JPL PUBLICATION 82-18

Telecommunications and Data Acquisition Systems Support for the Viking 1975 Mission to Mars

1 June 1978 to 30 April 1980

W.E. Larkin

April 15, 1982

NASA
National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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The research described in this publication was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

PREFACE

This report is a continuation of a documentation effort describing the Telecommunications and Data Acquisition Systems support of the Viking 1975 mission to Mars in five volumes corresponding to the five major phases of the Project. The first four volumes of the series have been published as JPL Technical Memorandum 33-783, Volumes 1 through 4.

The first volume presents organization, planning, implementation, and test activities from inception of the Project in 1969 to launch operations in 1975. Cruise-phase activities for both spacecraft from launch through Mars orbit insertion and the landing of Viking 1 are described in the second volume. The third volume discusses the support provided for the Mars orbit insertion and landing of Viking 2 and the landed operations of both spacecraft until the end of the prime mission on 15 November 1976. The fourth describes the Extended Mission support activities beginning in November 1976 and continuing through May 1978. This volume, the fifth, describes the Continuation Mission support activities beginning 1 June 1978 and ending 28 February 1979, the Survey Mission 1 March 1979 to 6 November 1979, the Orbiter Completion Mission and the Lander Monitor Mission. The latter two started on 6 November 1979 and continued through 30 April 1980.

The Telecommunications and Data Acquisition Systems activities described in this report were managed and/or carried out by the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California, under Contract NAS7-100 sponsored by the National Aeronautics and Space Administration.

N. A. Renzetti
Manager, TDA Mission Support

ABSTRACT

This document describes the support provided by the Deep Space Network to the Viking Project from 1 June 1978 to 30 April 1980. The Viking Project was supported by the worldwide network of Deep Space Stations with 26- and 64-meter-diameter antennas, together with a ground communications system, for the transmission of commands, telemetry, radio metric data, and operational instructions between the stations and the Network Operations Control Center (NOCC) in Pasadena, California. The support was substantially less than in the previous phases of the Viking Project in order to provide adequate support to the Pioneer and Voyager Projects.

CONTENTS

I. INTRODUCTION

A. MISSION BACKGROUND

At the commencement of the Continuation Mission, management of the Viking Project was transferred from the Langley Research Center to the Jet Propulsion Laboratory. During the earlier phases of the mission, the flight team numbered about 800 personnel. Reductions in this number began during the Extended Mission, and by the conclusion of the Continuation Mission, the flight team was reduced to about 150 personnel. JPL support for the spacecraft was reduced from 168 hours per week to a normal 40 hours per week, except during periods of spacecraft problems. A major factor in the reduced work load was the implementation of repetitive and automatic operations of Viking Landers 1 and 2 (VL 1 and 2), eliminating the necessity for daily intervention by ground controllers. This reduction in work load allowed the Deep Space Stations and other support personnel to redirect their efforts to the support of the Pioneer and Voyager Projects. The number of Project support personnel declined steadily until only 27 were supporting Viking at the conclusion of the Lander Monitor Mission. A corresponding decrease in station support level proved adequate for the new operations philosophy.

An integral part of the operations philosophy that contributed to the reduction in Viking Project manpower was the willingness to accept more than the normal level of risk, to be satisfied with less than perfection, and to postpone or forego sequences if their implementation became unduly time-consuming. The established procedures for sequence generation and commanding were streamlined and simplified, bypassing the many segments intended to provide visibility and checking.

At the beginning of the period of this report, the depletion of expendables had started to take their toll on the Viking orbiters and landers. Although Orbiter 1 (VO-1) was still performing in a normal manner, Orbiter 2 (VO-2) continued to be plagued by intermittent gas leaks in the yaw-axis gas jets. To maximize the value of returned data from the ailing spacecraft, VO-2 was commanded to the roll drift mode. In this mode, the spacecraft was perturbed by unmodeled forces and eventually started to roll. When this occurred, only the engineering data was meaningful, since science data required a stable spacecraft. Through the engineering telemetry stream the various subsystems of the spacecraft were observed. In mid-June 1978, the spacecraft was commanded out of the roll mode; its instruments were trained on the northern latitude of Mars to obtain water vapor and temperature measurements, and upon completion of these measurements, it was returned to the roll drift mode.

