Viking Extended Mission Support

T. W. Howe
Deep Space Network Operations Section

This report covers the period from 1 September through 31 October 1977. It reports on the status of Viking DSN Mark III '77 Data Subsystem Implementation Project (MDS), related testing at DSS 42/43, and also includes reports on the Viking DSN Discrepancy Reporting System, Viking command support, tracking support, and periodic tests conducted with the Viking spacecraft.

I. Viking Operations

A. Status

All four Viking spacecraft continued to return data during this reporting period. The communications link between the spacecraft and the Deep Space Stations (DSSs) continued to improve. This was a result of the combination of decreasing communications range to Earth and a decreasing Earth cone angle for the Orbiter low-gain antennas. The links will continue to improve until mid-January 1978. These improved links made possible the reception of 33-1/3 bps single-subcarrier telemetry data from the Orbiter low-gain antenna by a 64-m station. The 26-m stations processed dual-subcarrier 2-kbps telemetry data routinely during the period. Beginning in October it was possible to receive 8-1/3 bps single-subcarrier telemetry data at 26-m stations.

B. Spacecraft Problems

Two spacecraft problems occurred during this reporting period. The first occurred on September 19 on Viking Orbiter 2 (VO-2) during a planned switch from processor B to processor A. An anomaly caused the Orbiter to go into a safing routine and resulted in a switch to the low-gain antenna and single-subcarrier mode at a data rate of 8-1/3 bps. This was the first attempted processor switch for VO-2, the same switch having been successfully accomplished several times on Viking Orbiter 1 (VO-1).

The first indication of a problem was loss of downlink lock by DSS 44. When lock was reestablished, the downlink was found to be -167 dBm with a low rate engineering signal-to-noise ratio (SNR) near zero.

Following unsuccessful attempts to improve the signal level, a spacecraft emergency was declared by the Viking Project Manager. Since only 26-m stations were scheduled to support Viking from the time of the anomaly until some 10 hours later when DSS 14 would have the spacecraft in view, DSS 43 was contacted and requested to support. The station had not supported any spacecraft tracks since the beginning of the DSN Mark III '77 data Subsystem Implementation Project (MDS) upgrade on 15 July 1977, and was still in the process of conducting system performance tests. The personnel responded to the emergency in remarkable fashion and were able to obtain lock in less than one hour. Following analysis of telemetry downlink indications, it was confirmed that a safing sequence had occurred. Commands were transmitted to reestablish normal links. DSS 63 was brought up at the end of DSS 43's view period and received a spacecraft memory readout. DSS 63 was released from Viking support approximately 7 hours after the emergency.

The cause of the anomaly was determined to be a timing offset between Processor A and Processor B on the Viking Orbiter.

The second problem occurred over DSS 14 on 6 October 1977 during a VL-2 direct link. Downlink lock was lost approximately 14 minutes prior to the scheduled time of end of link. Attempts by DSS 14 and DSS 43, which was supporting a demonstration pass, to lock to the downlink were unsuccessful. An attempt to obtain lock the following day was also unsuccessful.

The apparent cause of the anomaly is a fault in the low-voltage power supply for the traveling wave tube amplifier (TWTA). About one year ago the other TWTA failed to come on during a scheduled direct link, and no attempt has been made to use it since that time. Lander 2 will continue to operate with an uplink capability and Lander-to-Orbiter relay links. The present VL-2 sequences provide a good science mission with most of the data being returned via the relay link.

C. Maneuvers

Three Mars Orbit Trim (MOT) maneuvers with VO-2 occurred during this reporting period.

MOT-11 occurred on 26 September 1977 during the DSS 63 view period. The purpose of this maneuver was to prepare for Deimos encounters on 10, 15, and 20 October. The trim maneuver was successful. DSS 63 was unable to obtain downlink telemetry lock during the 9-sec motor burn, even though the spacecraft was on the high-gain antenna and the downlink telemetry signal level was predicted to be -143 dBm. As a result, two-way tracking data was lost, and telemetry data was not available until played back from the Orbiter.

MOT-12 was supported by DSS 14 on 9 October 1977. Motor burn lasted 6 seconds and finalized the orbit for Deimos encounter. All uplink and downlink activities for this maneuver were accomplished properly and on time.

