Helios Flight 1 Spacecraft/Deep Space Network Compatibility Test Summary

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The Helios flight 1 spacecraft/DSN compatibility testing followed a very successful three-phase compatibility test program for the Helios prototype spacecraft. This article covers the tests from arrival of the flight 1 spacecraft at Cape Canaveral, Florida through launch. The compatibility tests consisted of (1) DSN/spacecraft radio frequency tests at both weak and strong signal levels, and (2) verification of radio frequency compatibility with the Helios flight 1 spacecraft mated to the launch vehicle at Launch Complex 41.

I. Introduction

This report covers the DSN/Helios flight 1 (F-1) spacecraft compatibility testing that extended over 56 hours from October 25 through 28, 1974, and for 8 hours on November 26, 1974. The compatibility tests performed during these periods were divided as follows:

(1) DSN/spacecraft radio frequency (RF) tests at both weak and strong signal levels during October 25–28, 1974.

(2) Verification of RF compatibility performed on November 26, 1974 with the Helios F-1 spacecraft mated to the launch vehicle at Launch Complex 41.

The DSN/Helios F-1 spacecraft compatibility testing followed a very successful three-phase program of compatibility testing between the DSN and the Helios prototype spacecraft (Ref. 1).

II. Test Report

The DSN/Helios F-1 spacecraft telecommunications compatibility testing utilized a test system that was operationally representative of a standard DSN station. The test system was under control of a computer to provide appropriate test conditions in an automatic mode of operation.

The spacecraft configurations during all of the tests were agreed upon by the Flight Project and the DSN. Spacecraft modes were selected to exercise a representative subset of all possible configurations, and to minimize the time required for completion of an adequate test program.

A. Telecommunications Compatibility Tests

These tests provided an assessment of telecommunications compatibility status between the Helios F-1 spacecraft and the Network based upon the results obtained between the DSN equipment in the STDN (MIL 71) station and the Helios F-1 spacecraft. These tests, conducted within the scheduled time period of October 25 through 28, 1974, were the final phase of the documented three-phase plan for establishing telecommunications compatibility between the Network and the Flight Project.

Procedures for conducting these tests were prepared by the Network. Test parameters and spacecraft design criteria were provided by the Helios spacecraft telecommunications engineers. The final procedures and test plans were reviewed and approved during a joint meeting of the DSN/Helios Project telecommunications representatives at Cape Canaveral. In particular, the Helios telecommunications representatives provided extensive support during the test procedure preparation and test planning phases.

The total time to accomplish the Helios F-1 spacecraft/STDN (MIL 71) compatibility tests was 56 hours. The successful completion of the tests during this time period was due in large measure to the excellent support provided by the JPL and Goddard STDN (MIL 71) management and operating personnel.

1. Test objectives. The objectives of the tests were to verify telecommunications design compatibility between the Network and the Helios F-1 spacecraft. The design compatibility was previously established between the DSN and the Helios prototype spacecraft in testing at the JPL Compatibility Test Area at Pasadena.

A selected set of standard tests, as specified in the Deep Space Network/Flight Project Interface Compatibility Test Design Handbook, for verifying transponder RF, command, telemetry, and metric data compatibility were performed. In addition, telemetry erasure rate tests were extended in response to Project requests, to include Data Decoder Assembly (DDA) statistical data. All tests were accomplished in accordance with the Network Test and Training Plan for Helios Project.

2. Test description. The Helios F-1 spacecraft was configured for flight operations and STDN (MIL 71) was configured to simulate a DSN station. The spacecraft was located in the clean room of Building AO, Cape Canaveral AFS, Florida, and STDN (MIL 71) was located at the MILA-STDN Station, Kennedy Space Center, Florida. An S-band RF air link of approximately 16 km (10 miles) was utilized between a 1.85-meter antenna at Building AO and a 1.2-meter antenna at the STDN station. RF link amplitude variations were 0.5 dB peak-to-peak for the critical tests in telemetry and command.

The STDN station software utilized in performing these tests was supplied by the DSN and was a subset of software officially released to the station for Helios Project support. The programs consisted of:

(1) Telemetry and Command Data Handling Program. This program provides independent control of the commanding and telemetry handling functions. Commands may be controlled manually from the station or automatically from the Mission Control and Computing Center. Telemetry may be decoded, formatted, and transmitted to the Mission Control and Computing Center for decommutation and display.