In late May 1978, VL-1 was placed in a six-month automatic condition. VL-2 was also placed in this mode in mid-June. The Landers continued to send weather, soil chemistry calibrations, and photographic information throughout this six-month unattended period.

The Project was concerned about the danger to VO-1 whenever it was commanded from the roll drift mode to a roll stabilized mode. If a yaw valve with a history of intermittent operations failed to seat properly, a round-trip light

time of 30 minutes would elapse before the situation was detected on earth and corrective commands were received by the spacecraft. The Computer Command Subsystem (CCS) aboard the spacecraft was reprogrammed to react to the roll data contained in the telemetry stream. As a result, any malfunction formatted in the contents of the telemetry system would be instantly detected by the CCS and corrective action internally generated aboard the spacecraft without the 30-minute time delay. This was an excellent example of the Viking Project's ability to react to abnormal situations and arrive at workaround procedures to assure continued success of the mission.

Approval was received to begin the Viking Continuation Mission (VCM) on 1 June 1978. Data collected from the orbiters increased, while information gathered by the landers was deemphasized. The main purpose of the VCM was to collect one Martian year of observations of the planet, and to fill in orbiter pictorial data that had been lost or degraded during Sun occultation periods. Radio Science activities including near-simultaneous lander-orbiter ranging, occultation and gravity fields experiments were observed. During this phase of the mission, the landers were in the automatic mode.

On 20 July 1978 VO-2 was again commanded out of the roll drift mode. It continued to send data until 24 July when a severe gas leak caused the remaining gas to be depleted. On 25 July 1978 the transmitter aboard VO-2 ceased operating. VO-1 continued to operate in a normal manner sending weather and photographic information to the DSN stations.

The time required to process Intermediate Data Records (IDRs) continued to show improvement, with delivery time reduced from 23 hours to less than 7 hours. This improvement can be attributed to the installation of additional equipment, changes in tape handling procedures and the assignment of an engineer dedicated to improving the IDR situation.

At an earlier date a failure had occurred in Transmitter #1, which is one of the direct links from the VL-2 to Earth. On 25 October 1978 a command was sent to the spacecraft to turn on Transmitter #2. This transmitter had been used only briefly immediately after touchdown and for a short period during the Viking Extended Mission. Transmitter #2 failed to respond to the commands and, as a consequence, information from VL-2 could be relayed to Earth only via VO-1. The lander-to-orbiter transmitters were still functioning, but both lander-to-Earth transmitters had failed. Now direct lander-to-Earth communications were impossible.

On 19 February 1979, commands were sent to VL-1 terminating the Lander Continuation Automatic Mission (LCAM), and new commands were sent placing that lander in a post-LCAM mode.

A new philosophy for sending commands was introduced. Previously the command routing had been from the Mission Control and Computing Center (MCCC) located at JPL to the Command Processor Assembly (CPA) located at the Deep Space Stations. New operational procedures bypassed the MCCC, and commands were manually loaded into the CPA at the station. Execution of the commands was initiated by verbal instructions to the station.

Both landers continue to collect meteorology and imaging data. VL-1 should be able to return data either directly to earth or relayed through VO-1 until 1990. VL-2 will be able to send data only as long as VO-1 can maintain its relay capability.

The Network generated near-simultaneous lander-orbiter ranging and Radio Science data during the conjunction period occurring between 1 December 1978 and 1 March 1979. General relativity experiments and the effect of the solar corona on the radio frequency link were observed.

The next phase of Viking support, the Survey Mission, started at the conclusion of the Continuation Mission and ceased on 31 October 1979. The Survey Mission acquired high resolution contiguous coverage using the Visual Imaging System (VIS). Possible landing sites for future missions were evaluated. The landers continue to provide the unique capability for the Network to track a transponder on the surface of another planet of our solar system and generate data to increase our knowledge of Earth-Mars dynamics. Long-range observations of surface activity or changes and meteorological cycles were investigated.

Throughout the Survey Mission, the landers remained in the automatic mode, operating autonomously on programs stored in their onboard computers. VL-1, because of its direct Mars-to-Earth communications capability, was able to collect and transmit a greater variety of data than VL-2, which had its data rates reduced because of the necessity of relaying through VO-1.