MOT-13 occurred on 23 October 1977 and accomplished three goals: (1) it changed the periapsis altitude from 591 to 300 km, (2) it changed the orbital period from 21 hours 13 minutes to 23 hours 59 minutes, and (3) it provided an orbit that will overfly the Viking Lander 1 (VL-1) site on 13 November. The maneuver was supported by DSSs 14 and 43 during an overlapping view period. Imaging Science data will be taken during the overflight of the VL-1 site on 13 November and a comparison will be made in terrain as seen from the Orbiter and as seen from the Lander to help pinpoint the exact VL-1 landing site.

D. Radio Science

Radio Science activities and data taking continued during September and October.

Experiments included Near Simultaneous Lander/Orbiter Ranging, Periapsis Gravity Field, and Occultation. Plans are now being made for a Bistatic Radar Experiment which will begin in November 1977. Details of this experiment will be covered in the next article of this series.

E. Spacecraft Tests

Routine spacecraft testing continued during this reporting period. An average of two Command Detector Unit (CDU) signal-to-noise ratio estimator (SNORE) tests were conducted each week for both Viking Orbiters. High-gain antenna calibrations were also supported.

II. Network Support

Table 1 shows the Viking Extended Mission (VEM) Tracking Support for 1977. The month of October produced the fewest number of tracking hours in support of Viking for 1977, with September showing the fewest number of Viking tracks for 1977. This may be due in part to the fact that Lander 2 direct telemetry link passes ended on 6 October due to the TWTA failure.

Table 2 gives the total number of commands transmitted during 1977. The month of September was a record month for commanding with 11,617 commands transmitted, more than half of which were sent from 26-m stations.

Table 3 identifies the DSN VEM Discrepancy Reports generated during the period and 1977.

A. Viking Uplink Spectrum Analysis

On September 2, during a lander direct link over DSS 63, the Viking Lander-1 uplink signal level was noted to be 37 dBm lower than predicted and the spacecraft receiver static phase error was in error by 13 Khz. Investigation by DSS 63 during subsequent Viking passes revealed sideband signal "spurs" on the station uplink carrier, both above and below the carrier at about 13 to 15 Khz from the carrier and a -30 dB below the actual carrier signal level. DSS 63 engineering tests revealed that the sidebands were caused by the data synthesizer or the 50 Mhz reference signal from the Frequency and Timing Subsystem (FTS). The remainder of the stations supporting Viking were requested to monitor their uplink carrier for sideband spurs which could result in a degraded uplink signal. However, no significant spurs were found on any of the other transmitters in the network.

III. DSN Mark III '77 Data Subsystem Implementation (MDS) Testing and Status

As indicated in the last report on this series, MDS test and training had been completed at DSSs 12, 44, 62 and 14. DSSs 42/43 had been released from tracking support and had started their MDS upgrade on July 15.

A. DSS 42/43 Test Status

The DSS 42/43 test and training began and was completed during this reporting period. The scheduled completion date for the MDS implementation phase at DSS 42/43 was 30 September 1977, with testing scheduled to begin on 1 October 1977. These stations completed their implementation phase ahead of schedule, and at the suggestion of station management Viking Operational Verification Tests (OVTs) were conducted during these extra days. It was the opinion of DSS 42/43 and DSN Operations personnel that Viking OVT's would provide the stations with the best training possible, since a Viking OVT would exercise more equipment and configurations than any other type of test. OVT testing began on the 26th of September.

The plan was to conduct 10 OVTs and to insure at least 2 OVTs with each of the 4 operational shifts. Of the OVTs conducted, 2 were unsuccessful, while the other 8 were successful. The tests exercised the MDS configurations to be used for Viking support. All telemetry data rates were processed, manual and automatic commanding demonstrated and data replay was exercised. Due to equipment problems, replay of analog telemetry data from the FR-1400 recorders could not be exercised. The last OVT was completed on 30 September 1977.

Viking Extended Mission DSN/MCCC System Interface Testing (SIT) was conducted on the 4th of October 1977. The test was successful and a scheduled retest was cancelled.

