Viking Mission Support

D. J. Mudgway, A. I. Bryan, and H. C. Thorman
DSN Systems Engineering Office

D. W. Johnston
Network Operations Office

This article reports the results of RF compatibility tests with the first Viking Flight Orbiter, Lander, and Spacecraft at the Spacecraft Compatibility/Monitor Station, Merritt Island, Florida (STDN(MIL 71)) in January and February 1975.

It also includes the status of the continuing series of mission configuration tests and operational training tests being conducted throughout the DSN, as well as a report on a series of data system compatibility tests involving the flight spacecraft on the launch pad at the Cape, STDN (MIL 71), and the Viking Mission Control and Computing Center at JPL, Pasadena.

I. Background

Previous articles in this series described progress in Viking RF compatibility testing at the Compatibility Test Area, JPL, Pasadena (CTA 21), the start of mission configuration testing at the Pioneer and Mars Deep Space Stations (DSSs 11 and 14), and some of the early work in operational testing at the stations. Activity in all these areas has continued, and in some cases, has now been completed. This article reports completed or continuing work in each of these areas.

II. Viking Lander No. 1 Radio Frequency Compatibility Tests

This assessment and status is derived from test results obtained between STDN (MIL 71) and the Viking Lander Capsule No. 1. These compatibility tests were conducted at the Kennedy Space Center (KSC), Florida for 55 h from 30 January through 7 February 1975, and the test results verify telecommunications design compatibility between Capsule No. 1 and the DSN.

A. Test Objectives

The objective of the tests was to verify telecommunications design compatibility between the DSN and the Viking Lander Capsule No. 1. The test criteria and parameters simulated direct communications between a Lander flight article on Mars and a 64-m antenna station. Design compatibility had been previously established between the DSN and the Spacecraft Test Lander at CTA-21.

A selected set of standard tests was performed for verifying transponder, RF, command, telemetry and radio metric compatibility. In addition, special tests to verify synchronization under varying data patterns were performed.

B. Test Conditions

An S-band radio frequency air link of approximately three miles was used between the capsule and the ground station. Radio frequency link amplitude variations were a maximum of 1.0 dB peak-to-peak as established from link stability tests conducted prior to the initialization of the compatibility test program. The test configuration used is shown in Fig. 1.

The ground station software used in these tests was the Telemetry and Command Data and the Planetary Ranging Assembly Data, both of which are officially released for Viking Project support.

C. Test Results

Significant events and other items of the test results, are described below.

(1) The following radio frequency acquisition tests were performed:

(a) Carrier acquisition and threshold: (1) downlink one-way, (2) uplink one-way, and (3) downlink two-way.

(b) Spacecraft receiver acquisition, pull-in range, tracking range and rate.

(c) Downlink phase jitter: (1) residual carrier phase jitter, and (2) residual subcarrier phase jitter.

(d) Radio frequency downlink spectrum analysis.

(e) Transponder rest frequency (voltage controlled oscillator).

(f) Auxiliary oscillator frequency.

The criteria that were established for these tests were met. For those tests without criteria, the data were obtained for information. No significant problems were encountered or identified.

(2) Tests of command performance with doppler were conducted. The criteria that were established for these tests were exceeded. Symbol period alarms/aborts were experienced when the subcarrier oscillator frequency was offset. An improper pulse polarity on the 1-k pulse per second signal to the millisecond clocks in the Telemetry and Command Processors was found to be the problem. This was corrected by inverting the pulse polarity of the 1-k pps at the Frequency and Timing Subsystem source. Proper corrective action was verified by retest with the spacecraft. DSN documentation will be revised to reflect proper polarity of all timing signals.

(3) The following metric data tests were performed:

(a) Ranging polarity verification.

(b) Ranging acquisition threshold.

(c) Ranging delay verification.

The polarity of the transmitted ranging signal was verified at strong uplink and downlink signal levels. The criteria for the ranging delay measurement were met. The Block IV exciter was found to invert the ranging code, whereas the Block III exciter did not show this anomaly. Corrective action requires only type-in changes to the Planetary Ranging Assembly software during operations. The software provides this capability.

(4) Tests were made for telemetry performance with and without doppler. The criteria that were established for these tests were met. Problems encountered were as follows: the station kept losing downlink signal while attempting to perform a low-signal telemetry performance test in a two-way mode with the spacecraft. A faulty switch module in the Block IV exciter was found to be operating intermittently, which switched the spacecraft between two-way and one-way. The faulty switch was bypassed and the test was successfully completed. The 9-track original data records gave excessive write errors during telemetry performance testing. A 1-h maintenance period was used to restore proper operation of the units; reseating of data decoder assembly-original data record interface cables resolved the problem.

(5) Viking Lander Capsule No. 1-STDN (MIL 71)-Network Operations Control Center telemetry verification tests were conducted. Figure 1 shows the configuration used during the telemetry performance tests to verify the capsule telemetry. The NOCC received and verified as good the 8.33-bps engineering data and the 250-bps block coded data.

III. Viking Orbiter No. 1 Radio Frequency Compatibility Tests

This assessment and status is derived from test results obtained between STDN (MIL 71) and the Viking Orbiter No. 1. These compatibility tests were conducted at the Kennedy Space Center, Florida, from 27 February to 1 March 1975 for 24 h. Although all tests specified were not completed and the air link signal variations during many of the tests exceeded the expected variations, sufficient tests were completed to verify that no incompatibility exists.

A. Test Objectives

The objective of the tests was to verify telecommunications compatibility between the DSN and the Viking Orbiter No. 1. The test criteria and parameters simulated direct communications between an Orbiter flight article in Martian orbit and a 64-m antenna station. Design compatibility had been previously established between the DSN and the Viking Orbiter No. 1 at JPL (CTA 21) as reported in Ref. 1.

A selected set of standard tests, as specified in Ref. 3 was performed for verifying transponder, RF, command, telemetry and radio metric compatibility.

B. Test Conditions

An S-band, two-way RF air link, and an X-band, one-way RF air down-link were used between the flight article and the ground station. Each RF air link was approximately seven miles long. The test configuration is shown in Fig. 1.

S-band RF link variations were observed to be 0.5 dB peak-to-peak during the first few hours of the test, but later degraded to 6.0 dB peak-to-peak. These conditions existed during daylight hours on 27 February 1975 and also during nightime hours on 28 February through 1 March 1975. X-band RF link variations were observed to be as low as 2.0 dB peak-to-peak and as high as 8.0 dB peak-to-peak. These conditions existed during nightime hours on 28 February through 1 March 1975 and appeared to be a function of wind velocity. With approximately 3 h of scheduled test time remaining on 1 March 1975, the STDN (MIL 71) S-Band antenna was found to be off boresight by approximately 4 deg (attributed to wind perturbations). The antenna was realigned and signal level increases of 12.0 dB uplink and 15.0 dB downlink resulted. The realignment also resulted in reduction of S-band RF link variation from 5.0 dB peak-to-peak to 0.2 dB peak-to-peak.

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 Viking Project support. The programs consisted of:

(1) Telemetry and Command Program, which 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, which provides either continuous spectrum or discrete spectrum operation for determining very accurate range estimates of a spacecraft at planetary distances.

C. Test Results

Significant events and/or other items in the areas of radio frequency acquisition and tracking performance, telemetry, command and metric data generation are described below.

