Helios Mission Support

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Having observed its first year anniversary in orbit about the Sun, the Helios-1 spacecraft has performed satisfactorily. During its first year, valuable scientific data were obtained about the Sun and our solar system. As Helios 1 enters its second year of successful operation, preparations for the launch of Helios B are in their final stage.

I. Introduction

This is the seventh article in a series that discusses the Helios-1 flight support and Helios-B test and training activities by the Deep Space Network (DSN). The previous article (Ref. 1) reported the results of the Helios-1 second superior conjunction and second perihelion operations as well as Helios-B test results. This article covers Helios-1 cruise operations after the second perihelion through second aphelion. Also discussed are significant spacecraft anomalies, DSN tracking coverage, Helios DSN-STDN cross-support, and Helios-B test and training results. Helios-B launch is presently scheduled for 0534Z on January 15, 1976.

II. Mission Status and Operations

A. Helios-1 Second Aphelion Operations

One year of successful flight operations was completed by Helios 1 on 10 December 1975. The solar probe with its attendant scientific instruments has performed well, with the only exceptions being the initial problems encountered with Experiments 1 and 5 after launch (Ref. 2), and the recent Traveling-Wave Tube Amplifier-1 (TWTA-1) failure on 31 October 1974.

The failure of TWTA-1 manifested itself when an approximate 28-dB drop in the downlink signal level was observed during a spacecraft tracking pass over DSS 11 at Goldstone. The anomaly occurred at 1834 GMT, and to accelerate isolation, Goldstone DSS 12 support was requested by the DSN. Both stations verified identical downlink signal levels at −167 dBm. This level was below the telemetry threshold for 26-meter stations. The Helios Project declared a spacecraft emergency at 2040 GMT and requested 64-meter support for the impending Australian viewperiod. At 2121 GMT, the Project commanded the spacecraft from the failed high-power TWTA-1 mode (20 watts) to the 10-watt medium-power mode. This seemingly returned the probe back to a normal operational mode. What had been thought of as normal operations was short-lived; a total TWTA-1 failure disrupted the DSS 43 downlink at 2253 GMT. The Project analyzed this failure, and the spacecraft was commanded to the low-power mode (0.5 watt) of operations at 2344 GMT. Once RF lock was achieved, the spacecraft was commanded to 16 bps, and normal operation in this mode was achieved.

With a satisfactory low-power downlink established, the Project continued to analyze the anomaly. The decision to switch to TWTA-2 medium-power mode was accomplished at 1610 GMT 1 November 1975. The spacecraft has operated normally since the switch to TWTA-2. Special DSN surveillance was provided by DSSs 11 and 63 until the spacecraft emergency was terminated during the DSS 11 track of the spacecraft on 1 November 1975 at 2130 GMT.

A Helios Project-sponsored TWTA Failure Analysis Review was conducted at JPL on 12–14 November 1975. The outcome of these meetings produced 14 action items plus 7 recommendations, directed to various Helios team members. The DSN was requested to continue to provide operational information on whether automatic gain control fluctuations are observable within the downlink after the switch to TWTA-2. The Failure Review also illustrated that further investigations will have to be conducted to reach a final conclusion about this TWTA failure.

B. Spaceflight Tracking and Data Network (STDN) Cross-Support

A DSN-STDN Helios Interface Agreement is now in preliminary form and will provide the necessary DSN-STDN Operations plans and interfaces which are required for Helios-1 and Helios-B STDN cross-support. The DSN-STDN cross-support configuration has also been defined, and 15 January 1976 is the designated target date to commence operations on a regular basis. Initially, only the Madrid STDN station will be available for support; the Goldstone STDN station, currently down for major rework, will become operational and provide Helios support after 1 March 1976.

There is one remaining interface problem concerning timing signal processing during tape recording playback. The problem has shown up as a time-tag offset between the Spacecraft Compatibility/Monitor Station, Merritt Island, Florida (STDN (MIL 71)) playback data records, produced from the Goldstone STDN tapes, and the Mission Control and Computing Center (MCCC) data records which were simultaneously recorded in real-time from DSS 12. The relative time-tag differences are a function of the Data Decoder Assembly (DDA) performance and the recorded bit rates. Indications are that the 1 pulse-per-second and 1000 pulse-per-second timing signals from the Time Code Translator to the DDA interface at STDN (MIL 71) are incorrect. A modified Time Code Translator has been shipped from JPL to STDN (MIL 71). When the timing problem is corrected, a test will be conducted to re-evaluate the STDN (MIL 71)-MCCC interface. The re-evaluation should be completed by the first week of January 1976.

C. Helios-B Test and Training

As we approach the launch of Helios B, DSN and Ground Data System testing is being successfully completed, and emphasis is shifting to Mission Operations System testing. Simulation System, Ground Data System, and DSN operational testing were completed during this reporting period. Only the DSN Configuration Verification Tests (CVTs) and the Mission Operations System tests remain before the final Operational Readiness Test and launch of the Helios-B spacecraft.

