# Viking Mission Support

D. J. Mudgway and A. I. Bryan
DSN Systems Engineering Office

D. W. Johnston
DSN Operations Office

*The work described in this article concludes all DSN preparations for the Viking A launch. The final spacecraft compatibility tests were completed by July 7, and the personnel test and training effort was concluded on August 7. The first spacecraft was launched on August 20, 1975, and a brief summary of the coverage provided in the near-Earth phase of the mission is included.*

## I. Background

The previous article in this series (Ref. 1) described the Viking compatibility testing with Viking Orbiter No. 1 in May 1975. This article describes the follow-on testing for Viking Spacecraft No. 2 (Orbiter and Lander combined). These tests mark the completion of formal radio frequency (RF) telecommunications compatibility testing between the DSN and the Viking Project for the 1975 mission. Also, in previous articles (Refs. 1, 2, and 3), the progress of the personnel test and training exercises at the deep space stations was described. Here, this activity is continued to its conclusion, and the strategy for initial acquisition has been included.

## II. Viking Spacecraft Radio Frequency Compatibility Test

This assessment and status is derived from test results obtained between STDN(MIL 71) and Viking Spacecraft No. 2 at Cape Canaveral, Florida, on July 7, 1975. Procedures for conducting this test were prepared by the DSN with test parameters and design criteria provided by the Martin Marietta Corporation and the JPL Orbiter Telecommunications Section.

The total test time was 11 hours. The successful completion of the tests within the scheduled time period was due in large measure to the excellent cooperation and coordination between the Spacecraft Test Teams and the JPL/Goddard STDN(MIL 71) Team.

### A. Test Objectives

The objectives of the compatibility tests were to verify, in the spacecraft configuration, the capability of:

(1) Viking Orbiter No. 2 to receive Viking Orbiter commands and reject Viking Lander Capsule commands.

(2) Viking Lander Capsule No. 2 to receive Viking Lander Capsule commands and reject Viking Orbiter commands.

These tests were accomplished in accordance with Ref. 4.

### B. Test Conditions

Viking Spacecraft No. 2 was configured for mission operations and STDN(MIL 71) was configured to simulate a 64-m-antenna station. Viking Spacecraft No. 2 was located in the clean room of Spacecraft Assembly and Encapsulation Facility No. 1, Cape Canaveral, Florida, and STDN(MIL 71) was located at Merritt Island, Florida. An S-band RF link (approximately 5 km (3 mi)) was utilized between the flight article and the ground station.

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

The following command tests were performed:

(1) Orbiter/Lander Command Discrimination Test 3A (Side 1).

(2) Orbiter/Lander Command Discrimination Test 3B (Side 2).

During the initial attempt to transmit commands to the spacecraft, commands were rejected because of an incorrect spacecraft identifier in the command bit structure. A new set of commands was then transmitted which contained the proper spacecraft identifier. All commands were successfully accepted and executed by the spacecraft. However, two commands (DC-2A, ranging channel ON, and DC-2AR, ranging channel OFF) gave indications of each command containing one bit error. This problem was traced to an error in the octal structure for these two commands.

In order for the DSN command modulator assembly to function correctly, the command modulator assembly command word must contain 63 bits, although only 62 bits are transmitted. Additionally, the 63rd bit of the command structure must always be high. This bit serves as a marker bit to flag the command software that the 62nd bit of the spacecraft command is the final bit to be transmitted. To verify that this was a true condition, the proper octals for DC-2A and DC-2AR were successfully transmitted to the spacecraft, accepted, executed, and gave no indication of bit errors or corrections.

## III. DSN Test and Training

The test and training effort was concluded on August 10, 1975, with the successful completion of the DSN configuration verification test program. The following paragraphs summarize events leading to this readiness milestone.

### A. Mission Configuration Tests

The system-level mission configuration test program for Viking launch and cruise was concluded successfully and included the following:

(1) Telemetry system strong and weak signal performance tests and telemetry simulation tests. In addition, planetary phase telemetry testing was accomplished at DSS 14 (Goldstone, California).