(1) The following radio frequency acquisition and tracking tests were performed:

(a) Downlink threshold one-way.

(b) Uplink threshold.

(c) Downlink threshold two-way.

(d) Spacecraft receiver pull-in range and rate.

(e) Carrier residual phase jitter.

(f) Transponder rest frequency.

(g) Auxiliary oscillator frequency.

(2) Problems encountered:

(a) The spacecraft Radio Frequency Subsystem (RFS) operator at the Spacecraft Checkout Facility (Building AO) had the test transmitter on, and the spacecraft was acquired during downlink threshold (one-way) test 1B. Test was performed in three-way instead of one-way.

(b) Two-way carrier phase jitter was performed with an uplink signal level of -121 dBm instead of -70 dBm. STDN (MIL 71) uplink power level during this test was adjusted for maximum spacecraft signal level. Test criteria were not met.

(i) Tests 4A and 4B specify the 700-Hz offset acquisition to be performed with the Block III exciter configured for ramping. However, the ramp generator does not provide a "clean" RF spectrum as does the voltage-controlled oscillator when not configured for ramping. During offset acquisition, one or more undesirable spectral components pushed the voltage controlled oscillator away from its "captive range" and prevented acquisition. With the ramp capability removed and the exciter driven by the voltage controlled oscillator, acquisition was accomplished on both RFS receivers.

(ii) Uplink ramp function stopped at +28-kHz carrier offset on two attempts during test 4A; switched to Block IV exciter and performed the test successfully.

(3) A test of command capability under doppler conditions was conducted.

(4) Problems encountered: during the command performance test 9A, with the Command Modulator Assembly in the Idle 1 mode (command subcarrier only), the Viking Orbiter Test Capsule reported "Ready for commanding." The station then sent the commands without first advancing to Idle 2 to acquire bit sync. Since the Orbiter cannot detect command data without having bit sync lock, the block of 5 commands was rejected. Subsequently, using the correct idle sequence, all commands were successfully completed.

(5) A ranging channel delay threshold and polarity verification test was performed.

(6) Problems encountered: during first run of test 10C, the S-band antenna at STDN (MIL 71) was found to be 4 deg off boresight as a result of high winds. The pointing error was corrected and the test was rerun successfully.

(7) a. The following telemetry tests were performed:

(a) Downlink Spectrum Analysis

(b) Modulation Index and Spectrum Analysis

(c) Telemetry Performance Test

(8) Problems encountered:

(a) Due to an insufficient downlink signal level over the Building AO/STDN (MIL 71) air link, the telemetry spectrum test 13B was not run. Some photos were taken and original data records were taped. However, the high noise level rendered both media unacceptable for spectrum analysis. The required photos will be taken of the spacecraft Radio Frequency Subsystem (RFS) support equipment when the Orbiter returns to Building AO for continued system testing.

(b) During the telemetry performance tests, 14A and 14B, the link variations were too large (signal varied from ± 1 to ± 3) to permit Y-factor settings. The tests were therefore run at higher signal levels with estimated signal-to-noise ratios based on downlink carrier settings. Under these conditions, telemetry demod losses could not be verified. However, the DSN capability to track and process telemetry data under doppler conditions was verified. Test results indicated no incompatibility.

D. Radio Frequency Air Link Performance

A posttest calibration of the RF link (S-band and X-band) was performed on 3 March 1975. A three-hour S-Band differenced range vs integrated doppler (DRVID) stability run was performed using the Planetary Ranging Assembly software to establish initial ranging acquisition and estimate drift changes over 5-min sample periods. A histogram of deviation vs number of samples is shown in Fig. 2. During the same time period, an S-band amplitude stability run was performed. Each printout shows the mean automatic gain control voltage, the one sigma standard deviation and the number of samples averaged over a 10-min. period. In similar fashion, a 2 h and 10 min. X-band DRVID stability run was performed. The data associated with this test are shown in Fig. 3.

E. Concerns

The fact that active command data can be sent without sending the "Idle 2" signal (subcarrier + bit sync) for a minimum of 6.25 s should draw special attention for mission operations. If the command software does not have a built-in constraint, special attention must be given to operating procedures (both at the Mission Control and Computing Center and the DSS) to ensure that the required command acquisition sequence is transmitted prior to command data.

The Block IV uplink ramp generator was the source of two problems as noted in subparagraph III-C. It should be noted that this ramp generator is not used during flight operations.

IV. Viking Spacecraft No. 1 Radio Frequency Compatibility Tests

This assessment and status is derived from test results obtained between STDN (MIL 71) and the Viking Spacecraft No. 1. This 6-h compatibility test was conducted at the Kennedy Space Center, Florida, on 22 March 1975.

A. Test Objectives

The objectives of the compatibility test were as follows:

(1) Verify in the spacecraft configuration the capability of the Viking Orbiter No. 1 to receive Viking Orbiter commands and reject Viking Lander Capsule commands.

(2) Verify in the spacecraft configuration the capability of the Viking Lander Capsule No. 1 to receive Viking Lander Capsule commands and reject Viking Orbiter commands.

B. Test Conditions

An S-band RF air link of approximately three miles was used between the flight article and the ground station. The test configuration is shown in Fig. 1.

The ground station software used in performing these tests was supplied by the DSN and was a subset of software officially released to the station for Viking Project support. The software consisted of the Telemetry and Command Program, which provides independent control of the commanding and telemetry 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.

C. Test Results

Significant events and other items of the test results are described below.

(1) The following command tests were performed:

  (a) Orbiter/lander command discrimination test 3A (Side 1).

  (b) Orbiter/lander command discrimination test 3B (Side 2).

(2) Problems encountered: during the initial attempt to transmit commands to the Orbiter on Side 1 (test 3A, Step 9), it was noted that Lander Command Detector 1 toggled in and out of lock. The test conditions under which this anomaly occurred were (1) uplink Signal Level (total power) set at −99.85 dBm, (2) orbiter subcarrier frequency of 512.0 Hz, and (3) bit sync acquisition sequence (Idle 2)

Upon detection of this discrepancy, on-line trouble shooting was initiated in real time. The Command Modulator Assembly was returned to Idle 1 (subcarrier only) and the lock status of Lander Command Detector 1 was monitored. Under this condition, a stable out-of-lock condition was detected. The Command Modulator Assembly was reconfigured to offset the orbiter subcarrier to a frequency of 512.1 Hz. Monitoring of the lock status of the Lander Command Detector 1 while Idle 1 and Idle 2 were transmitted showed that the detector toggled in and out of lock only with Idle 2 present. Photographs of the signal on the interface wires were taken during this on-line investigation with negative results. With these data for off-line investigation and analysis, it was decided to continue with the test in accordance with the procedure and to document test discrepancies.

During the conduct of test 3A, Lander Command Detector 1 lock status at no time indicated an in-lock condition when the command waveform to the Orbiter was Subcarrier $\oplus$ Bit Sync $\oplus$ Data. Further, the false in-lock condition of Lander Command Detector 1 with Idle 2 present occurred at strong uplink signal as evidenced by the test results at −143 dBm.

The anomolous in-lock conditions identified above were not noted on Lander Command Detector 2 during the accomplishment of test 3B.

V. Viking Lander No. 2 Compatibility Tests

These tests were performed from 7 April through 9 April 1975 for 24 h.

