Viking Mission Support

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A functional specification for the Viking mission and a NASA support plan have been completed. A complex scheduling problem, created by the Viking Project request for mission design verification tests in late 1974 and early 1975 has been solved by reworking early agreements on responsibility for software development.

The Viking Project poses the problem of simultaneous multiple RF links to the DSN for the first time. Consequently, it has been necessary to introduce multiple-link requirements into the current DSN techniques for single-link RF compatibility testing. The effect of these new requirements, with particular reference to Viking, is discussed in this article.

I. Introduction

DSN support for the *Viking* Project continues to move forward with the completion of the TDS Functional Specification and the development of the NASA Support Plan (NSP). Both of these documents are required to establish the framework for the *Viking* Capabilities Planning Team (CPT) to begin work on designing the configuration of each of the DSN systems for *Viking*.

In addition, both documents provide a formal response to the requirements levied on the TDS by the *Viking* Project in the Project Specifications and the Support Instrumentation Requirements Document (SIRD), respectively.

Considerable impact to the DSN long-term planning resulted from a recent Project requirement for DSN support for additional mission demonstration tests covering the period December 1974 through March 1975. The DSN response was complicated by the potential conflicts with the *Mariner* Venus/Mercury encounters in early 1974, *Helios A* launch in mid-1974, and *Pioneer G* encounter late in 1974.

A simplified version of the schedule finally negotiated is shown in Fig. 1. Two key assumptions in the agreement are:

(1) That *Viking* and *Pioneer G* are able to share mission support areas in late 1974 and early 1975.

(2) That all software which runs in the 360/75 is developed at JPL.

(3) That all software developed by the Martin-Marietta Corporation for the *Viking* Project will run in the 1108.

After final review and agreement, this schedule will replace the existing TDS level 3 schedule as the formal top level Project/TDS commitment.

For some time now, attention has been directed toward the unique problems of RF compatibility testing posed by the multiple RF links of the *Viking* Project. Reference 1 described the *Viking* mission design, showing that during Mars Operations the DSN is required to provide two simultaneous uplinks for command and tracking and three simultaneous downlinks for telemetry and tracking. Hitherto, DSN practice in RF compatibility testing has been limited to one uplink or downlink at a time, and a significant increase in the scope of the existing standard practice has been necessary to accommodate the *Viking* conditions and ensure the integrity of the links both individually and collectively.

The following section summarizes the new techniques in multiple-link RF testing. Complete details of the test procedures and the rationale for each of the tests are presented in Refs. 2 and 3.

II. *Viking* RF Link Compatibility Testing (Single Link)

Reference 3 explains how RF compatibility testing is conducted in three phases as follows:

Phase I: Subsystem design starting with initial assembly of prototype/flight-model subsystems.

Phase II: System design following assembly of the flight-model (or equivalent) spacecraft.

Phase III: System verification of all flight-model spacecraft before launch.

The objectives of the subsystem design tests are to demonstrate design compatibility between the spacecraft telecommunications subsystems and the DSN as represented by the special test stations, CTA 21 and DSS 71. Design compatibility of equipment, preliminary mission-dependent software, and operational procedures are demonstrated during these tests.

The subsystem design compatibility tests are performed at CTA 21 as early as practicable in the RF equipment development program. Details of the CTA 21 and DSS 71 capabilities are found in JPL Document 801-2, Addendum 1 and Addendum 2, respectively.

CTA 21 will be configured with applicable equipment and software to perform subsystem testing. The Spacecraft Telecommunications System for each test may be represented by a single subsystem or by a group of subsystems, and may consist of engineering-model equipment.

Subsystem design tests are as follows:

(1) RF tests
   (a) Transponder maximum sweep and acquisition rate measurements.
   (b) S-band spectrum tests.
   (c) Transponder rest frequency determination.
   (d) Transponder subcarrier and carrier threshold.
   (e) Transponder carrier phase jitter.
   (f) Ground receiver carrier and subcarrier threshold.
   (g) Ranging delay calibrations.

(2) Command tests
   (a) Command performance with and without doppler.

(3) Telemetry tests
   (a) Bit error rates (block coded and uncoded modes).
   (b) Subcarrier phase jitter.
   (c) Carrier doppler effects on telemetry.
   (d) Telemetry bit rates and acquisition times.
   (e) Telemetry modulation index measurement.

The objectives of the system design tests are to demonstrate that the DSIF/Spacecraft Telecommunications System design is mutually compatible. Equipment, mission-dependent software, and operational procedures are tested for compatibility.

System design compatibility tests involve the first fully assembled spacecraft, and may be supported by CTA 21 or DSS 71. The station configuration will be operationally representative of a Deep Space Station (DSS) as required

for mission support. Typically, these tests are performed at CTA 21 using a calibrated RF link and hardline function for telemetry bit error rate tests.

This phase of compatibility demonstration repeats most of the subsystem design tests and includes the following additional tests:

(1) RF tests
   (a) Multiple S-band carrier operation (interchannel interference resulting from simultaneous transmission of more than one S-band downlink carrier).
   (b) Ranging probability of acquisition (verify probability of correct ranging correlation vs signal level, RF and telemetry modes).
   (c) Dynamic doppler simulation.
   (d) Two-way phase jitter vs signal level.

