Laboratory tests to determine the spacecraft threshold using this technique will be proposed on the next step.

B. Voyager 2

Preparations for the Voyager 2 Saturn encounter became the primary DSN support activity. The first general activity was to revalidate the array configuration of the 34-meter/64-meter stations and to provide training for the station personnel. A series of array tests began on 1 April for DSS 42/43 (Australia) and DSS 61/63 (Madrid) and continued periodically throughout the period. The DSS 12/14 (Goldstone) tests were scheduled to begin on 20 April. The tests went comparatively smoothly, with equipment operation well within the desired performance range and personnel quickly displaying operational proficiency.

The Radio Science Operational Verification Test (OVT) at DSS 43 (Australia), started in March, continued periodically throughout the period. Several equipment and procedural problems were identified during the tests. The precalibration and configuration requirements were a matter of concern and took close coordination to ensure understanding by both the station and the Radio Science personnel. The main equipment problem appears to have been in the recorders and malfunction of the recorder bypass switch; the reproduce selection switch caused early concern until the problem was resolved. The recordings continued to be evaluated to ensure that the Intermediate Data Records (IDRs) reproduced from the recorded data were complete and processable by the user. This process continued throughout the period. The activity will reach a milestone on 1 July with the system being exercised during the Radio Science Operational Readiness Test (ORT) No. 2 by the Voyager Project Radio Science Team.

The Voyager Ground Data System Engineer was required to validate telemetry, monitor, and command data end-to-end system operation with the updated software prior to encounter operation. The facilities of CTA-21 (Compatibility Test Area, JPL) were used on 1 and 6 April to perform the initial validation. The tests were successfully completed. A long-loop Ground Data System (GDS) test was scheduled with DSS 43 (Australia) on 13 April. Although DSS 43 had a coded multiplexer/demultiplexer/simulation conversion assembly (CMD/SCA) interface problem that made it necessary to loop back the simulated high rate data at the CMD input jack panel, the test conductor considered the test as successful and further testing not required.

The adaptive tracking procedure (whereby the uplink frequency is changed in real-time based on current estimates of the receive frequency) was exercised three times during the reporting period. The first time was on 13 April and was supported by DSS 14 (Goldstone) and 63 (Madrid). The activity occurred after spacecraft activity that had caused a temperature change and corresponding receiver VCO frequency changes. DSS 63 (Madrid) performed the best-lock frequency (BLF) determination ramping and the initial adaptive tracking frequency offsets, with DSS 14 (Goldstone) continuing the offsets. The second period occurred during a target maneuver with the BLF determineation ramping by DSS 63 (Madrid) starting prior to the reacquisition of the downlink and subsequent to the ground receipt of the ramping results shortly after the reacquisition of the spacecraft. Adaptive tracking offsets were performed by DSS 63 and DSS 11 (Goldstone. The last period occurred on 17 April with the BLF determination ramping again being performed by DSS 63 and the adaptive tracking offsets performed by DSS 63 and 14. The tests were successfully completed and valuable training accomplished by station personnel.

The target maneuver mentioned above was performed by Voyager 2 on 15 April. The spacecraft performed a negative yaw turn followed by a positive roll turn in order to position the photometric calibration plate to be illuminated by the sun with a 30-degree angle of incidence. The return-to-earth point was accomplished by a negative roll unwind followed by a negative yaw turn. The spacecraft was off earth-point with no downlink for 3 hours and 31 minutes. DSS 63 supported the entire maneuver during a tracking pass, including the adaptive tracking activity. DSS 63 used the spectral signal indicator (SSI) capability to assist in the search for the return-to-earth point and reacquired the spacecraft downlink signal on time.

On 21-22 April, DSS 61 (Madrid) and DSS 12 (Goldstone) supported another dual spacecraft, dual station, differenced range exercise with the Voyager 1 and 2 spacecraft to provide additional data on the technique. Again both stations tracked both spacecraft during their view period. DSS 61 started the procedure by tracking Voyager 2. After DSS 12 rise, a transfer was performed from DSS 61. DSS 61 then made a turnaround to Voyager 1. DSS 62 was tracking at the time and made a transfer to DSS 61. DSS 12, after tracking Voyager 2 for the specified period of time, turned around to Voyager 1 and received the spacecraft from DSS 61. The passes went smoothly and the data are being evaluated along with the data provided by previous tests. Results are indicated as being promising.

On 28-29 May, a Cruise Science Maneuver was performed by Voyager 2. The maneuver consisted of 10 negative yaw rotations followed by 25 negative roll rotations, which allowed a full-sky survey by the spacecraft body-fixed instruments. During the maneuver the spacecraft was off earth-point for 18 hours and 53 minutes, during which there was no scheduled downlink from the spacecraft. DSS 63 supported the start of the maneuver, which included the real-time command to enable the maneuver and the loss of the downlink at the start of the yaw turns. The next day, during the DSS 63 tracking pass, the spacecraft completed its roll sequence and returned to earth-point. DSS 63 reacquired the downlink at the predicted time. The playback of the recorded maneuver data started about two hours later and was received by DSS 63 at the start and completed during the subsequent DSS 14 pass.

On 5 June the Observation Phase of the Saturn Encounter began. The first activity was the movie sequence, which started over DSS 61/63 and was concluded on 7 June over DSS 42/43. During the movie phase the arrayed (34-meter/64-meter) configuration was used at all complexes to enhance the received imaging telemetry data. During the movie sequence severe thunderstorms over Spain while DSS 63 was tracking caused a real-time data reception outage via the wideband data line. In spite of this, with data replay no images were lost for the entire period. Preliminary evaluation of results showed that the arraying was well within tolerance and the picture quality was excellent.

On 7 June, after the movie was completed, Voyager 2 entered the preliminary observation routine of performing cyclic periods of ultraviolet system scan in real-time, recording Saturn zoom imaging for spectral and dynamics study during the view periods of Australia and Goldstone, and playing back the recorded data during the view period of Spain. Also, over Spain, interspersed multicolor imaging for long-time base spectral and dynamics study sequences was executed, with real-time data being received. This activity continued throughout the remainder of June.

III. DSN Capabilities

DSS 12 completed antenna upgrade work ahead of schedule and returned to operational status on 20 April. A demonstration Voyager pass was conducted on that day to verify operational status. DSS 12 antenna gain improvements of about 0.7 dB were measured. The DSS 14/DSS 12 array system performance gain improved also as expected.