Viking Mission Support

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The previous article in this series covered the initial phases of the Network Implementation for Viking. This article briefly outlines the background on the establishment of the DSN/Viking test schedule and describes the progress that has been made in accomplishing the engineering tests and operational training and testing required to prepare the DSN for support of the Viking Project tests, training, and flight operations.

I. Background

The Deep Space Network (DSN) preparations for Viking 1975 (VK'75) have followed the same general pattern applied to previous missions. Briefly, the milestone dates for DSN support of Project tests were established jointly by the DSN, Viking Mission Control and Computing Center (VMCCC), and the Viking Project Office (VPO), in the Level 3 Schedule. These dates were then utilized by the DSN Manager and Network Operations Project Engineer (NOPE) as DSN target completion dates, and to establish the start dates reflected on the Level 5 Schedule for DSN Operations testing and training.

Agreements were then negotiated between the DSN Manager and the implementing organization (Division 33) concerning budgets and the design, procurement, prototype testing, and implementation of the new Viking equipment to meet the operations test start dates. The schedules detailed in the last DSN Progress Report (Ref. 1) varied for the different stations and consisted of five major blocks of time sequentially covering: (1) preparations at Compatibility Test Area 21 (CTA 21) and STDN (MIL-71) to support compatibility tests, (2) DSSs 11 and 14 to support Planetary Operations Tests, (3) DSSs 42, 43, 44, 61, and 63 to support launch and cruise tests, (4) DSS 12/62 to support cruise tests, and eventually (5) all DSSs to support planetary tests.

Previous articles have covered CTA 21 and STDN (MIL-71) activities. This article deals mainly with DSSs 11 and 14 in detail, with minor references to the other stations, and covers activities that had occurred as of February 21, 1975.

II. Mission Preparation Status Summary

There have been the usual technical and operational problems in preparing the DSN to support the VK'75 mission, but the biggest single problem with DSS 11 and 14 preparations has been the slip in the implementation completion milestone at DSS 14.

The 26-m stations require relatively minor hardware additions for Viking, but the 64-m stations require extensive equipment installations. The overseas 64-m stations (DSSs 43 and 63) are not scheduled to be fully implemented for Viking until after launch. DSS 14, however, was scheduled to be fully implemented to support the VK'75 Project pre-launch planetary tests.

The implementation completion milestone for DSS 14 was originally scheduled for September 15, 1974. It first moved to mid-October, then mid-November, early December, and finally to January 4, 1975. This total slip of 3-1/2 months can be attributed to the problems described in the last DSN Progress Report (Ref. 1).

The generation of procedures for DSN System Performance Tests (SPTs) and Mission Configuration Tests (MCTs), and actual test accomplishment, had originally been scheduled to take place between September 15 and mid-November; time was also scheduled during this period for on-site mission-independent training (MIT) and mission-dependent training (MDT). Then followed a six-week period to January 1, 1975, during which time the station "freeze" for DSN support of Pioneer 11 Jupiter encounter precluded accomplishment of SPT/MCTs at DSS 14. DSS Operational Verification Tests (OVTs) were to commence in mid-November and be completed on March 1, 1975, overlapping with DSN/VMCCC System Integration Tests (SITs) during February 1975.

Because of the lack of hardware, the on-site MIT and MDT activities were moved to January and the multimission SPTs had to be cancelled. The mission-dependent MCTs, which provide for adequate testing of the DSN systems to Viking specifications, started on December 21, 1974. The OVTs were then compressed and rescheduled to start the first week in February 1975; the length of each test and number of tests were reduced, but more tests per week had to be scheduled.

On-site training programs are well underway at DSSs 11 and 14. MCTs have almost been completed and OVTs are nearing completion. Details of these activities are provided in succeeding paragraphs of this article. Table 1 summarizes the current test and training status of those DSN stations that are committed for support of the launch and cruise phase of the mission.

