Pioneer Venus 1978 Mission Support

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The Tracking and Data System and Deep Space Network preparation and support activities for the Pioneer Venus 1978 Mission are described for the period from June 3, 1977 to April 24, 1978.

I. Introduction

The article contained in Ref. 1 described the DSN support status up to June 3, 1977. The following article describes those activities which have taken place from June 3, 1977 to April 24, 1978.

In general, at the time of the writing of this article, essentially all implementation required for support of the Multiprobe Mission and for the launch of the Orbiter and Multiprobe Missions has been completed. The most significant implementation item outstanding for Pioneer Venus support is the new Radio Science Subsystem required by the Orbiter Mission.

II. Major Project Activities and Milestones

A Preship Review for the Orbiter spacecraft took place at Hughes Aircraft Company February 20, 1978. At that time, the health of the spacecraft and all of the Orbiter instruments were found to be in very good state and the Orbiter was shipped to Cape Canaveral, Florida, arriving the week of March 13, 1978. The Preship Review for the Multiprobe spacecraft took place the week of April 24, and extended for six days at Hughes Aircraft Company. The current plan is for the Multiprobe spacecraft to arrive at the Cape the week of June 5, 1978. The launch window open for the Orbiter Mission is currently scheduled for May 20, 1978, and the launch window nominally extends through the 10th of June, although seven additional days are possible by compromising the arrival date at Venus.

The principal problem encountered in preparing for the launch of the Orbiter Mission has been with the Ames portion of the Ground Data System (GDS). The Project has been tackling an extremely difficult task of trying to accommodate a very complex mission on a very modestly sized computer system at Ames Research Center. The difficulties in accomplishing this task resulted in the GDS testing starting a full two months later than originally desired. Mission Operations Systems (MOS) testing started on the 20th of March 1978. The Project was forced into the position of stretching out a phased delivery of the capabilities required for support of the mission so that GDS testing has had to overlap completely with the MOS testing in preparation for launch. A reduced set of capabilities in telemetry and command were decided upon by the Project as being adequate to support launch. There will, therefore, be an extensive and continued development of the Ames portion of the Ground Data System after the Orbiter launch, extending up to the start of Orbiter operations in

December 1978. The Multiprobe launch opportunity extends from Aug. 7 to as late as Sept. 3, 1978. The Orbiter Mission will insert into orbit around Venus on Dec. 4, and the Multiprobe entry take place on Dec. 9, 1978.

III. DSN Prelaunch Preparations

The DSN achieved the state of readiness to support Project Ground Data System testing in late December 1977, which was about one month later than originally planned. This had no impact on the Project because of complementary delays on the Project side of the Ground Data System. The month delay in the DSN preparations was caused principally by problems encountered in trying to get data throughput using the new high-speed data system which involved 22-bit error polynomials. The new high-speed data system involves automatic switching at JPL and accommodates error detection-correction. Only one significant problem was uncovered outside of communications in the early testing executed by the Network Operations Project Engineer for Pioneer Venus, and that was the initial inability of the Telemetry Processor Assembly to handle Pioneer Venus uncoded data. Once the problem with uncoded data was discovered, it was quickly rectified.

The new equipment and software involved in the high-speed data transmission from the tracking station through JPL and on to the Project has been a continual source of difficulty in preparing for the Pioneer Venus Mission. The problems encountered in communications in the last two months of 1977 and in January 1978 were principally due to trying to use kludges and various patches in order to start Pioneer Venus testing prior to the committed date for the Communications System to be fully operational. The problems from February on have been principally due to less-than-desired reliability in the new hardware and software in the Ground Communications System. Many of the initial problems, of course, were due to operator unfamiliarity with the new hardware and software. The contractor changeover on March 27, 1978 compounded the problem by introducing a fairly significant number of new personnel who required training. As test activities progressed into April, it became clear that many remaining problems were not operator-related and that, indeed, the new hardware and software in the communications system had unsatisfactory reliability. In order to put a concentrated effort on solving the reliability problems, a special task team was formed April 20, 1978 to execute a concentrated effort to find ways of improving the communications reliability.