A. Test Objectives

The objectives of the tests were to verify telecommunications design compatibility between the DSN and the Viking Lander Capsule No. 2. The test criteria and parameters simulated direct communications between a Lander flight article on Mars and a 64-m antenna Deep Space Station.

A selected set of standard tests, was performed for verifying transponder, RF, command, telemetry and radio metric compatibility.

B. Test Conditions

An S-band RF air link of approximately three miles was utilized between the flight article and the ground station. RF link amplitude variations were a maximum of 1.0 dB peak-to-peak during the tests as established from link stability tests conducted prior to the initialization of the compatibility test program. The test configuration is shown in Fig. 1.

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 Viking Project support. The software consisted of the Telemetry and Command Program, which provides independent control of the commanding and telemetry 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.

C. Test Results

Significant events and/or other items in the areas of radio frequency acquisition and tracking performance, telemetry, command, and metric data generation are described below.

(1) The following radio frequency tests were performed:

(a) Carrier acquisition and threshold: downlink one-way, uplink one-way, and downlink two-way.

(b) Spacecraft receiver acquisition, pull-in range, tracking range and rate.

(c) Downlink phase jitter: residual carrier phase jitter and residual subcarrier phase jitter.

(d) RF downlink spectrum analysis.

(e) Transponder rest frequency (VCO).

(f) Auxiliary oscillator frequency.

The criteria that were established for these tests were met. For those tests without criteria, the data were obtained for information. No significant problems were encountered or identified.

(2) The following command test was performed: command performance with doppler. The criteria that were established for this test were met. No significant problems were encountered or identified.

(3) The following metric data tests were performed:

(a) Ranging polarity verification.

(b) Ranging acquisition threshold.

(c) Ranging delay verification.

The polarity of the transmitted ranging signal was verified at strong uplink and downlink signal levels. The criteria for the ranging delay measurement was met. No significant problems were encountered or identified.

(4) The following telemetry test was performed: telemetry performance with/without doppler. The criteria that were established for this test were met. No significant problems were encountered or identified.

VI. Mission Configuration Tests

The previous article covered the percentage of strong-signal Mission Configuration Tests (MCTs) completed at the time of writing, with details of the testing at the Mars Station at Goldstone, California. Figures 4 and 5 herein represent the current test status of the 64-m and primary Viking 26-m subnets, showing the planned vs actual status as of mid-April. The initial blocks of time, as previously stated, represent the strong signal tests preparatory to start of Operational Verification Tests (OVTs). System Integration Tests (SITs) and Ground Data System (GDS) Test.

The second time blocks represent the low signal telemetry bit error and doppler jitter tests, which do not affect the station configuration and are carried out on a non-interference basis for completion prior to launch.

Summarizing the test status, all the stations are on or ahead of schedule and there is a high degree of confidence that all remaining tests will be completed prior to launch as scheduled.

VII. Operational Verification Testing and Training

Personnel training is a multifaceted item and many different activities contribute to the preparation of the DSS staff for support of the Viking Flight Operations System tests and flight support. Examples are the mission independent training to familiarize the crews with the calibration, operation, and maintenance of equipment in a stand-alone mode, and reading of the Viking Network Operations Plan to apply the Viking procedures to the operation of the equipment. These are in conjunction with becoming familiar with the spacecraft and the Viking mission, with on-site exercises simulating Viking operations. The most significant training vehicle, however, is participation in the Operational Verification Tests, and these are designed expressly to exercise the Network functions and procedures to the greatest degree possible. Provided that the on-site training prerequisites have been met, these tests are instrumental in raising the level of training from approximately 15% to approximately 80% in a relatively short time.

This rapid increase in training proficiency, however, is dependent upon having each of the tests scheduled on a particular day and time of day to enable each DSS crew to participate equally. In practice, this is proving to be extremely difficult as the only time available is that between Pioneer and Helios tracks at the same time of day every day. Rescheduling crews is extremely difficult and costly, therefore the total block time is being stretched to complete the training for Viking.

Following is a brief synopsis of each of the tests carried out with DSSs 11, 14, 42, 43, 61, and 63 to date.

A. DSS 11

1. OVT — 1 (2-5-75). The first test with DSS 11 was a partial success but contained many Simulation Conversion Assembly (SCA) problems due to minor procedural errors and operator unfamiliarity. All telemetry and command procedures that were attempted were well executed, and the SCA procedures were modified subsequent to the test.

2. OVT — 2 (2-11-75). This test was considered 90% complete. Again, SCA problems were encountered, along with personnel interface problems with the Network Data Processing Area for SCA support. Interface procedures were modified to prevent a recurrence.

3. OVT — 3 (2-18-75). This test was attempted with little success. Due to data tansfer delays compounded by SCA and Data Decoder Assembly hardware problems, the test was only 10% successful. However, valuable training was obtained isolating and rectifying the failures.

4. OVT — 4 (2-19-75). This test was 75% successful. The test was delayed by SCA hardware problems, specifically video conditioners.

5. OVT — 5 (2-23-75). This test was considered 100% successful and all items were covered. Only minor procedural errors, which were corrected readily, hindered the test slightly, if at all.

6. OVT — 6 (2-25-75). This test was another completely successful effort.

7. OVT — 7 (2-26-75). This test was only 95% successful because the analog playback portion of the sequence of events had not been completed. A Symbol Synchronizer Assembly problem on the prime Telemetry and Command Subsystem string forced a change-over to the backup; the transition plus the repair of the Symbol Synchronizer Assembly during the test was excellent.

As a result of these seven OVTs, DSS 11 was considered capable of supporting Viking operations with no foreseen difficulty.

B. DSS 14

1. OVT — 1 (2-12-75). Test No. 1 was conducted with DSS 14 in a planetary configuration. Fifty percent of the sequence of events was accomplished and valuable training obtained. Familiarity with the 6-channel Simulation Conversion Assembly was gained along with Viking planetary configurations and procedures.

2. **OVT — 2 (2-15-75).** This test was 35% completed. Two Data Decoder Assembly failures coupled with Simulation Conversion Assembly procedural problems used up 3½ h of test time. A lot was learned to aid future tests, and the pretest calibration procedures for the 6-channel Simulation Conversion Assembly were generally overhauled in the light of experience gained from the test.

3. **OVT — 3 (2-16-75).** Test No. 3 was considered 90% successful. Only the playback portions were not met. Data-transfer/Simulation Conversion Assembly delayed the test start and this was the main reason for not being 100% complete.

4. **OVT — 4 (2-20-75).** This test was very successful (90%) considering only 4 of 6 data channels were available. Block decoder Assembly 2 and Data Decoder Assembly 4 were red allowing only 4 telemetry channels to be used. However, the test ran very smoothly and other than Original Data Record recall, all major objectives were met.

5. **OVT — 5 (2-27-75).** Two Data Decoder Assemblies were down plus a bad copy of the Simulation Conversion Assembly drop F was discovered. All objectives, except recalls, were met.

6. **OVT — 6 (3-19-75).** This test was considered 90% successful. Test time was lost due to real-time operations priority.

7. **OVT — 7 (3-30-75).** This test was considered 100% successful. All objectives accomplished.

C. DSS 42

1. **OVT — 1 (3-8-75).** This test was considered 70% successful; not all telemetry rates were processed due to loss of time because of unfamiliarity with the Simulation Conversion Assembly.

