Viking Extended Mission Support

T. W. Howe
Deep Space Network Operations Section

This report covers the period from 1 November through 31 December 1977. It reports on DSN support of Viking spacecraft activities during the period and continues reporting on the DSN Discrepancy Reporting System, Viking Command support and Tracking support. It also continues the reports on the status of Viking DSN Mark III Data Subsystem Implementation Project (MDS) related testing.

I. Viking Operations

A. Status

The two Viking Orbiters continued to make detailed photo maps of Mars during this reporting period. In addition they measured the temperature and water vapor content of the Martian atmosphere. Cloud patterns were checked to see how weather and storms develop. The Orbiters continue to act as relay stations for Viking Lander data transmission.

Spring equinox occurred in the northern hemisphere of Mars during early November. The frost seen earlier in Lander photos has disappeared and the polar hood clouds were breaking up. A record gust of wind of 122 km/h was recorded by Lander 2. The Landers continued to take soil samples for analysis.

The received signal level continued to improve by 0.5 dBm per week because of the shortening distance between Mars and Earth. December telecommunication links had improved to a point 10 dB stronger than levels recorded one year earlier. The December performance is summarized as follows:

Orbiter link quantity (high-gain antenna)	Dec. 1976	Dec. 1977
Uplink AGC, 64-meter, 20 kw, no modulation	−109 dBm	−99 dBm
Downlink AGC, 64-meter, single subcarrier	−143 dBm	−133 dBm
X-band downlink AGC, 64-meter	−153 dBm	−143 dBm

B. Spacecraft Problems

The Viking project declared a spacecraft emergency on November 1, when Orbiter 2 indicated a leaking yaw-axis attitude control jet. The Deep Space Station in Spain (DSS 62) was brought up to fill a tracking gap between DSS 43 (Australia) and DSS 11 (Goldstone). The leak was stopped by sending commands to perform a yaw turn and clear the leaky valve and then the Reaction Control Assembly (RCA) was commanded off.

Viking Orbiter 1 (VO-1) showed a small roll axis gas leak on November 18. DSS 62 was released early by the Voyager project so that data could be obtained to check the gas leak. When data came into lock, telemetry indicated that the leak had cleared itself. Monitoring continued for the next two days and performance was normal. It was thought that this particular gas leak was caused by a particle which cleared itself.

On November 25, VO-1 again showed a possible gas leak in the yaw-axis. DSS 62 was obtained to monitor the data. Analysis determined that the leak indications were not caused by a microleak but were due to a strong and variable gravity gradient torque experienced near periapsis, with Arcturus as the reference star. The effect was later confirmed using a computer model.

A problem first noticed during the interplanetary cruise phase of the mission was noted again in mid-October and continued sporadically throughout this reporting period. The Viking Orbiter highrate data content interferes with the low-rate signal-to-noise ratio. When either Orbiter is in the dual subcarrier mode at a data rate of 8 kbps or 16 kbps the 33.333 bps low-rate SNR is seen to fluctuate by several dB. The effect is most notable during an all zeros data condition. Sidebands of the high-rate channel occur near the 24-kHz low-rate subcarrier and in some cases are strong enough to cause the stations Subcarrier Demodular Assembly to lose lock.

C. Maneuvers

There were no propulsive maneuvers during this reporting period. Nonpropulsive maneuvers continued to occur on both Orbiters in order to take pictures and to support the Bistatic Radar experiment.

D. Radio Science

Radio Science activities and experimentation continued during November and December. There were 7 Near Simultaneous Lander/Orbiter Ranging passes during the period. Gravity Field experiment data taking occurred nearly every day during the period.

Occultation data was collected during the period except during the times in which there was no DSN coverage, a Bistatic Radar pass, Viking Lander Ranging, or a spacecraft roll maneuver.

Viking Orbiter 2 occultations began on November 19 and will continue through January of 1978.

Differential VLBI coverage occurred on 7 days during the period. The Owens Valley Radio Observatory and the Haystack Observatory in Massachusetts supported this experiment using Viking Orbiter 1 data.

Two new Radio Science experiments began during this reporting period. The Gravity Wave Experiment, using DSS's 14 and 43 and Orbiters 1 and 2, was conducted on 12, 14, 23, and 29 December.

This experiment requires six hours of closed-loop two-way, S/X-band doppler, taken at a sample rate of one sample per second. It also requires simultaneous two station tracking with two and three way S/X doppler for one hour taken at the one sample per second rate.

The second new experiment which began during this period was Bistatic Radar (BSR). The Bistatic Radar experiment requires the Viking Orbiter high-gain antenna to be pointed at the Martian surface. The transmitted signal is reflected off the surface of Mars and received and recorded on the occultation open-loop receivers and analog recorders at DSS 14 and/or 43.