III. DSN Training

A. Mission-Independent Training

Network mission-independent training, though normally not a part of a Mission Test and Training Plan, is an essential prerequisite to VK'75-oriented training and testing. The majority of the subsystems to be used during the VK'75 mission remain unchanged from previous missions, although the VK'75 configurations require up to six full telemetry streams and two command streams at a single 64-m station in place of the total of four telemetry streams and one command stream as for previous missions.

Training data and documentation for new equipment are supplied to the DSN Training Unit Supervisor of Section 422 by the Cognizant Operations Engineers of the affected subsystems. The DSN Training Unit prepares a training package to be sent along with the new equipment to the affected locations. It is the responsibility of the Facility Managers to see that personnel training on mission-independent equipment is carried out.

New Network equipment required as part of the VK'75 mission 64-m configurations consists of:

(1) 100-kW transmitter and exciter selector (400 kW at DSS 14).

(2) Six-channel Simulation Conversion Assembly (SCA).

(3) Block IV Receiver/Exciter and Subcarrier Demodulator Assemblies (SDAs).

(4) Faraday rotation equipment.

(5) Automated weather station.

(6) Planetary Ranging Assembly and Range Demodulator Assembly.

(7) SDA/Symbol Synchronizer Assembly (SSA)/Data Decoder Assembly (DDA)/Block Decoder Assembly (BDA)/Telemetry and Command Processor (TCP)/Command Modulator Assembly (CMA) switching modifications.

(8) Simulated time switching.

(9) Dual Doppler Counter.

(10) S/X-band antenna modifications.

(11) Antenna Pointing Conical Scan System.

Mission-independent training has to be completed at all locations prior to the start of System Performance Tests.

B. Network Mission-Dependent Training

1. General. The Network mission-oriented training consists of classroom instruction and training exercises conducted at each facility for the facility staff. It includes any "in-house" operational tests designed by the Facility Director to exercise the VK'75 configuration.

All mission-oriented operator training carried out at a facility is the direct responsibility of the Facility Director, who is the Training Controller for the "in-house" training at his location.

A comprehensive training package was delivered to each station by the VK'75 Network Operations Project Engineer (NOPE) to assist the facility directors in this phase of training. The package includes lists of Viking Lander and Orbiter commands from which the stations produce Mylar command tapes for their use, and use for operator training in manual command exercises. All Viking unique computer "type-ins" for standard operations, plus those used for troubleshooting and failure isolation and recovery, were also included for use in conjunction with the Standard Operations Procedures and the procedures in the Network Operations Plan for Viking 1975.

2. Objective. The objective of this training is to ensure that all Network operational personnel are adequately trained to support the VK'75 pre-launch and mission activities.

3. Training Requirements. Each Facility Director, acting as Training Controller at his facility, considers the following list in determining training needs and preparing plans:

(1) Operations personnel proficiency in mission-independent tasks.

(2) Knowledge of mission design and sequences.

(3) Spacecraft radio frequency (RF) modes and data formats.

(4) DSN configurations corresponding to spacecraft modes.

(5) DSN commitments for data acquisition, ground transmission, and real-time and nonreal-time data handling.

(6) Ground system performance requirements, standards and limits, and alarm conditions.

(7) Priorities and constraints.

(8) Spacecraft commands that affect DSN configurations and procedures.

(9) Reaction times for system initialization, configuration, reconfiguration, acquisition, etc.

(10) Failure detection, analysis, and recovery.

(11) Backup modes and alternate procedures.

(12) Flight Operations System (FOS) interface and procedures for mission direction, planning, sequence of events, schedules, operational parameters, etc.

(13) Problem and failure reporting procedures.

(14) Configuration and change procedures.

Information on these subjects is found in the Network Operations Plan (NOP) for Viking 1975 and other project documents supplied to each facility by the NOPE.

4. Operational Procedures. Every endeavor is made during the training tests to exercise the procedures contained in the NOP, with particular emphasis on the voice backup command procedures and manual TCD configuration and initialization.

5. Sequence of Events. The sequence of events (SOE) given in NOP Table 4-1 may be adapted or modified by the station for the training exercises. Copies of the Operational Verification Test SOE produced by the NOPE is now available at the stations.

