# Summary Report on the Mariner Venus/Mercury 1973 Spacecraft/Deep Space Network Test Program

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*The Mariner Venus/Mercury 1973 (MVM'73) Spacecraft/Deep Space Network (DSN) compatibility test program consisted of three phases of testing. Subsystem design, system design, and system verification tests were performed at JPL and Cape Canaveral. Preliminary design tests, initiated in late 1971, preceded the formal compatibility test program that culminated in final verification of DSN/MVM'73 Spacecraft compatibility on October 23, 1973. This report describes the tests and test results that provided the basis for establishment and continuous verification of DSN/MVM'73 Spacecraft compatibility.*

## I. Introduction

The initial efforts to establish DSN/MVM'73 Spacecraft compatibility consisted of an intensive series of tests to determine the Telemetry and Command Data Handling (TCD) Subsystem performance for MVM'73 telemetry modes. The tests were performed in late 1971 at the Compatibility Test Station (DSS 71), the Compatibility Test Area (CTA 21), and the Telemetry Development Laboratory (TDL) utilizing telemetry simulators and test software.

Preliminary design tests utilizing MVM'73 Spacecraft components were performed at CTA 21 and TDL during the early part of 1972. These tests were accomplished with TCD software that consisted of modified Mariner Mars 1971 (MM'71) operational software and revised TCD test software.

Phase I of a three-phase test program to establish DSN/MVM'73 Spacecraft compatibility was performed with CTA 21 and TDL starting in September, 1972. This phase

of testing continued through April 1973, and demonstrated design compatibility between the spacecraft telecommunications subsystems and the DSN.

Phase II of the test program was performed with CTA 21 in July 1973. The objective of this series of tests was to establish system design compatibility between the flight spacecraft and the DSN. Operational TCD software was utilized by CTA 21, and the spacecraft was located in the thermal-vacuum facility at JPL.

Phase III compatibility tests were performed at Cape Canaveral between DSS 71 and both of the MVM'73 flight Spacecraft located in the Assembly and Checkout Facility (Building AO), the Explosive Safe Facility (ESF), and Launch Complex 36. The objective of these tests was to verify continued interface integrity and maintenance of compatibility during prelaunch preparations.

## II. Test Report

Initial tests to determine the TCD performance for MVM'73 telemetry modes were performed at DSS 71 in September 1971. These tests indicated losses that were higher than predicted for the high-rate modes, and minor operational difficulties with the low-rate modes. These test results prompted an intensive series of tests at TDL and CTA 21 in an effort to better understand the TCD performance for MVM'73 telemetry. These tests utilized simulated MVM'73 telemetry, MM'71 hardware, and software that consisted of modified MM'71 operational software combined with revised TCD test software. Details concerning test configuration and measured test results are contained in Division 33 correspondence and reports.

Preliminary design tests with spacecraft components were performed at CTA 21 and TDL during the period April through August 1972. This series of tests could not demonstrate subsystem design compatibility because TCD operational software was not available and the spacecraft components consisted of breadboards. The primary objective of these tests was to provide insight into spacecraft and DSN performance capabilities and to enhance analysis and conclusions derived from compatibility testing.

In September 1972, the three-phase test program to establish DSN/MVM'73 Spacecraft compatibility was initiated. Each phase of testing was divided into segments as shown in Fig. 1; the individual tests performed in each phase and segment are shown in Table 1. Test descriptions for all test phases are contained in Ref. 1. Details concerning spacecraft modes, test criteria, and measured test results are contained in DSN test procedures prepared in response to PD 615-115 and in Office 420/430 test reports.

### A. Phase I Tests

The objective of tests in this phase was to demonstrate design compatibility between the MVM'73 spacecraft telecommunications subsystems and the DSN.

**1. Flight No. 1 tests.** These tests were conducted at CTA 21 on September 29, 1972, utilizing Flight No. 1 spacecraft components and TCD test software. Although S-band RF interface testing was emphasized, preliminary telemetry and command tests were performed. The use of TCD test software did not ensure subsystem design compatibility, but did provide a functional test of the DSN and spacecraft hardware.

