Pioneer Venus 1978 Deep Space Network Telecommunications Compatibility Test Program Status

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The Pioneer Venus 1978 Flight Project DSN Telecommunications Compatibility Test Program consists of three phases: Subsystem Design, System Design and System Verification Tests, which are to be performed at JPL and at the U.S. Air Force Eastern Test Range and Kennedy Space Center Complexes. Subsystem Design Tests were performed during April 1977. A subset of System Design Tests were performed during November 1977. This article describes the tests that have been completed through 1977.

I. Introduction

This report summarizes the DSN Pioneer Venus 1978 (PV'78) Flight Project Telecommunications Compatibility Test Program, covering the period from April 1977 through November 1977. This test program is following the standard three-phase plan of establishing telecommunications compatibility as specified in the DSN Standard Practice Document, *Deep Space Network – Flight Project Interface Compatibility Test Design Handbook*, and in the Pioneer Venus Project – DSN Spacecraft Compatibility Test Plan.

The plan specifies that telecommunications design compatibility will be established at the subsystem and system levels and conclude with a final verification at Cape Canaveral, Florida, prior to launch. In addition, the DSN and flight project equipment, software configurations, requirements and test objectives in all phases are specified.

Procedures for conducting the tests as well as test design criteria and test parameters for the ground station hardware and software were prepared by Network personnel. Spacecraft telecommunications design performance criteria and test parameters to establish flight project nominal and threshold telecommunications conditions were provided by the PV'78 Telecommunications group. The test criteria were included as part of the test procedures to provide real-time assessment of performance. All test procedures were jointly approved by the DSN and flight project representatives.

II. Types of Tests

As of this report, the test program has included Subsystem Design Tests (Phase I) with the PV'78 Prototype and System Design Tests (Phase II) with the PV'78 Orbiter, BUS and the three Small Probe Spacecrafts. System Design Tests yet to be

completed are those involving the PV'78 Large Probe and the Multisignal (five simultaneous downlink signals) tests.

III. Objectives

The objectives of the test program is to demonstrate, in the major areas of radio frequency acquisition and tracking, command and telemetry, compatibility between the spacecraft telecommunications subsystems and the Network, to establish system design compatibility between the spacecraft and the Network, and to verify continued interface integrity and maintenance of compatibility during prelaunch activities.

IV. DSN Subsystem Compatibility Tests

A. PV'78 Prototype, 5–13 April 1977

1. Test objectives. The objectives of these tests were to establish telecommunications design compatibility between the DSN and the Pioneer Venus Project in the areas of Radio Frequency acquisition, tracking and telemetry. Specifically, the objectives were as follows:

(1) Verify the capability to receive S-band and X-band carrier signals from the PV'78 Prototype Spacecraft Orbiter RF Subsystem without degradation of DSN receiver thresholds.

(2) Verify the capability to receive S-band carrier signals from the DSN transmitter without degradation of the PV'78 Orbiter receiver threshold.

(3) Determine the maximum DSN transmitter offsets and the minimum DSN transmitter sweep rates for reliable PV'78 receiver acquisition.

(4) Determine the maximum DSN transmitter sweep rates for proper PV'78 receiver tracking.

(5) Verify the DSN Telemetry System capability to receive and process coded and uncoded telemetry without degradation.

All tests performed were in accordance with JPL internal Document 810-8; Rev. B, *Deep Space Network/Flight Project Interface Compatibility Test Design Handbook.*

2. Test conditions. The Pioneer Venus Prototype Transponder and Telemetry Subsystems were located in the Compatibility Test Area RF screen room at JPL. The Radio Frequency Subsystem was configured as follows:

(1) S-band: receiver, Channel 17 (2114.335648 MHz) transmitter, equipped with solid state amplifier coherent and non-coherent modes of operation

(2) X-band: transmitter, equipped with solid state amplifier

The DSN, as represented by CTA 21, was configured to simulate a Pioneer Venus Flight Project committed Deep Space Station. The ground hardware included the Block IV Receiver-Exciter Subsystem and the Mark III Data Subsystem for telemetry.

The S-band and X-band RF links between the DSN and the PV'78 prototype transponder were coaxial cables (with suitable attenuators) which had previously been calibrated for attenuation losses and impedance characteristics. The DSN software provided at CTA 21 was the preliminary (unreleased) Pioneer Venus operational software.

3. Test results. Table 1, DSN Pioneer Venus Prototype Spacecraft Telecommunications Compatibility Test Summary provides a listing of test configurations, test criteria, parameters and results. Refer to Fig. 1 for DSN mode configurations. Significant test results and comments are discussed below:

a. Radio frequency acquisition and tracking. All objectives of this phase of testing were successfully met. However, while performing the rest frequency measurement, it was observed that the rest frequency of the VCO was quite unstable under no signal conditions. Additionally, it was discovered that the prototype receiver VCO was being "pushed" while ramping the uplink frequency (S-band) at 5 Hz per second. Investigation of these two conditions revealed that both problems were known to exist under similar test conditions at the factory. The test conditions and parameters were modified as follows:

(1) The prototype receiver was located on an open table in the RF screen room and was subjected to a changing ambient temperature environment. An insulated enclosure was constructed around the prototype receiver which allowed the VCO to meet the stability requirements of the test.

(2) The uplink ramp rate was changed from 5 Hz per second to 10 Hz per second and successful acquisition of the spacecraft receiver was accomplished.

b. Telemetry. Initial attempts to perform sequential decoding of Orbiter spacecraft convolutionally encoded data resulted in aborted acquisitions by the DSN sequential decoder. This condition was encountered regardless of data rate and/or signal level. It was observed, however, that the DSN Telemetry Subsystem performed satisfactorily on station generated simulated spacecraft encoded data and performed satisfactorily on the prototype spacecraft encoded data up to the sequential decoder itself.

During the performance of trouble-shooting procedures, the spacecraft data generation program was re-initialized, and that

seemed to fix the problem. Every morning for the remainder of the test, the spacecraft data generation program had to be re-initialized to correct the problem before testing could begin.

As the telemetry tests got underway, it was noted that during periods when the signal strength was high enough that there should not have been any errors in the telemetry, the decoder was detecting and correcting errors. This was indicated by the fact that the number of computations per bit was more than 1.00 and the deletion rate was 0.00.

By taking a dump of the raw data symbols from the telemetry processor assembly data symbol buffer, it was discovered that the spacecraft encoder reset pulse was not being applied properly at the beginning of the 24-bit tail sequence.

The problem was independently verified by the spacecraft hardware personnel by looking at the encoder signals on an oscilloscope.

After the encoder was reworked to the correct configuration, satisfactory operation of the sequential decoder was achieved.

The encoder that was initially configured incorrectly was an orbiter-type encoder. To insure that the probe-type encoder was correctly configured, an analog recording of the encoded data stream from one of the flight units was prepared at HAC and brought to JPL for processing through the DSN telemetry equipment. This effort proved successful and demonstrated that the probe-type encoders were configured correctly.

Following resolution of the encoder problem, the telemetry threshold tests were completed. The coded telemetry tests were performed over a two-day period with a noticeable difference in performance for the two days. On the first day, the decoder was deleting frames (as expected) as the input signal level was lowered. However, during the second day of testing, the deletion rate did not exceed zero until the sequential decoder completely dropped lock from lack of input signal. Because of insufficient performance data at threshold conditions with the new DSN sequential decoder, it was not known which, if either, condition was normal.

Subsequent to the subject tests, a software error that prevented proper read-out of the frame deletion statistics was discovered and corrected. After this software error had been identified, a new series of tests were performed at CTA 21 to determine proper operation (frame deletion rate as a function of input signal level) of the new sequential decoder.

A plan was generated by the DSN to extensively test telemetry performance for sequential decoding in order to identify and document proper performance characteristics. The plan utilized was to repeat only the coded data portions of the telemetry threshold tests performed during the DSN PV'78 Prototype testing. The spacecraft telemetry generating function was simulated utilizing the Simulation Conversion Assembly (SCA) and the DSN test transmitter. The resulting signal was processed through the Block III Receiver, Subcarrier Demodulation Assembly (SDA) and the Telemetry Processor Assembly (TPA).

In order to facilitate test time, a frame deletion rate of 10^{-2} was used as the criterion for a specified signal-to-noise (ST_b/N_o) input level. Additionally, revised ST_b/N_o values were used. Based on theoretical system losses and measured performance characteristics of the old Data Decoder Assembly (DDA), these revised ST_b/N_o values reflected a more accurate estimate of sequential decoder performance and project requirements. Results of the tests were satisfactory as all frame deletion rate (DLR) measurements were well within the tolerances of the controlled test conditions, i.e., setting of ST_b/N_o by the y-factor method. In addition to DLR data, the symbol error rate (SER) for each test was also provided.

The telemetry test data shown in Table 1 are the data that were obtained during the sequential decoder performance testing without the prototype spacecraft.

V. DSN System Compatibility Tests

A. PV'78 Orbiter, 1–4 November 1977

1. Test objectives. The objectives of these tests were to establish telecommunications design compatibility between the DSN and the Pioneer-Venus Orbiter in the areas of radio frequency acquisition, tracking, telemetry, and command at strong signal levels. Specifically, the objectives were as follows:

(1) Determine the maximum DSN transmitter offsets and the minimum DSN transmitter sweep rates for reliable PV'78 receiver acquisition.

(2) Determine the maximum DSN transmitter sweep rates for proper PV'78 receiver tracking.

(3) Verify the DSN Telemetry System capability to receive and process coded and uncoded telemetry.

(4) Verify the DSN Command System capability to successfully transmit timed commands, untimed commands and contiguous commands to the PV'78 Orbiter.

(5) Verify the DSN spectral signal indicator (SSI) to display and correctly identify major PV'78 RF signal components.

(6) Verify the DSN capability to perform predetection recording and playback on actual PV'78 RF signals and telemetry data.

All tests performed (with the exception of (5) and (6)) were in accordance with JPL internal Document 810-8, Rev. B, *Deep Space Network/Flight Project Interface Compatibility Test Design Handbook.* Tests (5) and (6) were performed to demonstrate the operational capabilities of the SSI and pre-detection recording and playback.

2. Test conditions. The Pioneer-Venus Orbiter Spacecraft was located at the Hughes Aircraft Company, El Segundo, California. The Radio Frequency Subsystem was configured as follows:

(1) S-band: Receiver No. 1, Channel 11 (2112.290394 MHz); Receiver No. 2, Channel 12 (2112.629760 MHz); and Transmitter No. 1 and No. 2, equipped with 20-W solid state amplifiers

(2) X-band: Not tested

The DSN, as represented by CTA 21, was configured to simulate a Pioneer-Venus Flight Project committed Deep Space Station. The ground hardware included the Block III and IV Receiver-Exciter Subsystems and the Mark III Data Subsystem for telemetry and command.

The S-band RF link between the DSN and the PV'78 Orbiter Spacecraft was an open RF link between the Hughes Aircraft Company, El Segundo, California and the Jet Propulsion Laboratory, Pasadena, California. A description of the link is provided in the Appendix. The link had been previously tested for amplitude and phase stability and was found to be acceptable for strong signal testing.

The DSN software provided at CTA 21 was the Pioneer-Venus operational software for telemetry and command.

3. Test results. Table 2, DSN Pioneer-Venus Orbiter Spacecraft Telecommunications Compatibility Test Summary, provides a listing of test configurations, test criteria, parameters, and results. Refer to Fig. 1 for DSN mode configurations. Significant test results and comments are discussed below:

a. Radio frequency acquisition and tracking. All objectives of this phase of testing were successfully met. The acquisition test was performed by off-setting the CTA 21 exciter plus and minus 5 kHz about the spacecraft receiver theoretical best-lock frequency, and ramping toward best lock until spacecraft receiver acquisition was achieved. The two acquisition frequencies were averaged and became the actual best lock frequency.