6. Simulation. DSS On-Site Training Tests are accomplished using the SCA as a self-contained VK'75 spacecraft telemetry simulator, using the fixed pattern data tapes supplied by the NOPE.

7. Reporting. A problem on previous missions has been for the NOPE, and DSN Operations Management, to obtain a clear understanding of a facility's current training status. An instance is where a four-shift station would report 75% trained prior to supporting a project test, and, when queried on their poor performance, would reply that the shift involved was completely untrained on the project in question (implying that the other three shifts were 100% trained).

To avoid situations where "75% trained" could mean four shifts three-quarters trained, or three shifts fully trained and one shift untrained, or any number of combinations, the reporting format illustrated by Table 2 has been adopted.

The percentage of "training complete" is the Facility Director's estimate of a shift's ability to support any phase of the VK'75 mission. The fractional number is to represent the number of shift personnel (including the Shift Supervisor) who are fully trained, over the total number of operators on the shift. This includes those operators who are fully experienced with their particular subsystem and who require little or no reorientation to support the new mission, e.g., Digital Instrumentation Subsystem (DIS), Analog Instrumentation Subsystem (AIS), and Antenna Mechanical Subsystem (ANT). The remarks should cover pertinent items such as "New Transmitter Subsystem (TXR) Operator," "New Command System Analyst," etc.

IV. DSN Testing

The DSN testing falls in the two specific categories of engineering and operational tests described below.

A. Engineering Tests

1. System Performance Tests

a. Purpose. The purpose of the Telemetry Command, Monitor, or Tracking Facility SPT is to demonstrate that each system meets the specified level of performance when tested simultaneously with operational software. The tests normally are conducted with hardware that has been transferred from the development to the operations organization and software that has been transferred to the DSN Program Library. The test procedures are contained in DSN 850-series documents. They make use of all elements of the Deep Space Station subsystems within a given station and provide a basis for DSS system-level maintenance, performance verification, and prepass testing. The successful completion of an SPT verifies that the system meets documented specifications and qualifies it for Network-level support on a mission-independent basis.

b. Prerequisites. The main prerequisites to running an SPT are:

(1) Implementation of DSS/GCF and NOCC complete.

(2) Hardware and software transferred to Operations.

(3) Facility mission-independent training complete.

c. Personnel. The SPTs are supported by the following individuals:

(1) Test Conductor: Section 421 System Cognizant Operations Engineer (SCOE).

(2) DSS, GCF, and NOCC personnel as required.

d. Comment. SPTs have been successfully completed at DSS 11, but late equipment implementation precluded their accomplishment at DSS 14 (see Section II, above).

2. Mission Configuration Tests

a. Purpose. The purpose of the Telemetry, Command, Monitor, or Tracking MCT is to demonstrate that the Network system(s) meets the specified level of performance when tested singly or simultaneously in the Viking configurations specified in the Network Operations Plan. The tests utilize software and hardware that have been transferred to Operations and are run with all elements of the DSN, DSS, GCF, and NOCC. Test procedures are contained in DSN 850-series documents, which provide the basis for system-level maintenance, performance verification, and prepass testing. Successful completion of the MCTs verifies the Network's capability to support VK'75.

b. Prerequisites. The following should be accomplished before MCTs are run:

(1) Completion of SOTs.

(2) Configuration of the DSN for VK'75 operations completed.

c. Personnel. MCTs are supported by the following individuals:

(1) Test Conductor: SCOEs at direction of VK'75 NOPE (or his designate).

(2) DSS, GCF, and NOCC personnel as required.

d. DSS 14 MCT status. Table 3 provides a summary of DSS 14 Configuration/Interface (C/I) MCTs and Performance Test (PT) MCTs, the results of which are described below.

(1) MCT periods 1 through 6 (from December 21, 1974 to January 5, 1975) consisted solely of isolating and rectifying hardware failures and interface problems mostly related to the newly implemented Viking telemetry and command configurations. No meaningful test results were obtained, but numerous necessary minor modifications to the hardware and streamlining of MCT procedures were accomplished.