(2) Planetary Ranging Assembly Program. This program provides either continuous spectrum or discrete spectrum operation for determining very accurate range estimates of a spacecraft at planetary distances.

(3) Helios Decommutation and Data Validation Program. This program provides the capability of decommutating spacecraft engineering data and display at the station for verifying spacecraft parameters during compatibility testing.

(4) Multiple-Mission Test Program. This program provides a flexible test capability for performing bit error rate, word error rate, and signal-to-noise estimates.

3. Test results. Table 1 provides a summary of the test results. Significant events and data in the areas of RF, telemetry, command and metric data are described below:

a. Radio frequency acquisition and tracking. The criteria established for acquisition and sweep rates, spectrums, threshold, carrier, and subcarrier phase jitter measurements were either successfully met or exceeded. Special RF spectrum data required for the launch and first Goldstone pass modes were performed and provided to the DSN Network Operations Project Engineer for initial spacecraft acquisition procedures.

b. Telemetry. Bit error rate (BER) measurements at 8 and 32 bps uncoded were very successful with respect to test criteria. The spacecraft was configured for all experiments during these two tests in order to provide maximum data density to the Symbol Synchronizer

Assembly. ST_B/N_0 levels corresponding to an expected BER of 10^{-4} were established for both tests.

Frame deletion rate measurements at 256, 1024, and 2048 sps were equally successful. A special overfill program to the Helios Decommutation and Data Validation Program, provided by Office 420, was utilized to output Data Decoder Assembly statistical data. The data included number of frames counted, number of computations per frame, erased frames counted, and a distribution table of these data. The ST_s/N_0 levels established for these tests simulated 0.418 AU for 256 sps, 0.202 AU for 1024 sps, and 0.705 AU for 2048 sps. Additionally, the utilization of the special overfill to the Helios Decommutation and Data Validation Program provided the means of extending these tests to obtain the distribution of computations per frame. Therefore, the system telemetry performance was more critically determined.

c. Command. Command performance was performed on a functional basis due to limited test time. Command performance was successfully simulated for 2.0-AU conditions from a 26-meter antenna station at 10 kW (uplink -142.1 dBm, without ranging) and a 64-meter antenna station at 20 kW (uplink -136.6 dBm, with ranging). Both spacecraft command detectors (512 and 448 Hz) were tested.

d. Metric. The polarity of the spacecraft "ranging channel" was found to be INVERTED. This condition, different from the prototype spacecraft, represented no major impact as provisions for correcting phase reversal was resident in the Planetary Ranging Assembly software. With the exception of phase reversal, both continuous and discrete ranging measurements were well within expected values.

No differenced range versus integrated doppler (DRVID) testing was performed due to limited test time and higher priority items.

B. RF and Data Verification Tests

These tests provided an assessment of telecommunications compatibility status between the DSN, represented by DSN equipment in the STDN (MIL 71) station, and the Helios F-1 spacecraft after encapsulation and mating to the launch vehicle. These tests conducted on November 26, 1974, were a subset of tests performed previously between the F-1 and the DSN equipment in the STDN (MIL 71) station at Merritt Island, Florida, in October 1974.

Procedures for conducting these tests were prepared by the DSN, and spacecraft test parameters and design criteria were provided by the Helios Telecommunications Project. The final procedures were reviewed and approved during a joint meeting of the DSN/Helios Project Test Team at Cape Canaveral.

The total time to accomplish the Helios F-1 spacecraft STDN (MIL 71) compatibility tests was 8 hours.

1. Test objectives. The objective of the tests was to verify continued compatibility between the DSN and the Helios F-1 spacecraft after the spacecraft had been configured for launch operations. All tests were accomplished in accordance with the Network Test and Training Plan for Helios Project.

2. Test description. The Helios F-1 spacecraft was in launch configuration and STDN (MIL 71) was configured to simulate a DSN station. The spacecraft was located at Launch Complex 41, Cape Canaveral AFS, Florida and STDN (MIL 71) was located at the STDN (MIL Station, Kennedy Space Center, Florida). An S-band RF air link of approximately 16 km (10 miles) was utilized to establish the spacecraft/ground station interface. The spacecraft transmit/receive function was performed by connecting a test point at the shroud to a 1.2-meter antenna connected to the launch service tower.