(2) Command system tests.

(3) Monitor and control system tests.

(4) Tracking system tests (radio metric data).

(5) Simulation system tests.

### B. Operational Verification Tests

The launch/cruise series of operational verification tests was completed with all of the deep space stations (DSSs 11, 12, and 14 at Goldstone, California; DSSs 42, 43, and 44 in Australia; and DSSs 61, 62, and 63 in Spain). The personnel manning the stations, the Ground Communications Facility, and the Network Operations Control Center are considered fully trained to support the launch and cruise phases of the Viking mission.

Recent effort was directed toward the training of personnel at the prime and backup stations in Australia (DSSs 42 and 44) for the initial acquisition of the Viking spacecraft downlink signal and subsequent establishment of uplink capability (command, ranging, etc.) with the spacecraft. The initial acquisition sequence occurs shortly after spacecraft injection into the trans-Mars trajectory and separation from the launch vehicle.

Although "prime crews" are designated for the actual launches, initial acquisition operational verification tests were conducted with all crews at DSSs 42 and 44, as well as the Network Operations Teams at the Jet Propulsion Laboratory. Dual-station initial acquisition operational verification tests with simulated anomalies have been conducted.

### C. Configuration Verification Tests, Control, and Freeze

To ensure that all DSN facilities maintained their "ready" state for the Viking launch and cruise support, the facilities were placed under configuration control on July 4, 1975. This ensures that the facilities can return to the Viking configuration in less than 12 hours from notification.

On July 22, 1975, all deep space stations were placed under modified configuration control, which meant that no Engineering Change Orders could be initiated (for Viking planetary implementation, as well as other projects) without prior concurrence by the Viking Network Operations Project Engineer or DSN Manager.

Configuration freeze was applied to the initial acquisition stations in Australia (DSSs 42 and 44) on August 10, upon completion of a configuration verification test which concluded with the stations configured for the initial acquisition pass. This automatically prohibited the stations from supporting any other spacecraft tracks. This configuration control and freeze activity for Viking is shown in "bar chart timeline" form in Fig. 1.

### D. Operational Readiness Test

An operational readiness test was conducted by the Project on August 6, 1975, and provided a final check on the ability of the deep space stations, the Ground Communications Facility, and the Network Operations Control Center to support the launch and cruise phases of the Viking mission.

### E. Flight Operations Personnel Test and Training

The DSN has successfully participated in the flight operations personnel test and training exercises required to prepare the Viking flight team personnel for their role in supporting the Viking dual-spacecraft flight operations.

### F. Initial Acquisition Strategy

The initial acquisition strategy was jointly worked out by the DSN and other Viking flight team members.

Several safeguards must be part of the initial acquisition configuration plan: (1) to ensure that the spacecraft locks to the ground transmitter signal, the S-band Acquisition Antenna must be used; and (2) to avoid receiver saturation, when receiving downlink on the S-band Cassegrain Monopulse (SCM) Antenna, the maser bypass mode must be used. The Project made a decision to run a Canopus Star map prior to Canopus Star lock. This dictates that uplink transmitter power from the "SCM Antenna" and "SCM Maser in" is required to ensure continuous up and down link lock during the 720-degree roll. The attitude of the spacecraft is such that nulls greater than 40 dB are anticipated.

All concerned agreed that the station reconfiguration should be done at $L + 1$ hour 36 minutes, but since telemetry was critical at this time, the reconfiguration had to be accomplished without loss of telemetry, which means that DSS 42 could not simply turn off its transmitter and reconfigure, as this would result in loss of two-way lock and 1 minute of telemetry data.

The plan worked out to accomplish the station uplink and downlink reconfiguration was to transfer the uplink to DSS 44 while DSS 42 reconfigured its transmitter and maser; then transfer the uplink back to DSS 42. This unusual transfer permitted the reconfiguration and ensured that valuable bioshield telemetry data would be continuously received.

The initial acquisition, initial conditions at DSSs 42 and 44, and the strategy are illustrated as a function of time in Figs. 2 and 3.

