Viking Extended Mission Support

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This report covers the period from May 1 through June 30, 1977 and includes the initial two weeks of post-MDS Viking related testing at DSS 14. Some of the periodic tests routinely carried out with the Viking Orbiter spacecraft by the spacecraft telecom and DSN teams to ensure optimum performance or detect any degradation in the spacecraft radio or command equipment are also addressed.

I. Viking Operations

A. Status

During May and June 1977 all four Viking Spacecraft continued to perform as planned, with the two landers in their low activity hibernation mode and the two orbiters continuing their photography, weather and water mapping missions.

A major dust storm covering a large part of the entire planet became evident in early June, and excellent pictures of the cloud formations were obtained by the orbiters, although the landers' pictures quickly deteriorated to the point where the sun was practically obscured. At the end of June this dust storm condition remained unchanged.

On May 27, 1977 VO-1 passed within 100 km of Phobos and obtained some spectacular pictures of the Martian moon.

The only orbiter spacecraft performance change noted during May and June was the degradation of 2-5 dB in the performance of the VO-1 Radio Frequency System (RFS) and/or the Command Detector Unit (CDU).

B. VO High-Gain Antenna (HGA) Calibration

Periodically during the Viking mission, calibration tests have been carried out to check the VO HGA pointing angles and confirm that the HGA is optimized to bore sight on the Earth, and check the HGA angles relative to the spacecraft scan platform, etc. A VO-2 high-gain antenna (HGA) calibration test took place on May 23, during the beginning of the DSS 43 view period. The station performed the X-band CONSCAN work per the sequence of events. Each of the 10 calibration points was held for 10 min.

C. Maneuvers

VO-1 MOT-15 took place on May 15, 1977. This was a sunline maneuver to eliminate the possibility of a tangential grazing (or impact) with Phobos during the flyby on May 27, 1977.

VO-1 MOT-16 took place on July 1, 1977. This orbit trim maneuver changed the orbit period to 24 hours and caused the Earth occultations to occur during the DSS 14/DSS 43 overlap period.

II. Radio Science

Viking has been continuing to acquire data for five Radio Science experiments since the end of the superior conjunction period when the intensive coverage for the General Relativity Time Delay and Solar Corona Experiments were completed.

A. General Relativity Dynamics Experiment

The data collected for this experiment is primarily the near simultaneous lander and orbiter ranging data. Orbiter ranging and VLBI data are also useful. Over the past three months the Viking Project has scheduled at least two lander ranging passes per week, and the DSN has acquired good data on most of these passes. The problems during the prime mission with acquiring good near simultaneous lander-orbiter ranging seem to have disappeared due to increased attention that the Viking Project and DSN planning and operations personnel have given to the ranging data acquisition.

The last Orbiter/Quasar VLBI pass for several months occurred on April 14. Since DSS 14 or DSS 43 will be down for Mark III conversion there will not be another opportunity until fall to continue these observations.

B. Mars Physical Ephermerides Experiment

This experiment is concerned with the motion of the Mars pole and spin rate for the purpose of determining the internal mass distribution of the planet. The same near simultaneous lander/orbiter ranging data used for the General Relativity Experiments is also used for this experiment.

C. Earth Occultation Experiment

Orbiter 1 (VO-1) started Earth occultations in mid-March 1977. Occultations will continue to occur through November 1978 (~1½ years). Orbiter 2 (VO-2) started Earth occultation in mid-January and stopped at the end of May. Therefore, there were two occultations every day from mid-March through May 1977. Unfortunately, both orbiters were in non-Earth synchronous orbits with different periods, so the occultation "walked" through the DSN stations at different rates. This fact plus the non-availability of DSS 14 due to station modification and of DSS 63 due to Helios support means that most of the recent Earth occultation support comes from DSS 43. The confusion that has been caused by the changing time of occultations also resulted in the loss of occultation data due to operational procedure errors.

D. Earth Occultation

Two basic station configurations are used to acquire Earth occultation data:

In Configuration One (Fig. 1) the 64-m DSS is locked up two-way to the occulting orbiter at entry, and the DSS acquires S- and X-band Open-Loop Receiver data, and S- and X-band closed-loop high-rate doppler at 10 points/second. At exit, the open- and closed-loop receivers acquire only one-way data, because the spacecraft loses lock when the orbiter disappears behind the planet.