The tracking test was performed by ramping the spacecraft receiver to plus and minus 100 kHz about center (best lock) frequency at a rate of 100 Hz per second.

b. Telemetry. The telemetry tests were begun by first performing predetection recording and playback of 16.0 bits/s coded and 256.0 bits/s coded data rates. This particular set of tests was performed in order to demonstrate that the predetection recording and playback technique was viable utilizing actual spacecraft data in preparation for the multisignal tests which are scheduled to be performed at a later date. Results of these tests indicate that the system was satisfactory for recording and playback of the data.

As part of these compatibility tests, the spectral signal indicator (SSI) being developed by Section 333 was made available for displaying and analyzing the PV'78 Orbiter RF spectrum. Results of the tests that were performed with the SSI indicated quite clearly that the SSI has extremely good sensitivity and resolution. It was easily demonstrated that the RF carrier, subcarrier and data modulation components could be identified.

The remainder of the telemetry processing tests were performed with no significant problems noted. It was discovered that a 5 db error in observed SSA SNR values versus expected values was the result of a shifted AGC curve in the Block IV receiver. The AGC curves were recalibrated and testing was continued without impact.

A significant product of these tests was the telemetry subsystem lock-up times. These data provide a good measure of the software operational capabilities under relatively strong signal level conditions. In addition to the lock-up times, the sequential decoder deletion rate, average computation per bit and symbol error rate data were also provided.

c. Command. In order to test the DSN PV'78 Orbiter command interface for compatibility, a variation from the test plan, PC'464, was utilized. It was agreed that since the PMOCC was not yet ready to support the command test, as specified in PC-464, the commands would be transmitted from CTA 21 utilizing the manual mode capability of the software.

All commands scheduled to be utilized during the compatibility test were successfully transmitted by CTA 21 and successfully processed by the PV'78 Orbiter Spacecraft.

During initial attempts to send the single timed commands, it was discovered that an interference problem by the HAC ground support equipment was preventing proper reception of the DSN generated commands. The HAC ground support equipment configuration included the capability of locally

generating spacecraft commands via a hardline to the spacecraft command processor. After several unsuccessful attempts to send the single timed commands, HAC reported that it was a known problem that the hardline configuration would inhibit commands received through the RF system when command processor No. 1 was receiving commands via receiver No. 1 and when command processor No. 2 was receiving commands via receiver No. 2. However, in the cross-strapped configuration (receiver No. 1 – command processor No. 2/Receiver No. 2 – command processor No. 1), this condition did not exist.

After resolving this problem, it was discovered that several commands provided to the DSN contained erroneous bit-structures. When the proper command bit structures were made available, the remainder of the command sequences were sent successfully and processed successfully by the spacecraft.

Strip chart recordings of the DSN command subsystem displayed an obvious difference in several bit lengths of the Idle 2 mode just prior to a timed preamble. It was subsequently learned that this was a normal occurrence (and one that does not adversely affect spacecraft command processor operation) because of the manner in which the Command Modulator Assembly (CMA) must achieve 0.1-s command synchronization accuracy.

B. PV'78 Bus, 8–10 November 1977

1. Test objectives. The objectives of these tests were to establish telecommunications design compatibility between the DSN and the Pioneer Venus BUS in the areas of radio frequency acquisition, tracking, telemetry, and command at strong signal levels. Specifically, the objectives were as follows:

(1) Determine the maximum DSN transmitter offsets and the minimum DSN transmitter sweep rates for reliable PV'78 BUS receiver acquisition.

(2) Determine the maximum DSN transmitter sweep rates for proper PV'78 Bus receiver tracking.

(3) Verify the DSN Telemetry System capability to receive and process coded and uncoded telemetry.

(4) Verify the DSN Command System capability to successfully transmit timed commands, untimed commands and contiguous commands to the PV'78 Bus.

All tests performed were in accordance with JPL Document 810-8, Rev. B, *Deep Space Network/Flight Project Interface Compatibility Test Design Handbook.*

2. Test conditions. The Pioneer Venus bus spacecraft was located at the Hughes Aircraft Company, El Segundo, California. The Radio Frequency Subsystem was configured at S-band as follows: Receiver No. 1, Channel 6 (2110.583352 MHz); Receiver No. 2, Channel 8 (2111.268744 MHz); and Transmitter No. 1 and No. 2, equipped with 20-W solid-state amplifiers.

The DSN, as represented by CTA 21, was configured to simulate a Pioneer Venus Flight Project committed Deep Space Station. The ground hardware included the Block III and IV Receiver-Exciter Subsystems and the Mark III Data Subsystem for telemetry and command.

The S-band RF link between the DSN and the PV'78 Orbiter spacecraft was an open RF link between the Hughes Aircraft Company, El Segundo, California and the Jet Propulsion Laboratory. A description of the link is provided in the Appendix. The link had been previously tested for amplitude and phase stability and was found to be acceptable for strong signal testing.

The DSN software provided at CTA 21 was the Pioneer-Venus prereleased operational software for telemetry and command.

3. Test results. Table 3, DSN Pioneer Venus Bus Spacecraft Telecommunications Compatibility Test Summary provides a listing of test configurations, test criteria, parameters, and results. Refer to Fig. 1 for DSN mode configurations. Significant test results and comments are discussed below:

a. Radio frequency acquisition and tracking. All objectives of this phase of testing were successfully met. The acquisition test was performed by off-setting the CTA 21 exciter plus and minus 5 kHz about the spacecraft receiver theoretical best lock frequency, and ramping toward best lock until spacecraft receiver acquisition was achieved. The two acquisition frequencies were averaged and became the actual best lock frequency.

The tracking test was performed by ramping the spacecraft receiver to plus and minus 100 kHz about center (best lock) frequency at a rate of 100 Hz per second.

b. Telemetry. The telemetry processing tests were performed with no problems noted. Downlink signal levels were adjusted to values which yielded frame deletion rates (DLR) that were equal to or slightly less than zero. Digital original data records (DODR) were made of all bit rates for later playback and evaluation by the Pioneer Mission Operations Control Center (PMOCC). These records will aid in finalizing the PMOCC software.

c. Command. In order to test the DSN PV'78 Bus command interface for compatibility, a variation from the test

plan, PC-464, was utilized. It was agreed that since the PMOCC was not ready to support the command test, as specified in PC-464, the commands would be transmitted from CTA 21 utilizing the manual mode capability of the software.

All commands that were scheduled to be sent to the Bus spacecraft during these tests were successfully sent and processed. However, as was the case with the Orbiter spacecraft, several operational problems had to be overcome in order to complete the test.

Initial attempts to send single timed commands to the spacecraft were unsuccessful because the command bit structures were such that the probes had to be mated to the Bus for the commands to be successfully processed. Later it was discovered that one of the contiguous timed commands (CMD 8) was also in error and had to be changed. With these errors corrected, all commands were successful.

In addition to the normal command bit structures; a second group of single timed commands were successfully transmitted and processed that were composed of a leading hexidecimal "zero" at the beginning of each command. This special test assured that the spacecraft command detector maintained lock in the absence of four consecutive one's and zero's.

Strip chart recordings were made of all DSN generated commands to the spacecraft.

C. PV'78 Bus Small Probe (Dual Subcarrier), 11 November 1977

1. Test objectives. The objective of this test was to establish telecommunications design compatibility between the DSN and the Pioneer-Venus BUS-Small Probe (dual subcarrier) in the area of telemetry at strong signal levels. Specifically, the objective was to verify the DSN Telemetry System capability to receive and process coded telemetry from a single downlink with dual subcarriers (PCM/PSK/PM). This test was performed in accordance with JPL Document 810-8, Rev. B, *Deep Space Network/Flight Project Interface Compatibility Test Design Handbook.*

2. Test conditions. The Pioneer Venus Bus Small Probe Spacecraft was located at the Hughes Aircraft Company, El Segundo, California. The Radio Frequency Subsystem was configured at S-band as follows: receiver No. 2, Channel 12 (2110.583328 MHz); transmitter No. 2, equipped with 20-W solid-state Amplifier; and Auxiliary Oscillator No. 2 (2292.034784 MHz).

The DSN, as represented by CTA 21, was configured to simulate a Pioneer Venus Flight Project committed Deep Space Station. The ground hardware included the Block III and IV Receiver-Exciter Subsystems and the Mark III Data Subsystem for telemetry and command.

The S-band RF link between the DSN and the PV'78 Orbiter spacecraft was an open RF link between the Hughes Aircraft Company and the Jet Propulsion Laboratory. A description of the link is provided in the Appendix. The link had been previously tested for amplitude and phase stability and was found to be acceptable for strong signal testing.

The DSN software provided at CTA 21 was the Pioneer Venus prereleased operational software for telemetry and command.

3. Test results. Table 4, DSN Pioneer-Venus Bus-Small Probe Spacecraft Telecommunications Compatibility Test Data and Table 5, Telemetry Lock-Up Times provides a listing of test configurations, test criteria, parameters, and results. Refer to Fig. 1 for DSN mode configurations. Significant test results and comments are discussed below:

a. Telemetry. The dual subcarrier telemetry test was completed with no problems noted. All testing (as shown by the results in Tables 4 and 5) was performed with independent TPA strings processing. As can be seen from the lockup times in Table 5, the independent strings were not simultaneously initialized for each run. However, the signal levels associated with each run were set for that particular run. The SNR values shown in Table 4 are the result of the signal level shown.

The lock-up times and sequential decoder statistics are additional and significant data points for the strong signal level telemetry processing function.

An additional telemetry threshold test (results not included) was performed to demonstrate the dual telemetry channel single sequential decoder operation of the software. Preliminary indications were that operation was satisfactory. A more thorough and rigorous testing of this capability is planned during the DSN PV'78 multisignal compatibility test scheduled for a later date.

D. DSN PV'78 Small Probes (1, 2 and 3), 14–17 November 1977

1. Test objectives. The objectives of these tests were to establish telecommunications design compatibility between the DSN and the Pioneer Venus Orbiter in the areas of radio frequency acquisition and telemetry at strong signal levels. Specifically, the objectives were as follows:

(1) Determine telemetry processing degradation characteristics due to wind-shear perturbations during the planetary atmospheric entry sequence.

(2) Determine telemetry processing degradation characteristics due to pyrotechnic firing perturbations during the planetary entry sequence.

(3) Verify small probe ultra-stable oscillator frequency stability during initial RF turn on sequence.

(4) Verify the DSN Telemetry System capability to receive and process coded telemetry.

(5) Verify the DSN capability to perform predetection recording and playback on actual PV'78 Small Probe RF signals and telemetry data.

Test (4) was performed in accordance with JPL Document 810-8, Rev. B, *Deep Space Network/Flight Project Interface Compatibility Test Design Handbook.* Tests (1), (2), (3) and (5) were special tests to determine those characteristics described. The test configuration for the small probe tests is shown in Fig. 2.

2. Test conditions. The Pioneer Venus Small Probe Spacecraft were located at the Hughes Aircraft Company, El Segundo, California. The Radio Frequency Subsystems were configured as S-band as follows: Small Probe 1, 10-W transmitter (2292.282020 MHz); Small Probe 2, 10-W transmitter (2292.437720 MHz); and Small Probe 3, 10-W transmitter (2291.552280 MHz).

The DSN, as represented by CTA 21, was configured to simulate a Pioneer Venus Flight Project committed Deep Space Station. The ground hardware included the Block III and IV Receiver-Exciter Subsystems and the Mark III Data Subsystem for telemetry and command.

The S-band RF link between the DSN and the PV'78 Orbiter Spacecraft was an open RF link between the Hughes Aircraft Company, El Segundo, California and the Jet Propulsion Laboratory, Pasadena, California. A description of the link as provided in Appendix 1. The link had been previously tested for amplitude and phase stability and was found to be acceptable for strong signal testing.