The second area in which the DSN had difficulty in meeting the schedule and delivering satisfactory reliability performance was in the implementation of a new direct interface between the DSN and the Navigation area for the delivery of radiometric data. This new system involves the generation of Intermediate Data Records of radio metric data by the DSN for direct delivery to Navigation without using the Mission Control and Computing Center's 360-75 computers. This capability was planned to be fully operational by Feb. 1, 1978, but software development problems delayed the system going on-line until March 13, 1978. The system, therefore, went on-line nearly coincident with the contractor changeover, which compounded problems that followed in the inability of the DSN to reliably deliver the radio metric IDR to Navigation. By the second week of April, a growing concern about whether the DSN would achieve satisfactorily reliable flow of the radio metric data to Navigation prior to launch resulted in formation of a briefly lived task team whose efforts led to the Pioneer Navigation Chief declaring on April 17, 1978 that the new radio metric data interface was no longer a major concern in preparing for launch.

IV. Multiprobe Entry Preparations Status

The original plan was to complete the multiprobe entry configuration at DSS 14 by Feb. 15, 1978 and at DSS 43 by March 1, 1978, with only two exceptions. The two exceptions were (1) the redundant recorder for the differential long baseline interferometry (DLBI) experiment which was delayed to an FY-78 procurement to save FY-77 funds; and (2) the automation of certain functions in the spectrum signal indicator, which could not be completed until the summer of 1978. The purpose of establishing the multiprobe configuration well in advance of the mission need date was twofold: first, to allow for adequate procedure development using the actual configuration, and sufficient time for the complex test and training activity that would be required; and second, to enable the tracking and processing of ALSEP data well in advance in order to shake down the end-to-end DLBI wind measurement experiment system.

In mid-December, it became clear that lack of completed ECOs and cables had placed the early completion of the Multiprobe configuration very much in jeopardy. The problem was compounded by the fact that the installation of this major configuration at DSS 14 was going to have to take place concurrent with the DSN Mark III Data Systems (MDS) downtime at DSS 11. The concurrent DSS 11 downtime was a potential problem because of the consolidated Maintenance and Integration crew at Goldstone. The individual cognizant development engineers responsible for the equipment involved in the Multiprobe entry had identified all of their cable requirements well in advance. The breakdown occurred at various levels in the myriad steps that take place between the time that a CDE specifies what cables are necessary and the

delivery of an accepted ECO kit for the installation. The basic problem is that no one person or organization accepts responsibility for coordinating all of those myriad of steps which must take place in various organizations. The DSN has encountered problems of this kind in the past with major implementations, but found that the very major MDS implementation was nearly free of such difficulties because it had been projectized. In order to attack the immediate Pioneer Venus problem, an Implementation Project Manager was named within Office 430 to spearhead the coordination of the remaining implementation and installation for Pioneer Venus. Due to the concerted effort supported by a large number of people (the Cognizant Development Engineers, the Division 33 System Engineers, the Cognizant Operation Engineers, the cable group and Station Maintenance and Integration personnel) the Multiprobe configuration was completed at both stations only one week later than the original (two-year-old) plan.

The remaining implementation for the Multiprobe consists of the redundant transport for the DLBI (Digital Recording Assembly (DRA)) recorders at DSS 14 and 43 which will be shipped to the stations in late April, and microcontrollers to automate some of the Spectral Signal Indicators functions in August 1978.

