Voyager Mission Support (II)

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This is a continuation of the Deep Space Network report on Tracking and Data Acquisition for Voyager Project. This article covers the period August through October 1980.

I. Introduction

Voyager 1 has entered the Encounter Phase of the mission, while Voyager 2 continues in the Jupiter-Saturn Cruise Phase.

The Saturn Encounter activities are divided into five phases based on the field of view of the narrow-angle camera in relation to the distance to the planet. The five phases are Observatory, Far Encounter 1, Far Encounter 2, Near Encounter, and Post Encounter.

The Observatory Phase for Voyager 1 started on 22 August and ended on 24 October, when the Far Encounter 1 (FE1) Phase started. The FE1 Phase will not be concluded until 2 November 1980.

II. DSN Support

A. Near Encounter Test

Starting in July 1980, the Voyager Mission Support Team, including all support facilities, entered the Test and Training period for the forthcoming encounter. The DSN performed the required System Performance Tests and Operational Verification Tests necessary to check out and train operations personnel on the new capabilities as implemented. This training activity was culminated in a Near Encounter Test on 19 and 20 August 1980. The Near Encounter Test (NET) was a simulation of the 1%hour period of closest approach to Saturn. During this test both the 34-meter and 64-meter Deep Space Stations were configured and supported the Project in the same manner as will be required during the actual closest approach. During the NET, a Radio Science Operational Readiness Test (ORT No. 3) was conducted with DSSs 43 and 63. The period tested corresponds to the one required to support the closest approach and occultation periods.

Although the support provided by the Deep Space Network was considered satisfactory overall, several areas were identified for which additional attention was required. It was found that generally the arrayed antenna performance was lower than expected. Problems causing this were suspected to be telemetry string degradation due to improper calibration, an adverse weather condition affecting the X-band data, and variations between the 34-meter and 64-meter station symbol signal-to-noise ratio. Special emphasis was given to improving the array performance for the movie phase that was included in the observatory phase.

Problems were likewise encountered during the ORT. Occultation Data Assembly halts were experienced, which caused some data loss. Appropriate calibration on the antenna at DSS 63 could not be performed one time due to an unusually heavy rain storm during the pretrack preparation period. Although the Spectral Signal Indicator (SSI) and Precision Signal Power Monitor (PPM) data was generally good, problems were experienced in displaying the data at JPL. These were determined to be procedural problems that had not been fully resolved due to the newness of the capability. Additional voice communication had been provided for the radio science support, which was improperly configured and caused operational confusion.

Other minor operational problems, procedural and equipment failures, were experienced that provided insight into the events that could occur during the actual closest approach. The test results provided a valuable insight into the areas for improvement and correction. Actions have been taken to accomplish this and internal testing has validated the measures taken.

B. Observatory Phase

1. Movie phase – solar conjunction. A time-lapse movie was compiled from photographs taken during the period 12 to 14 September 1980. Photographs were taken every 4.8 minutes during four Saturn rotations. The photographs were transmitted in either real-time or during a playback period over DSS 14. To obtain the telemetry data, including the photographs, the 34-meter and 64-meter networks were arrayed for the entire support period. Overlapping this movie activity was the solar conjunction (3 September to 6 October) when the Sun was between the Earth and spacecraft. The smaller the angle of the Sun-Earth Probe, the more hampering of the radio communications was experienced. However, the condition did allow study of the Sun as the radio signals passed through the corona. Although the "noise" was evident in some photographs, the movie requirement was met. Likewise, the solar conjunction data were collected from both Voyager 1 and Voyager 2 to complete the experiment data requirements.