2. **OVT — 2 (3-27-75).** Outside of an initially bad attempt at Analog Original Data Record playback, all objectives were met and the test was a complete success.

3. **OVT — 3 (3-29-75).** This test was 90% successful. No Digital Original Data Record replay was attempted because of a delay caused by a Simulation Conversion Assembly to Subcarrier Demodulation Assembly data routing problem.

4. **OVT — 4 (4-4-75).** This test was 100% successful from an operational standpoint. A discrepancy report referred to the inability to locate frame synchronization of 8.333 bps.

5. **OVT — 6 (4-16-75).** Because the prime processor string was down, the shared processor was used for half of the test. The test proved 100% successful.

6. **OVT — 7 (4-17-75).** This test was 100% successful. At this point DSS 42 appears to be well qualified to support the Viking Mission.

D. DSS 43

OVT — 1 (4-14-75) was 60% successful. Problems with the Simulation Conversion Assembly's channels 5 and 6 caused considerable delays.

E. DSS 61

1. **OVT — 1 (4-8-75).** This test was considered 85% successful. Encountered some minor procedural errors and failed in an attempt at Digital Original Data Record recall.

2. **OVT — 2 (4-13-75).** This test was 100% successful. All test objectives were met.

3. **OVT — 3 (4-16-75).** This test was 100% successful. All objectives achieved.

F. DSS 63

1. **OVT — 1 (4-5-75).** This test was considered 100% successful. A slight core allocation problem in the Simulation Conversion Assembly core buffer, but it was corrected and did not impact test result.

2. **OVT — 2 (4-9-75).** This test was 100% successful with all objectives met.

3. **OVT — 3 (4-14-75).** This test was 100% successful, meeting all test objectives. Also, mated-Lander commanding was successfully performed, as an additional sequence of events item.

G. Conclusion

The planned schedule was to support System Integration Tests after each Station shift had participated in at least one Operational Verification Test; the OVTs were to be completed with all shifts prior to support of the first Ground Data System test at that station. These criteria could not be met at DSS 14. While Fig. 6 reflects this problem, it also shows that the testing and training will be completed before the Planetary Verification Tests commence.

VIII. Viking Data System Compatibility Tests

From January through April 1975, STDN (MIL 71) participated in a series of Viking command and telemetry tests with communications support by NASA Communications/Ground Communications Facility (NASCOM/GCF) and operations support by the Network Operations Control Center. The test series began with a DSN-Viking Mission Control and Computing Center Systems Integration Test and proceeded to a Ground Data System Test. Both of these tests involved simulated command operations and simulated telemetry data. These tests were followed by a set of Mission Precursor tests with the Viking Orbiter and Viking Lander mated flight spacecraft mounted on the launch vehicle at Kennedy Space Center. After completion of the precursor tests, a set of flight article compatibility tests was conducted with the Orbiter and Lander located at their respective Eastern Test Range system test buildings.

The precursor tests and the flight article compatibility tests were supervised by the Viking Project Compatibility Test Manager with participation by the Viking Flight Team in the mission support area at JPL.

A. STDN (MIL 71) Equipment Configuration and Performance

The DSS Command Subsystem configuration used for these tests is shown in Fig. 7.

The DSS Telemetry Subsystem configuration for mated-spacecraft tests, in which the telemetry was received on the orbiter downlink, is shown in Fig. 8.

The DSS Telemetry Subsystem configuration for the Viking Lander flight compatibility test, FCT-1, in which the telemetry was received on the Lander direct downlink, is shown in Fig. 9.

The Simulation Conversion Assembly of the DSS Test and Training Subsystem was operated in the computer-remote ("long-loop") mode to support telemetry simulation for the system integration test and the ground data system test, and was operated in the computer-local ("stand-alone") mode for pretest telemetry data transfer verification in each of the remaining tests. During these tests, there were no failures in the Simulation Conversion Assembly. A couple of malfunctions occurred in the Command Subsystem, and several failures were encountered in the Telemetry Subsystem.

B. System Integration Test

The STDN (MIL 71) system integration test was conducted on 9 January and 18 February. The purpose of the test was to verify the integrity of the STDN (MIL 71)/Viking Mission Control and Computing Center interfaces. The sequence of events provided for simulated Viking Orbiter, Viking Orbiter-Lander, and Viking Lander command operations and processing of dual-subcarrier simulated telemetry data at all the rates shown in Figs. 8 and 9.

Approximately half of the test objectives were completed on 9 January and the remainder on 18 February. Discrepancies encountered during the 9 January portion of the test were:

(1) A timing problem in the Data Decoder Assembly-A1 introduced frequent errors in the Viking Lander 500-bps and 1000-bps block coded telemetry data.

(2) The Block Decoder Assembly on channel 3 of the TCP-A caused errors in the Viking Orbiter 16-kbps block coded telemetry data.

Subsequent to the 9 January test, intensive troubleshooting and testing were done at STDN (MIL 71) to prepare the station for the Lander telecommunications RF compatibility testing of 30 January through 7 February and for the remaining system integration test. Prior to 18 February, two engineering verification tests were conducted with Network Operations Control Center support. The system integration test was successfully completed on 18 February and no discrepancies were encountered on that date.

C. Ground Data System Test 7.0

This test was conducted on 11 March and 18 March. From the DSN viewpoint, the test sequence was equivalent to the system integration test sequence. In the Mission Control and Computing Center, however, the ground data system test involved more ouput and display processing. STDN (MIL 71) encountered the following equipment malfunctions on 11 March, but the backup capability available permitted the test to proceed so that over half of the test objectives were completed on that date.

(1) The first problem encountered was that the Original Data Record tape unit on Telemetry and Command Processor (TCP)-A did not operate properly. The low- and medium-rate telemetry data were therefore paralleled through TCP-B to obtain a good Original Data Record.

(2) The second problem encountered was that Subcarrier Demodulator Assembly-1 would not lock up on data from the receiver. Subcarrier Demodulator Assembly-2 was used and the test continued in that configuration until the end of the test.

(3) The third problem encountered was that Data Decoder Assembly-A1, which was assigned to TCP channel 3 for this test, was putting the wrong time in the wideband data blocks. This did not impact the real-time processing of the high-rate telemetry data but did cause impact on the 9-track Original Data Record playback.

(4) The fourth problem encountered was that Command Modulator Assembly-2 started giving alarms that would not clear when a reinitialization was performed. Command Modulation Assembly-2 was to be used for Lander-direct commanding. The Lander-direct command operation was transferred to TCP-A and Command Modulator Assembly-1.

Ground Data System Test 7.0 was successfully completed on 18 March. The only DSN anomally encountered on that date was a 10-min. data outage that occurred when Symbol Synchronizer Assembly-A2 and the Block Decoder Assembly were unable to acquire lock when the data rate was changed from 16 kbps to 2 kbps. A reinitialization of TCP channel 3 cleared the problem.

The results of the System Integration Test and Ground Data System Test 7.0 indicated that the Ground Data System was ready for the Mission Precursor Tests and the Flight Article Compatibility tests.

D. Mission Precursor Tests

The precursor tests were conducted with the mated spacecraft mounted on the launch vehicle with S-band telecommunications from the Orbiter.

1. Flight Events Demonstration. The Flight Events Demonstration was conducted on 1 April. The STDN (MIL 71) received low- and high-rate telemetry on the Orbiter link and also processed low-rate telemetry received from nearby near-Earth stations. There was no commanding required. No problems were experienced at STDN (MIL 71) during this test.