(2) Telemetry and command tests
   (a) End-to-end tests with SFOF using mission-dependent and multi-mission software.

The objectives of the system verification tests, typically performed at Cape Kennedy, are to verify that design compatibility, established during Phase II tests, is maintained for each flight-model spacecraft. If flight spacecraft system compatibility tests are not previously performed at CTA 21, the compatibility tests performed at Cape Kennedy become system design tests.

The system verification or system design tests involve the flight-model spacecraft, DSS 71, GCF, and SFOF. Both the spacecraft and the DSN must be in a mission-ready status to meet the test objectives.

The system verification or system design tests follow the same outline and use the same test procedures as Phase II testing. Maximum use will be made of the DSS 71 semi-automated test capabilities for measuring and recording test data. Spacecraft status and response will be determined from spacecraft telemetry received at DSS 71 via a calibrated RF link.

For *Viking* purposes each orbiter and each lander will proceed individually through each of these three phases. Under various configurations of exciters, receivers, antennas, and TWTs, the following classes of tests will be made:

(1) Downlink threshold, one-way.

(2) Uplink threshold.

(3) Receiver pull-in range.

(4) Tracking range and rate.

(5) Transmitter phase jitter.

(6) Best lock frequency.

(7) Auxiliary oscillator frequency.

(8) Telemetry bit error rate with ranging.

(9) Subcarrier phase jitter.

(10) Command polarity and acquisition.

(11) Ranging acquisition and delay.

(12) Downlink spectral analysis.

At this point, it will have been established that, individually, each orbiter and each lander is RF-compatible with the DSN. It now remains to be proved that two orbiters and one lander are simultaneously compatible with the DSN. This is accomplished in the next section.

III. *Viking* RF Link Compatibility Testing (Multiple Link)

For convenience in conducting the multiple-link tests, two orbiters and one lander will be set up in a fixed configuration of exciters, TWT, and low-gain antenna. The conditions of telemetry data rates listed in Table 1, with and without doppler and ranging, will then be established and a spectrum analysis and bit error rate check will be made under each condition for comparison with the results obtained previously under single-link conditions.

The objective of the test is to detect the presence of any interfering carrier or subcarrier cross products which may fall within the receiver pass band and cause degradation in the telemetry or tracking functions of the DSS receivers. The test configuration for the multiple S-band carrier tests is shown in Fig. 2.

Simultaneous acquisition of the three downlink carriers is possible by this configuration with any two of the links being also in a two-way coherent mode. Computer control of the RF attenuators in the downlink paths allows all S-band carriers to be set to the desired power levels.

The discrete Fourier transform technique described in Ref. 3 is used to analyze the RF spectrum around each carrier.

In addition, telemetry from each orbiter and lander will be processed and evaluated for interference using the standard bit error rate tests.

References

1. Mudgway, D. J., "*Viking* Mission Support," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. II, pp. 28–32. Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1971.
2. *Viking Project Master Integrated Test Plan; TDS Compatibility Test Plan*, PL-3701037. Martin-Marietta Corp., Denver, Colo.
3. *DSN Standard Practice, Deep Space Network/Flight Project Interface Compatibility Test Design Handbook*, Document 810-8, Rev. A, Oct. 1, 1971 (JPL internal document).

Table 1. *Viking* multiple-carrier telemetry conditions[a]

Orbiter 1	Orbiter 2	Lander
33⅓; 1w	33⅓; 1w	8⅓; 1w
33⅓; 1w	8⅓ and 16.2 k; 2w; R	8⅓; 1w
33⅓; 1w	8⅓ and 16.2 k; 2w; R	8⅓; 1w
33⅓; 1w	8⅓ and 16.2 k; 2w; R	1000; 2w
33⅓; 1w	8⅓ and 16.2 k; 2w; R	1000; 2w; R
8⅓ and 16.2 k; 1w	8⅓ and 16.2 k; 2w; R	1000; 2w; R
8⅓ and 16.2 k; 2w; R	8⅓ and 16.2 k; 2w; R	1000; 2w; R
8⅓ and 16.2 k; 2w; R	133⅓; 2w	1000; 2w; R
8⅓ and 16.2 k; 2w; R	2000; 2w	1000; 2w; R
8⅓ and 16.2 k; 2w; R	2000; 2w; R	1000; 2w; R
8⅓ and 16.2 k; 2w; R	2000; 2w; R	1000; 2w; R
8⅓ and 16.2 k; 2w; R	8⅓ and 16.2 k; 2w; R	1000; 2w; R
8⅓ and 16.2 k; 2w; R	8⅓ and 16.2 k; 2w; R	1000; 2w; R
8⅓ and 16.2 k; 2w; R	8⅓ and 16.2 k; 2w; R	1000; 2w; R
8⅓ and 16.2 k; 2w; R	8⅓ and 16.2 k; 2w; R	1000; 2w; R

[a]33⅓; 2w; R = 33⅓ bits/second in two-way RF lock with ranging modulation applied.