(2) MCT period 7 (January 8, 1975) resulted in achievement of the objectives of C/I tests 1, 2, and 3 (strong signal) with data passing successfully through the three telemetry channels of Telemetry

and Command Data Subsystem (TCD) 1. Subsequent tests through February 3, 1975 resulted in completion of all TLM strong signal VK'75 MCTs and completion of Command System tests 1, 2, and 3 on the alpha Block III Receiver/Exciter (BLK III RCV/EXR) Subsystem string.

(3) The completion of these tests qualified DSS 14 to support the DSN Operational Verification Tests (OVTs) and DSN/VMCCC System Integration Tests (SITs). Final transfer of the BLK IV RCV/EXR and some associated equipment from engineering to operations will permit completion of weak signal telemetry system MCTs and the remainder of the Command and Tracking System MCTs prior to the Viking Project Ground Data System (GDS) tests and Planetary Verification Tests (PVTs).

(4) The extra time required for this testing that was necessitated by the equipment failures and debugging activities was obtained by reducing Pioneer, Mariner, and Helios tracking coverage.

3. DSN/VMCCC System Integration Tests

a. Purpose. These tests verify the interface between elements of the DSN and the VMCCC. All data flow interfaces are verified at data rates expected during mission operations. These tests also verify hardware interfaces in a multiple-mission environment.

b. Prerequisites. Successful completion of the DSN SPTs and MCTs and some DSN Operational Verification Tests (OVTs) are prerequisites to the SITs. However, while OVT completion is desirable, it is not mandatory as operational procedures are not necessarily followed during these tests.

c. Personnel. The following individuals support the SITs:

(1) Test Supervisor: VMCCC Facility Engineer.

(2) Test Conductor: VMCCC Integration Test Supervisor.

(3) DSN Test Support: VK'75 NOPE, SCOEs, and Network Operations Analysts (NOAs), plus DSS, GCF, and NOCC personnel as required.

(4) Performance Evaluation: VK'75 Ground Data System Engineer.

d. Comments. The first SITs, which are scheduled for February 25 at DSSs 11 and 14, were slipped to February 28 and March 2, respectively, to allow interfacing of the Planetary Ranging Assembly (PRA) with the BLK IV RCV/EXC to be accomplished so that ranging support could be provided to the Pioneer 10/11 and Helios Projects.

B. Operational Verification Tests

1. Purpose. The purpose of these tests is to verify the operational readiness of the Network to support the Project Test and Training and Operational Phases. They demonstrate the operational proficiency of Network personnel in the use of operating procedures, interfaces, and equipment. They demonstrate that Network personnel are adequately trained and, in addition, provide valuable training. OVTs follow a time-compressed SOE designed to exercise all DSN operational procedures and confirm the ability of the stations to send manual commands and carry out telemetry bit rate changes in the time specified.

2. General. The first OVTs with any facility are considered to be a phase of training coupled with performance demonstration. The training aspect diminishes progressively as the tests proceed. Since all DSS, GCF, and NOCC operational shifts of personnel must be adequately exercised, it will be necessary for the Viking NOPE to initiate the scheduling of extra OVTs at specified times.

3. Prerequisites. Satisfactory completion of the following tests is a prerequisite to running OVTs with a facility:

(a) Software Acceptance Tests for all systems.

(b) System Performance Tests for all systems.

(c) Mission Configurations Tests.

4. Personnel. The following DSN Operations personnel are required:

(a) Test Conductor: VK'75 NOPE (or his designate).

(b) Normal shift complement at each of the supporting facilities required for each test, unless otherwise specified.

5. DSS 11 OVT status. Three OVTs have been conducted with DSS 11. The station was configured for VK'75 cruise/planetary operations and was cycled through simulated events with two Orbiters and a Lander. The tests are proceeding very well, and, as indicated by the following, the station is fully qualified to support the forthcoming SITs and Project tests:

a. OVT 1, February 5, 1975. This was the first Viking OVT with any station and was considered 80% successful despite the occurrence of numerous minor problems.

b. OVT 2, February 11, 1975. Some simulation problems; 85% success.

c. OVT 3, February 17, 1975. Some new problems; 75% success.