There are two types of observations. During a "Specular Reflection" pass the Orbiter high-gain antenna pointing is maintained for an angle of incidence equal to the angle of reflection towards Earth. The reflection point scans the surface of Mars because of orbital motion. Figure 1 illustrates the geometry of a Specular Reflection pass. Of primary interest during these BSR passes are the northern, middle, and polar latitudes of Mars, which cannot be studied from Earth.

For "Fixed Target" passes, the high-gain antenna is pointed at a fixed location on Mars. Figure 2 shows a Fixed Target pass. This type of BSR pass will investigate the equatorial region of Mars to develop information on known sites of interest.

Table 1 lists potential Bistatic Radar targets.

Figure 3 shows the station configuration for this experiment. The reflected signal contains information about Martian surface roughness and electrical properties. Similar experiments have been conducted using earth based transmitters for radar studies of Mars. Bistatic Radar passes took place beginning November 8. A total of 10 passes were used during this reporting period.

Stations have been able to maintain some closed loop receiver lock during Bistatic Radar passes. This is believed to be lock on a sidelobe of the Orbiter high-gain antenna. Although the received signal level is relatively weak, at times it increased to the point at which telemetry lock was achieved.

E. Spacecraft Tests

Routine spacecraft testing continued during November and December. Orbiter Command Detector Unit (CDU) signal-to-noise ratio estimator (SNORE) tests were conducted on an average of two per week. High-gain antenna calibrations were also performed.

Effective December 7, the routine CDU SNORE checks were cancelled. Stations were having difficulties setting low output transmitter power levels with the provided calibration time. Without accurate settings, the SNORE test results were questionable. Future tests will be scheduled periodically and appropriate precalibration time provided to insure valid output power levels.

II. Network Support

Table 2 shows the Viking Extended Mission (VEM) Tracking Support for 1977. Noticeable during this period is the fact that December produced more tracking passes than November but had less tracking hours. This resulted from shorter passes throughout the network.

Table 3 gives the total number of commands transmitted by the DSN for the Viking project during 1977. The monthly total number of commands has declined since the record amount transmitted during September of this year. Fewer commands were sent in November than any other month of 1977.

Table 4 identifies the DSN VEM Discrepancy Reports generated during the period and 1977. The total number of open discrepancy reports has been on the increase since September.

A. Operational Use of Ampex FR-2000A Recorders

Ampex FR-2000A analog recorders were installed at each of the 64-meter DSN stations under engineering change order 75.291 early in 1976. These machines were used for playback of baseband analog data previously recorded on FR-1400 type of recorders.

Data was available from either Subcarrier Demodular Assembly (SDA) detected data output or from receiver baseband.

Following the MDS implementation, SDAs at 64-meter stations were reduced from six to four and of these four, only two detected data outputs were recorded on analog tape. This coupled with the requirement to record the third RF carrier when more than two spacecrafts were being tracked caused more reliance on baseband recovery.

By September 1977, the analog baseband record and replay capability had deteriorated below acceptable operational levels of performance and impacted the quality of operational Viking support. Attempts at corrective action did not improve the overall situation.

The Viking Tracking and Data Acquisition Manager established a task team on September 16, 1977 to coordinate the work necessary to reestablish analog baseband record and replay as a dependable operational capability.

The task team determined that reliable analog record and replay could be accomplished by:

(1) Recording and replaying data on the FR-2000A recorders.

(2) Changing track assignments to effect better replay characteristics by reducing interference between adjacent tracks (see Tables 5 and 6).

(3) Recording baseband data only.

The conditions underwhich this capability could be made available for operational use are as follows:

(1) A 5-minute gap in recording every 30 minutes was required to change tapes since only one FR-2000A recorder had been implemented at each 64-meter station.

(2) An additional 30 minutes of prepass preparation time was required to set up the tape machines.

(3) Analog recordings would only be made if the minimum specified signal-to-noise ratios were met.

(4) A failure of the prime recorder would result in a loss of analog data since no backup existed.

Successful demonstrations of the analog baseband record and replay capability were run with DSS 14 on November 18, and with DSS 43 on November 25. DSS 63 was down for the MDS reconfiguration and no demonstrations were possible with this station.

The Viking Project Manager approved this new plan on November 22 with the single qualification that the project might choose the time at which the recording gaps would occur so as to minimize the loss of critical data.

The FR-2000A recorders were authorized for use for all project support on December 2, 1977. The Network Operations Plans for each project were revised to show the new analog recorder configuration.