1. **Ground Data System Test.** One Ground Data System test was conducted on 5 December. This was a retest to validate a few items which failed to meet specifications during other U.S.-German Ground Data System tests. This test was successful, completing Ground Data System testing for Helios B.

2. **DSN Testing.** Network testing for initial acquisition with Australia Deep Space Stations 42 and 44 was completed by mid-November. Each station's operational crews participated in at least one Operational Verification Test; some in as many as three. Test scheduling conflicts with operational commitments, plus some doubt about the exact Helios-B launch date (the official date of 15 January 1976 being announced later), prevented the conduct of as many initial acquisition Operational Verification Tests with the crew selected to support launch activities as would have been desired. However, several Mission Operations System tests will exercise these procedures with the station launch support crew.

Step II maneuver Operational Verification Tests began with the first test at Goldstone DSS 12 on 7 November. As of this writing, six successful tests were conducted, four with DSS 12 and two with Goldstone DSS 11.

The plan for DSN support for the Helios-B Step II maneuver will differ slightly from that of Helios 1. This difference lies in the antenna polarization configuration prior to track. DSS 12 (prime) will configure for linear horizontal polarization. DSS 11 will configure for linear vertical polarization. As the spacecraft's aspect angle is changed by attitude commands, the downlink signal polarization will go from linear horizontal to linear vertical. Thus the signal level received at DSS 12 will decrease while that at DSS 11 will increase. When the signal strength at DSS 11 surpasses that at DSS 12, the Project will transfer the uplink signal to DSS 11 for the remainder of the track. DSS 12 will reconfigure to linear vertical polarization for the remainder of the pass.

3. **Mission Operations System Test and Training.** Mission Operations System test and training activity continued at a predetermined pace throughout this reporting period. Three Inter-Team Training Tests, without DSN participation, were conducted in October. The DSN support began with two Combined Test and Training exercises in mid-November. Four Operational Demonstration Tests are scheduled from 25 November through 6 January 1976. These tests are designed to demonstrate the combined U.S.-German Networks ability to properly support all phases of the mission from launch to cruise. To date, all Mission Operations System testing has met objectives and has been considered successful.

The Operational Readiness Test is scheduled to take place on 12 January 1976. Launch for Helios B is now scheduled for 0534 GMT on 15 January 1976.

D. Actual Tracking Coverage Versus Scheduled Coverage

Helios-1 tracking coverage, along with Pioneer 10 and 11 tracking coverage, is now allocated on an equal priority basis for extended mission operations. This report covers a 56-day period for Helios-1 tracking coverage, from 17 October through 11 December 1975. Operations during this period consisted of normal cruise phase operations.

The total tracking coverage shared between the two Pioneers and Helios-1 spacecraft was 322 passes, equaling 2290 hours. The Helios allocation was approximately one-third of this total, or 99 passes and 699 hours of tracking coverage.

Due to Viking flight operations, the number of Helios-1 passes, the number of hours tracked, and the percentage of coverage supported during this period were all decreased from those of the last period. In conjunction with the other decreases, the duration of the average pass dropped from 7.6 hours to 7.0 hours. Inasmuch as the 26-meter subnet can support at a data rate of 2048 bps, its support increased 58 percent during this time frame; but the 64-meter network only supported Helios 1 for 183 hours, which was a drop of 71 percent from the last reporting period.

Helios-1 coverage should remain relatively stable at the level allocated during this period if the STDN support is provided as planned.

III. DSN System Performance for Helios

A. Command System

The command activity for Helios 1 continued to rise during this reporting period. The spacecraft's second perihelion occurring on 21 September 1975 (coverage lasting until 5 October) and the fact that this is the spacecraft's closest approach to Earth since launch phase have contributed to this increase in the spacecraft scientific data, and resulted in increased command activity. A total of 4669 spacecraft commands were processed through the Command System in the months of October and November. This is an increase of 1320 commands over the last period, and boosted the DSN cumulative command total to 23,301. Two Command System aborts were experienced in October; none in November. Both system aborts were attributed to operator error and involved no command equipment malfunctions. The Command System aborts cumulative total was increased to 5, with the overall abort total at 13 since spacecraft launch.

Command System downtime due to equipment problems during this reporting period was only 3.81 hours. There were an additional 1.95 hours lost due to high-speed data line outages. These figures show a significant decrease in downtime over the last period. Three transmitter failures were included in the 17 instances reported. Two of these occurred at Goldstone DSS 14 and one at Australia DSS 42.

B. Tracking System

The DSN Tracking System continued to provide very good support to the Helios Project during the second perihelion and aphelion. Several anomalies were detected during this period which required considerable support and analysis of the DSN Tracking System data.

What was later diagnosed as a Helios-1 spacecraft failure was noticed on 9 October. Ranging modulation on the downlink was just barely detectable, even at 64-meter stations operating with high power. At the time, it was believed that spacecraft ranging was lost forever. However, this was later determined to be associated with the spacecraft Traveling-Wave Tube Amplifier (TWTA-1) failure of 31 October. Ranging returned after the switch to TWTA-2. To utilize Helios-1 spacecraft ranging, the modulator-exciter 1 must be configured to TWTA-2 by command from the Project. The first ranging in this manner was used on 9 November 1975. This operational procedure is being used and all spacecraft ranging commitments are being met.