2. Target maneuver. On 5 to 6 August, a target maneuver with Voyager 1 was supported by Deep Space Network. The purpose of the maneuver was to calibrate the imaging and IRIS instruments. The spacecraft was maneuvered to point at the science calibration target and several wide- and narrow-angle images plus IRIS data are recorded. Following the calibration, the scan platform was slewed to a safe position for a turn unwind. The spacecraft then maneuvered to reacquire the Sun and Canopus, and the scan platform slewed back to a neutral position. Recorded calibration data were played back on 7 August. DSSs 12, 61, and 43 were involved in the transmission of the command load, the enable file, tracking until loss of data due to the spacecraft turning, reacquisition of the spacecraft signal on return to Earth point, and receipt of the transmission of the calibration data, The sequence went as scheduled, and the spacecraft was reacquired by DSS 43 as anticipated.

3. Trajectory correction maneuver (TCM-A8). On 10 to 11 October, Voyager 1 was again maneuvered; however, this time it was to accomplish a trajectory correction. The correction was to change the trajectory so that the spacecraft would pass the Saturnian satellite Titan at a closest point of 4600 km from the surface. Without the maneuver, there was the possibility of a collision with Titan.

The spacecraft was rolled 90 degrees and then turned through a yaw of 136.7 degrees to place it in the proper position for the change in velocity vector. A "burn" of 806 seconds was used to produce a velocity delta change of 1.778 meters/second. The spacecraft was then maneuvered back to Earth point.

During this maneuver, the downlink was lost from the spacecraft after the positioning for the "burn," and reacquired after the spacecraft reposition on Earth point. This maneuver was supported by DSSs 61, 12, and 14.

To provide a small margin of additional capability, the stations were instructed to put in the bypass to the antenna film-height detector. Under normal operation when the antenna film-height detector senses a low film height, the antenna is automatically stopped. By placing the bypass "IN," the operator will manually stop the antenna if the film-height detector alarm is activated for 15 seconds or, more. By using this option, false alarms are reduced, and unnecessary data loss avoided during critical data periods.

4. Array **readiness.** After the implementation of the Real-Time Combiner (RTC) at the 64-meter stations, and during the testing of the arraying operation, it was found that there was a variation in the actual gain achieved by a station during a series of passes. A good deal of the variation was due to the calibration of the telemetry string. Precise and consistent calibration was required to produce the desired gain over a series of passes, To assist the stations in this effort, a period of RTC and telemetry string maintenance was scheduled each week for the station to accomplish the required work.

DSSs 12 and 14 started operational support of Voyager 1 with the array configuration on 23 August 1980. The level of proficiency and improved results were evident after a few days of aperation. To insure DSSs 42 and 43 and DSSs 61 and 63 crew proficiency, a series of proficiency test passes were provided during the normal scheduled support of Voyager 1 by these stations. The gain on the arrayed data has been within the desired level for the encounter period. DSSs 42 and 43 and DSSs 61 and 63 began active support of Voyager 1 on 24 October at the start of the Far Encounter Phase.

5. Radio Science Subsystem (RSS) Operational Readiness Test-4 (ORT-4). The fourth RSS ORT-4 was conducted on 2 to 3 October 1980. The ORT was to demonstrate (1) Occultation Data Assembly (ODA) medium band width right circular polarization/left circular polarization (RCP/LCP) S- and X-band and narrow-bandwidth S- and X-band data acquisition, (2) acquisition of radio science wideband width backup data acquisition using the Digital Recorder Assembly (DRA), (3) capability of measuring and recording system temperatures in real-time, and (4) demonstrate SSI performance and utility for occultation data acquisition.

Although the ORT was conditionally successful, there were problems with the SSI equipment and the wideband backup equipment. There were misunderstandings on the calibration procedures for input and/or output levels of equipment.

To resolve these problems and to increase the proficiency in the operation and support of the RSS effort, a series of 14 OVTs were scheduled for DSS's 43 and 63. The results obtained from the OVTs in increased efficiency and effectiveness became more evident with each succeeding test. Procedures for calibration and operation of system and equipment were clarified and standardized as a product of the tests. By the end of October, the RSS problems were mainly resolved and the system operation greatly improved. ORT-5 is now scheduled for 5 to 6 November 1980 for the final validation of the system and operations for support of the closest approach and occultation experiments with Saturn and Titan.