Voyager Mission Support (II)

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This article is a continuation of the Deep Space Network report on Tracking and Data Acquisition for Project Voyager. This article covers the period of 12 August through September 1981.

I. Introduction

Voyager I was in the extended mission phase of operations during this reporting period. Voyager 2 completed the Far Encounter-2 (FE-2), Near Encounter (NE), and Post Encounter 1 and 2 (PE-1 and -2) phases of the encounter operations and entered the Uranus Interstellar cruise phase.

II. DSN Support

A. Voyager 1

During the period covered by this report, the support provided Voyager 1 activities was accomplished primarily during the viewperiod of Spain and by DSS 62. During the Saturn closest approach celestial mechanics data were obtained by DSS 11, 42, and 44 to assist in the calibration of the Voyager 2 radio science data. One navigation cycle (Nav Cycle) was completed by the 64-meter net during the period of 26-27 September.

B. Voyager 2

1. **Ring movie.** On 13 August, a series of ring images were started during the pass of DSS 61/63 and continued around the network for several days. The images were used to produce the ring movie under better lighting and approach angle than that obtained during the Voyager 1 approach. The sequence was scheduled for some 31 hours and 42 minutes, including a playback period. The 34/64 meter stations were arrayed for this activity and the real-time data were received at the 44.8-kbps rate, with the required playbacks at a rate of 29.8 kbps. All through the Far Encounter period, high-rate imaging data were very successfully obtained nearly continuously by the DSN. This imaging included Saturn, its rings and the many Saturnian satellites. Dual DODRs were produced by the tracking 64-meter station to insure maximum data return. The sequence was completed and the images were considered of excellent quality.

2. **TCM B-9.** The final pre-Saturn Encounter trajectory correction maneuver (TCM B-9) was successfully supported on 18 August 1981. This maneuver was required to make the final correction so the spacecraft would arrive at the Saturn Encounter target point on-time per the mission requirement. A 1.018-m/sec delta-V change was required to achieve this, and was accomplished by a 380-sec motor burn. The actual burn was accomplished over DSS 12/14. The spacecraft performed a roll and yaw turn to place it in the correct position for the burn trajectory. This placed the spacecraft antenna off earth point and the downlink was lost for 1 hour and 17 minutes. DSS 14 reacquired the downlink at the predicted time and the data evaluation indicated that the burn was successful. This

was also confirmed by comparison of the orbit determination data taken during the navigation cycles conducted prior to and following the TCM.

3. ORT-B3. On 19/20 August, the final Radio Science Operational Readiness Test (ORT-B3) was conducted with DSS 43. All the encounter required equipment had been installed and was operational and the finalized operational plan was used for the ORT. The test was successfully supported by the station with only a few very minor problems. The DSN was declared ready for the Saturn Encounter.

4. Saturn Near Encounter. The Near Encounter mission phase started on 25 August 1981. The recording of Celestial Mechanics data started on 15 August and extended through the Near Encounter to 10 days afterwards. Gravity fields of the planet, rings and satellites were mapped as well as data on gravitational redshift and ultrastable oscillator frequent stability. The 64/34-meter nets supported this activity in the arrayed configuration with the data being successfully recorded at the 64-meter station utilizing closed-loop doppler and range tracking.

The Radio Science Near Encounter Saturn occultation data and ring scattering data were recorded by DSS 43 utilizing both the open-loop (medium-band) and closed-loop systems. The data consisted of Saturn atmosphere and ionosphere information and microwave scattering properties of the rings at oblique angles.

High-rate imaging data of the closest approach images of Saturn and several of its satellites were very successfully obtained by the DSN. Most of these images were obtained with the narrow angle camera at 44.8 kb/s.

Concurrently with these high activity science operations, the spacecraft was maneuvered so that the directional properties of plasma fields and particles in near-Saturn environment could be characterized. The maneuvers were also structured so that the spacecraft accomplished such other goals as establishing Miaplacidus as a roll reference star, aligning the scan platform to obtain dark limb/bright limb observation, F-ring imagery, and limb tracking, acquiring Vega as the roll reference star, and aligning the spacecraft yaw axis with the Saturnian rotational axis for information on plasma flow and particle fluxes in directions other than those normally viewed. These activities were sequenced throughout the closest approach phase and were successfully executed (except for the last maneuver) and supported by the 64/34-meter nets. The last maneuver was cancelled due to a spacecraft problem.

After the near-encounter activities were executed and the spacecraft exited from Saturn occultation, it was discovered that the scan platform was stationary in a position away from the desired pointing at Saturn and the rings. Only black sky image frames were being received. The Project went into a troubleshooting and investigative mode and the DSN geared for schedule and SOE changes in support of the Project activities. Primarily the last sequenced maneuver was cancelled and the first post encounter images were not received.

Initially, the scan platform position was determined and limited changes in elevation and azimuth were attempted. It was determined that the changes in elevation were normal, but the changes in azimuth were erratic and slow in one direction and less so in the other direction. Playback of data indicated that the scan platform had functioned properly while the spacecraft was occulted, and that it faulted just prior to egress. The platform was repositioned through a short series of stepped moves so that the camera was pointed back at Saturn's rings as the spacecraft continued away from the planet. Ring images were received in this mode; although it was not the planned sequence the data were deemed satisfactory. The DSN supported this entire nonstandard period with no significant problems.