The DSN software provided at CTA 21 was the Pioneer Venus prereleased operational software for telemetry and command.

3. Test results. Tables 6 through 10, DSN PV'78 small probe telemetry tests, provide a listing of test results for verifying the DSN Telemetry System capability to receive and process coded telemetry. Tables 12 through 14 provide data relative to the spacecraft frequency stability measurements. Table 14 provides data showing results of the predetection recording playback.

a. Windshear and pyrotechnic firing. These tests were simulated by applying pulsed signals to the PIN modulator attenuator in the downlink (Figs. 2 and 3). These pulses suppressed the downlink signal level to simulate conditions expected to be encountered during firing of the spacecraft pyrotechnics and the windgust perturbations during descent through the Venusian atmosphere. However, these pulses were completely masked by variations that were encountered over the HAC-JPL open RF air link and therefore no conclusions regarding their contribution to telemetry processing degradation could be discerned.

In further efforts to verify possible degradation because of windshear and pyro firing effects, a closed loop test, internal to CTA 21, was performed off line following regularly scheduled testing with the small probe spacecrafts.

Utilizing the DSN test transmitter, modulated with PV'78 type data from the simulation conversion assembly, these tests were again performed. For the windshear test, the following conclusion was made:

(1) Only when the DSN receiver was operating at threshold conditions was there any effect noted.

(2) At threshold, one telemetry data frame was deleted, for each windgust.

(3) Assuming one or two windgusts and threshold conditions at 30-km altitude and at the surface, the deletion rate did not change significantly.

For the pyro firing test, the following was observed:

(1) No telemetry system loss of lock was observed.

(2) No deleted frames.

b. Small probe ultra-stable oscillator frequency stability. Performance of these tests was satisfactory, the data compares closely with unit data measured by HAC. The systems performance test software was a valuable tool in the successful conduction of this test.

c. Telemetry system processing test (planetary entry sequence). This test was conducted by simulating events scheduled to be encountered during the small probe entry-to-impact phase of the mission. Each small probe spacecraft was run through this sequence two times, with CTA 21 processing the telemetry data and producing a Digital Original Data Record (DODR). The DODR's will be converted to a different format and provided to the PMOCC for later processing and training purposes.

Each run was recorded (Tables 6 through 10) and this data provides DSN system lock times as well as the Sequential Decoder statistical data. A shift in the CTA 21 Receiver AGC

curve occurred during the Small Probe No. 3, Run No. 2 test, but post calibrations validated the test data. Data readout (received power, P_c) shown in Table 11 have been adjusted to reflect this change.

d. Predetection recording and playback. The predetection recording scheme, to be utilized during the actual mission, was exercised during these tests to demonstrate that the system was compatible with mission requirements. Recordings were made during those tests described in paragraph *c* above. Following those tests, selected playbacks produced the results that are shown in Table 15. As can be seen, the DSN predetection recording technique appears to function within expectations.

Table 1. DSN-Pioneer Venus prototype spacecraft telecommunications compatibility test

Test date	Test title	DSN mode	Spacecraft TM mode	Test conditions	Criteria	Performance	Test, min
4/6/77, Test 1	Receiver rest frequency	002 3/6 00		UL signal level: -90.0 dBm UL frequency at best lock: 2114.327016 MHz	Acquire spacecraft receiver	Acquired	26
		002 3/6 00		UL signal level: -140.0 dBm Offset = +2 kHz at S-band Ramp rate = 10 Hz/s		Acquired at 2114.327280 MHz	
				UL signal level: -140.0 dBm Offset = -2kHz at S-band Ramp rate = 10 Hz/s		Acquired at 2114.326752 MHz	
4/5/77, Test 2	Receiver tracking	002 3/6 00		UL signal level: -140.0 dBm UL center frequency: 2114.316720 MHz DL center frequency: 2296.090560 MHz Ramp rate: 55 Hz/s at S-band	Ramp spacecraft receiver to ±67.5 kHz offset and record SPE/AGC at increments of 2.5 kHz	Satisfactory	104

Table 1 (contd)

Test date	Test title	DSN mode	Spacecraft TM mode	Test conditions	Criteria	Performance	Test, min
4/5/77, Test 3	Spacecraft receiver threshold	002$\frac{3}{6}$00		S-band UL frequency: 2114.316864 MHz S-band DL frequency: 2296.090740 MHz	<-152.0 dBm	-153.0 dBm	22
4/5/77, Tests 4 and 7 combined	RF & telemetry spectrum analysis	000300	Low mod index 16 bps	S-band DL frequency: 2296.093040 MHz Spacecraft VCO mode	Observe presence of unpredicted spectral components	None observed	197
		002300		S-band DL frequency: 2296.087160 MHz S-band UL frequency: 2114.313552 MHz		None observed	
		000300		S-band DL frequency: 2296.073700 MHz Auxiliary oscillator mode		None observed	
		000300	High mod index 64 bps	S-band DL frequency: 2296.073700 MHz auxilliary oscillator mode		None observed	
		002300		S-band DL frequency: 2296.092240 MHz		None observed	

Table 1 (contd)

Test data	Test title	DSN mode	Spacecraft TM mode	Test conditions	Criteria	Performance	Time, min
4/5/77, Tests 4 and 7 combined	RF & telemetry spectrum analysis (cont'd)			S-band UL frequency: 2114.318256 MHz			
4/5/77, Test 5A	RF downlink threshold (non-coherent)	000300	2048 bps coded	S-band DL frequency: 2296.106080 MHz	-159.0 ± 1.0 dBm	-158.0 dBm	2.0
4/10/77, Test 5B	Telemetry downlink threshold (non-coherent)	000312		16-bps coded Lo mod index	ST_b/N_o = 8.39 dB DLR = 10^{-2}	Frame deletion rate = 0.0% SER = 1.2%	
				64-bps coded Hi mod index	ST_b/N_o = 6.98 dB DLR = 10^{-2}	Frame deletion rate = 0.965% SER = 2.8%	
4/5/77, Test 6A	RF downlink threshold (coherent) S- and X-band	002$\frac{3}{6}$00		S-band UL frequency: 2114.321328 MHz			50
				S-band DL frequency: 2296.095560 MHz	-159.0 ± 1.0 dBm	-158.0 dBm	
				X-band DL frequency: 8419.017220 MHz	-151.0 ± 1.0 dBm	-150.5 dBm	
4/12/77, Test 6B	Telemetry downlink threshold (coherent)	002312		8.0 bps coded Low mod index	ST_b/N_o = 8.5 dB DLR = 10^{-2}	Frame deletion rate = 0.0% SER = 1.0%	

Table 1 (contd)

Test date	Test title	DSN mode	Spacecraft TM mode	Test conditions	Criteria	Performance	Time, min
4/12/77, Test 6B	Telemetry downlink threshold (coherent) (cont'd)	002312		128.0-bps coded Hi mod index Y-factor = 8.92 dB Pad = 19.98 dB	ST_b/N_o = 6.6 dB DLR = 10^{-3}	Frame deletion rate = 1.2% SER = 3.2%	
				170.66-bps coded Hi mod index Y-factor = 10.66 dB Pad = 19.98 dB	ST_b/N_o = 6.3 dB DLR = 10^{-3}	Frame deletion rate = 0.26% SER = 3.2%	
				170.66-bps uncoded Hi mod index Y-factor = 12.2 dB Pad = 19.98 dB ST_b/N_o = 8.45 dB	SSA SNR = 7.0 dB	SSA SNR = 7.0 dB	
				256.0-bps coded Hi mod index Y-factor = 11.27 dB Pad = 19.98 dB	ST_b/N_o = 6.1 dB DLR = 10^{-3}	Frame deletion rate = 0.56% SER = 2.3%	
				341.33 uncoded Hi mod index Y-factor = 14.29 dB Pad = 19.98 dB ST_b/N_o = 8.15 dB	SSA SNR = 7.0 dB	SSA SNR = 6.85 dB	
				341.33 coded Hi mod index Y-factor = 12.25 dB Pad = 19.98 dB	ST_b/N_o = 6.0 dB DLR = 10^{-3}	Frame deletion rate = 0.965% SER = 4.5%	

Table 1 (contd)

Test date	Test title	DSN mode	Spacecraft TM mode	Test conditions	Criteria	Performance	Time, min
4/12/77, Test 6B	Telemetry downlink threshold (coherent) (cont'd)	002312		512.0-bps coded Hi mod index Y-factor = 15.18 dB Pad = 19.98 dB	ST_b/N_o = 5.8 dB DLR = 10^{-3}	Frame deletion rate = 0.504% SER = 4.3%	
				682.66 uncoded Hi mod index Y-factor + 7.92 dB Pad = 10.34 dB ST_b/N_o = 7.8 dB	SSA SNR = 7.0 dB	SSA SNR = 7.08 dB	
				682.66 coded Hi mod index Y-factor - 7.83 dB Pad = 10.34 dB	ST_b/N_o = 5.7 dB DLR = 10^{-3}	Frame deletion rate = 0.45% SER = 4.3%	
				1024.0 coded Hi mod index Y-factor = 8.8 dB Pad = 10.34 dB	ST_b/N_o = 5.5 dB DLR = 10^{-3}	Frame deletion rate = 0.492% SER = 5.2%	
				2048.0 uncoded Hi mod index Y-factor = 12.2 dB Pad = 10.34 dB ST_b/N_o = 7.8 dB	SSA SNR = 7.0 dB	SSA SNR = 6.82 dB	
				2048.0 coded Hi mod index Y-factor = 13.4 dB Pad = 10.34 dB	ST_b/N_o = 4.8 dB DLR = 10^{-3}	Frame deletion rate = 0.847% SER = 5.6%	

Table 1 (contd)

Test date	Test title	DSN mode	Spacecraft TM mode	Test conditions	Criteria	Performance	Time, min
4/6/77, Test 8	Residual carrier phase jitter	$000\frac{3}{4}00$		S-band DL frequency: 2296.102820 MHz (one-way)	6.6 deg RMS	2.69 deg RMS	100
				DL signal level: -80.0 dBm			
				UL signal level: -90.0 dBm			
				X-band DL frequency: 8419.043740 MHz (one-way)	24.2 deg RMS	7.39 deg RMS	
				DL signal level: -100.0 dBm			
				S-band UL frequency: 2114.321088 MHz	5.8 deg RMS	1.84 deg RMS	
				S-band DL frequency: 2296.095320 MHz			
				DL signal level: -80.00 dBm			
				UL signal level: -90.0 dBm			
				X-band DL frequency: 8419.016370 MHz	21.3 deg RMS	6.21 deg RMS	
				DL signal level: -100.0 dBm			

Table 1 (contd)

Test date	Test title	DSN mode	Spacecraft TM mode	Test conditions	Criteria	Performance	Time, min
4/6/77, Test 9	Subcarrier frequency and phase jitter	$000\frac{31}{42}0$		S-band DL frequency: 2296.117780 MHz DL signal level: -80.0 dBm	Time period variation shall be less than 0.5% over 10 consecutive square wave periods	1.46 deg RMS Subcarrier frequency: 16384.0 Hz	35

Table 2. Deep Space Network/Pioneer Venus Orbiter telecommunications compatibility test data

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/1/77, Test 1	Receiver rest frequency	002300	Transmitter 1 Receiver 1	UL signal level: -131.6 dBm UL frequency at best lock: 2112.290352 MHz	Acquire spacecraft receiver		
				Offset = +5 kHz at S-band Ramp rate = 15 Hz/s at S-band		Acquired at 2112.290352 MHz VCO temp: 28.9°C	
				Offset = -5 kHz at S-band Ramp rate = 15 Hz/s at S-band		Acquired at 2112.290352 MHz VCO temp: 29.86°C	
		002300	Transmitter 2 Receiver 2	UL signal level: -131.6 dBm UL frequency at best lock: 2112.628056 MHz			
				Offset = +5 kHz at S-band Ramp rate = 15 Hz/s at S-band		Acquired at 2112.627840 MHz VCO temp: 28.81°C	
				Offset = -5 kHz at S-band Ramp rate = 15 Hz/s at S-band		Acquired at 2112.628272 MHz VCO temp: 28.81°C	