III. DSN Mark III Data Subsystem Implementation MDS Testing and Status

Except for DSSs 11, 61, and 63, all stations had completed the MDS implementation and testing prior to this reporting period. DSS 61/63 was released from tracking support on 15 October 1977 to begin it's implementation phase. The testing phase is scheduled to begin on 1 January 1978. DSS 11 will begin the MDS upgrade on 15 January 1978.

Table 1. Potential Bistatic-Radar targets

	Target	Prior radar inferences	Other information	Questions
A	Chryse Basin	Above average dielectric constant and roughness	Large number of surface rocks; Viking 1 site	Basin Characteristics Are surface rocks detectable?
B	Utopia	No data	Large number of surface rocks; Viking 2 site	Are surface rocks detectable?
C	Apollinares-Memnonia C site area	Variable echoes, generally weak; high diffuse-to-specular ratio	Low plains with little relief; surface features subdued	Nature of high angle scattering
H	Hellas	No data	Southern basin; few features	Basin Characteristics?
Pl	Plateau	Strong, sharp echoes; average dielectric constant; unusually smooth	Massive (recent?) flows; low crater counts	Scattering function in very specular region?
Po	Polar regions	No data	Ice forms, terracing, sculpturing	Polar characteristics?
T	Tharsis	Weak, diffuse echoes	Volcanic ridge and flanks	Nature of weak scattering?
S	Soviet landing sites	No data	Cratered uplands; basin	Possible clues to mission failures
SM	Syrtis Major	Strong echoes; smooth surface	Wind-blown surface; variable albedo	Basin characteristics?

Table 2. VEM tracking support 1977

DSS	Tracks[a] / h	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	1977 Total
11	Tracks	23	22	10	17	38	40	44	42	26	40	35	42	379
	h	135	142	100	118	228	289	322	343	210	408	310	320	2925
12	Tracks	4	1	—	24	17	1	1	1	—	—	—	—	49
	h	11	6		176	119	4	1	7					324
14	Tracks	52	59	50	20	—	—	10	16	28	43	41	45	364
	h	341	392	368	176			46	126	363	329	358	254	2753
42	Tracks	21	25	58	17	17	14	10	—	—	14	18	20	214
	h	247	226	453	138	162	112	69			100	116	126	1749
43	Tracks	68	62	—	63	60	57	31	—	1	24	36	48	450
	h	721	627		603	521	486	238		01	141	214	196	3748
44	Tracks	—	—	7	1	—	—	16	26	6	12	—	—	68
	h			7	4			99	166	22	51			349
61	Tracks	35	29	12	40	54	51	37	35	38	22	—	—	353
	h	261	227	72	317	461	475	337	322	345	203			3020
62	Tracks	—	2	4	9	3	2	—	—	—	3	5	9	37
	h		7	22	55	14	7				23	28	36	192
63	Tracks	38	28	66	15	23	15	40	64	57	15	—	—	361
	h	327	202	525	78	186	136	399	590	590	136			3169
Total	Tracks	241	228	207	206	212	180	189	184	156	173	135	164	2275
	h	2043	1829	1547	1665	1691	1509	1511	1554	1531	1391	1026	932	18229

[a]Number of tracks represent the summation of all Viking spacecraft tracked. Track time, in hours, represents scheduled station support.

Table 3. Number of commands transmitted in Viking Extended Mission during 1977

DSS	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	1977 Total
	CMDS												
11	1,521	1,394	1,027	117	811	-0-	1	795	2,028	3,687	3,064	4,746	19,191
12	-0-	-0-	-0-	1,314	721	-0-	-0-	-0-	-0-	-0-	-0-	-0-	2,035
14	769	1,404	1,206	274	-0-	-0-	74	108	2,704	2,108	1,134	1,589	11,370
42	2,072	953	1,778	8	1,886	1,619	-0-	-0-	-0-	18	1,250	-0-	9,589
43	919	2,523	-0-	2,094	1,447	972	1,190	-0-	-0-	456	656	491	10,748
44	-0-	-0-	2	1	-0-	-0-	-0-	5	19	2	-0-	-0-	29
61	605	1,116	1,328	1,925	1,922	3,838	4,257	5,589	5,256	1,371	-0-	-0-	27,207
62	-0-	-0-	1	1,991	-0-	496	-0-	-01	-0-	-0-	14	5	2,507
63	795	472	2,039	381	675	383	2,579	2,318	1,610	847	-0-	-0-	12,099
Total	6,681	7,862	7,381	8,105	7,462	7,308	8,101	8,815	11,617	8,489	6,118	6,831	94,770