Viking Extended Mission Ground Data System (GDS) testing was conducted on the 8th of October 1977. Due to problems with MCCC computer support, simulation, and the Ground Communications Facility (GCF), the test could not be completed. A retest was conducted on 11 October 1977 to complete a 2-hour portion of the timeline and to test the replay capability of Digital Original Data Records (DODR). This retest was successful.

Demonstration passes began on 7 October 1977 and involved both DSS 42 and 43. Passes also occurred on the 9th, 10th, 12th, 15th, and 16th of October. The third demonstration pass demonstrated the ability of DSS 43 to support the Viking project while DSS 42 was supporting another flight project (PN-11). The pass was successful in that no interference was detected.

The testing phase at DSS 42/43 was completed on 16 October 1977 and these stations were placed under Viking configuration control on 18 October 1977.

Table 1. VEM tracking support 1977

DSS	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
	Track / hr											
11	23 135	22 142	10 100	17 118	38 228	40 289	44 322	42 343	26 210	40 408		
12	4 11	1 6	–	24 176	17 119	1 4	1 1	1 7	–	–		
14	52 341	59 392	50 368	20 176	–	–	10 46	16 126	28 363	43 329		
42	21 247	25 226	58 453	17 138	17 162	14 112	10 69	–	–	14 100		
43	68 721	62 627	–	63 603	60 521	57 486	31 238	–	1 01	24 141		
44	–	–	7 7	1 4	–	–	16 99	26 166	6 22	12 51		
61	35 261	29 227	12 72	40 317	54 461	51 475	37 337	35 322	38 345	22 203		
62	–	2 7	4 22	9 55	3 14	2 7	–	–	–	3 23		
63	38 327	28 202	66 525	15 78	23 186	15 136	40 399	64 590	57 590	15 136		
Total	241 2043	228 1830	207 1547	206 1665	212 1691	180 1509	189 1511	184 1554	156 1531	173 1391		

Number of tracks represent the summation of all Viking spacecrafts tracked. Track time, in hours, represent scheduled station support.

Table 2. Number of commands transmitted in Viking Extended Mission during 1977

DSS	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
11	1521	1394	1027	117	811	0	1	795	2028	3687		
12	0	0	0	1314	721	0	0	0	–	–		
14	769	1404	1206	274	–	–	74	108	2704	2108		
42	2072	953	1778	8	1886	1619	–	–	–	18		
43	919	2523	0	2094	1447	972	1190	–	–	456		
44	0	0	2	1	–	–	–	5	19	2		
61	605	1116	1328	1925	1922	3838	4257	5589	5256	1371		
62	0	0	1	1991	–	496	–	–	–	–		
63	795	472	2039	381	675	383	2579	2318	1610	847		
Total	6681	7862	7381	6180	7465	7308	8101	8815	11,617	8489		

Table 3. DSN VEM discrepancy reports

DSS	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
	0[a] / C[b]											
11	4 0	3 4	4 6	1 3	2 3	2 6	2 7	1 7	1 1	1 3		
12	4 0	0 0	0 0	5 2	7 5	0 7	0 0	0 0	0 0	0 0		
14	14 2	11 19	4 33	3 9	2 2	0 2	6 2	4 18	5 14	10 24		
42	0 1	2 3	0 7	0 2	0 0	0 0	0 0	0 0	0 0	1 0		
43	10 13	11 10	0 12	9 11	8 17	2 14	1 6	0 1	0 0	0 5		
44	0 0	0 0	0 2	0 1	0 0	0 0	1 0	1 4	0 1	0 0		
61	1 9	1 6	0 3	0 1	1 2	0 6	1 4	0 7	0 4	0 4		
62	0 0	0 8	1 2	2 1	0 2	0 1	0 0	0 0	0 0	2 0		
63	1 4	7 3	1 18	0 6	4 4	3 12	4 4	9 17	8 17	4 7		
Others[c]	4 3	3 9	2 10	4 7	7 12	10 13	8 16	5 9	7 8	10 15		
Total	38 32	38 62	12 93	24 43	31 47	17 61	23 39	20 63	21 45	28 58		

[a] 0 = Number remaining open at end of month.

[b] C = Number closed during month.

[c] Other = DSN, NDPA, NOCA, GCF