The ground station software utilized in performing these tests was supplied by the DSN and was a subset of software officially released to the station for Helios Project support. The programs consisted of:

(1) Telemetry and Command Data Handling Program. This program provides independent control of the commanding and telemetry handling functions. Commands may be controlled manually from the station or automatically from the Mission Control and Computing Center. Telemetry may be decoded, formatted, and transmitted to the Mission Control and Computing Center for decommutation and display.

(2) Planetary Ranging Assembly Program. This program provides either continuous spectrum or discrete spectrum operation for determining very accurate range estimates of a spacecraft at planetary distances.

(3) Helios Decommutation and Data Validation Program. This program provides the capability of decommutating spacecraft engineering data and display at the station for verifying spacecraft parameters during compatibility testing.

3. Test results. Table 2 provides in summary form the test results. Significant events and/or items in the areas of RF, telemetry, command, and metric data are described below:

a. Radio frequency. Short-term RF link fluctuations throughout the test period were observed to ±1.5 dB on the link between Launch Complex 41 and MIL 71. All phases of the RF tests were successfully completed.

b. Telemetry. Short-term RF link variations during subtest 1 were observed to be ±1.5 dB. However, variations during subtest 3 were observed to be ±7.5 dB and resulted in the Telemetry and Command Subsystem (TCD) dropping lock occasionally. (This same situation was experienced during the Helios prototype spacecraft/Launch Complex 41 test.) In view of the adverse conditions under which subtest 3 was conducted, it was an "engineering judgement" that both telemetry tests performed satisfactorily.

c. Command. Short-term RF link variations during command subtest 1 were observed to be ±6 dB. Variations during subtest 3 were ±2 dB. During subtest 1, 114 commands were sent successfully, and during subtest 3, 118 commands were sent successfully.

d. Metric. Ranging system acquisition time was successfully completed with no problems experienced.

III. Conclusions

The successful conclusion of the formal DSN/Helios compatibility program enabled the establishment of telecommunications compatibility and was evidenced by the successful launch of the Helios F-1 spacecraft on December 10, 1974.

The importance of a formal compatibility test program is clearly demonstrated by the problem areas uncovered, verified, and resolved during the DSN/Helios testing. Prominent problem areas discovered and resolved during this test program were:

(1) Deficiencies in the engineering model transponder. The transponder exhibited lag in sensitivity, pushing effects at strong uplink signal levels, instability of the voltage-controlled crystal oscillator, and improper shielding.

(2) Polarity of the ranging channel in the F-1 spacecraft was inverted. This condition was different from the prototype spacecraft.

(3) Many hundreds of hours of test time were used at the DSN station (DSS 71) to determine optimum modulation indices for the Helios Mission. A full description of this testing was published in Ref. 2.

(4) An elaborate test system to simulate uplink and downlink amplitude, phase, and frequency modulation conditions during the spacecraft Step II maneuver was performed. This simulation demonstrated that the spacecraft could be successfully commanded during this very critical phase of flight.

These problems, undetected and unresolved prior to launch, would have presented serious operational problems to the Network with the spacecraft in flight.

References

1. Bryan, A. I., "Helios Prototype Spacecraft Deep Space Network Compatibility Test Summary," in *The Deep Space Network Progress Report 42-23*, pp. 22–36, Jet Propulsion Laboratory, Pasadena, California, Oct. 15, 1974.
2. Layland, J. W., "DSS Tests of Sequential Decoding Performance," in *The Deep Space Network Progress Report 42-20*, pp. 69-77, Jet Propulsion Laboratory, Pasadena, California, Apr. 15, 1974.