The completed Multiprobe configuration was utilized in March for four 8-hour procedure development tests. The two Australian shift supervisors who will be handling the actual entry event in Australia came to JPL in April and March 1978 for training. They assisted the Network Operations Project Engineer and his staff in formulating a first cut at the detailed procedures for handling the Multiprobe entry. These procedures were executed during the procedure development tests (with the participation of the Australians) and a further refinement of the procedures developed. Several observations were noted from the March 1978 procedure development tests: First, the Multiprobe entry is every bit as operationally complex as has been anticipated. Second, the acquisition of the Probe data with closed-loop receivers in real-time will be extremely difficult because of the combination of large uncertainties, low-signal levels, and (after blackout) small subcarrier frequencies. Rapid acquisition of the signals in real-time appears to have a lower probability than anticipated. Third, the open-loop receiver precarrier detection recording must be considered the prime means of recovering the data for the actual mission. Fourth, the Spectral Signal Indicators are crucial to successful real-time acquisition of data. Fifth, successful handling of the Multiprobe entry would have been impossible if the DSN had not built simulators for the Probe entry. Sixth, the extensive test and training activity planned for the Multiprobe entry will be essential to ensure success.

V. DLBI Wind Measurement Experiment Status

A major review of the differential long baseline interferometry (DLBI) experiment was held at the Massachusetts Institute of Technology on Aug. 11, 1977. The Review Board consisted of interferometry expertise from around the country who were not directly involved with the experiment. During that review, the detailed design and plans for the Tracking and Data System support for the experiment were reviewed and accepted.

The second week of November 1977, the DSN and STDN provided equipment for the DLBI Experiment underwent a trial installation at the STDN station located at Goldstone, Calif. The primary purpose of this trial installation was to execute a complete integration test for the DSN and STDN equipment prior to the shipment of the equipment to the overseas sites at Guam and Santiago, Chile. Some minor interface problems were discovered and corrected as a part of this activity and actual Apollo Lunar Surface Experiment Package (ALSEP) signals were recorded. These ALSEP recordings were processed using developmental software at JPL to bandwidth-reduce the data to produce the deliverable recording which was further processed by MIT where the recorded ALSEP signals were detected.

The equipment necessary for supporting the DLBI wind experiment was completed at all four stations at the same time that the rest of the Multiprobe entry implementation was completed. Starting Feb. 28, ALSEP tracks have been scheduled every two weeks in order to shake-down the system. During the first ALSEP track of Feb. 28, the two stations scheduled were DSS 14 at Goldstone and the STDN Santiago station. Station 14 experienced considerable difficulties during that attempted track due to a combination of equipment and procedural problems that were compounded by the fact that two of the three ALSEPs that were to be used for that track were malfunctioning. The end-to-end DLBI experiment system involves the taking of data at at least two tracking stations, the shipment of the data from overseas to JPL, processing of that data at JPL, and then shipment of the data to MIT where the final processing takes place. It will not be known whether the equipment is working sufficiently well to enable the experiment to take place until the final processing takes place at MIT and fringes are detected. This process involves, in the best case, on the order of a month from the time data is taken until MIT can declare whether the interferometer is working and required this implementation to be completed early enough to give several chances for a complete end-to-end check by taking multiple station data using ALSEP's as the signal source. After the first track, there were problems in subsequent tracks associated with tape shipment time. One station's tapes were

lost, one station's tapes arrived degaussed, and so far one incident of hardware failure. The majority of problems encountered have not been technical. The first two-station data successfully processed at JPL was shipped to MIT on April 15, (more than a month after equipment installation was completed), but MIT had not completed evaluation at the time of this writing. Several procedural problems were resolved in the process, but protracted tape shipment problems have not yet been solved. It may be necessary for the actual mission tapes to be hand-carried from the overseas sites. Although not enough time has elapsed for MIT to evaluate the data, the processing of the data at JPL does involve a low-resolution, fast Fourier transform of the reduced bandwidth data and all indications are (as best as can be determined, looking at one station at a time) that the station equipment and the bandwidth reduction equipment at JPL are operating properly.

Reference

1. Miller, R. B., "Pioneer Venus 1978 Mission Support", in *The Deep Space Network Progress Report 42-40*, pp. 14-20, Jet Propulsion Laboratory, Pasadena, Calif., Aug. 15, 1977.