To help alleviate the loading problem placed on the DSN capacity by Voyager and Pioneer Projects, VO-1 was placed in the housekeeping mode on 25 March 1979. In this mode only engineering data was transmitted from the spacecraft. The science systems were deactivated. New operating and safing sequences and instructions were stored in the VO-1 CCS, making the spacecraft as self-sufficient as possible. Daily contact was not required, but VO-1 was interrogated about once every two weeks to check on its status. This mode continued until 15 July 1979. Special tracking was scheduled to play back about 70 VIS photos that were stored on the spacecraft tape recorder. Other special tracking was required to relay data collected by VL-2 in May 1979.

Viking support activity increased later in 1979, and by the end of the year about 300 pictures per week were being received and processed by the Project. On 6 November 1979 a trim maneuver ended the Survey Mission and signaled the start of the Viking Orbiter Completion Mission. Now the orbiter would concentrate its activities on completing imaging areas of Mars not previously photographed, or retaking photographs of surface areas inadequately covered in earlier picture-taking efforts.

During the early part of 1980, both landers continued in the same mode that had provided so much surface data during the previous mission. Major modifications to the Ground Communications Facility (GCF), in preparation for the next mission phase (Fig. 1), were accomplished with little impact on this Project. In January, because of the geometry of Mars, the celestial sphere and Earth, an unambiguous bright star could not be located with enough certainty to assure that the orbiter high-gain antenna would be pointed at the Earth. The Project elected to switch the spacecraft-to-Earth link from the high-gain antenna to the omniantenna. The weaker signal affected operations, but by