2. Viking Orbiter Precount Test. The Viking Orbiter Precount Test was conducted on 2 April. This test involved remote commanding as well as telemetry processing over the full range of data rates. Again, no problems were experienced at STDN (MIL 71).

3. Viking Lander Prelaunch Checkout. The prelaunch checkout precursor was conducted on 3 April. The test sequence included Orbiter commanding and also Lander-capsule commanding through the Orbiter. Telemetry included both Orbiter and Lander data on the Orbiter subcarriers.

At the start of the test, the Command Modulator Assembly on TCP-B(CMA-2) was not ready to be turned over to the Project. The Command System Cognizant Operations Engineer at JPL was called in and he isolated the problem and instituted a temporary fix that permitted Command Modulator Assembly-2 to provide its scheduled support of the test.

During this test, the Data Decoder Assembly-A1 started putting the wrong time in the wideband data blocks output on TCP channel 3. A front panel reload was tried, to no avail. Then the Frequency and Timing Subsystem drawer was replaced without correcting the problem. Finally, TCP-A was reloaded and Data Decoder Assembly-A2 was assigned to channel 3. TCP-A was checked out by command and telemetry data flow tests and returned to Project use. After the test, STDN (MIL 71) found and replaced a bad power supply that appeared to be causing the time error problem in Data Decoder Assembly-A1. However, the same symptoms have occurred on this Data Decoder Assembly in subsequent tests, and the cause of this malfunction was not finally determined until April 29.

4. Terminal Countdown Demonstration. The Terminal Countdown Demonstration was conducted on 5 April. The test sequence was essentially the same as for the Flight Events Demonstration. The STDN (MIL 71) function was to receive and process telemetry received from the spacecraft and from nearby near-Earth stations.

The test was successfully completed, but during the first half of this test the Demodulator Decoder Assembly-A1 timing problem showed up again in the 2-kbps output of

TCP-A, channel 2. Also, an unusually large number of data block error bursts occurred in the NASCOM line during this test.

E. Flight-Article Compatibility Tests (FCT)

Tests FCT 3, 4, and 1 were conducted after the Viking Orbiter and Lander had been returned from the pad to their respective system test facilities. Test FCT-2 had been conducted earlier at JPL, and is reported here for completeness.

(1) FCT-3 was conducted on 10 April. The test sequence represented the command and telemetry activities related to the preseparation checkout portion of the mission. Telecommunications to STDN (MIL 71) were via the Orbiter link. Telecommunication from the Lander to the Orbiter were via cable between the two spacecraft. The start and end of the test sequence were delayed about 3½ h due to spacecraft trouble. STDN (MIL 71) encountered some equipment faults but was able to switch to backup equipment. The command activities and the telemetry stream processing were not impaired, except that the telemetry time tags were in error during a short portion of the test.

During the pretest data transfers, the Block Decoder Assembly (on TCP-A, channel 3) was turned back to the station for troubleshooting and repair. It was repaired and brought back into service in time for processing of high-rate telemetry. TCP-B was used for low-rate telemetry while the Block Decoder Assembly was being repaired.

Timing errors in Data Decoder Assembly-A1 were observed when that equipment was configured for processing of high-rate telemetry on TCP-A, channel 3. Therefore, TCP-A was reconfigured to use Data Decoder Assembly-A2 on channel 3.

The Data Decoder Assembly on channel 2 of TCP-B (DDA-B1) also exhibited some time-tag errors during this test. That equipment has subsequently been repaired and retested with no recurrence of the problem. Recall of Original Data Records was not required at end of test. However, if a recall had been needed, it would have been necessary to recall the entire Original Data Record because the occasional erroneous time tags might have precluded a time-selective recall. Also, due to the exchange of equipment, it would have been difficult to know which recorder contained data for a given time period.

(2) FCT-4 was conducted on 15 April. The test sequence represented the command and telemetry activities related to the Lander capsule separation, descent, entry, and Mars landing events of the mission. The VHF link from the Lander capsule to the Orbiter was by cable. Spacecraft anomalies encountered during the test extended the time required to complete the test. There were no equipment malfunctions and only one procedural problem.

(3) FCT-1 was conducted on 17 April. The test sequence represented a set of Lander activities on the Martian surface with direct S-band telecommunications to STDN (MIL 71).

Upon completion of pretest telemetry and command data transfer verifications, an operational system was available to the Project prior to start of the test. Due to two problems in TCP-A, STDN (MIL 71) was configured to use TCP-B as the prime string at FCT-1A "test start" time. During the pretest data transfer, an input/output control problem was encountered on TCP-A. After this unit was reloaded and verified, TCP-A was declared prime and used throughout the remainder of the test without any impact on telemetry data or command activity. During this test, the TCP-B string was kept in a hot backup mode. It was found in the pretest checkout that Data Decoder Assembly-A1 still had a timing error problem, therefore Data Decoder Assembly-A1 was not used during the test.

In the final hour of the FCT-1B test, when the downlink was acquired, it was observed in the Network Control Center that the high-rate telemetry from TCP-A was good. However, the low-rate telemetry (8⅓ bps) output from TCP-A was poor due to fluctuations of signal-to-noise ratio. Therefore, the low-rate telemetry from TCP-B was added to the high-speed data line and validated in the Network Operations Control Center. The test conductor was then given the choice to process the good 8⅓ bps stream from TCP-B instead of the poor stream from TCP-A. After completion of the test, a test of the TCP-A low-rate channel was conducted in which it was determined that a simple, two-type-in, reinitialization of the channel eliminated the signal-to-noise ratio fluctuations. The only other problem encountered by the DSN was a 5-min outage of one of the eight NASCOM voice circuits. Support of command activity was satisfactory throughout the test as it was in most of the previous tests.

(4) FCT-2 was conducted at CTA 21 on 20 January while Orbiter-2 was still in the Spacecraft Assembly Facility prior to shipment to KSC. This test and also a special Orbiter Performance Analysis Group (OPAG) "end-to-end test" and a special VHF relay test, were supported by CTA 21, GCF, and NOCC. As with subsequent FCTs, these tests were supervised by the Viking Compatibility Test Manager, and the Viking Flight Team participated.

The DSN elements supporting FCT-2 and the associated special tests performed very satisfactorily and with no malfunctions.

F. NASCOM/GCF Support

The satisfactory operation of voice, high-speed data, and wideband data circuits provided by NASCOM and GCF was vital to the success of these tests.

G. Network Operations Control Center (NOCC) Support

The network data processing area function implemented by the Network Control System Block II provided real-time displays of telemetry data and command system data received via high-speed data line.

The Block II Network Control System (NCS) implementation does not provide any real-time displays of telemetry data received via wideband data line; therefore, the only visibility of wideband telemetry was by Block I line printer dumps of data blocks, which is an awkward and time-consuming method to validate telemetry system status. (Block III NCS implementation will provide real-time wideband telemetry displays.)

There was no station monitor data available in the Network Operations Control Center nor at the station because STDN (MIL 71) does not have a monitor subsystem. Within the implementation constraints described, the Network Operations Control Center performed admirably throughout this series of tests.