The changeover from the special 2-MHz doppler bias for Helios-1 tracks to the standard 1-MHz bias occurred as scheduled on 11 October. Almost immediately, Australia DSS 43 and Spain DSS 63 began to show a very large doppler residual. The problem was traced in real-time to the Biased Doppler Detector Module of the Doppler Extractor. When the unit was tested at the Helios 1-MHz biased doppler frequency, a harmonic distortion showed up. Several replacement modules were tried. Some gave good doppler residuals while some did not. It was concluded that operation of the module so near its design specification is marginal and risky.

The Helios-B DSN Initial Acquisition Study, detailing DSN acquisition strategy at Australia DSS 42, was released on 10 November 1975. The report, prepared by the Network Operations Analyst for Tracking, was very comprehensive. Portions of the study will be published as part of the Helios-1 and Helios-B Network Operations Plan (Document 613-21), Revision B.

C. Telemetry System

Telemetry System analysis, as an on-going effort, was initiated during this reporting period as a result of the Traveling-Wave Tube Amplifier Failure Study Meeting. This action item was to analyze the Helios-1 AGC dropouts occurring after the switch to TWTA-2. The intent of the study which followed was to determine the presence of dropouts and to compare them with those dropouts previously found on TWTA-1. AGC strip-chart data were collected from several 26-meter stations which tracked Helios 1 from 14 to 22 November 1975. Examination of the data found that large cyclic variations in the AGC clouded any search of dropouts. Automatic Gain Control variations ranged from 2 dB to 5 dB in amplitude, with a period of approximately 20 seconds. This periodic variation seemed to have a secondary fluctuation (possibly AGC dropouts) having an amplitude of about 0.5 dB with an occasional 1 to 2 dB, and an occurrence frequency of approximately 30 per hour. Starting on 21 November, the periodic function decreased in amplitude, and by Pass 348 on 22 November (over DSS 11) the data showed that the periodic variation had gone. Remaining, however, was the secondary fluctuation which appeared to be AGC dropouts. (Figure 1 gives a picture of a typical strip-chart record.) The study is continuing.

There were only six Telemetry System Discrepancy Reports recorded during October, with an average mean-time-between-failures of 62 hours. The breakdown of November Discrepancy Reports is not yet available.

Helios-1 telecommunication link analysis for October and November is still in progress at this writing by the DSN Telemetry Analysis Group.

IV. Conclusions

Just prior to reaching its second aphelion, the Helios-1 spacecraft experienced its first major malfunction, a Traveling-Wave Tube Amplifier failure. Extra DSN tracking coverage and surveillance were given in support of this spacecraft emergency. Special recording and analysis of telemetry data were provided in support of the Helios Spacecraft Team's investigation of the anomaly.

A DSN-STDN Helios Interface Agreement was prepared during this reporting period which defines interfaces, configurations, and dates for STDN support of the Helios Project. Minor problems exist, but solutions are seen in the near future, and the plan has promise for providing future Helios telemetry coverage.

Helios-B launch preparations are progressing according to plan. Several test phases have been successfully completed during this reporting period. MOS testing will culminate with the Helios-B Operational Readiness Test scheduled for 12 January 1976. First opportunity for launch is 0534Z on 15 January 1976, and overall testing success has provided reassurance that all elements of the DSN are prepared for this opportunity.

With the launch of Helios B and increased activities of the Viking Project in preparation for the Mars encounter and landing, DSN coverage of Helios 1 is likely to decrease in favor of Helios B.

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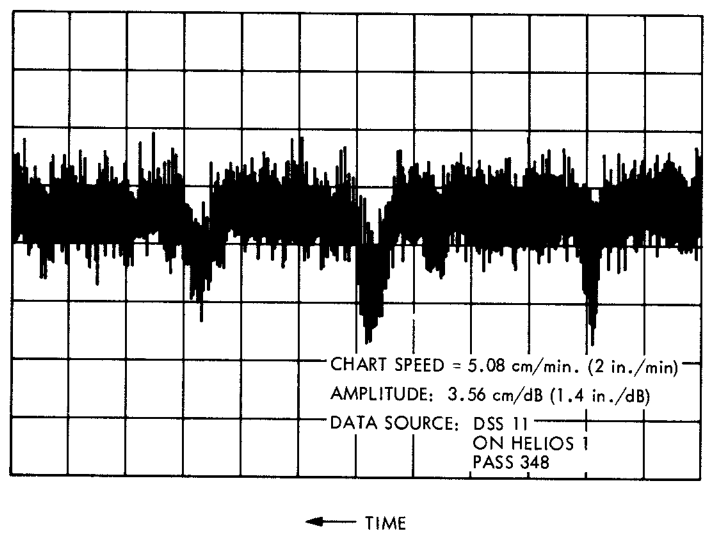

Fig. 1. Typical dropouts on Helios 1 downlink using TWT-2