### G. Additional Testing

Due to launch date slippage caused by problems with the Titan booster portion of the launch vehicle (defective vector control valve) and the Viking Orbiter spacecraft (battery power drain), it was necessary to formulate a plan to reverify certain stations of the DSN prior to any rescheduled launch time. This plan is illustrated in Fig. 4. The testing required for reverification included:

(1) Cruise phase operational verification tests for DSSs 11, 43, and 61.

(2) Mission configuration tests, configuration verification tests, and dual-station initial acquisition operational verification tests for DSSs 42 and 44.

(3) Extended precalibration checkouts of DSSs 42, 44, and 61.

This degree of retesting was needed in order to re-establish the high level of confidence prevailing at the originally scheduled launch time.

### H. Summary

Because the Viking Project is the most complex deep space mission ever supported by the DSN, a heavy test schedule has been utilized to verify the various steps toward readiness and has resulted in a high degree of confidence in the ability of the Deep Space Network to support the launch and cruise phases of the Viking mission. Additionally, the Launch - 48-Hour Contingency Pre-launch Testing Plan ensures continued readiness regardless of slip in launch date.

Mission configuration and operational verification testing in preparation for Viking planetary operations is scheduled to begin in September 1975.

## IV. Conclusions

With the completion of RF compatibility testing on both Viking Orbiters and Landers and personnel test and training exercises at all stations of the network, the DSN declared its readiness to support launch and cruise mission operations on July 23, 1975, at the formal Launch Readiness Review and again at an update review on August 9, 1975.

The lengthy planning, implementation, testing, and training activity required to achieve this state of readiness has occupied the DSN at various levels of activity for nearly seven years. During this time, demands have been made on all elements of the DSN and the Telecommunications Engineering Division to meet scheduled milestones and to find solutions to cope with unexpected problems. All who contributed to this effort are to be commended.

## References

1. Mudgway, D. J., Bryan, A. I., and Johnston, D. W., "Viking Mission Support," in *The Deep Space Network Progress Report 42-28*, pp. 11–14, Jet Propulsion Laboratory, Pasadena, Calif., Aug. 15, 1975.

2. Mudgway, D. J., et al. "Viking Mission Support," in *The Deep Space Network Progress Report 42-27*, pp. 10–27, Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1975.

3. Mudgway, D. J., and Johnston, D. W., "Viking Mission Support," in *The Deep Space Network Progress Report 42-26*, pp. 8–16, Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1975.

4. *Master Integrated Test Plan, Viking 75 Spacecraft/Orbiter/Lander to Launch and Flight Operations System and Tracking and Data System Compatibility Test Plan*, Rev. L, NASA Document PL-3710005, Mar. 29, 1975.

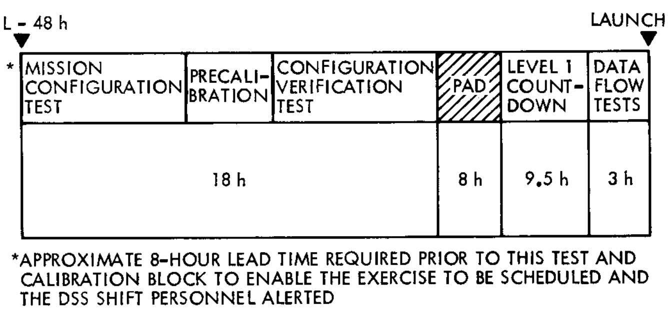
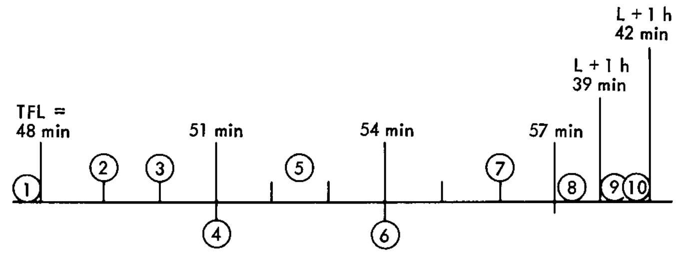