**2. Flight No. 2 tests.** Tests were performed in December 1972, and January 1973, with CTA 21 and the MVM'73 Flight II radio frequency subsystem (RFS) and modulation/demodulation subsystem (MDS). Emphasis was placed on the RF and command interfaces. A total of eighteen tests were successfully completed with no anomalies observed. All telemetry tests were performed as functional tests since operational software had not yet been developed.

**3. Command and telemetry tests.** Formal compatibility testing was changed to informal software checkout and development testing status. This action was the result of delays in acceptance testing of the operational software, and was performed over the time period April through July 1973. Several problems with the software were discovered. Most of these problems were related to the inability to acquire 8⅓ bits/s at high signal conditions. Of lesser significance was loss of TCD program control when selecting a redundant Subcarrier Demodulator Assembly (SDA) or initialization of 490 bits/s.

Hardware problems uncovered were a possible alignment problem with the SDA and an interference problem using the discrete spectrum from the Planetary Ranging Assembly (PRA). With the former problem, one of the two SDAs at CTA 21 would not acquire at the project-specified Mercury encounter telemetry threshold $ST_b/N_0$ (0.63 dB).

A special alignment of the SDA was considered to be a resolution to the problem. With the latter problem, the telemetry signal-to-noise ratio (SNR) estimators in both telemetry channels (22.05/2.45 kilobits/s) indicated an increase in SNR with the PRA discrete spectrum ranging as opposed to the Mark 1-A continuous ranging.

**4. Block IV exciter tests.** Block IV exciter (S-band) command capability was established during tests on August 3, 1973, utilizing a flight radio (S/N 006) and the prototype command unit. The S/X-band receiver tests were not accomplished because of the nonavailability of Block IV receiver equipment.

### B. Phase II Tests: Flight No. 2 Spacecraft/ CTA 21 Testing

This testing was performed during the month of July 1973 with the spacecraft located in the Thermal Vacuum Chamber. Testing was conducted at various sun levels to simulate: (1) 1.0 Sun, (2) 2.0 Sun, (3) 4.8 Sun, and (4) Ambient. Several problem areas were uncovered and are listed below:

(1) The SDA lock indicator would not indicate in-lock at threshold, $5 \times 10^{-2}$ data bit error rate (BER), for 22 kilobits/s, block coded data.

(2) For some SDA Symbol Synchronizer Assembly (SSA) combinations, insufficient SDA correlation voltage was achieved for 22 kilobits/s block coded data to achieve SSA lock.

(3) The Mission and Test Computer (MTC) experienced difficulty in achieving frame sync at threshold for 22 kilobits/s, block coded data.

(4) The operational software (DSN Program Library Software No. (DOI-5050-OP) would not achieve reliable bit sync lock for 8⅓ bits/s at high signal level conditions.

These problems were not resolved during the July 1973 testing at CTA 21, but were given high priority for continued investigation during the Flight No. 1 testing to be conducted at DSS 71. All other objectives of the test plan for Flight No. 2 spacecraft were successfully completed during this phase.

### C. Phase III Tests

**1. Flight No. 1 compatibility verification tests.** This testing was performed at Cape Canaveral on August 26, 1973. The spacecraft was located in Building AO and an RF link was established to DSS 71; however, Revision A of the operational TCD software was not available. Special emphasis was placed on problems uncovered at CTA 21 during Flight No. 2 testing. A summary of the testing and results is as follows:

(1) Command: the DSN/Spacecraft command system design was declared compatible. There were no outstanding problems remaining upon completion of this testing.

(2) Telemetry: the SDA and SSA lock problems discussed under Phase II testing were tested extensively during this period. A standard alignment of the SDAs was performed followed by a series of acquisition tests at an $ST_B/N_0$ of 0.63 for 22 kilobits/s coded data.

The SDA/SSA combination acquired and performed without any difficulty. A decision was made to abandon further tests. Although the telecommunications system was designed to operate at a point below SDA/SSA design threshold, there appeared to be no problem in meeting project requirements at Mercury encounter.