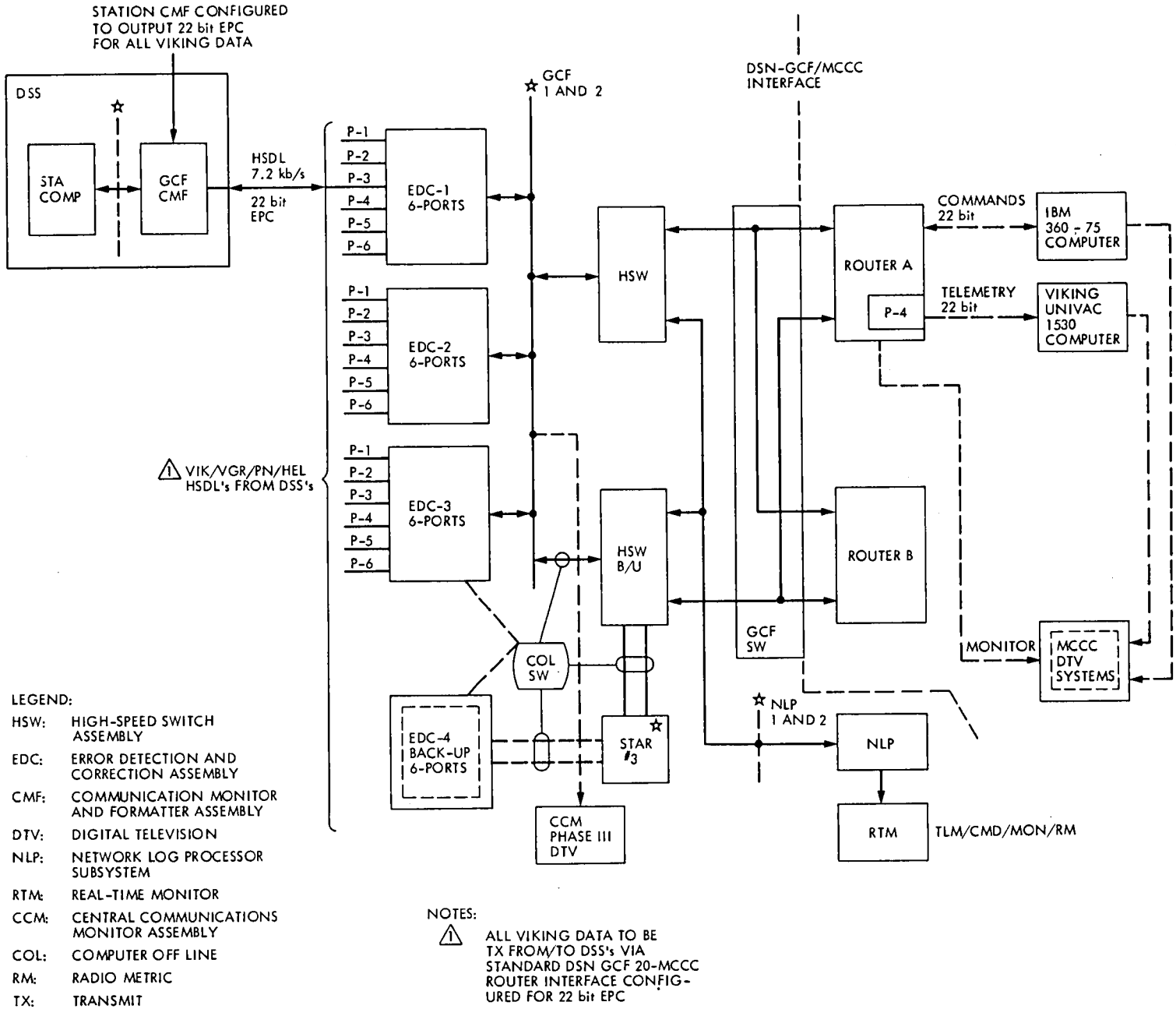

Figure 1. Viking Orbiter Completion Mission and Viking Lander Monitor Mission

February the geometry had changed enough to again employ the high-gain antenna for the spacecraft-to-Earth link.

In late 1979, VL-1 became a separate mission called the Lander Monitor Mission (LMM). This was concurrent with VO-1 being designated the Orbiter Completion Mission (OCM). VL-1 ranging data had a high priority, but meteorology and imaging data were also obtained. The lander operated in the autonomous mode from previously stored loads to the onboard sequencer.

The orbiter was occulted by Mars on a daily basis, giving the Radio Science team an opportunity to determine atmospheric fluctuations every 24 hours. A better understanding of the topographic features of Mars was obtained during these occultations. VO-1 cameras continued to function, sending back to Earth high-quality photographs of the Martian surface features. The photograph mosaic shown in Fig. 2 was taken on February 1980.

During March and April of 1980 the landers remained in the autonomous mode; only one command was sent during this two-month period. An intermittent failure which had previously plagued VL-2 reappeared. It is believed it was aggravated by the elevated temperatures of the Martian summer. The inorganic analysis experiment continued processing its last surface sample.

The atmosphere and topography of Mars were studied using the spacecraft's unique ability to transmit at both S- and X-band frequencies. Network-generated data from these signals showed meteorological variations in temperatures and extensive inversion layers. Electron density profiles of the light and dark sides of the planet were noted. Occultation data was used to correlate topographic features (Ref. 1).

Network-generated doppler data were helpful in the determination of parameters of the physical ephemeris of Mars, while ranging data helped refine the Mars/earth ephemeris (Ref. 2). Radio metric data obtained during occultation of the spacecraft revealed much about the shape of the planet. Radio metric measurements also helped define anomalies in the gravity field (Ref. 3).

When the Viking spacecraft was at conjunction, the mass of the sun affected the path of the radio signals. This was detected by range data generated by the Network with an estimated 0.1% accuracy of the prediction of the general theory of relativity (Ref. 4).

During 40 orbits, the spacecraft was used as a CW radar transmitter. Its high-gain antenna was pointed at the Martian surface, and reflected signals were detected by the 64-meter antennas of the DSN. The reduced data from these reflected signals revealed roughness and electrical properties of the surface (Ref. 5).

B. BACKGROUND INFORMATION

JPL Technical Memorandum 33-783 (Volumes 1-4) describes the previous tracking and data systems support for the Viking 1975 Mission to Mars.

Volume I. Prelaunch Planning, Implementation, and Testing, by D. J. Mudgway and M. R. Traxler, dated January 15, 1977.

Volume II. Launch Through Landing of Viking 1, by D. J. Mudgway and M. R. Traxler, dated March 15, 1977.