One-way data is inferior to two-way or three-way data because the spacecraft auxiliary oscillator is not as stable as the station frequency reference. Generally one-way data will provide planetary radii and ionospheric profiles but not atmospheric temperature and pressure profiles.

In Configuration Two (Fig. 2) the 64-m DSS is locked up two-way to the non-occulting orbiter throughout the time when the other orbiter is being occulted. The DSS acquires S- and X-band open-loop receiver data from the occulting orbiter, and S- and X-band closed-loop high-rate doppler at 10 points/second from the non-occulting orbiter.

In this configuration the carrier signal from the occulting orbiter passes through the Martian atmosphere and ionosphere plus the interplanetary plasma and the Earth's atmosphere and ionosphere, while the signal from the non-occulting orbiter passes through everything except the Martian atmosphere and ionosphere. These data can then be processed by differencing the signal perturbations, and this difference will be the Martian atmosphere and ionosphere effects, which is the object of the Earth occultation experiment.

As can be seen the Configuration Two observations are more complicated, and therefore less reliable, and more costly to process. When another station is two-way with the occulting orbiter, the open- and closed-loop entry data are three-way, which is as effective as two-way for the Earth occultation experiment (Figs. 3, 4). Because DSS 63 does not have open-loop receivers and recorders, only closed-loop data in Configuration One is obtainable from this station.

E. Gravity Field Experiment

Full orbits of S-band doppler data for both orbit determination and gravity field determination continued to be collected. Very little good S- and X-band doppler short-arc coverage near periapsis for local gravity anomoly analysis has been collected during the entire mission due to conflicts for 64-m coverage, orbiter roll, and orbiter occultations near periapsis.

F. Surface Properties Experiment

Lander-to-orbiter relay link engineering data used for the Surface Properties Experiment continues to be acquired about once per week.

G. Near Simultaneous Lander and Orbiter Ranging

The VL-1 ranging passes during late April and early May occurred during the early part of the DSS 43 pass, followed by VO-1 ranging during the latter part of the passes.

Since VL-2 does not have any direct downlinks, the radio science relativity and planetology experiments depended completely upon the VL-1 direct links. Also because of lack of VL-2 relay links there was competition between the direct link telemetry data and ranging data.

The orbiter near simultaneous ranging is used primarily to calibrate for the ranging group delay due to interplanetary and ionospheric plasma. The orbiter S- and X-band ranging can be used to measure the total electron content in the beam between spacecraft and station and these calibrations are extrapolated back to the lander ranging measurement time to get a more accurate lander ranging measurement. Since the plasma is a time variable, the lander and orbiter ranging measurements must be made as closely together as possible. Normally the time between a lander and orbiter ranging measurement has been about 2 hours.

The near simultaneous lander and orbiter passes have been generally successful during the Viking Extended Mission, and the radio science experimenters will achieve many of their objectives using this data.

III. Network Support

Table 1 gives the DSN tracking support; Table 2 the commands transmitted; and Table 3 the Discrepancy Report status for May and June 1977. The same category statistics for the previous months of 1977 are also shown to give a more complete picture and emphasize any trends in the data.

IV. DSN Mark III Data Subsystem (MDS) Testing

As indicated in the last report of this series the DSN Mark III Data Subsystem has been implemented and tested at DSS 12, DSS 44, and DSS 62. During this reporting period DSS 14 completed their implementation and system performance testing and in mid-June started Viking operational training and testing. The tests completed up to June 30, 1977 follow.

A. DSS 14 Viking Extended Mission (VEM) OVT I, June 24, 1977, 1900–0330 PDT

The test was unsuccessful. Due to problems with NOCA test and training RTM and the station SCA, telemetry could not be simulated in accordance with the SOE. After TPA 1 failed, the remaining time was turned back to the station for maintenance, as the station had to be ready for the first Viking SIM test on June 25, 1977.