6. DSS 14 OVT status. To date, the three OVTs described below have been conducted with DSS 14. The station was configured for planetary, three-spacecraft operations (two Orbiters and one Lander) with the DSS Simulation Conversion Assembly (SCA) operating in a six-channel, fixed-pattern mode, remotely controlled from the Network Operations Control Center (NOCC). Each test was supported by a different DSS crew.

a. OVT 1, February 12, 1975. Used NOP backup configuration because of Symbol Synchronizer Assembly and Data Decoder Assembly failure (SSA and DDA). Initial problems setting up the SCA caused a late test start. The test progressed through the sequence of events (SOE) completing 74 out of the total 146 events. It was partially successful, and excellent training was obtained.

b. OVT 2, February 14, 1975. Used backup configuration (two DDA failures). Initial SCA setting up problems used substantial portion of the test time. Approximately 30% successful.

c. OVT 3, February 16, 1975. Again used backup configuration (DDA failure). Approximately 90% successful.

As anticipated with such a complex DSS configuration, numerous minor procedural problems and difficulties have become apparent and are being corrected. The DSS and NOCC operations personnel are adapting more quickly than expected to this complex mode of operations, and should be fully qualified to support the project tests and flight mission. The hardware failures are a source of concern; however, the first three tests have demonstrated that the backup configurations documented in the NOP have been a valuable investment of time and effort.

V. Conclusion

Based on the experience gained to date, and barring any serious slippages in implementation completion dates at the overseas 64-m stations, no problems are anticipated in completing the DSN test and training programs for VK'75. Successful completion of these programs will assure a high level of DSN performance in support of the subsequent VK'75 Ground Data System (GDS) tests, Project test and training exercises, and actual flight operations.

A total of 26 VK'75 GDS tests will be supported by the DSN. Initially, single system telemetry, command, and tracking tests are conducted with DSSs 11 and 14, followed by combined system/combined DSS tests with the same stations. Combined system tests are then conducted with each DSS, with some combined DSS tests simulating specific mission sequences.

DSSs 11, 14, 42, 43, 61, and 63 will have completed all GDS tests by June 15, 1975 (this includes the Planetary Verification Tests (PVTs) scheduled for DSSs 11 and 14 on April 21 and 28). On completion of the GDS tests, the DSN is committed to support the Project Flight Operations Personnel Tests (FOPTs) including Personnel Test/Training Tests (TTs), Verification Tests (VTs), Demonstration Tests (DTs) and finally the Operational Readiness Tests (ORTs), as specified in the VK'75 Flight Operations Test on Training Plan.

Reference

1. Mudgway, D. J., "Viking Mission Support," in *The Deep Space Network Progress Report 42-25*, pp. 37–42, Jet Propulsion Laboratory, Pasadena, Calif., Feb. 15, 1975.

Table 1. Completion of DSN training/testing for VK '75

DSS	Training		Testing	
	MIT, %	MDT, %	MCT,[a] %	OVT, %
11	77	25	100	50
14	75	20	85	45
42/43	40	10	75	0
61/63	45	12	80	0

[a]Percentages are for Telemetry and Command System testing required prior to first DSN/VMCCC System Integration Tests.

Table 2. Example of a VK '75 operational training status report

Facility	Total number of shifts	Report date	
DSS 14	4	5-15-75	
Shift	% Training complete	Total number 100% trained / Total number on shift	Remarks
A	50	5/10	New RCVR/EXC operator
B	70	7/10	
C	66	6/9	
D	37	3/8	Two on vacation

Average training status of station = 223/4 = 55%.