H. Conclusions

Results of the tests described above lead to the following conclusions:

(1) STDN (MIL 71), NASCOM/GCF, and NOCC were effectively utilized as elements of the ground data system for premission engineering tests and flight team preliminary training.

(2) The successful support of these tests depended heavily on the availability of redundant equipments, particularly in the telemetry subsystem.

(3) The most persistent problems encountered were related to low reliability of Data Decoder Assemblies A-1 and B-1, and the Block Decoder Assembly hardware. In contrast, Data Decoder Assembly-A2 exhibited surprisingly high reliability.

(4) Command Subsystem performance and Simulation Conversion Assembly performance at STDN (MIL 71) were very satisfactory.

(5) NASCOM/GCF performance was also quite satisfactory.

(6) The Network Data Processing functions provided useful, independent DSN validation of command and telemetry status, within the constraints of the present implementation.

(7) There were no software problems in the STDN (MIL 71) subsystems nor in the Network Data Processing Area during these tests.

Acknowledgment

The work described above was carried out under the cognizance of the following members of the DSN Engineering Staff: Viking Orbiter and Lander RF Compatibility Tests, A. I. Bryan and R. P. Kemp; STDN (MIL 71)/VMCCC Data System Compatibility Tests, H. C. Thorman and H. G. Lemasters. The MCT and OVT testing were carried out under the supervision of the Network Operations Project Engineer, D. W. Johnston.

Reference

1. *The Deep Space Network Progress Report 42-24, September and October 1974.* Jet Propulsion Laboratory, Pasadena, California, Dec. 15, 1974.

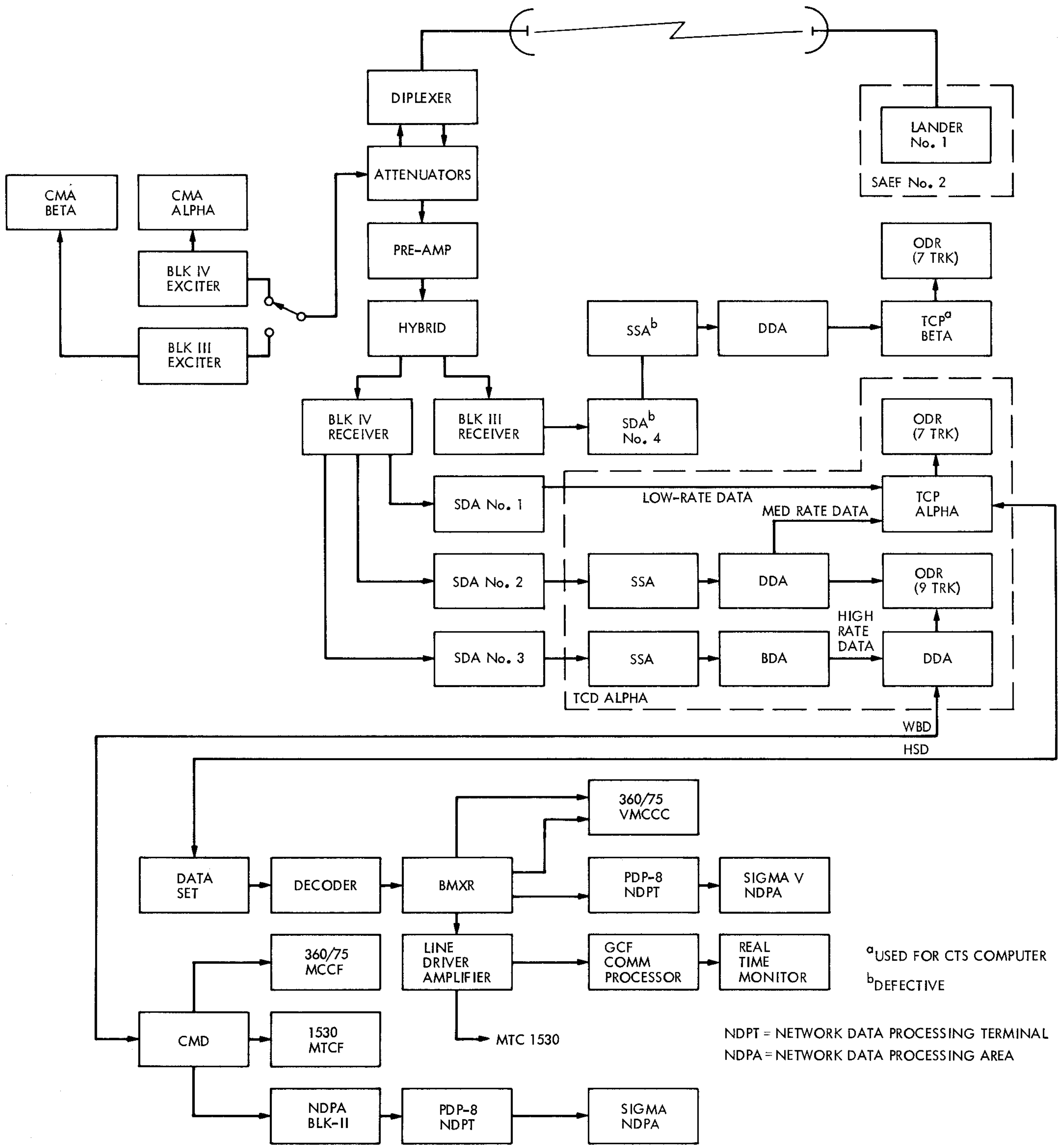


Fig. 1. DSN/Viking lander capsule No. 1/NOCC/VMCCC telecommunications test configuration, Jan. 30, 1975