Table 2 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/1/77, Test 2	Receiver tracking	002300	Transmitter 1 Receiver 1	UL signal level: -131.6 dBm UL center frequency: 2112.288624 MHz VCO temp: 31.78°C	Spacecraft receiver maintain phase lock to UL signal while ramping ±100 kHz	Satisfactory	2 h 57 min
				DL center frequency: 2293.888180 MHz	About center frequency		
				Ramp rate: 100 Hz/s at S-band			
		002300	Transmitter 2 Receiver 2	UL signal level: -131.4 dBm UL center frequency: 2112.629808 MHz VCO temp: 29.8°C		Satisfactory	
				DL center frequency: 2294.258615 MHz			
				Ramp rate: 100 Hz/s at S-band			
11/3/77, Test 3	Telemetry processing	001411	Transmitter 1 Receiver 1 Telemetry processor 1	UL frequency at S-band: 2112.290304 MHz UL signal level: -125.5 dBm DL frequency at S-band: 2293.889984 MHz	Process telemetry		

Table 2 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/3/77, Test 3	Telemetry processing (contd)			Subcarrier frequency: 16.384 kHz			
				Bit rate: 8.0 bps coded data Mod index: 37.2 deg DL signal level: -142.4 dBm		SSA lock: 328 s SEQ lock: 621 s SSA SNR: 4.75 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.6442%	
				Bit rate: 16.0 bps coded data Mod index: 37.2 deg DL signal level: -138.0 dBm		SSA lock: 161 s SEQ lock: 363 s SSA SNR: 7.27 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.0925%	
				Bit rate: 32.0 bps coded data Mod index: 37.2 deg DL signal level: -136.2 dBm		SSA lock: 321 s SEQ lock: 354 s SSA SNR: 5.83 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.415%	
11/3/77, Test 3	Telemetry processing	001411	Transmitter 1 Receiver 1 Telemetry processor 1	Bit rate: 64.0 bps coded data Mod index: 67.6 deg DL signal level: -144.0 dBm	Process telemetry	SSA lock: 64 s SEQ lock: 98 s SSA SNR: 7.13 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.109%	
				Bit rate: 128.0 bps coded data Mod index: 67.6 deg DL signal level: -141.5 dBm		SSA lock: 49 s SEQ lock: 64 s SSA SNR: 4.81 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.921%	

Table 2 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/3/77, Test 3	Telemetry processing (cont'd)			Bit rate: 170.66 bps coded data Mod index: 67.6 deg DL signal level: -139.5 dBm		SSA lock: 90 s SEQ lock: 45 s SSA SNR: 5.64 dB SEQ DLR: 0.00% SEQ ACB: 1.003 SEQ SER: 0.3023%	
				Bit rate: 256.0 coded data Mod index: 67.6 deg DL signal level: -137.0 dBm		SSA lock: 84 s SEQ lock: 59 s SSA SNR: 8.21 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.0305%	
				Bit rate: 256.0 bps uncoded Mod index: 67.6 deg DL signal level: 133.0 dBm		SSA lock: 49 s SSA SNR: 13.38 dB	
				Bit rate: 341.33 bps coded data Mod index: 67.6 deg DL signal level: -136.3 dBm		SSA lock: 48 s SEQ lock: 36 s SSA SNR: 7.07 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.0652%	
				Bit rate: 512 bps coded data Mod index: 67.6 deg DL signal level: -134.1 dBm		SSA lock: 199 s SEQ lock: 149 s SSA SNR: 7.53 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.0202%	

Table 2 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/3/77, Test 3	Telemetry processing (cont'd)			Bit rate: 682.66 bps coded data Mod index: 67.6 deg DL signal level: -132.4 dBm		SSA lock: 43 s SEQ lock: 5 s SSA SNR: 8.05 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.0163%	
				Bit rate: 682.66 bps uncoded Mod index: 67.6 deg DL signal level: -128.4 dBm		SSA lock: 52 s SSA SNR: 12.72 dB	
				Bit rate: 1024.0 bps coded data Mod index: 67.6 deg DL signal level: -131.0 dBm		SSA lock: 17 s SEQ lock: 9 s SSA SNR: 8.13 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.0154%	
				Bit rate: 2048.0 bps coded data Mod index: 67.6 deg DL signal level: -124.7 dBm		SSA lock: 64 s SEQ lock: 7 s SSA SNR: 10.81 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.0%	
				Bit rate: 2048.0 bps uncoded Mod index: 67.6 deg DL signal level: -125.0 dBm		SSA lock: 25 s SSA SNR: 12.53	

Table 2 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/4/77, Test 3	Telemetry processing	001411	Transmitter 2 Receiver 2 Telemetry processor 2	UL frequency S-band: 2112.629760 MHz UL signal level: -125.2 dBm DL frequency S-band: 2294.258528 MHz Subcarrier frequency: 16.384 kHz Bit rate: 8.0 bps coded data Mod index: 37.2 deg TLM format: PSB DL signal level: -142.4 dBm	Process telemetry	SSA lock: 321 s SEQ lock: 602 s SSA SNR: 5.22 dB SEQ DLR: 0.00% SEQ ACB: 1.0008 SEQ SER: 0.45%	
				Bit rate: 16.0 bps coded data Mod index: 37.2 deg TLM format: PSD DL signal level: -140.0 dBm		SSA lock: 160 s SEQ lock: 342 s SSA SNR: 3.66 dB SEQ DLR: 0.00% SEQ ACB: 1.025 SEQ SER: 1.859%	
				Bit rate: 32.0 bps coded data Mod index: 37.2 deg TLM format: PSE DL signal level: -136.4 dBm		SSA lock: 129 s SEQ lock: 176 s SSA SNR: 6.98 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.07%	

Table 2 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/4/77, Test 3	Telemetry processing (cont'd)			Bit rate: 64.0 bps coded data Mod index: 67.6 deg TLM format: ASB DL signal level: -144.3 dBm		SSA lock: 83 s SEQ lock: 165 s SSA SNR: 4.78 dB SEQ DLR: 0.00% SEQ ACB: 1.04 SEQ SER: 0.70%	
				Bit rate: 128.0 bps coded data Mod index: 67.6 deg TLM format: ASA DL signal level, -141.2		SSA lock: 49 s SEQ lock: 58 s SSA SNR: 4.6 dB SEQ DLR: 0.00% SEQ ACB: 1.007 SEQ SER: 0.72%	
				Bit rate: 170.66 bps coded data Mod index: 67.6 deg TLM format: PSC DL signal level: -137.7 dBm		SSA lock: 192 s SEQ lock: 90 s SSA SNR: 6.85 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.118%	
				Bit rate: 256.0 bps coded data Mod index: 67.6 deg TLM format: PSA DL signal level: -137.6 dBm		SSA lock: 64 s SEQ lock: 40 s SSA SNR: 6.61 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.13%	
				Bit rate: 341.33 bps coded data Mod index: 67.6 deg TLM format: ENG DL signal level: -136.7 dBm		SSA lock: 48 s SEQ lock: 35 s SSA SNR: 7.04 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.06%	

Table 2 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/4/77, Test 3	Telemetry processing (cont'd)			Bit rate: 512.0 bps coded data Mod index: 67.6 deg TLM format: ENG DL signal level: -134.8 dBm		SSA lock: 32 s SEQ lock: 74 s SSA SNR: 6.63 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.154%	
				Bit rate: 682.66 bps coded data Mod index: 67.6 deg TLM format: ENG DL signal level: -131.8 dBm		SSA lock: 27 s SEQ lock: 13 s SSA SNR: 7.7 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.02%	
				Bit rate: 682.66 bps uncoded Mod index: 67.6 deg TLM format: ENG DL signal level: -130.3 dBm		SSA lock: 49 s SSA SNR: 11.32 dB	
				Bit rate: 1024.0 bps coded data Mod index: 67.6 deg TLM format: ENG DL signal level: -131.0 dBm		SSA lock: 33 s SEQ lock: 9 s SSA SNR: 6.44 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.13%	
				Bit rate: 2048.0 bps coded data Mod index: 67.6 deg TLM format: ENG DL signal level: -127.6 dBm		SSA lock: 129 s SEQ lock: 7 s SSA SNR: 8.48 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.014%	

Table 2 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/4/77, Test 3	Telemetry processing (cont'd)			Bit rate: 2048.0 bps uncoded Mod index: 67.6 deg TLM format: ENG DL signal level: -124.4 dBm		SSA lock: 33 s SSA SNR: 11.26 dB	
11/2/77, Test 4	Command	021100	Transmitter 1 Receiver 1 Command processor 1	UL S-band frequency: 2112.290304 MHz UL signal level: -127.1 dBm	Spacecraft process and verify command execution		
				Single timed commands			
				Preamble with time: AAAAAAAAAAAA8			
				Single timed commands			
				CMD 1: EB04D4000E5D8		Verified	
				Preamble with time: AAAAAAAAAAAA8			
				CMD 5: EB04D4000E988		Verified	
				Preamble with time: AAAAAAAAAAAA8			
				CMD 2: EB04D68011D28		Verified	

Table 2 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/2/77, Test 4	Command (cont'd)			Preamble with time: AAAAAAAAAAAA8			
				CMD 3: EB04D6800BEC8		Verified	
				Preamble with time: AAAAAAAAAAAA8			
				CMD 4: EB04D6801D828		Verified	
				Single untimed commands			
				CMD 1: EB04D000E5D8		Verified	
				CMD 5: EB04D4000E988		Verified	
				CMD 2: EB04D68011D28		Verified	
				CMD 3: EB04D6800BEC8		Verified	
				CMD 4: EB04D6801D828		Verified	
				Spacecraft command timing check			
				CMD 11: EB04D700023E8		Verified	
				CMD 12: EB04D7000E6E8		Verified	
				CMD 13: EB04D7000DBF8		Verified	
				CMD 16: EB04D70001EF8		Verified	

Table 2 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/2/77, Test 4	Command (cont'd)			CMD 14: EB04CF2582E68		Verified	
				CMD 15: EB04CF4B02F78		Verified	
		021100	Transmitter 2 Receiver 2 Command processor 2	UL S-band frequency: 2112.628056 MHz			
				UL signal level: -125.2 dBm			
				Contiguous timed commands			
				Preamble with time: AAAAAAAAAAAA8			
				CMD 6: EB04D4000E178		Verified	
				CMD 7: EB05DA8011918		Verified	
				CMD 8: EB05DA800BAF8		Verified	
				CMD 9: EB05DA801DC18		Verified	
				CMD 10: EB05D4000ED28		Verified	
11/1/77	Special predetection recording and playback	001211	Transmitter 1 Receiver 1 Telemetry processor 1	Bit rate: 16.0 bps coded data Mod index: 32.7 deg DL signal level: -138.0 dBm	Maximum of dB between real-time SNR and playback SNR	Real-time SSA SNR: 7.27 dB Playback SSA SNR: 7.13 dB	

Table 2 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/1/77	Special predetection recording and playback (cont'd)			Bit rate: 64.0 bps coded data Mod index: 67.6 deg DL signal level: -144.0 dBm		Real-time SSA SNR: 7.13 dB Playback SSA SNR: 7.24 dB	
				Bit rate: 256.0 bps coded data Mod index: 67.6 deg DL signal level: -137.0 dBm		Real-time SSA SNR: 8.21 dB Playback SSA SNR: 7.95 dB	

Table 3. Deep Space Network PV'78 bus spacecraft telecommunications compatibility test data