Volume III. Planetary Operations, by D. J. Mudgway, dated September 1, 1977.

Volume IV. Extended Mission Operations, by D. J. Mudgway, dated December 15, 1978.

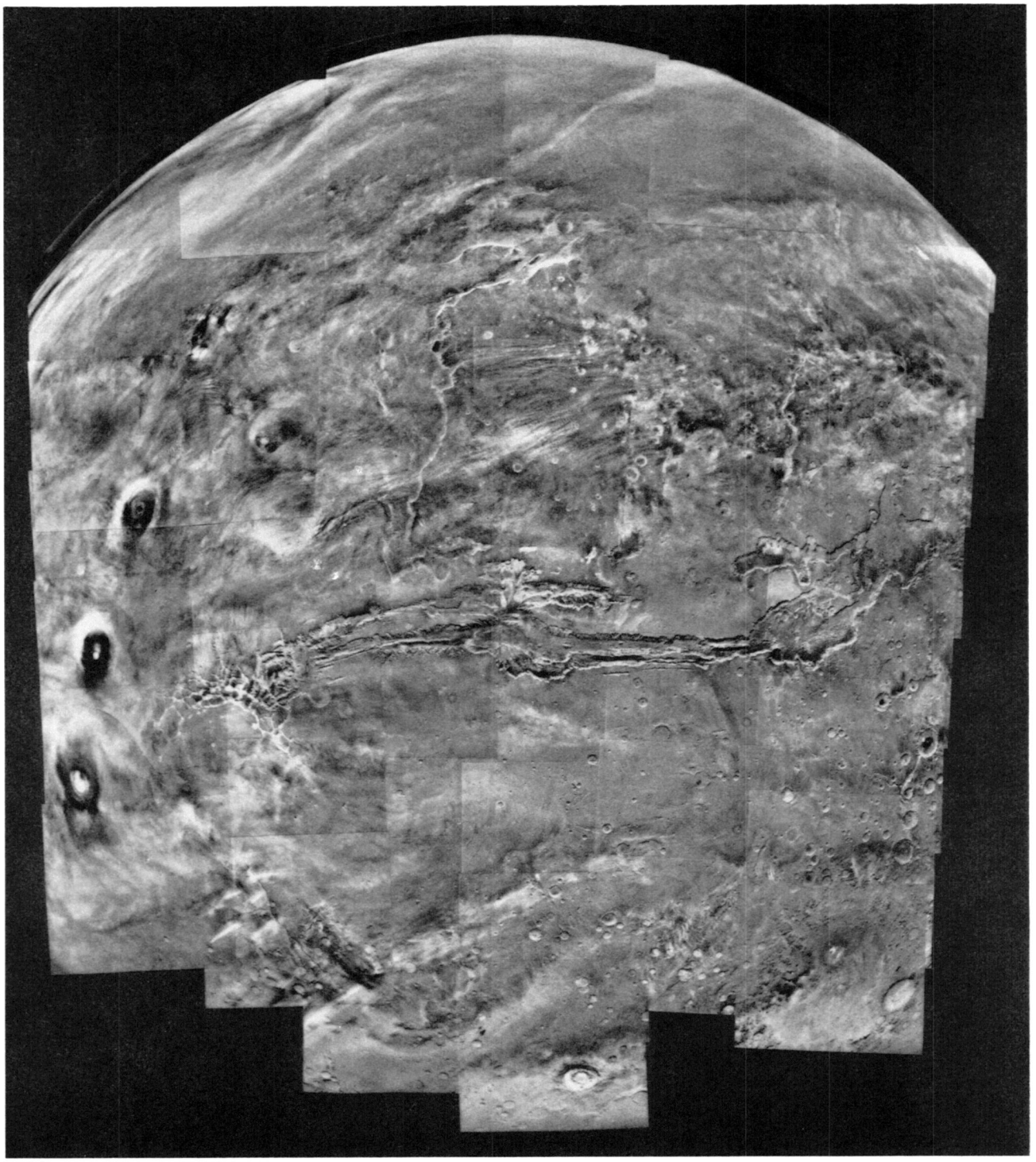

Figure 2. Viking Orbiter 1 Mosaic

II. VIKING CONTINUATION MISSION OPERATIONS

A. JULY - AUGUST 1978 (Ref. 6)

Owing to serious gas leaks in the roll-axis control jets, the VO-2 spacecraft continued in a roll drift mode of operation during the major portion of this reporting period. In this mode, the roll control jets are disabled, allowing the spacecraft to slowly roll as it orbits around Mars. During the roll drift mode the VO-2 spacecraft could not observe Mars with its science instruments. However, engineering data monitoring the status of the spacecraft continued to be transmitted to Earth.