Test date (1974)	Test title	Test No.	Deep Space Network										
			BLK III RCV	BLK III EXC	PRA RNG	CMD	Uplink doppler, Hz/s	Uplink offset, kHz	CMA SUBC offset	SDA SUBC offset	CAR SUP	Bit rate	EXC
10/25	Spacecraft maximum sweep and acquisition rate	I. 1	1	1	OFF	OFF	500	−30	NA	NA	HI	2048	1
			1	1	OFF	OFF	500	+30	NA	NA	HI	2048	1
			1	1	OFF	OFF	80	−9.7	NA	NA	HI	2048	1
			1	1	OFF	OFF	80	+9.9	NA	NA	HI	2048	1
10/26	Downlink spectrum analysis	II. 1	1	1	OFF	OFF	NA	NA	NA	NA	HI	2048	1
		II. 2	1	1	OFF	OFF	NA	NA	NA	NA	HI	128	1
		II. 3	1	1	OFF	OFF	NA	NA	NA	NA	LO	32	1
		II. 7	1	1	ON (Idle seq.)	NA	NA	NA	NA	NA	HI	2048	1
		II. 10	1	1	ON	ON	NA	NA	NA	NA	HI	128	1
10/25	Uplink threshold	III. 1	1	1	OFF	OFF	NA	NA	NA	NA	HI	128	1
		III. 2	1	1	ON	OFF	NA	NA	NA	NA	HI	128	1
		III. 3	1	1	OFF	OFF	NA	NA	NA	NA	HI	128	1
10/25	Carrier residual phase jitter	IV. 1	1	1	OFF	OFF	NA	NA	NA	NA	HI	2048	1
		IV. 2	1	1	OFF	OFF	NA	NA	NA	NA	HI	2048	2
		IV. 3	1	1	OFF	OFF	NA	NA	NA	NA	HI	2048	1
			1	1	OFF	OFF	NA	NA	NA	NA	HI	2048	1
		IV. 4	1	1	OFF	OFF	NA	NA	NA	NA	HI	2048	1
			1	1	OFF	OFF	NA	NA	NA	NA	HI	2048	1

Table 1. DSN/Helios F-1 spacecraft telecommunication test summary

Spacecraft							Test data		Test Time, min	Test comments
RCV	PWR	ANT	TWT	RNG	S/C DM	S/C FM	Performance	Criteria		
1	HP	MGA	2	OFF	0	4	Acquired @ −100.0 dBm; tracked to +32.5 kHz	Acquire @ −100.0 dBm; track to +32.5 kHz	125	Acquired U/L @ best lock (VCXO 1) 2115.679152 MHz
1	HP	MGA	2	OFF	0	4	Acquired @ −100.0 dBm; tracked to −32.5 kHz	Acquire @ −100.0 dBm; track to −32.5 kHz		Acquired U/L @ best lock (VCXO 1) 2115.679152 MHz
1	HP	MGA	2	OFF	0	4	Acquired @ −141.0 dBm; tracked to +32.5 kHz	Acquire @ −141.0 dBm; track to −32.5 kHz		Acquired U/L @ best lock (VCXO 1) 2115.679152 MHz
1	HP	MGA	2	OFF	0	4	Acquired @ −141.0 dBm; tracked to −32.5 kHz	Acquire @ −141.0 dBm; track to −32.5 kHz		Acquired U/L @ best lock (VCXO 1) 2115.679152 MHz
1	HP	MGA	1	OFF	0	4	No spurs observed	No spurious signal within 30 dB of carrier	17	Subcarrier OSC No. 2 noncoherent mode
1	LP	LGA	NA	OFF	0	4	No spurs observed	No spurious signal within 30 dB of carrier	15	Subcarrier OSC No. 1 noncoherent mode
1	LP	LGA	NA	OFF	0	4	No spurs observed	No spurious signal within 30 dB of carrier	20	Subcarrier OSC No. 1 noncoherent mode
1	LP	LGA	1	OFF	0	4	No spurs observed	No spurious signal within 30 dB of carrier	15	VCXO 1, coherent (Goldstone first acq) mode
1	HP	MGA	1	ON	0	4	No spurs observed	No spurious signal within 30 dB of carrier	16	VCXO 1, coherent mode
1	HP	MGA	2	OFF	0	4	−155 dBm	−155.0 ± 1 dBm	35	Threshold value is average of 3 measurements
1	HP	MGA	2	ON	0	4	−155 dBm	−155.0 ± 1 dBm	43	
2	HP	LGA	2	OFF	0	4	−154 dBm	−155.0 ± 1 dBm	38	
1	HP	MGA	1	OFF	0	4	1.95 deg rms	5.7 deg rms	40	U/L level −100 dBm
1	HP	MGA	2	OFF	0	4	1.74 deg rms	5.7 deg rms	9	U/L level −100 dBm
1	HP	MGA	2	OFF	0	4	1.77 deg rms	2.86 deg rms	25	U/L level −100 dBm
1	HP	MGA	2	OFF	0	4	14.80 deg rms	22.9 deg rms		U/L level −144 dBm
2	HP	LGA	2	OFF	0	4	1.73 deg rms	2.86 deg rms	20	U/L level −100 dBm
2	HP	LGA	2	OFF	0	4	16.00 deg rms	22.9 deg rms		U/L level −144 dBm