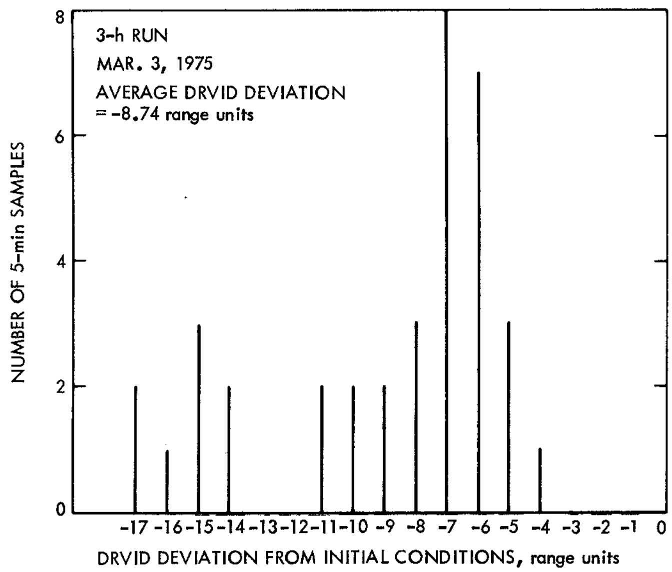


Fig. 2. Building AO/STDN (MIL 71) S-band DRVID stability

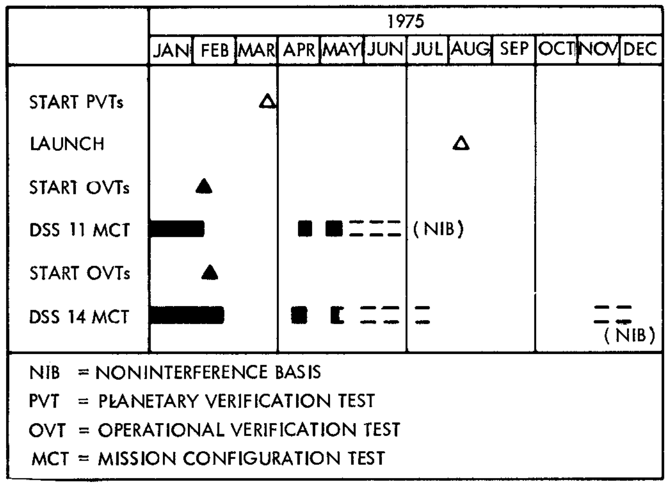


Fig. 4. MCT status for DSSs 11 and 14

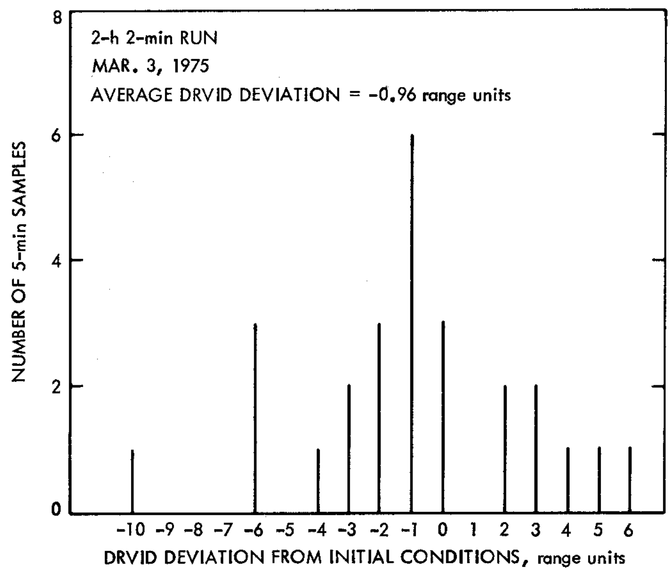


Fig. 3. Building AO/STDN (MIL 71) X-band DRVID stability

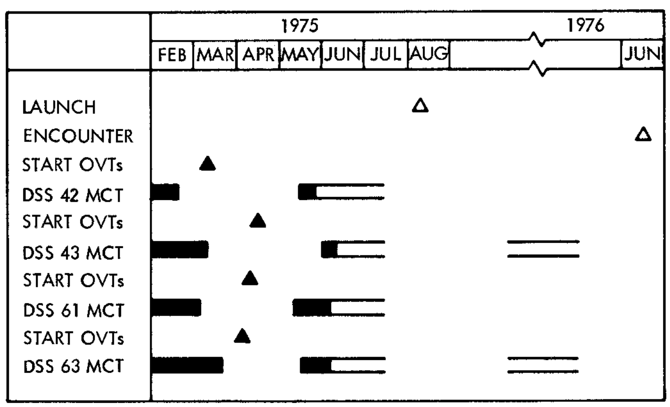


Fig. 5. MCT status for DSSs 42, 43, 61, and 63

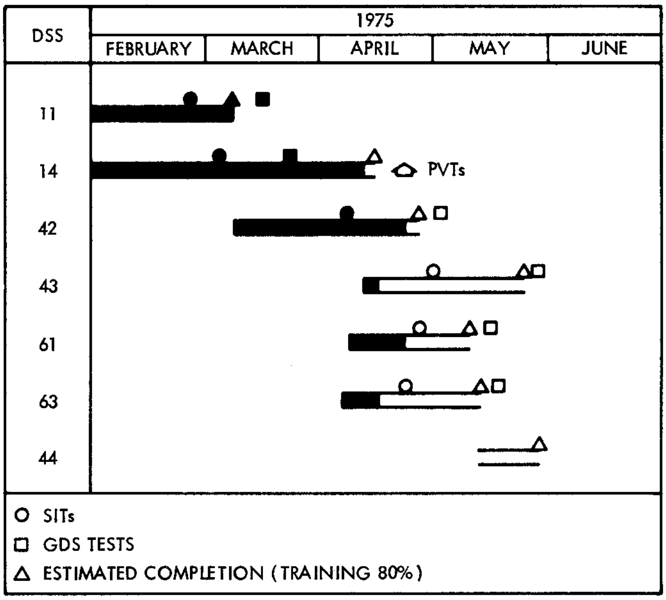


Fig. 6. OVT/training status summary

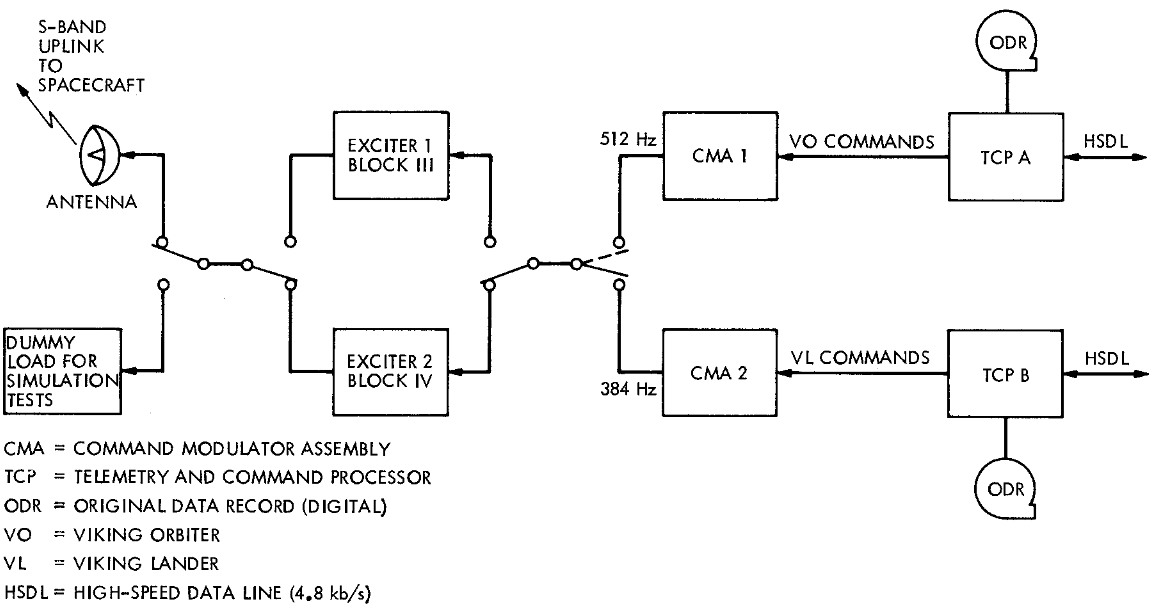
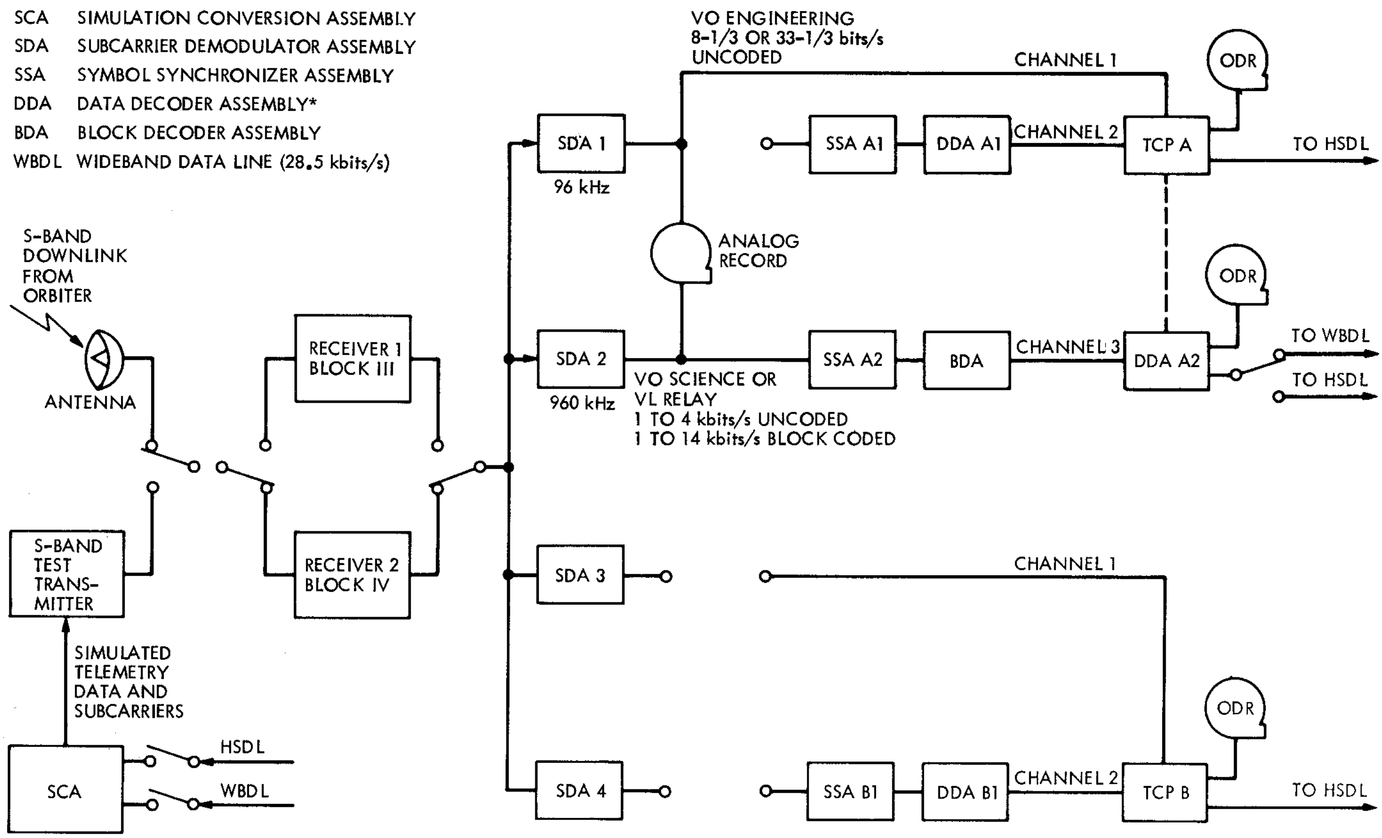