5. Phoebe movie. One of the primary Post Encounter mission objectives was to obtain pictures of the satellite Phoebe. Rather than make extensive movements by the scan platform alone, it was decided to maneuver the spacecraft to star reference Canopus and make minor step movements of the scan platform to center Phoebe in the field of view. The Phoebe movie sequence was completed successfully in this mode, with the supporting DSN stations providing excellent data. At the completion of the image sequence, the spacecraft was maneuvered again to star reference Miaplacidus and the scan platform stepped to a safe position. During the spacecraft maneuver, the supporting stations were required to configure for a ramp, commanding operation for the Maneuver Recovery Block No-Op sequence. This activity was successfully executed by the DSN.

6. Saturn medium-band occultation data. DSS 43 was required to make duplicates of the Medium-Band Digital Original Data Records (MB DODR). These duplicates were used to produce Intermediate Data Records (IDR) for Radio Science processing. The original DODRs were held at the station for further use as required in accordance with the Radio Science Operations Plan.

Data reduction from the IDRs was performed at CTA-21. The ODR validation consisted of two steps; the first was a dump of the header information for each record. This gave information as to station, spacecraft, time, record count and configuration. It also gave an indication of data loss due to weak spots in the ODRs or malfunctions in the record-reduction process. The second step is to perform fast Fourier transforms (FFT) and do a power spectrum analysis for all data on each tape. This gave the approximate signal frequency, signal-to-noise ratio and the character of the recorded passband. Comparison of these values with expected levels gave an indication of the value of the data for scientific analysis.

Preliminary evaluation of the first processed duplicate IDRs indicated that the original ODRs should be sent from the station to CTA-21 for reduction. In general, the quality of the data was reasonable; however, there was concern about the consistent pattern of data dropouts, with one tape in particular showing an unacceptable number of dropouts. Passband frequencies and SNRs were as expected and the passband was clean. Under strong signal conditions, DRA recorder B appeared to be of slightly better quality than recorder A. The original DRA recordings are expected to be of better quality than the duplicates, as indicated by past experience, and therefore will be used for all final data reduction.

7. **Near Encounter Operation.** The DSN support of the Near Encounter Operation was accomplished without any significant fault. In addition to the normal science DODRs provided by the 64-meter net, a backup DODR was provided by both the 64- and 34-meter stations. During the closest approach, DSS 43 generated 10 medium-band and 40 wide-band radio science DODRs, which will be used to produce 484 radio science IDRs. Image reception in the arrayed configuration was of excellent quality and no images were lost, due to DSN operation. Playback of the image data taken while the spacecraft was occulted was accomplished as scheduled and the image data before the scan platform malfunction were likewise of high quality. Even with the postoccultation platform problem, the mission objectives were essentially met and DSN support considered excellent.

8. **TCM B-10.** Trajectory correction maneuver B-10 was accomplished by the spacecraft on 29 September 1981. The maneuver occurred during the viewperiod of Goldstone and was supported by DSS 14, with DSS 12 as backup. DSS 12 was diverted from support of Voyager 1 as backup support to DSS 14 during this period due to a low film height problem experienced at DSS 14, which caused the antenna to go to "brake" due to an alarm on Pad 3 (left front). DSS 14 began support again in a few minutes. The maneuver was designed to place the spacecraft on the proper trajectory for the 1986 Uranus Encounter. The spacecraft was turned to the proper orientation for the correction vector and a "burn" of 5754 seconds accomplished. This sequence placed the spacecraft in an off earth-point for approximately 2 hours, 40 minutes during which no downlink was available. The return to earth point occurred on time as a result of the programmed unwind and the downlink reacquired. Vega was acquired after the maneuver for star reference. DSS 14 ramp-commanded a low gain antenna (LGA) select No-Op, which prevented the spacecraft from going into the contingency mode that would have occurred if the maneuver had not been successful. The maneuver was successful and the primary evaluation indicates the "burn" was nominal. The next TCM will not take place until January 1985.

9. **Voyager Uranus Interstellar Mission (VUIM).** On 28 September 1981 the Post Encounter phase of the Saturn Encounter was completed and the VUIM phase started. Spacecraft activities affecting the scan platform will be severely curtailed for several months as analysis continues on the problem that affects platform motion in azimuth (side to side). The platform will be operated only at low rates of speed and over a limited range from 180 to 270 deg azimuth. This range gives a satisfactory set of positions for Post Saturn, Uranus and Neptune observations. Special configurations or operational procedures may be required to support future scan platform activities.

C. DSN Capabilities

On 9 September 1981, the DSS 14 hydrostatic bearing runner joints failed, and DSS 14 was unable to move the antenna to point for support of the Voyager 2 pass. This required rescheduling of DSN support while DSS 14 was down for hydrostatic bearing runner repairs. DSS 12 and 13 were primarily used to support the Voyager requirements, causing a minimum of impact to the Voyager and other projects.

The hydrostatic bearing runner joints were repaired and DSS 14 was able to resume normal tracking operations on 25 September 1981.