Test date (1974)	Test title	Test No.	Deep Space Network										
			BLK III RCV	BLK III EXC	PRA RNG	CMD	Uplink doppler, Hz/s	Uplink offset, kHz	CMA SUBC offset	SDA SUBC offset	CAR SUP	Bit rate	EXC
10/25	Downlink threshold	V. 1	1	1	OFF	OFF	NA	NA	NA	NA	HI	128	1
		V. 3	1	1	OFF	OFF	NA	NA	NA	NA	HI	128	2
		V. 5	1	1	OFF	OFF	NA	NA	NA	NA	HI	128	1
			1	1	OFF	OFF	NA	NA	NA	NA	HI	128	1
		V. 6	1	1	ON	OFF	NA	NA	NA	NA	HI	128	1
			1	1	ON	OFF	NA	NA	NA	NA	HI	128	1
10/26	Spacecraft ranging delay	VI. 2	1	1	ON	OFF	NA	NA	NA	NA	HI	128	1
		VI. 4	1	1	ON	OFF	NA	NA	NA	NA	HI	128	1
		VI. 9	1	1	ON	OFF	NA	NA	NA	NA	HI	128	1
		VI. 10	1	1	ON	OFF	NA	NA	NA	NA	HI	128	1
10/26	Ranging system acquisition time	VII. 1	1	1	ON	OFF	NA	NA	NA	NA	HI	128	1
		VII. 2	1	1	ON	OFF	NA	NA	NA	NA	HI	128	1
10/26	Bit error rate	VIII. 1	1	1	OFF	OFF	NA	NA	NA	NA	LO	8 (UNC)	1
		VIII. 2	1	1	OFF	OFF	NA	NA	NA	NA	LO	32 (UNC)	1
10/28	Telemetry erasure rate	IX. 1	1	1	OFF	ON	NA	NA	NA	NA	HI	128	1
10/27		IX. 2	1	1	ON	ON	NA	NA	NA	NA	HI	512	1
		IX. 3	1	1	OFF	ON	NA	NA	NA	NA	HI	1024	1

Table 1 (contd)

Spacecraft							Test data		Test Time, min	Test comments
RCV	PWR	ANT	TWT	RNG	S/C DM	S/C FM	Performance	Criteria		
1	HP	MGA	1	OFF	0	4	−158.8 dBm	−159.5 ± 3 dBm	21	Noncoherent mode
1	HP	MGA	2	OFF	0	4	−158.7 dBm	−159.5 ± 3 dBm	20	Noncoherent mode
2	HP	LGA	1	OFF	0	4	−158.3 dBm	−159.5 ± 3 dBm	19	Coherent mode; U/L level −100 dBm
2	HP	LGA	1	OFF	0	4	−158.7 dBm	−159.5 ± 3 dBm	18	Coherent mode; U/L level −144 dBm
1	HP	MGA	1	ON	0	4	−159.0 dBm	−159.5 ± 3 dBm	20	Coherent mode; U/L level −100 dBm
1	HP	MGA	1	ON	0	4	−159.0 dBm	−159.5 ± 3 dBm	22	Coherent mode; U/L level −100 dBm
1	HP	HGA	1	ON	0	4	S/C delay: 1364 ns		15	−100 dBm U/L
1	HP	MGA	1	ON	0	4	S/C delay: 13.70 ns	No requirement	15	−100 dBm D/L
1	MP	MGA	2	ON	0	4	S/C delay: 1384 ns	RNG stability: ±500 ns	22	"Phase reversal" vs prototype spacecraft
1	MP	MGA	2	ON	0	4	S/C delay: 1369 ns		15	VI 2, 4, 10 discrete VI 9 continuous
1	HP	MGA	1	ON	0	4	22 min 40 s	<45 min	25	Continuous spectrum
1	HP	MGA	1	ON	0	4	1 min 18 s	<2 min	10	Discrete spectrum U/L level −134.5 dBm D/L level −135.0 dBm
1	HP	MGA	1	OFF	0	4	0 errors in 10^4 bits	10^{-4}	210	U/L −148.1 dBm D/L −135 dBm
1	HP	MGA	1	OFF	0	4	0.09×10^4	10^{-4}		Uncoded mode
1	HP	MGA	2	OFF	0	4	D/L threshold −147.5 D/L level −128.3	10^{-3}	230	D/L levels providing 10^{-3} erasure rate were below link criteria
1	HP	MGA	2	ON	0	4	D/L threshold −141.0 U/L level −137.9	10^{-3}	200	Test to estimate telemetry performance by distribution of computations/frame
1	HP	HGA	2	OFF	0	4	D/L threshold −138.4	10^{-3}	60	