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/8/77, Test 1	Receiver rest frequency	002300	Transmitter 1 Receiver 1	UL signal level: -138.0 dBm UL frequency at best lock: 2110.583352 MHz	Acquire spacecraft receiver		2 h 3 min
				Offset = +5 kHz at S-band Ramp rate = 15 Hz/s at S-band		Acquired at 2110.583568 MHz VCO temp: 28.9°C	
				Offset = -5 kHz at S-band Ramp rate = 15 Hz/s at S-band		Acquired at 2110.583136 MHz VCO temp: 28.9°C	
		002300	Transmitter 2 Receiver 2	UL signal level: -137.8 dBm UL frequency at best lock: 2111.268744 MHz			
				Offset = +5 kHz at S-band Ramp rate = 15 Hz/s at S-band		Acquired at 2111.268912 MHz VCO temp: 27.63°C	
				Offset = -5 kHz at S-band Ramp rate = 15 Hz/s at S-band		Acquired at 2111.268576 MHz VCO temp: 27.63°C	

Table 3 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/8/77, Test 2	Receiver tracking	002300	Transmitter 1 Receiver 1	UL signal level: -139.3 dBm UL center frequency: 2110.583040 MHz	Spacecraft receiver maintain phase lock to UL signal while ramping ±100 kHz	Satisfactory	2 h 43 min
				DL center frequency: 2292.035960 MHz Ramp rate: 100 Hz/s at S-band	About center frequency		
		002300	Transmitter 2 Receiver 2	UL signal level: -137.2 dBm UL center frequency: 2111.267712 MHz		Satisfactory	
				DL center frequency: 2292.779520 MHz			
				Ramp rate: 100 Hz/s at S-band			
11/10/77, Test 3	Telemetry processing	001411	Transmitter 1 Receiver 1 Telemetry processor 2	UL frequency S-band: 2110.583040 MHz UL signal level: -131.5 dBm DL frequency S-band: 2292.02400 MHz	Process telemetry		

Table 3 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/10/77, Test 3	Telemetry processing (contd)			Subcarrier frequency: 16.384 kHz			
				Bit rate: 8.0 bps coded data Mod index: 37.2 deg DL signal level: -147.5 dBm TLM format: ENG		SSA lock: 320 s SEQ lock: 569 s SSA SNR: 4.41 dB SEQ DLR: 0.00% SEQ ACB: 1.0092 SEQ SER: 1.21%	
				Bit rate: 16.0 bps coded data Mod index: 37.2 deg DL signal level: -144.8 dBm TLM format: ENG		SSA lock: 576 s SEQ lock: 696 s SSA SNR: 2.05 dB SEQ DLR: 0.00% SEQ ACB: 1.113 SEQ SER: 3.01%	
				Bit rate: 128.0 bps coded data Mod index: 67.6 deg DL signal level: -146.7 dBm TLM format: ENG		SSA lock: 145 s SEQ lock: 161 s SSA SNR: 2.74 dB SEQ DLR: 0.00% SEQ ACB: 1.0785 SEQ SER: 2.398%	
				Bit rate: 170.66 bps coded data Mod index: 67.6 deg DL signal level: -145.1 dBm TLM format: ENG		SSA lock: 193 s SEQ lock: 87 s SSA SNR: 3.18 dB SEQ DLR: 0.00% SEQ ACB: 1.062 SEQ SER: 1.95%	

Table 3 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/10/77, Test 3	Telemetry processing (contd)			Bit Rate: 256.0 coded data Mod Index: 67.6 deg DL signal level: -143.9 dBm TLM format: ENG		SSA lock: 129 s SEQ lock: 39 s SSA SNR: 1.36 dB SEQ DLR: 0.00% SEQ ACB: 1.2 SEQ SER: 4.07%	
				Bit rate: 256.0 bps uncoded Mod index: 67.6 deg DL signal level: -142.8 dBm TLM format: ENG		SSA lock 48 s SSA SNR: 6.14 dB	
				Bit rate: 341.33 bps coded data Mod index: 67.6 deg DL signal level: -140.5 dBm TLM format: ENG		SSA lock: 48 s SEQ lock: 34 s SSA SNR: 4.39 dB SEQ DLR: 0.00% SEQ ACB: 1.004 SEQ SER: 0.849%	
				Bit rate: 341.33 bps uncoded Mod index: 67.6 deg DL signal level: -139.9 dBm TLM format: ENG		SSA lock: 96 s SSA SNR: 11.02 dB	

Table 3 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/10/77, Test 3	Telemetry processing (contd)			Bit rate: 512 bps coded data Mod Index: 67.6 deg DL signal level: -139.8 dBm TLM format: ENG		SSA lock: 65 s SEQ lock 12 s SSA SNR: 2.98 dB SEQ DLR: 0.00% SEQ ACB: 1.033 SEQ SER: 2.04%	
				Bit rate: 682.66 bps coded data Mod index: 67.6 deg DL signal level: -138.4 dBm TLM format: ENG		SSA lock: 52 s SEQ lock: 13 s SSA SNR: 3.59 dB SEQ DLR: 0.520% SEQ ACB: 2.603 SEQ SER: 1.54%	
				Bit rate: 1024.0 bps coded data Mod index: 67.6 deg DL signal level: -137.5 dBm TLM format: ENG		SSA lock: 34 s SEQ lock: 27 s SSA SNR: 2.61 dB SEQ DLR: 0.52% SEQ ACB: 2.652 SEQ SER: 2.53%	
				Bit rate: 1024.0 bps uncoded Mod index: 67.6 deg DL signal level: -138.0 dBm TLM format: ENG		SSA lock: 32 s SSA SNR: 7.96 dB	

Table 3 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/10/77, Test 3	Telemetry processing (contd)			Bit rate: 2048.0 bps coded data Mod index: 67.6 deg DL signal level: -132.5 dBm TLM format: ENG		SSA lock: 64 s SEQ lock: 6 s SSA SNR: 6.14 dB SEQ DLR: 0.00% SEQ ACB: 1.113 SEQ SER: 3.01%	
11/9/77, Test 3	Telemetry processing	001411	Transmitter 2 Receiver 2 Telemetry processor 1	UL freq. S-band: 2111.265696 MHz UL signal level: -130.9 dBm DL freq. S-band: 2292.777344 MHz Subcarrier frequency: 16.384 kHz	Process telemetry		
				Bit rate: 8.0 bps coded data Mod index: 37.2 deg TLM format: ENG DL signal level: -147.0 dBm		SSA lock: 315 s SEQ lock: 653 s SSA SNR: 2.6 dB SEQ DLR: 0.00% SEQ ACB: 1.146 SEQ SER: 1.994%	
				Bit rate: 16.0 bps coded data Mod index: 37.2 deg TLM format: ENG DL signal level: -144.3 dBm		SSA lock: 160 s SEQ lock: 308 s SSA SNR: 5.22 dB SEQ DLR: 0.00% SEQ ACB: 1.0007 SEQ SER: 0.39%	

Table 3 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/9/77, Test 3	Telemetry processing (contd)			Bit rate: 32.0 bps coded data Mod index: 37.2 deg TLM format: ENG DL signal level: -141.3 dBm		SSA lock: 326 s SEQ lock: 377 s SSA SNR: 4.65 dB SEQ DLR: 0.00% SEQ ACB: 1.0026 SEQ SER: 0.64%	
				Bit rate: 64.0 bps coded data Mod index: 67.6 deg TLM format: ENG DL signal level: -149.0 dBm		SSA lock: 58 s SEQ lock: 34 s SSA SNR: 4.01 dB SEQ DLR: 0.00% SEQ ACB: 1.028 SEQ SER: 0.967%	
				Bit rate: 128.0 bps coded data Mod index: 67.6 deg TLM format: ENG DL signal level: -146.7 dBm		SSA lock: 49 s SEQ lock: 58 s SSA SNR: 2.02 dB SEQ DLR: 0.00% SEQ ACB: 1.039 SEQ SER: 1.846%	
				Bit rate: 170.66 bps coded data Mod index: 67.6° TLM format: ENG DL signal level: -144.6 dBm		SSA lock 96 s SEQ lock: 51 s SSA SNR: 4.84 dB SEQ DLR: 0.00% SEQ ACB: 1.01 SEQ SER: 0.56%	
11/8/77				Bit rate: 256.0 bps coded data Mod index: 67.6 deg TLM format: ENG DL signal level: -142.6 dBm		SSA lock: 65 s SEQ lock: 41 s SSA SNR: 4.91 dB SEQ DLR: 0.00% SEQ ACB: 1.0025 SEQ SER: 0.5%	

Table 3 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/9/77, Test 3	Telemetry processing (contd)			Bit rate: 256 bps uncoded Mod index: 67.6 deg TLM format: ENG DL signal level: -139.6 dBm		SSA lock: 59 s SSA SNR: 11.05 dB	
				Bit rate: 341.33 bps coded data Mod index: 67.6 deg TLM format: ENG DL signal level: -140.9 dBm		SSA lock: 144 s SEQ lock: 77 s SSA SNR: 5.73 dB SEQ DLR: 0.00% SEQ ACB: 1.00008 SEQ SER: 0.243%	
				Bit rate: 512.0 bps coded data Mod index: 67.6 deg TLM format: ENG DL signal level: -139.6 dBm		SSA lock: 65 s SEQ lock: 14 s SSA SNR: 5.99 dB SEQ DLR: 0.00% SEQ ACB: 1.0004 SEQ SER: 0.217%	
				Bit rate: 682.66 bps coded data Mod index: 67.6 deg TLM format: ENG DL signal level: -137.4 dBm		SSA lock: 25 s SEQ lock: 11 s SSA SNR: 7.2 dB SEQ DLR: 0.00% SEQ ACB: 1.000 SEQ SER: 0.046%	
				Bit rate: 682.66 bps uncoded Mod index: 67.6 deg TLM format: ENG DL signal level: -137.4 dBm		SSA Lock: 48 s SSA SNR: 9.8 dB	

Table 3 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/8/77, Test 3	Telemetry processing (contd)			Bit rate: 1024.0 bps coded data Mod index: 67.6 deg TLM format: ENG DL signal level: -135.0 dBm		SSA lock: 33 s SEQ lock: 8 s SSA SNR: 5.56 dB SEQ DLR: 0.00% SEQ ACB: 1.193 SEQ SER: 3.328%	
				Bit rate: 2048.0 bps coded data Mod index: 67.6 deg TLM format: ENG DL signal level: -135.0 dBm		SSA lock: 63 s SEQ lock: 7 s SSA SNR: 3.92 dB SEQ DLR: 0.00% SEQ ACB: 1.019 SEQ SER: 1.144	
11/9/77				Bit rate: 2048.0 bps uncoded Mod index: 67.6 deg TLM format: ENG DL signal level: -132.5 dBm		SSA lock: 17 s SSA SNR: 9.17 dB	
11/9/77, Test 4	Command	021100	Transmitter 2 Command processor 2	UL S-band frequency: 2110.582848 MHz UL signal level: -132.5 dBm Single timed commands Preamble with time: AAAAAAAAAAAA8	Spacecraft process and verify command execution		

Table 3 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/9/77, Test 4	Command (contd)			CMD 1: EB00D4000E3A8 Preamble with time: AAAAAAAAAAAA8		Verified	
				Single timed commands			
				CMD 5: EB00D8000EF68 Preamble with time: AAAAAAAAAAAA8		Verified	
				CMD 2: EB00D68011B58 Preamble with time: AAAAAAAAAAAA8		Verified	
				CMD 3: EB00D6800B8B8 Preamble with time: AAAAAAAAAAAA8		Verified	
				CMD 4: EB00D6801DE58		Verified	
				Single untimed command			
				CMD 1: EB00D4000E3A8		Verified	
				CMD 5: EB00D8000EF68		Verified	
				CMD 2: EB00D68011B58		Verified	
				CMD 3: EB00D6800B8B8		Verified	