The Viking orbiter flight software in the CCS was updated to provide for downlink telemetry monitoring. During roll maintenance on May 8 and June 1, the VO-2 CCS successfully issued a series of commands to the Attitude Control Subsystem. As a result of the onboard telemetry monitoring, both the May 8 and June 1 operations were successful on the first try. Backup procedures were available to clear the valve by a series of earth-based commands if necessary, but they were not needed. The spacecraft automatically terminated roll drift, sampled the data, checked for leaks and returned from roll inertial mode to the roll drift mode.

For the first time, a JPL operationally supported spacecraft used onboard processing of telemetry data for spacecraft control, representing a milestone in spacecraft operations. All previous responses to unusual circumstances had been specified prior to launch and implemented into the CCS. Using telemetry monitoring, a large number of parameters or functions of sets of parameters can be used to control the spacecraft autonomously. The daily loading of lander commands was terminated, but one lander could communicate with Earth directly; range measurements by the Network continued to be made for another year.

All three orbiter science experiments were continued, but their observational sequences were simpler and more repetitious than previously. After 1 December 1978, their operation will be terminated or still further reduced. The operational aspects of the Viking Mission were planned to be terminated on 28 February 1979. Figure 3 shows the Viking Continuation Mission Profile strategy.

During the Viking Continuation Mission, radio science investigations, including the occultation experiment, local gravity anomaly experiment, and lander ranging were continued, and during the next solar conjunction period in December, January, and February the solar corona and relativity experiments will be repeated.

During the May and June period, over 75% of Network support was from the 64-meter subnet. This was due primarily to the Earth-Mars distance, which required the additional 8-dB antenna gain of the 64-meter antenna versus the 26-meter antenna to obtain the Viking high-rate telemetry data. Also noticeable during the May and June period was the reduction in total Network communications support, which followed the basic guidelines of a reduced level of operations during the Continuation Mission. Command activity further reflects the lessened Project activity.