Fig. 7. STDN (MIL 71) DSS command subsystem configuration for Viking orbiter and lander tests



*THE DDA ON CHANNEL 3 IS USED FOR OUTPUT FORMATTING

Fig. 8. STDN (MIL 71) DSS telemetry subsystem configuration for Viking orbiter and lander capsule mated spacecraft tests

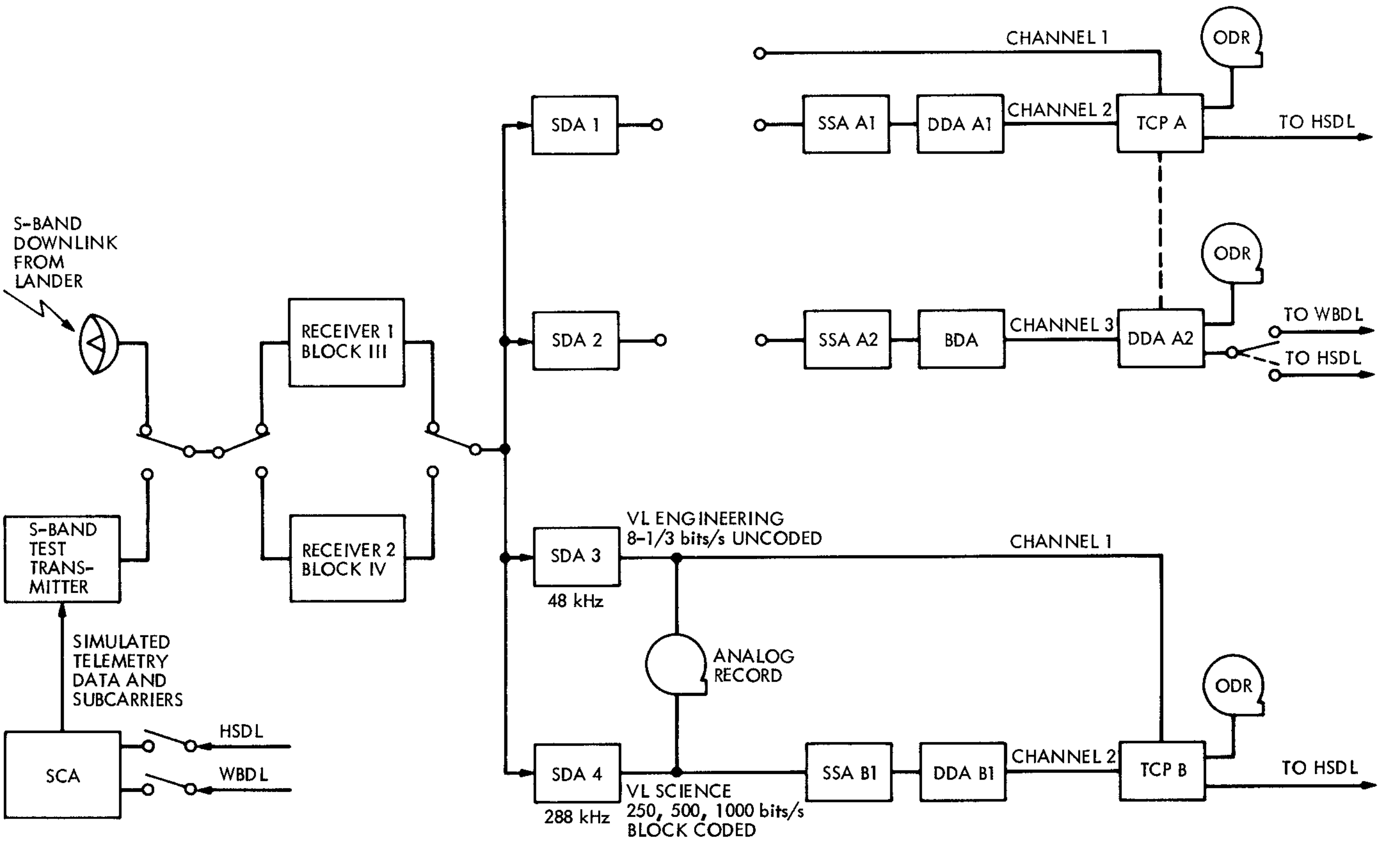


Fig. 9. STDN (MIL 71) DSS telemetry subsystem configuration for Viking lander (direct) tests