Table 3 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/9/77, Test 4	Command (contd)			CMD 4: EB00D6801DE58		Verified	
				Contiguous timed commands			
				Preamble with time: AAAAAAAAAAAA8			
				CMD 6: EB01D4000E708		Verified	
				CMD 7: EB01DA8011F68		Verified	
				CMD 8: EB01DA800BC88		Verified	
				CMD 9: EB01DA801DA68		Verified	
				CMD 10: EB01D8000EBC8		Verified	
				Spacecraft command timing check			
11/9/77		021100	Transmitter 1 Receiver 1 Command processor 1	UL S-band frequency: 2111.265792 MHz			
				UL signal level: -131.0 dBm			
				CMD 11: EB00D70002598		Verified	
				CMD 12: EB00D7000E098		Verified	
				CMD 13: EB00D7000DD88		Verified	
				CMD 16: EB00D70001888		Verified	

Table 3 (contd)

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/9/77, Test 4	Command (contd)			CMD 14: EB00CF2582818		Verified	
				CMD 15: EB00CF1302C48		Verified	
11/10/77				Single untimed commands with leading HEX zero			
				CMD 1: 0EB00D4000E3A8		Verified	
				CMD 5: 0EB00D8000EF68		Verified	
				CMD 2: 0EB00D68011B58		Verified	
				CMD 3: 0EB00D6800B8B8		Verified	
				CMD 4: 0EB00D6801DE58		Verified	

Table 4. Deep Space Network/PV'78 bus-small probe telecommunications compatibility test data

Test date	Test title	DSN mode	Spacecraft RFS mode	Test conditions	Criteria	Performance	Time, min
11/11/77 Test 1	Dual Subcarrier	$0004\frac{11}{22}$	Transmitter 2 Aux. oscillator 2 TLM processor 2	DL S-band frequency: 2292.034784 mHz Bus subcarrier Frequency: 16.384 kHz S.P. subcarrier Frequency: 4.096 kHz	Process telemetry	See below and Table 2	

	Bus		Small probe									
					Bus Sequential decoder			Small probe Sequential decoder				
P_c, dBm	Bit rate, coded data	Mod index, deg	Bit rate, coded data	Mod index, deg	DLR	ACB	SER	DLR	ACB	SER	Bus SSA SNR, dB	Small probe SSA SNR, dB
-141.0	8.0	37.2	16.0	44.7	0.00	1.000	0.00	0.00	1.000	0.00	9.98	12.86
-143.9	8.0	37.2	64.0	44.7	0.00	1.000	0.105	0.00	1.018	0.82	9.39	4.95
-141.0	16.0	37.2	64.0	44.7	0.00	1.000	0.036	0.00	1.000	0.00	8.16	13.25
-143.9	16.0	37.2	16.0	44.7	0.00	1.003	0.83	0.337	1.012	0.643	4.91	5.28
-143.9	16.0	37.2	64.0	58.7	0.00	1.006	0.938	0.00	1.043	0.529	5.09	6.01

Table 5. Telemetry lock-up times

	Bus		Small Probe							
					Bus			Small Probe		
P_C, dBm	Bit rate, coded data	Mod. index	Bit rate, coded data	Mod. index	TPA init h:min:s	SSA lock h:min:s	SEQ lock h:min:s	TPA init h:min:s	SSA lock h:min:s	SEQ lock h:min:s
-141.0	8.0	37.2	16.0	44.7	17:32:30	17:37:50	17:41:28	16:52:04	16:54:45	16:59:06
-143.9	8.0	37.2	64.0	44.7	17:32:30	17:37:50	17:41:28	18:05:24	18:06:26	18:06:55
-141.0	16.0	37.2	64.0	44.7	18:34:24	18:44:00	18:46:30	18:05:24	18:06:26	18:06:55
-143.9	16.0	37.2	16.0	44.7	18:34:24	18:44:00	18:46:30	19:09:34	19:12:15	19:13:44
-143.9	16.0	37.2	64.0	58.7	18:34:24	18:44:00	18:46:30	20:09:47	20:10:51	20:11:09

Table 6. DSN-PV'78 Small Probe No. 1 telemetry test, Run No. 1 (TPA No. 1, 2292.282020 MHz)

Event GMT	Bit rate mod. index, coded data	Received power, dBm P_T	Received power, dBm P_c	Received power, dBm P_D	RCVR lock (GMT)	SDA lock (GMT)	TPA init (GMT)	SSA lock (GMT)	SEQ lock (GMT)	SSA SNR, dB	SEQ SER, %	SEQ DLR %	SEQ ACB
E - 22					21 h								
	None	-136.86	-136.86	None	55 min								
21:55:07					22 s								
E - 17	64					21 h	21 h	22 h	22 h				
	at					56 min	55 min	01 min	01 min	8.94	0.00	0.00	1.000
22:00:07	58.44 deg	-134.38	-140.00	-135.77		44 s	07 s	12 s	46 s				
E = 0	64				22 h	No out-		22 h	22 h				
	at	2-s Blackout			17 min	of-lock		18 min	19 min	6.55	0.00	0.00	1.000
22:17:07	58.44 deg	-138.78	-144.4	-140.17	47 s	indi-		47 s	14 s				
						cation							
E + 16	16						22 h	22 h	22 h				
	at						33 min	36 min	38 min	10.2	0.00	0.00	1.000
22:33:07	44.7 deg	-139.63	-142.6	-142.69			27 s	09 s	59 s				
E + 27	16												
	at												
22:44:07	44.7 deg	-138.03	-141.0	-141.09						8.82	0.00	0.00	1.000
E + 38	16												
	at												
22:55:07	44.7 deg	-140.93	-143.9	-143.99						8.13	0.00	0.00	1.000
E + 49	16												
	at												
23:06:07	44.7 deg	-139.93	-142.9	-142.99						8.36	0.00	0.00	1.000

Table 6 (contd)

Event GMT	Bit rate mod. index, coded data	Received power, dBm P_T	P_c	P_D	RCVR lock (GMT)	SDA lock (GMT)	TPA init (GMT)	SSA lock (GMT)	SEQ lock (GMT)	SSA SNR, dB	SEQ SER, %	SEQ DLR %	SEQ ACB
E + 60	16 at												
23:17:07	44.7 deg	-139.83	-142.8	-142.89						7.43	0.048	0.00	1.000

Table 7. DSN-PV'78 Small Probe No. 1 telemetry test, Run No. 2 (TPA 1, at 2292.282020 MHz)

Event GMT	Bit rate mod. index, coded data	Received power, dBm P_T	P_c	P_D	RCVR lock	SDA lock	TPA init	SSA lock	SEQ lock	SSA SNR, dB	SEQ SER, %	SEQ DLR, %	SEQ ACB
E - 22					23 h 26 min								
23:24:05	None	-139.96	-139.96	None	08 s								
E - 17	64 at					23 h 29 min	23 h 29 min	23 h 31 min	23 h 31 min	5.05	0.55	0.00	1.0058
23:29:05	58.44 deg	-139.38	-145.0	-140.77									
E = 0	64 at	20-s Blackout			23 h 47 min	No out-of-lock		23 h 47 min	No out-of-lock				
23:46:05	58.44 deg	-140.78	-146.4	-142.17	09 s	indi-cation		15 s	indi-cation	3.21	1.84	0.00	1.027
E + 16	16 at						00 h 02 min		00 h 07 min	None	None	None	None
00:02:05	44.7 deg	-142.83	-145.8	-145.89			13 s	None	27 s				
E + 27	16 at						00 h 09 min	00 h 19 min	00 h 21 min				
00:13:05	44.7 deg	-144.53	-147.5	-147.59			47 s	24 s	51 s	3.21	1.84	0.00	1.027

Table 7 (contd)

Event GMT	Bit rate mod. index, coded data	Received power, dBm P_T	Received power, dBm P_c	Received power, dBm P_D	RCVR lock	SDA lock	TPA init	SSA lock	SEQ lock	SSA SNR, dB	SEQ SER, %	SEQ DLR, %	SEQ ACB
E + 38	16	-140.03	-143.0	-143.09									
	at		to										
00:24:05	44.7 deg	-148.03	-151.0	-151.09		Link variations were too excessive to be meaningful for 0.5 dB changes. Data were averaged for remainder of test.							
E + 49	16		-143.0										
	at		to	Same									
00:35:05	44.7 deg		-151.0							6.05	0.238	0.00	1.000
E + 60	16		-143.0										
	at	Same	to	Same									
00:46:05	44.7 deg		-151.0										

Table 8. DSN-PV'78 Small Probe No. 2 telemetry test, Run No. 1, TPA 1 at 2292.437720 MHz

Event GMT	Bit rate mod. index, coded data	Received power, dBm P_T	P_c	P_D	RCVR lock	SDA lock	TPA init	SSA lock	SEQ lock	SSA SNR, dB	SEQ SER, %	SEQ DLR, %	SEQ ACB
E - 22					20 h 07 min								
20:04:05	None	-142.5	-142.5	None	27 s								
E - 17	64 at					20 h 09 min	20 h 09 min	20 h 11 min	20 h 11 min				
20:09:05	58.44 deg	-136.88	-142.5	-138.27		07 s	17 s	25 s	58 s	10.47	0.00	0.00	1.000
E = 0	64 at	20-s Blackout			20 h 26 min	No out-of-lock		20 h 27 min	No out-of-lock				
20:26:05	58.44 deg	-131.38	-137.0	-132.77	29 s	indi-cation		25 s	indi-cation	9.90	0.036	1.339	1.000
E + 16	16 at						20 h 42 min	20 h 44 min	20 h 46 min				
20:42:05	44.7 deg	-139.53	-142.5	-142.59			13 s	55 s	54 s	15.38	0.00	0.00	1.000
E + 27	16 at												
20:53:05	44.7 deg	-134.03	-137.0	-137.09						8.61	0.00	0.00	1.000
E + 38	16 at												
21:04:05	44.7 deg	-141.53	-144.5	-144.59						7.17	0.00	0.00	1.000
E + 49	16 at												
21:15:05	44.7 deg	-140.03	-143.0	-143.09						6.49	0.048	0.00	1.000

Table 8 (contd)

Event GMT	Bit rate mod. index, coded data	Received power, dBm P_T	Received power, dBm P_c	Received power, dBm P_D	RCVR lock	SDA lock	TPA init	SSA lock	SEQ lock	SSA SNR, dB	SEQ SER, %	SEQ DLR, %	SEQ ACB
E + 60	16 at												
21:26:05	44.7 deg	-142.03	-145.0	-145.09						7.47	0.00	0.00	1.000

Table 9. DSN-PV'78 Small Probe No. 2 telemetry test, Run No. 2, TPA No. 1, at 2292.437720 MHz

Event GMT	Bit rate mod. index, coded data	Received power, dBm P_T	P_c	P_D	RCVR lock	SDA lock	TPA init	SSA lock	SEQ lock	SSA SNR, dB	SEQ SER, %	SEQ DLR, %	SEQ ACB
E - 22 20:22:50	None	None	None	None									
E - 17 20:27:50	64 at 58.44 deg	-139.68	-145.3	-141.07	20 h 28 min 22 s	20 h 28 m 59 s	20 h 29 min 04 s	20 h 30 min 09 s	20 h 30 min 35 s	4.8	0.695	0.00	1.000
E = 0 20:44:50	64 at 58.44 deg	20-s Blackout -140.18	-142.8	-142.89	20 h 48 min 04 s	No out-of-lock indication		20 h 49 min 53 s	No out-of-lock indication	4.76	1.11	0.00	1.118
E + 16 21:00:50	16 at 44.7 deg	-139.83	-142.8	-142.89			21 h 00 min 53 s	21 h 03 min 34 s	21 h 05 min 40 s	4.12	1.027	0.00	1.010
E + 27 21:11:50	16 at 44.7 deg	-144.03	-147.0	-147.09						4.17	1.108	0.00	1.010
E + 38 21:22:50	16 at 44.7 deg	-144.63	-147.6	-147.69						3.84	1.49	0.00	1.010
E + 49 21:33:50	16 at 44.7 deg	-144.93	-147.9	-147.99						2.97	2.47	0.00	1.085