Test date (1974)	Test title	Test No.	Deep Space Network										
			BLK III RCV	BLK III EXC	PRA RNG	CMD	Uplink doppler, Hz/s	Uplink offset, kHz	CMA SUBC offset	SDA SUBC offset	CAR SUP	Bit rate	EXC
10/26	Subcarrier frequency and phase jitter	X. 1	1	1	OFF	OFF	NA	NA	NA	NA	HI	128	1
		X. 2	1	1	OFF	OFF	NA	NA	NA	NA	HI	128	2
		X. 3	1	1	OFF	OFF	NA	NA	NA	NA	HI	128	2
10/26	Spacecraft command performance	XI. 1	1	1	OFF	ON	NA	NA	NA	NA	HI	128	1
		XI. 2	1	1	ON	ON	NA	NA	NA	NA	HI	512	1
10/27		XI. 3	1	1	OFF	ON	NA	NA	NA	NA	HI	1024	1

NOTE: See Table 3 for definition of terms used.

Table 1 (contd)

Spacecraft							Test data		Test Time, min	Test comments
RCV	PWR	ANT	TWT	RNG	S/C DM	S/C FM	Performance	Criteria		
NA	LP	LGA	NA	OFF	0	4	0.835 deg rms 32,768 Hz	1.15 deg rms 32,768 Hz	25	S/C DHE OSC No. 1 Chain 1
NA	LP	LGA	NA	OFF	0	4	0.84 deg rms 32,768 Hz	1.15 deg rms 32,768 Hz	24	S/C DHE OSC No. 1 Chain 2
NA	LP	LGA	NA	OFF	0	4	0.86 deg rms 32,768 Hz	1.15 deg rms 32,768 Hz	25	S/C DHE OSC No. 2 Chain 2
1	HP	MGA	2	OFF	0	4	54 commands accepted and processed	All commands accepted by spacecraft	20	VCXO 1, coherent, command S/C @ 512 Hz
1		MGA		ON	0	4	54 commands accepted and processed	All commands accepted by spacecraft	14	U/L @ −142.1 dBm (2.9 dB above command threshold)
2	HP	HGA	2	OFF	0	4	23 commands accepted and processed	All commands (continuous) accepted and processed	14	VCXO 2, coherent, command S/C @ 448 Hz U/L @ −138.1 dBm (5.9 dB above command threshold)