**Fig. 1. Contingency prelaunch testing plan**

| | |
|---|---|
| DSS 42/44 SCM D/L GAIN | = 53.3 dB (0.33 deg) |
| DSS 42/44 SCM U/L GAIN | = 51.8 dB (0.36 deg) |
| DSS 42 SAA D/L GAIN | = 21.7 dB (16 deg) |
| DSS 42 SSA U/L GAIN | = 18.9 dB (17 deg) |
| DSS 44 SAA D/L GAIN | = 20.8 dB (5 deg) |

| DSS 42 | DSS 42 |
|---|---|
| RECEIVER 5 - SCM (MASER BY-PASS) | RECEIVER 1 - SCM (MASER BY-PASS) |
| RECEIVER 6 - SAA (MASER 2) | RECEIVER 2 - SAA (MASER 2) |
| TXR (10 kW) SAA | TXR (1 kW) - SCM |
| T/MODE APS TAPE | T/MODE APS TAPE |

**Fig. 2. Initial acquisition strategy: initial conditions**




1 DSS 42 RECEIVER 6 1-WAY TELEMETRY TO LINE MD 1 PER SECOND
  DSS 44 RECEIVER 2 1-WAY TELEMETRY TO LINE MD 1 PER 10 SECONDS
2 START SIDE BAND SEARCH DSS 42 RECEIVER 5/DSS 44 RECEIVER 1
3 CONFIRM MAIN CARRIER/MAIN BEAM
4 DSS 42 TXR ON - START TUNING SWEEP
5 DSS 42 COMPLETE TXR SWEEP - CONFIRM 2-WAY LOCK MAIN CARRIER
  DSS 44 CONFIRM REACQUISITION 3-WAY
6 DSS 42 CONFIRM TRACKING RATES AND GO AUTO TRACK TELEMETRY FROM 5 OR 6 AT PROJECT DISCRETION
7 DSS 42 COMMAND MOD ON - CALIBRATION 2 MODE - GREEN FOR COMMAND
8 DSS 42 REMAIN TXR - SAA RECEIVER 5 SCM AUTO TRACK
9 DSS 42 XFER UPLINK TO DSS 44 - DSS 44 TX ON AT 1 kW SCM (DSS 42 RECONFIGURE TX TO SCM/SCM TO MASER IN TCP-3 TLM TO HSDL)
10 DSS 44 XFER UPLINK BACK TO DSS 42 - DSS 42 TX ON AT 10 kW SCM (DSS 44 RECONFIGURE SCM TO MASER IN/TCP-1 TLM TO HSDL)

**Fig. 3. Initial acquisition strategy: time line**

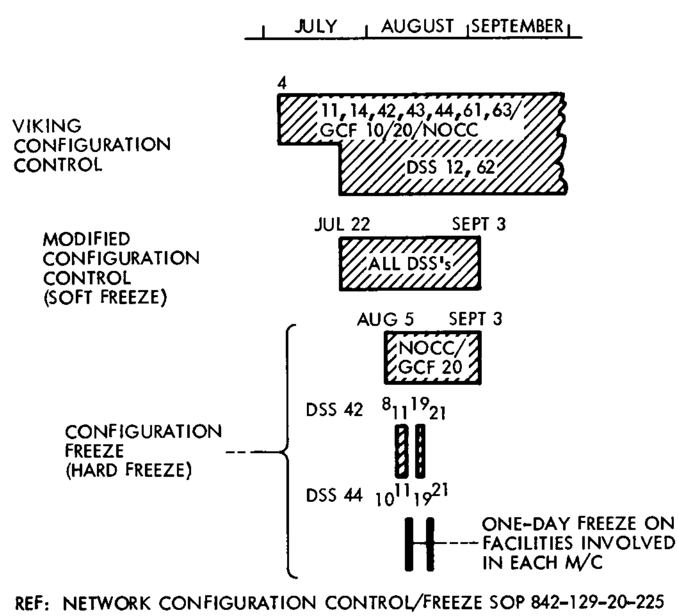



**Fig. 4. Viking DSN configuration control**