(3) Ranging: an interference problem in the telemetry signal-to-noise estimator occurred when the PRA discrete code was applied to the up-link. This problem was manifested by higher-than-normal SNR printouts. An operational resolution of this compatibility problem was to operate the uplink RF signal at or below −100-dB signal levels.

(4) RF tests: all RF tests were successfully completed and compatibility was declared satisfactory.

**2. Flight No. 2 compatibility verification tests.** This test was performed on September 22 and October 23, 1973 at Cape Canaveral. The spacecraft was located in Building AO for the September 22 test, and Launch Complex 36 for the October 23 test. All testing was performed via an RF link and the launch version (Revision A) of the TCD operational software was utilized successfully.

Tests performed on September 22, 1973 cleared an outstanding compatibility problem. For the first time, a video picture was sent from the spacecraft to MTC and fully reconstructed. Data rate for this event was 22 kilobits/s, block coded. The M26X software module was also successfully exercised during this test. All other objectives of testing on this date were successfully completed.

Following completion of these tests, an operational readiness review was held on September 26, 1973 with a report of compatibility status as follows:

(1) Command design compatibility established.

(2) Telemetry design compatibility established with additional testing of DOI-5050-OP-A scheduled for October 23, 1973.

(3) RF design compatibility established.

(4) Ranging design compatibility established with additional operational testing scheduled for October 23, 1973.

On October 23, 1973, final compatibility testing was conducted with the Flight No. 2 spacecraft encapsulated in its launch configuration and located at Launch Complex 36. All compatibility deficiencies encountered during the September 22, 1973 testing were resolved. Therefore, complete compatibility was established for all elements of the Spacecraft/DSN interface.

## III. Conclusions

The successful conclusion of the formal DSN/MVM'73 compatibility program enabled the establishment of telecommunications compatibility as evidenced by the successful launch of the MVM'73 spacecraft on November 3, 1973.

The importance of the performance of a formal compatibility test program is clearly demonstrated by the problem areas uncovered, verified, and resolved during the DSN/MVM'73 testing.

## Reference

1. *Mariner Venus/Mercury 1973 DSN–Spacecraft Compatibility Test Plan*, Project Document (PD) 615-115. Jet Propulsion Laboratory, Pasadena, Calif., Feb. 12, 1973. (JPL internal document.)