Table 3. DSS 14 MCT status

Period	Test	Purpose	Time required, hours
1	Configuration Interface Test 1 on TCD String 1	Verify primary interfaces with one TCD (data flow, lock indicators, AGC voltage) with DDA-1 and SSA-1 in use.	7
	Configuration Interface Test 3 on TCD String 1	Same as Test 1 but with DDA-2 and SSA-2 in use.	5
		Period 1 total	12
2	Configuration Test 3 on TCD String 1	Same as Test 1 but interfacing secondary receiver and SDA combinations.	7
	Configuration Interface Test 4 on both TCD strings	Tests interface between all SDAs and each TCD internal bit sync loop.	3
		Period 2 total	10
3	Configuration Interface Test 1 on TCD String 2	Same as Period 1.	7
	Configuration Interface Test 2 on TCD String 2	Same as Period 1.	5
		Period 3 total	12
4	Configuration Interface Test 3 on TCD String 2	Same as Period 2.	8
		Period 4 total	8
5	Performance Test 1 (12 hours required due to strong signal system verification test and learning curve; note that subsequent test times are reduced)	Configure both TCD strings; simulating 2 Orbiters, 1 Lander at the following data rates: ORB = 16.0 kbps coded 33⅓ bps uncoded LDR = 1.0 kbps coded 8⅓ bps uncoded	8
		Period 5 total	8
6	Performance Test 2	Same as previous Performance Test (PT) but with data rates: ORB = 8.0 kbps coded 33⅓ bps uncoded LDR = 500.0 bps coded 8⅓ bps uncoded	5
	Performance Test 3	Same as previous PT but with data rates: ORB = 4.0 kbps coded 33⅓ bps uncoded LDR = 250.0 bps coded 8⅓ bps uncoded	5
		Period 6 total	10
7	Performance Test 4	Same as previous PT but with data rates: ORB = 2.0 kbps coded 33⅓ bps uncoded LDR = 250.0 bps coded 8⅓ bps uncoded	5
	Performance Test 5	Same as previous PT but with data rates: ORB = 1.0 kbps coded 8⅓ bps uncoded LDR = 250.0 bps coded 8⅓ bps uncoded	5
		Period 7 total	10

Table 3 (contd)

Period	Test	Purpose	Time required, hours
8	Performance Test 6	Same as previous PT but with data rates: ORB = 16.0 kbps uncoded 33⅓ bps uncoded LDR = 1.0 kbps coded 8⅓ bps uncoded	5
	Performance Test 7	Same as previous PT but with data rates: ORB = 8.0 kbps uncoded 33⅓ bps uncoded LDR = 500.0 bps coded 8⅓ bps uncoded	5
		Period 8 total	10
9	Performance Test 8	Same as previous PT but with data rates: ORB = 4.0 kbps uncoded 33⅓ bps uncoded LDR = 250.0 bps uncoded 8⅓ bps uncoded	5
	Performance Test 9	Same as previous PT but with data rates: ORB = 4.0 kbps uncoded 33⅓ bps uncoded LDR = 250.0 bps coded 8⅓ bps uncoded	5
		Period 9 total	10
10	Performance Test 10	Same as previous PT but with data rates: ORB = 1.0 kbps uncoded 8⅓ bps uncoded LDR = 250.0 bps coded 8⅓ bps uncoded	5
	Performance Test 11	Tests 8⅓ bps uncoded data utilizing both the internal bit sync loop (IBS) and the SSA.	5
		Period 10 total	10
11	Performance Test 11	Repeat for remaining TCD string.	5
	Performance Test 12	Same as Test 11 but 33⅓ bps uncoded data rate.	5
		Period 11 total	10
12	Performance Test 12	Same as previous but on remaining TCD string.	5
	ODR record/playback demonstration	Self explanatory.	7
		Period 12 total	12
13	Command Test 1	Manual mode test for Viking Orbiter.	4
	Command Test 2	Manual mode test for Viking Lander.	4
		Period 13 total	8
14	Command Test 3	Automatic tests.	7
	Command Test 4	Reliability Tests (with telemetry).	4
		Period 14 total	11
		Period 1 through 14 total	141