Table 4. DSN VEM discrepancy reports

DSS	O[a] / C[b]	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
11	O	4	3	4	1	2	2	2	1	1	1	2	1
	C	0	4	6	3	3	6	7	7	1	3	2	4
12	O	4	0	0	5	7	0	0	0	0	0	0	1
	C	0	0	0	2	5	7	0	0	0	0	0	0
14	O	14	11	4	3	2	0	6	4	5	10	14	7
	C	2	19	33	9	2	2	2	18	14	24	13	16
42	O	0	2	0	0	0	0	0	0	0	1	3	3
	C	1	3	7	2	0	0	0	0	0	0	2	3
43	O	10	11	0	9	8	2	1	0	0	0	3	11
	C	13	10	12	11	17	14	6	1	0	5	7	14
44	O	0	0	0	0	0	0	1	1	0	0	0	0
	C	0	0	2	1	0	0	0	4	1	0	0	0
61	O	1	1	0	0	1	0	1	0	0	0	0	0
	C	9	6	3	1	2	6	4	7	4	4	0	0
62	O	0	0	1	2	0	0	0	0	0	2	0	2
	C	0	8	2	1	2	1	0	0	0	0	2	0
63	O	1	7	1	0	4	3	4	9	8	4	1	0
	C	4	3	18	6	4	12	4	17	17	7	5	1
Others[c]	O	4	3	2	4	7	10	8	5	7	10	13	13
	C	3	9	10	7	12	13	16	9	8	15	21	13
Total	O	38	38	12	24	31	17	23	20	21	28	36	39
	C	32	62	93	43	47	61	39	63	45	58	52	51

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

[b]C = Number closed during month.

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

Table 5. FR-1400 analog recorder configuration showing high-density track assignments leading to interference between adjacent channels[a]

Track	Data		
	IRIG channel	Function	VCO center frequency kHz
1	5	RCVR 1 DAGC	1.30
	6	RCVR 2 DAGC	1.70
	7	RCVR 3 DAGC	2.30
	8	RCVR 4 DAGC	3.00
	A	Voice	22.00
	C	CMA 1	40.00
	18	CMA 2	70.00
	19	NASA time	93.00
2		RCVR 3 baseband	Direct
3		RCVR 1 baseband	Direct
4		RCVR 4 baseband	Direct
5		RCVR 2 baseband	Direct
6		Speedlock (100 kHz)	Direct
		SDA 2 output	525.00
7		Speedlock (100 kHz)	Direct
		SDA 1 output	13.50

[a]Tape speed to be 1.52 m/s (60 in./s).

Table 6. FR-2000 analog recorder configuration showing reallocation of track assignments to reduce adjacent track interference[a]

Track	Data		
	IRIG channel	Function	VCO center Frequency kHz
1	19	NASA time	93.00
2		RCVR 3 baseband	Direct
3		RCVR 1 baseband	Direct
4		Speedlock (100 kHz)	Direct
5		Speedlock (100 kHz)	Direct
6		RCVR 4 baseband	Direct
7		RCVR 2 baseband	Direct

[a]Tape speed to be 1.52 m/s (60 in./s).