Table 9 (contd)

Event GMT	Bit rate mod. index, coded data	Received power, dBm P_T	P_c	P_D	RCVR lock	SDA lock	TPA init	SSA lock	SEQ lock	SSA SNR, dB	SEQ SER, %	SEQ DLR, %	SEQ ACB
E + 60	16 at												
21:44:50	44.7 deg	-145.33	-148.3	-148.39						2.64	3.75	0.00	1.147

Table 10. DSN-PV'78 Small Probe No. 3 telemetry test, Run No. 1, TPA 1, at 2291.552280 MHz

Event GMT	Bit rate mod. index, coded data	Received power, dBm P_T	P_c	P_D	RCVR lock	SDA lock	TPA init	SSA lock	SEQ lock	SSA SNR, dB	SEQ SER, %	SEQ DLR, %	SEQ ACB
E - 22					16 h 48 min								
16:48:05	None	-142.5	-142.5	None	29 s								
E - 17	64 at					16 h 53 min	16 h 53 min	16 h 54 min	16 h 55 min				
16:53:05	58.44 deg	-136.88	-142.5	-138.27		19 s	23 s	27 s	02 s	9.03	0.00	0.00	1.000
E = 0	64 at	20-s Blackout			17 h 10 min	No out-of-lock		17 h 11 m	No out-of-lock				
17:10:10	58.44 deg	-136.38	-142.0	-137.77	32 s	indi-cation		31 s	indi-cation	7.95	0.146	1.293	1.000
E + 16	16 at						17 h 26 min	17 h 28 min	17 h 31 min				
17:26:05	44.7 deg	-140.53	-143.5	-143.59			14 s	55 s	27 s	10.53	0.00	0.00	1.000
E + 27	16 at												
17:37:05	44.7 deg	-139.03	-142.0	-142.09						8.44	0.00	0.00	1.000
E + 38	16 at												
17:48:05	44.7 deg	-139.03	-142.0	-142.09						8.15	0.00	0.00	1.000
E + 49	16 at												
17:59:05	44.7 deg	-140.53	-143.5	-143.59						8.55	0.00	0.00	1.000

Table 10 (contd)

Event GMT	Bit rate mod. index, coded data	Received power, dBm P_T	P_c	P_D	RCVR lock	SDA lock	TPA init	SSA lock	SEQ lock	SSA SNR, dB	SEQ SER, %	SEQ DLR, %	SEQ ACB
E + 60	16 at												
18:10:05	44.7 deg	-142.03	-145.0	-145.09						7.26	0.00	0.00	1.000

Table 11. DSN-PV'78 Small Probe No. 3 telemetry test, Run No. 2, TPA No. 1, at 2291.552360 MHz

Event GMT	Bit rate mod. index, coded data	Received power, dBm P_T	P_C	P_D	RCVR lock	SDA lock	TPA init	SSA lock	SEO lock	SSA SNR, dB	SEQ SER, %	SEQ DLR, %	SEQ ACB
E - 22					16 h 56 min 18 s								
		-145.5	-145.5	None									
E - 17	64 at 58.44 deg	-140.38	-146.0	-141.77		17 h 01 min 15 s	17 h 01 min 17 s	17 h 02 min 53 s	17 h 02 min 54 s	0.95	4.10	0.00	1.338
E = 0	64 at 58.44 deg	20-s Blackout -142.38	-148.0	-143.77	17 h 18 min 28 s	No out-of-lock indication		17 h 19 min 26 s	No out-of-lock indication	0.64	5.57	2.272	
E + 16	16 at 44.7 deg	-146.03					17 h 34 min 13 s	17 h 37 min 26 s	17 h 39 min 26 s	-0.75	4.88	0.00	1.158
E + 27	16 at 44.7 deg	-146.43									5.47	0.00	2.93
E + 38	16 at 44.7 deg	-146.13								0.31	6.59	0.00	4.29
E + 49	16 at 44.7 deg	-145.63								-0.37	6.05	0.00	1.353

Table 11 (contd)

Event GMT	Bit rate mod. index, coded data	Received power, dBm P_T	Received power, dBm P_c	Received power, dBm P_D	RCVR lock	SDA lock	TPA init	SSA lock	SEQ lock	SSA SNR, dB	SEQ SER, %	SEQ DLR, %	SEQ ACB
E + 60	16 at 44.7 deg	-146.23								-0.93	7.275	0.00	1.734

Table 12. Small Probe 1 stable oscillator measurements

Run 1. Initial frequency 2292.282020 MHz		
Time	Point, Hz	Residual, Hz
E −10	0.0	0.50
E +2	−1.27	−0.77
E +12	−2.86	−2.36
E +20	−3.97	−3.47
E +29	−5.17	−4.67
E +40	−7.26	−6.67
E +50	−8.82	−8.32

Frequency drift for 1 h from E −10 to E +50 = −8.82 Hz, stability = 3.85×10^{-9} for 1 h.

Run 2. Initial frequency 2292.282020 MHz		
E −10	0.0	0.83
E −0	−2.04	−1.21
E +31	−4.71	−3.88
E +40	−5.46	−4.63
E +50	−6.80	−5.97
E +60	−7.58	−6.75

Frequency drift for 1 h from E −0 to E +60 = 5.54 Hz, stability = 2.42×10^{-9}

Table 13. Small Probe 2, stable oscillator measurements

Run 1. Initial frequency 2292.437720 MHz		
Time	Point, Hz	Residual, Hz
E +4	0.0	1.27
E +10	0.17	1.44
E +20	0.25	1.52
E +30	0.38	1.65
E +40	0.27	1.54
E +50	0.34	1.61
E +60	0.33	1.60
E +64	0.26	1.53

Frequency drift for 1 h from E +4 to E +64 = 0.26 Hz, stability = 1.13×10^{-10} for 1 h.

Run 2. Initial frequency 2292.437780 MHz		
E −10	0.0	0.81
E −0	0.31	1.12
E +11	0.61	1.42
E +20	0.77	1.58
E +30	1.01	1.82
E +39	1.04	1.85
E +50	1.07	1.88
E +60	1.13	1.94

Frequency drift for 1 h from E −0 to E +60 = 0.82 Hz, frequency stability = 3.57×10^{-10} for 1 h.

Table 14. Small Probe 3, stable oscillator measurements

Run 1. Initial frequency 2291.552280 MHz		
Time	Point, Hz	Residual, Hz
E -5	0.0	-0.38
E -1		
E +1	0.35	-0.73
E +10	-1.07	-1.45
E +20	-2.33	-2.71
E +30	-3.15	-3.53
E +40	-3.02	-3.40
E +50	-4.70	-5.08
E +59		

Frequency drift for 1 h from E -1 to E +59 = 5.24 Hz, stability = 2.29×10^{-9} for 1 h.

Run 2. Initial frequency 2291.552360 MHz		
E +2	0.0	1.27
E +10	0.55	1.83
E +21	-0.08	1.19
E +30	-0.32	0.95
E +40	-1.23	0.04
E +50	-1.32	-0.05
E +60	-2.10	-0.83

Frequency drift for 58 min. from E +2 to E +60 = -2.10 Hz, stability = 9.16×10^{-10} for 58 min.

Table 15. Predetection recording playback

Event	P_c	Rate, bits/s coded data	Real time SSA SNR	Playback SSA SNR
Small probe 1, Run 2 Nov. 15, 1977				
E −17	−145.0 dBm	64	5.05	No data
E −0	−146.4 dBm	64	4.53	4.88
E +16	−145.8 dBm	16	–	5.60
E +27	Link variations of	16	No data to	2.39
E +38	up to 8. dB	16	compare	1.17
E +49		16	–	End of tape
E +60	−143 to −151 dBm	16	–	–
On playback the SNR varied from −1.5 to 5.6 dB in places. This agrees with the real-time variations. All data recorded was recoverable with zero deletions.				
Small probe 3, Run 2 Nov. 16, 1977, 3 dB error in RCV AGC settings due to AGC curve shift				
E −17	−143.0 dBm	64	Computer	1.70
E −0	−145.0 dBm	64	problems no	1.02
E +16	−146.0 dBm	16	real time	0.98
E +27	−146.4 dBm	16	data	1.75
Shift in AGC curves made settings 3 dB lower than expected. At true levels of −145 dBm, SNR values of 4.8 dB were obtained. Actual levels obtained were −148 dBm which yielded SNRs of approximately 1.8 dB, which were obtained at playback. All data is recoverable from tape.				
Small probe 2, Run 1, Nov. 15, 1977				
E −22	−142.5 dBm	64	–	–
E −17	−142.5 dBm	64	10.47	10.96
E −0	−137.0 dBm	64	9.90	9.47
E +16	−142.5 dBm	16	15.38	15.74
E +27	−137.0 dBm	16	8.61	8.86
E +38	−144.5 dBm	16	7.17	6.52
E +49	−143.0 dBm	16	6.49	End of tape
E +60	−143.0 dBm	16	7.47	–
Small probe 3, Run 1, Nov. 15, 1977				
E −17	−142.0 dBm	64	9.03	Data did not lock up
E −0	−142.0 dBm	64	7.95	8.27
E +16	−143.5 dBm	16	10.53	10.21
E +27	−142.0 dBm	16	8.44	8.17
E +38	−142.0 dBm	16	8.15	8.99
E +49	−143.5 dBm	16	8.55	End of tape
E +60	−145.0 dBm	16	7.26	–

Table 16. Definition of terms for Tables 1 Through 15

ACB	Average computations per bit time
ARC	Ames Research Center
BER	Bit error rate
Bit rate	Clock frequency of the telemetry bit Information
CPA	Command Processor Assembly
CMF	Communications Monitor and Formatting Assembly
CTA 21	Deep Space Network Ground Station Compatibility Test Area at JPL
dBm	Decibel referenced to one milliwatt
DDA	Data decoder assembly
DL	RF downlink signal
DLR	Frame deletion rate
DSN mode	The Deep Space Network Ground Station Operational configuration
FDS	Spacecraft Flight Data Subsystem
HAC	Hughes Aircraft Corp.
MCD	Maximum likelihood convolutional decoder
MDA	Metric Data Assembly
MDS	Spacecraft Modulation/Demodulation Subsystem
MDS	The DSN-MARK III Data Subsystems Implementation Project
No	Noise spectral density
P_c	power in RF carrier
P_T	power total
PRA	Planetary Ranging Assembly
PFR	Problem/Failure Report
RDA	Ranging Demodulator Assembly
RF	Radio frequency
RFS	Spacecraft Radio Frequency Subsystem
RU	Range unit
SAF	Spacecraft Assembly Facility (JPL Building 179)
S/C RFS mode	Spacecraft Radio Frequency Subsystem Operational configuration
SCA	Simulation Conversion Assembly
SDA	Subcarrier Demodulator Assembly
SE	Spacecraft Ground Support Equipment
SER	Symbol error rate
SEQ	Sequential decoder
SNR	Signal-to-noise ratio
SPS	Symbols per second
SSA	Symbol Synchronizer Assembly
SSF	Space Simulator Facility (JPL Building 150)
ST_b/N_o	Signal-to-noise spectral density ratio
Symbol rate	Clock frequency of the telemetry symbol information
TBD	To be determined
TBS	To be supplied
TDL	Telemetry Development Laboratory
TLM	Telemetry
TPA	Telemetry Processor Assembly
TWT	Travelling wave tube amplifier
UL	RF uplink signal
Uplink doppler	Ramp rate of uplink RF carrier frequency
Uplink offset	Uplink RF carrier frequency displacement Relative to the spacecraft receiver test frequency
USO	Ultrastable oscillator
VCO	Voltage-controlled oscillator