**Table 1. DSN/MVM'73 compatibility test matrix**

| | Phase | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | | | | | | II[a] | | | III | | |
| | Segment | | | | | | | | | | | |
| System tests | 1 | 2 | 3 | 4 | 5 | 6 | 7a | 7b | 7c | 8 | 9 | 10 |
| S-Band RF | | | | | | | | | | | | |
| Downlink, one-way | X | | X | | | | | | | | | |
| Uplink threshold, two-way | X | | X | | | | | X | X | X | X | |
| Two-way | X | | X | | | | | | | | | |
| Spacecraft receiver pull-in range | X | | X | | | | | | | X | X | |
| Spacecraft receiver tracking rate and range | X | | X | | | | | | | X | X | |
| Carrier residual 0 jitter | X | | X | | | | | | | X | X | |
| Uplink spectrum analysis | X | | X | | | | | | | | | |
| Downlink spectrum analysis | X | | X | | | | | | | X | X | |
| Simulated dynamic conditions | X | X | X | | | | | | | | | |
| Spacecraft receiver best-lock frequency | X | | X | | | | | X | | X | X | |
| Auxiliary oscillator frequency | X | | X | | | | | | | X | X | |
| Dynamic acquisition | | | | | | | X | | | | | |
| X-Band RF | | | | | | | | | | | | |
| Carrier residual 0 jitter | | | | | X | | | | | | | |
| Tracking range and rate | | | | | X | | | | | | | |
| Downlink threshold | | | | | X | | | | | | | |
| Command | | | | | | | | | | | | |
| Polarity verification | | X | X | | | | X | | | | | |
| Acquisition | | X | X | | | | X | X | X | X | X | |
| Capability under doppler | | X | X | | | | | | | | | |
| Capability with ranging | | X | | | | | | | | | | |
| Operational capability | | X | | | | | X | X | X | | | |
| Dynamic acquisition | | | | | | | X | | | | | |
| Telemetry | | | | | | | | | | | | |
| Functional (strong signal) | | | X | X | | | | | | X | X | |
| Mode 1 | | X | X | X | | | X | X | | | | |
| Mode 2 | | | X | X | | | | | X | | | |
| Mode 3 | | | X | X | | | | | | | | |
| Mode 4 | | | X | X | | | X | | | | | |
| Mode 5 | | | X | X | | | | X | | | | |
| Mode 6 | | X | X | X | | | X | | | | | |
| Mode 7 | | | X | X | | | | | | | | |
| Threshold | | | | X | | | | | | | | |
| Mode 1 | | X | | X | | | X | X | X | | | |
| Mode 2 | | | | X | | | | X | X | | | |
| Mode 3 | | | | X | | | | | X | | | |
| Mode 4 | | | | X | | | X | X | X | | | |
| Mode 5 | | | | X | | | | | X | | | |
| Mode 6 | | X | | X | | | X | X | X | | | |
| Mode 7 | | | | X | | | | X | X | | | |
| S-band ranging | | | | | | | | | | | | |
| Acquisition | X | | X | | X | | | | | X | X | |
| Polarity verification | X | | X | | X | | | | | | | |
| Channel delay | X | | X | | X | | | | | | | |
| Under doppler conditions | X | | | | X | | | | | | | |
| X-band ranging | | | | | | | | | | | | |
| Acquisition | | | | | X | | | | | | | |
| Polarity verification | | | | | X | | | | | | | |
| Channel delay | | | | | X | | | | | | | |

[a]Tests 7a, b, and c are Sun levels 1, 2, and 4.8, respectively.

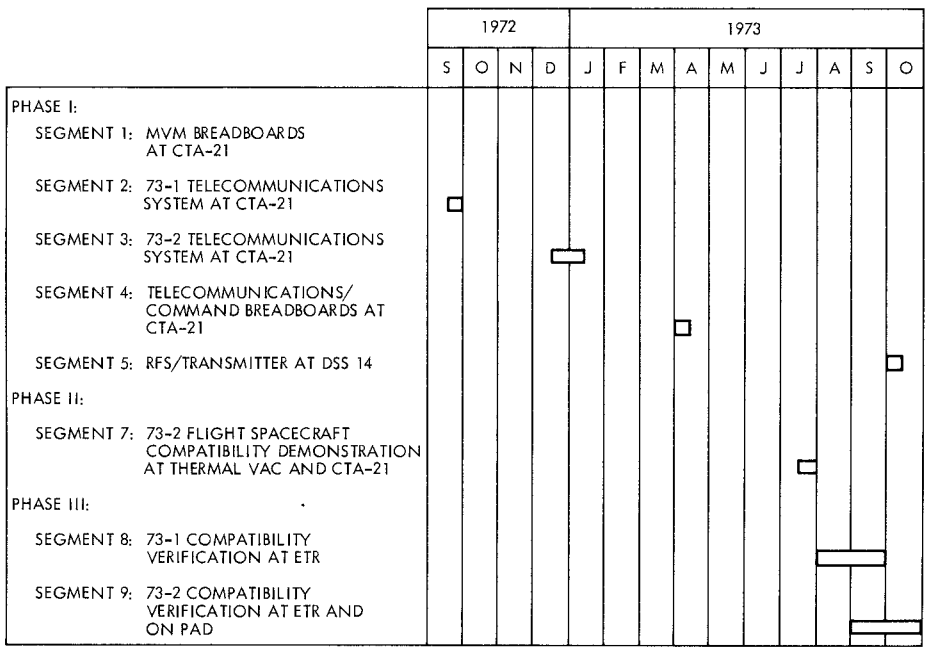


**Fig. 1. DSN/MVM'73 compatibility test schedule**