B. DSS 14/NOCA/VMCCCC Viking SIM test, June 25, 1977

This test was very successful. The test was intended to check out the long loop simulation system prior to the initial Viking SIT test on June 28, 1977. This was accomplished in the first three hours of the test, and the remainder of the test time was used to follow the SIT sequence of events, and approximately 70% of the SIT sequence was successfully accomplished.

C. DSS 14 VEM SIT 1, June 28, 1977, 0710–2110 PDT

The test was successful. This test fully demonstrated the capability to support the Viking Mission system requirements with long loop simulated telemetry from VMCCCC to DSS 14 and back to VMCCCC and NOCA.

D. DSS 14 OVT 2, June 29, 1977, 0200–1410 PDT

Test successful and completed SOE items on real-time data; however, lack of time prevented completion of the digital and analog telemetry replay items.

Table 1. VEM tracking support 1977

DSS	Jan.		Feb.		March		April		May		June	
	Tracks	Hours	Tracks	Hours	Tracks	Hours	Tracks	Hours	Tracks	Hours	Tracks	Hours
11	23	135	22	142	10	100:12	17	118:00	38	227:59	40	289:16
12	4	11	1	6			24	175:59	17	119:20	1	04:03
14	52	341	59	392	50	368:35	20	176:21	–	–	–	–
42	21	247	25	226	58	453:24	17	138:36	17	162:29	14	112:42
43	68	721	62	627			63	603:21	60	521:41	57	486:21
44	-0-	-0-	-0-	-0-	7	7:02	1	3:56	–	–	–	–
61	35	261	29	227	12	72:07	40	317:45	54	461:32	51	474:55
62	-0-	-0-	2	7	4	22:25	9	55:10	3	13:54	2	07:32
63	38	327	28	202	66	525:23	15	78:01	23	185:56	15	136:22
Total	241	2043	228	1830	207	1549:38	206	1667:09	212	1692:51	180	1398:39

Table 2. VEM commands transmitted

DSS	Jan.	Feb.	March	April	May	June
11	1521	1394	1027	117	811	–
12	0	0	0	1314	721	–
14	769	1404	1206	274	–	–
42	2072	953	1778	8	1886	1619
43	919	2523	0	2094	1447	972
44	0	0	2	1	–	–
61	605	1116	1328	1925	1922	3838
62	0	0	1	1991	–	496
63	795	472	2039	381	675	383
Total	6681	7862	7381	6180	7465	7308

Table 3. DSN VEM discrepancy reports

DSS	Jan.		Feb.		March		April		May		June	
	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Closed
11	4		3	4	4	6	1	3	2	3	2	6
12	4						5	2	7	5	0	7
14	14	2	11	19	4	33	3	9	2	2	0	2
42		1	2	3		7		2	0	0	0	0
43	10	13	11	10		12	9	11	8	17	2	14
44						2		1	0	0	0	0
61	1	9	1	6		3		1	1	2	0	6
62				8	1	2	2	1	0	2	0	1
63	1	4	7	3	1	18		6	4	4	3	12
DSN, NDPA, NOCA	4	3	3	9	2	10	4	7	7	12	10	13
Total	38	32	38	62	12	93	24	43	31	47	17	61