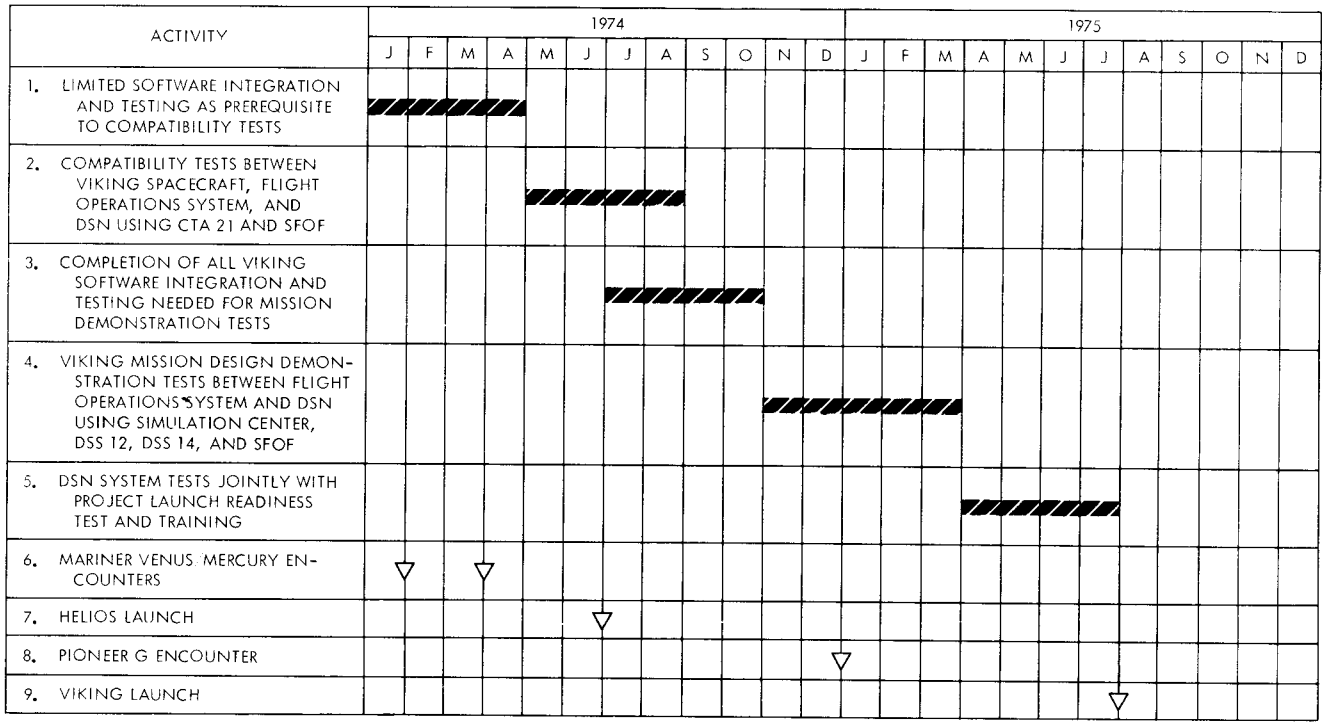

Fig. 1. Basic TDS schedule for support of *Viking* compatibility and mission design verification tests

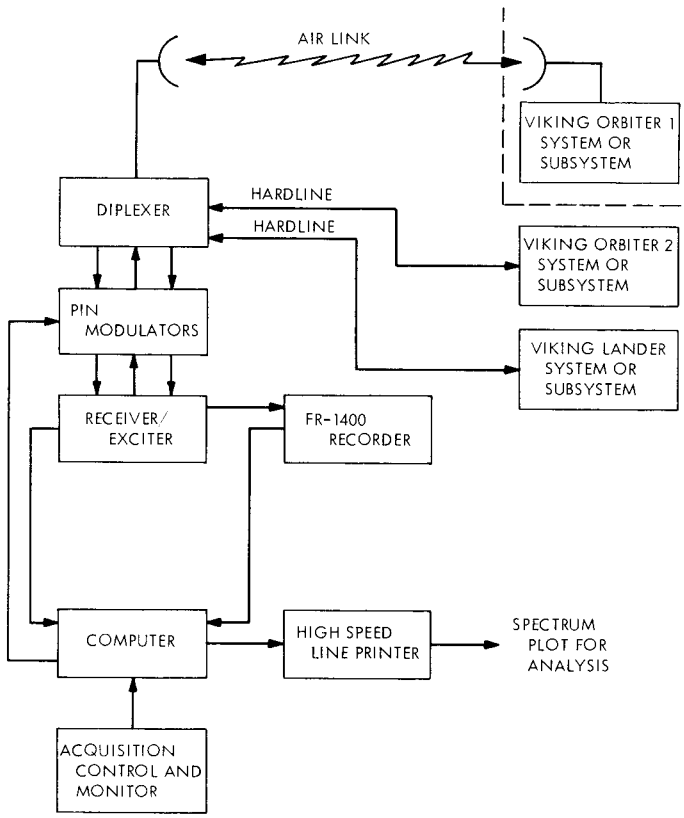

Fig. 2. Configuration for *Viking* multiple-link spectrum tests