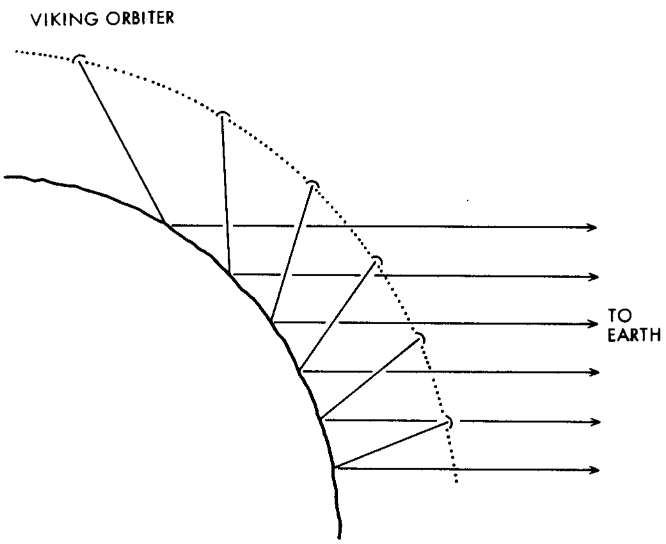

Fig. 1. Specular reflection pass

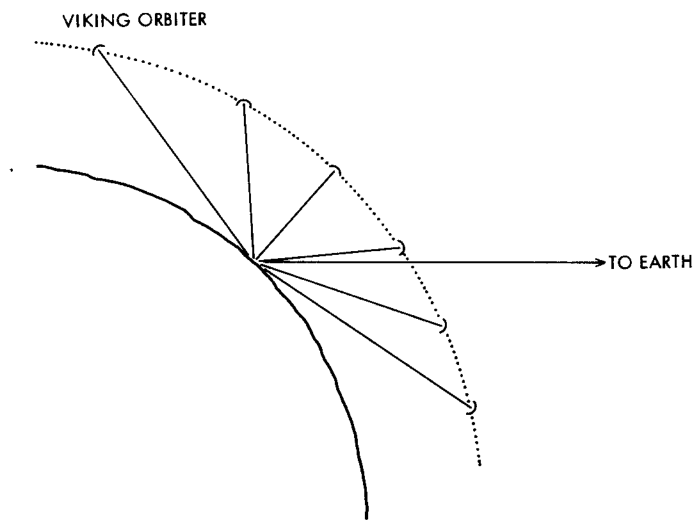

Fig. 2. Fixed target pass

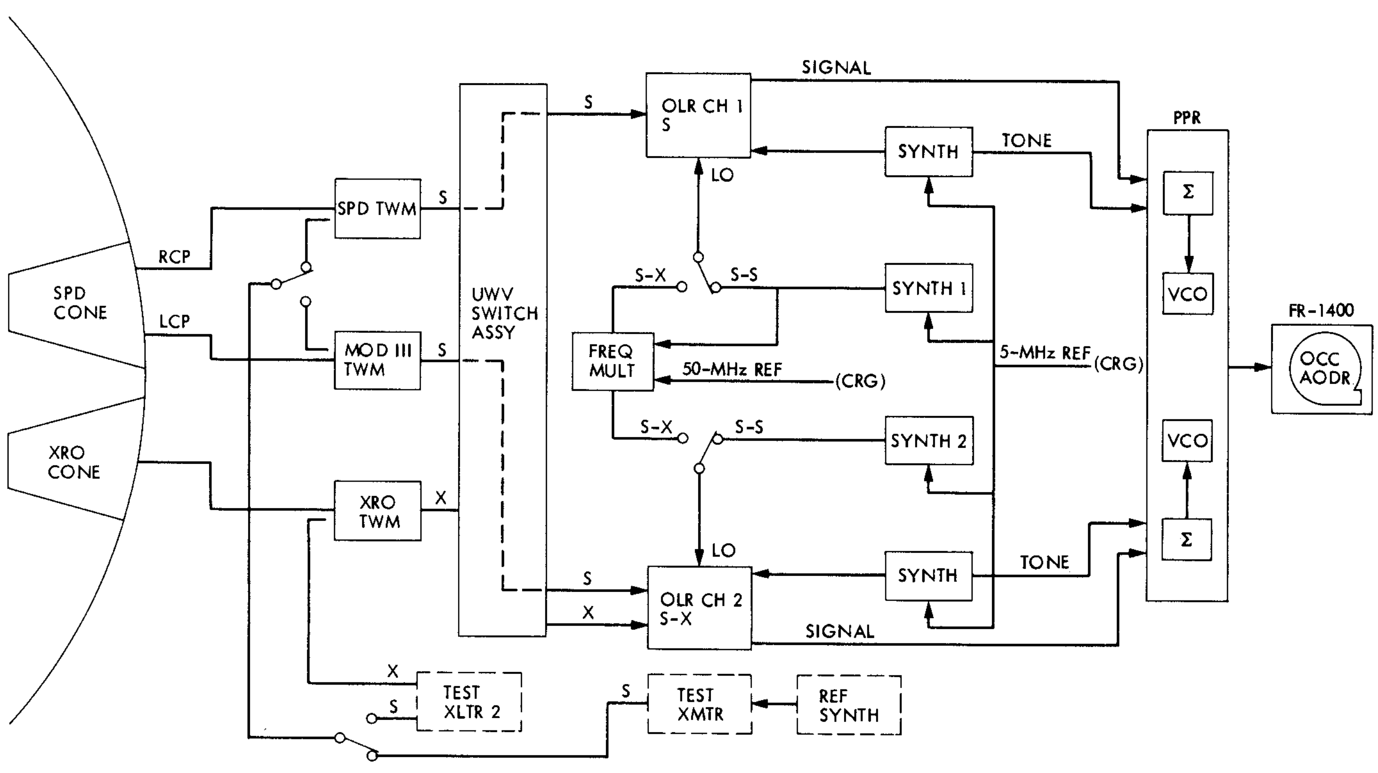

Fig. 3. Bistatic Radar DSN station configuration