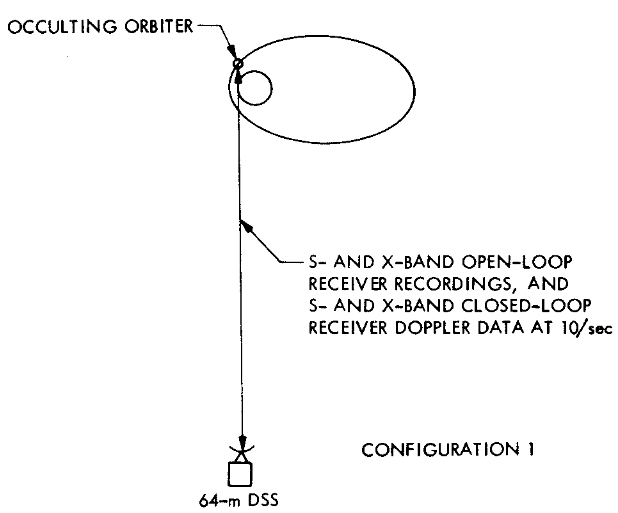

Fig. 1. One 64-m DSS two-way with occulting orbiter at entry and one-way at exit

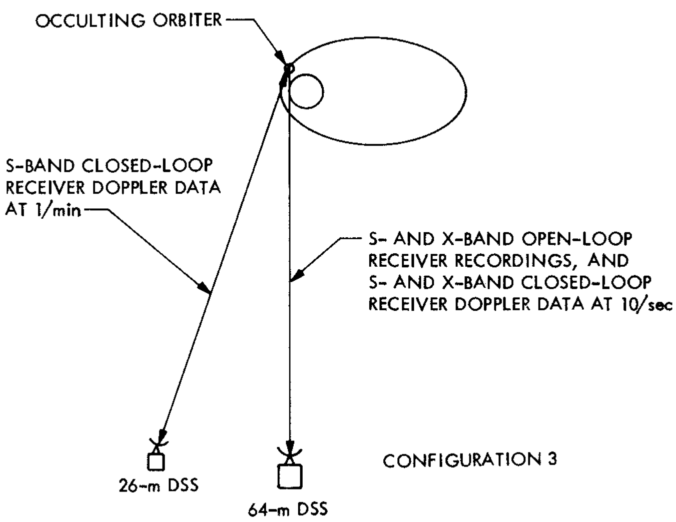

Fig. 3. One 64-m DSS three-way with occulting orbiter at entry and one-way at exit, and one 26-m DSS two-way with occulting orbiter at entry and one-way at exit

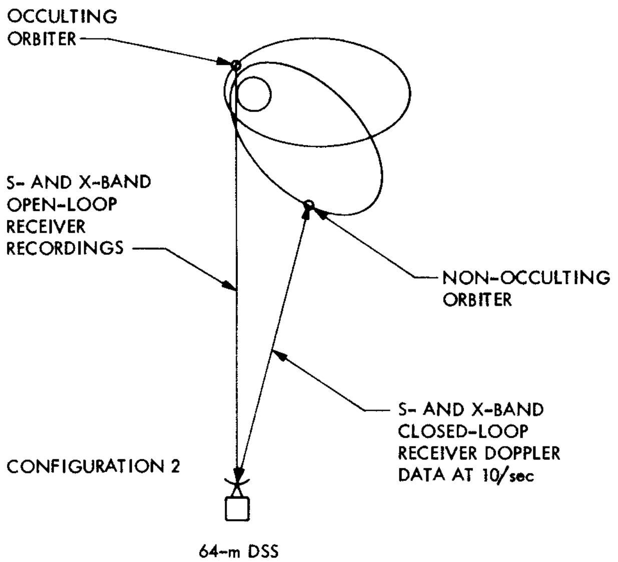

Fig. 2. One 64-m DSS two-way with non-occulting orbiter and one-way with occulting orbiter at entry and exit

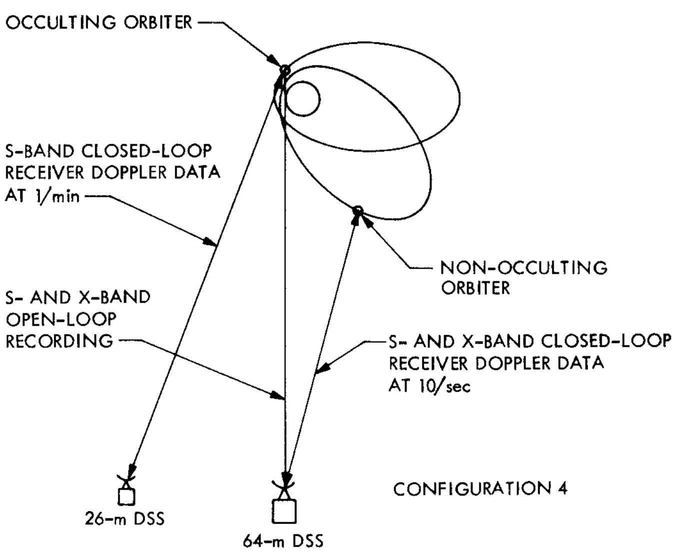

Fig. 4. One 64-m two-way with non-occulting orbiter and three-way with occulting orbiter at entry and one-way at exit