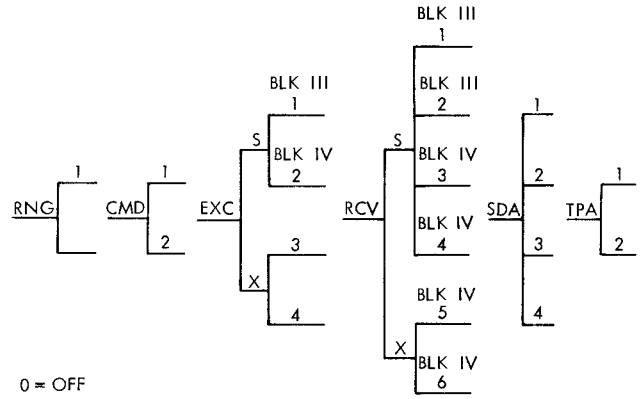

Fig. 1. DSN modes

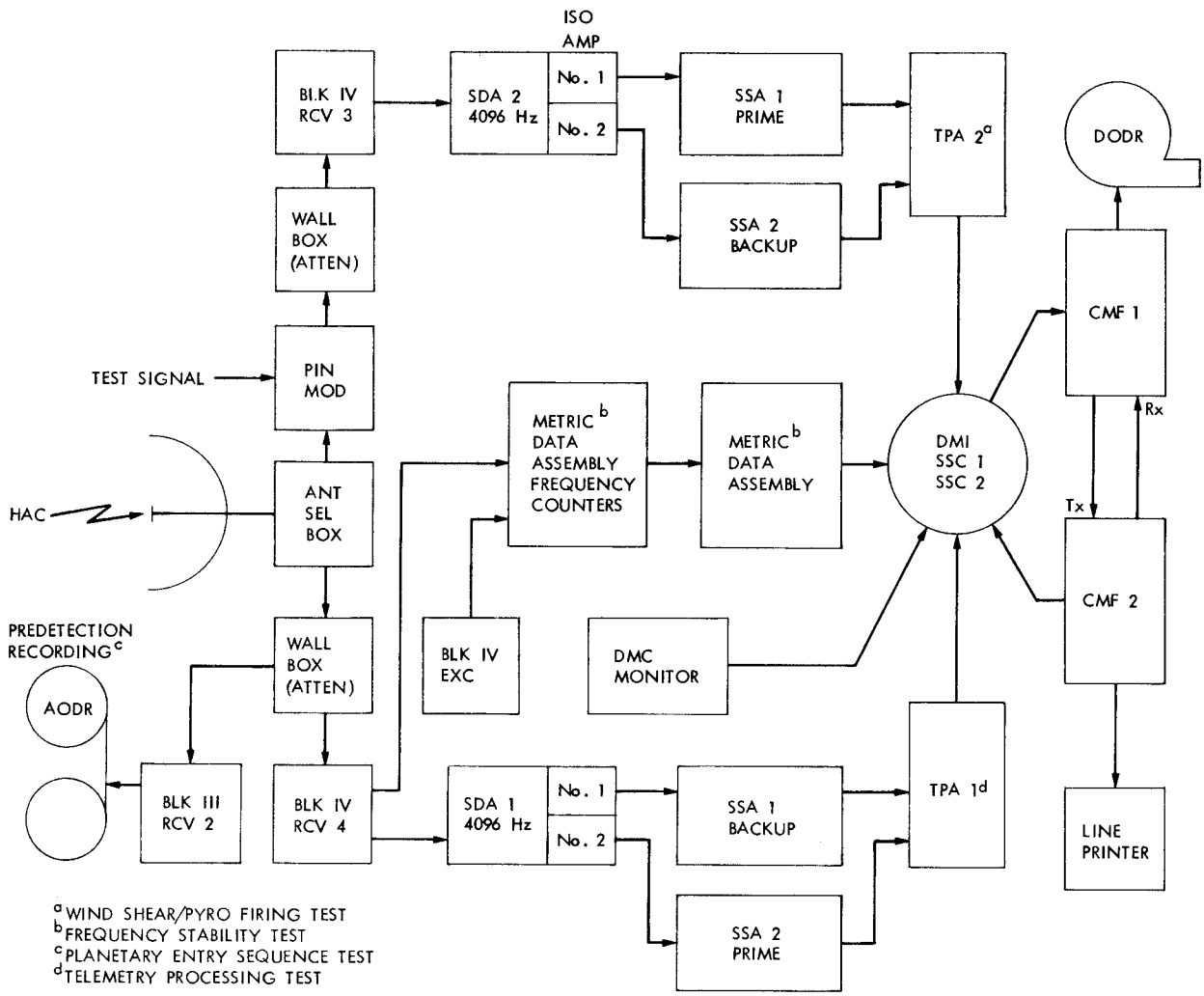

Fig. 2. DSN-PV'78 Small Probe test configuration

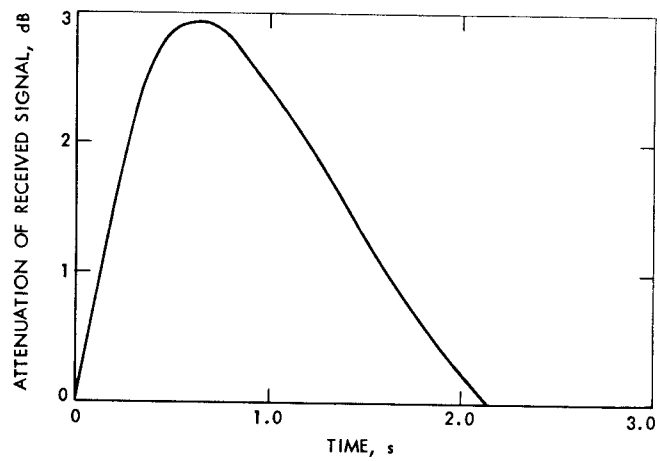

Fig. 3. Small Probe response to 5-ms step wind gust

Appendix A
S-band Microwave Link Terrain Profile

Table A-1. CTA 21/HAC link analysis

Antenna gains at midband frequency (2.296 GHz)		
	Loss, dB	Gain, dB
Cable (CTA 21 to JPL antenna)		
76 m (250 ft) of 1.9 cm (7/8 in.) hardline at −2.25 dB/30 m (100 ft)	−5.6	
Link 1 (JPL to tower): 3,590 m		
Free space loss (32.4 + 20 log f + 20 log d) where f = 2.296 GHz and d = 3590 m	−110.7	
Antenna gain		
1.8 m (6 ft) antenna (with radome)		29.1
2.4 m (8 ft) antenna		32.4
Misalignment	−2.0	
Link 2 (HAC to tower) 33,220 m		
Free space loss (32.4 + 20 log f + 20 log d) where f = 2.296 GHz and d = 33,220 m	−130.0	
Antenna gain (same as Link 1)		61.5
Misalignment	−2.0	
Cable loss (spacecraft to HAC antenna)		
122 m (400 ft) of 1.9 cm (7/8 in.) hardline at −2.25 dB/30 m (100 ft)	−9.0	
Totals	−257.3	124.0
Overall link loss	−136.3 dB	

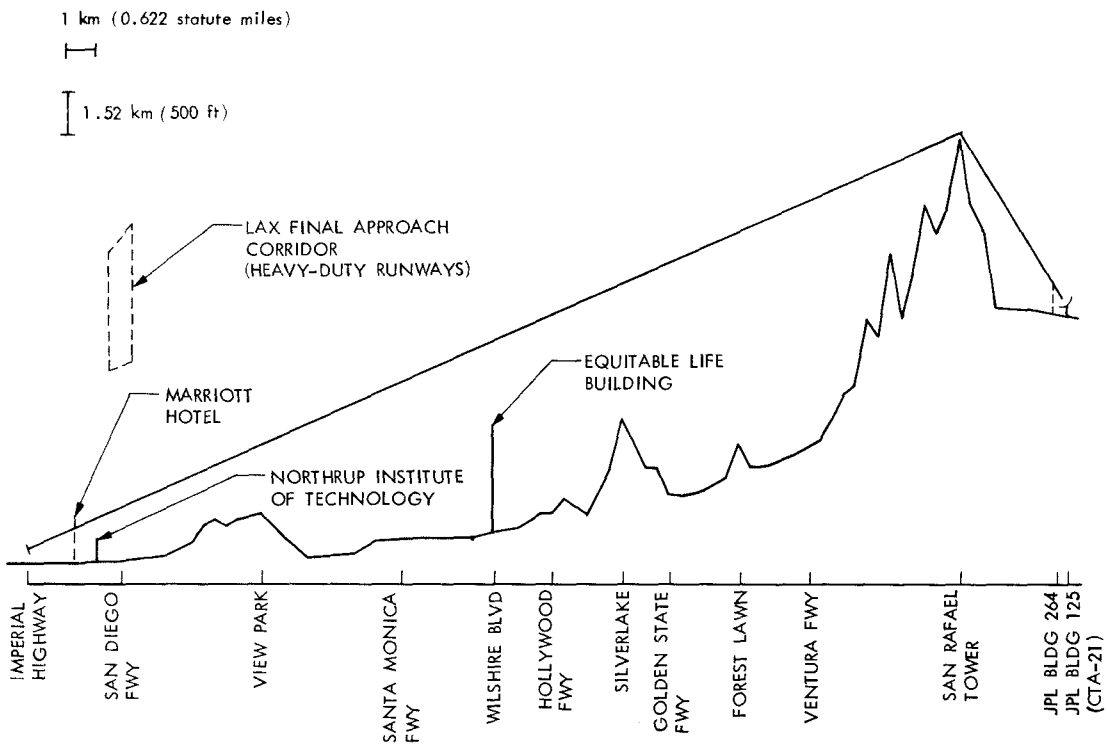

Fig. A-1. S-band microwave link terrain profile

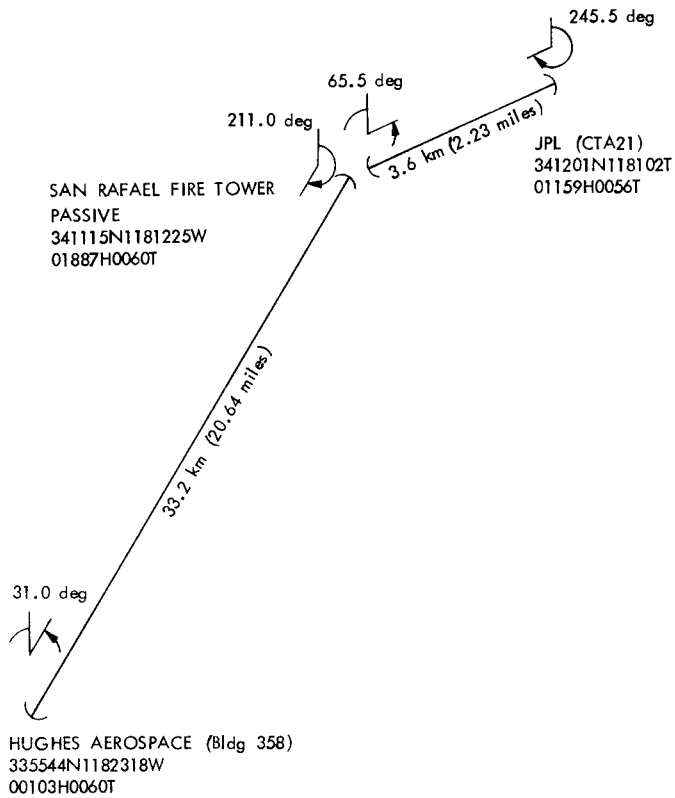

Fig. A-2. JPL/HAC microwave link