Test date (1974)	Test title	Test No.	Deep Space Network									
			BLK III RCV	BLK III EXC	PRA RNG	CMD	Uplink doppler, Hz/s	Uplink offset, kHz	CMA SUBC offset	SDA SUBC offset	CAR SUP	Bit rate
11/26	Spacecraft maximum sweep and acquisition rate	I.1	−106 dBm 23.412423	−108.5 dBm 22.038540	OFF	OFF	500	−30 to +32.5	NA	NA	HI	2048
			−106 dBm 23.412423	−108.5 dBm 22.038540	OFF	OFF	500	+30 to −32.9	NA	NA	HI	2048
11/26	Uplink threshold	III. 1	−110 dBm 23.412423	22.038540	OFF	OFF	NA	NA	NA	NA	HI	128
		III. 3	−113 dBm 23.412481	22.038594	OFF	OFF	NA	NA	NA	NA	HI	128
11/26	Downlink threshold	V. 1	23.412401	−110 dBm 22.038520	OFF	OFF	NA	NA	NA	NA	HI	128
11/26	Ranging system acquisition time	VII.1	−112 dBm 23.412401	−112 dBm with mod 22.038520	ON	OFF	NA	NA	NA	NA	HI	128
11/27	Telemetry performance	IX. 1	−112 dBm 23.412401	−109 dBm 22.038520	OFF	ON	NA	NA	NA	NA	HI	128
		IX. 3	−116 dBm 23.412483	−107 dBm 22.038595	OFF	ON	NA	NA	NA	NA	HI	1024
11/27	Spacecraft command performance	XI. 1	−117 dBm 23.412423	−113.5 dBm 22.038540	ON	ON	NA	NA	NA	NA	HI	128
		XI. 3	−116 dBm 23.412482	−108 dBm 22.038494	ON	ON	NA	NA	NA	NA	HI	1024

NOTE: 1. Block III receiver 1, exciter 1 used for all tests.
2. See Table 3 for definition of terms used.

Table 2. DSN/Helios F-1 spacecraft telecommunications test summary

Spacecraft								Test data		Test time, min	Test comments
EXC	RCV	PWR	ANT	TWT	RNG	S/C DM	S/C FM	Performance	Criteria		
1	1 & 2	HP	LGA	2	OFF	0	4	Acquired and tracked	Acquire at best lock; track to +32.5 kHz	71	2115.699 kHz best lock frequency S/C receiver 1
1	1 & 2	HP	LGA	2	OFF	0	4	Acquired and tracked	Acquire at best lock; track to −32.5 kHz		
1	1	HP	LGA	2	OFF	0	4	−158.8 dBm	To be measured	40	Average of 3 runs; link variance 1.5 dB p-p
1	2	HP	LGA	2	OFF	0	4	−159.0 dBm	To be measured	34	Average of 3 runs; link variance 1.5 dB p-p
1	1	HP	LGA	1	OFF	0	4	−158.3 dBm	−139.0 ± 2 dBm	24	Average of 3 runs; link variance 1.5 dB p-p
1	1	HP	LGA	1	ON	0	4	1-min acquisition 98738 RU	TBD	23	15 components discrete; 1 min integration time
1	1	HP	LGA	2	OFF	0	4	Decommutated data satisfactory	30 min of decommutated data	83	Link variance 3 dB p-p
1	2	HP	LGA	2	OFF	0	4	Decommutated data satisfactory when TCD in lock	30 min of decommutated data	74	Link variance 15 dB p-p; TCD out of lock periodically
1	1	HP	LGA	2	OFF	0	4	All good commands (114 commands)	All commands successfully received by spacecraft	46	Discrete ranging on commands 501-506
1	2	HP	LGA	2	OFF	0	4	All good commands (118 commands)	All commands successfully received by spacecraft	39	Discrete ranging on commands 501-502

Table 3. Definitions for Tables 1 and 2

ANT	Spacecraft antenna
Bit rate	Clock frequency of the telemetry bit information
BLK III exciter	The standard DSN S-band exciter equipment
BLK III receiver	The standard DSN S-band receiving equipment
CAR SUP	Downlink carrier suppression due to telemetry modulation
CMA SUBC offset	Command modulation assembly subcarrier frequency offset relative to nominal
CMD	Telemetry and command data handling command modulation
EXC	Spacecraft S-band exciter equipment
HGA	High-gain antenna
LGA	Low-gain antenna
MGA	Medium-gain antenna
PRA RNG	Planetary ranging assembly modulation
PWR	Spacecraft transmitter power mode
RCV	Spacecraft S-band receiving equipment
RNG	Spacecraft ranging channel
S/C DHE	Spacecraft data handling equipment
S/C DM	Spacecraft data mode
S/C FM	Spacecraft data format
SDA SUBC offset	Subcarrier demodulator assembly subcarrier frequency offset relative to nominal
TWT	Traveling wave tube amplifier
UNC	Uncoded
Uplink doppler	Ramp rate of the uplink carrier frequency
Uplink offset	Uplink carrier frequency offset relative to the spacecraft receiver rest frequency