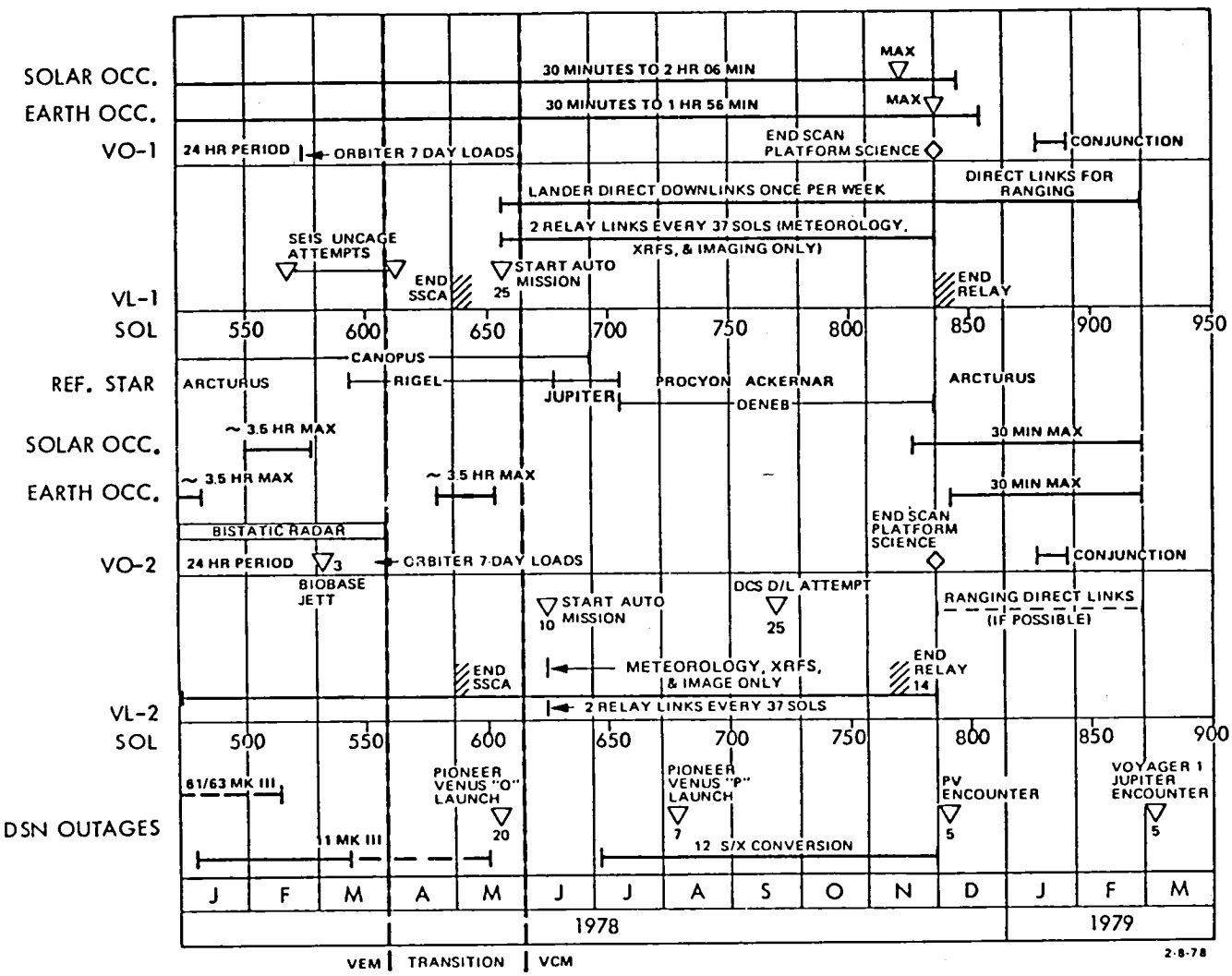

Figure 3. Viking Continuation Mission Profile Strategy

B. SEPTEMBER-OCTOBER 1978 (Ref. 7)

The VO-2 ceased operating during this reporting period after a severe gas leak depleted its remaining supply of attitude stabilizing gas. On 20 July, the VO-2 spacecraft was brought out of its roll-drift mode of operation to collect its last sequence of scientific observations of Mars. On 24 July the spacecraft developed a severe gas leak in the positive roll valve, and on 25 July drifted off Sun acquisition.

The Mars mission officially ended for VO-2 at 11:02 p.m. on 25 July 1978, when radio signals from the spacecraft were no longer detectable. Launched from Earth on 20 August 1975, VO-2 will now slowly tumble about Mars for at least 50 years before crashing to the surface.

The VO-1 spacecraft functioned normally during this reporting period as it collected and returned to Earth weather data and Mars photos, as well as relaying to Earth data from the two Viking landers. The Viking landers, operating in the automatic mode, collected and relayed to Earth, via VO-1, Mars weather information and photos.

Figure 4 shows the performance of Network delivery of the telemetry IDRs during January 1977 through August 1978. The IDR is a magnetic tape, produced by the Network, containing digital telemetry data. As a goal, within existing time constraints, the Network attempts to provide 100 percent of the data recorded at the Deep Space Stations on the Digital Original Data Record (DODR) magnetic tapes. IDRs are required to be delivered within 24 hours following the end of a station pass.

During July and August 1978, the IDR delivery time significantly improved from the previous months. The delivery time dropped from 23 hours to under 7 hours. In May 1978 a new position, titled Network Data Records Engineer, was created. The primary function of the Data Records Engineer was to resolve the IDR production conflicts among the many projects, including Viking. The improvement in IDR delivery times can be attributed to the coordination efforts of the Data Records Engineer.

During July and August an average of 99.1 percent of telemetry data received on Earth was delivered to the projects at the Jet Propulsion Laboratory in Pasadena.

C. NOVEMBER 1978 - APRIL 1979 (Ref. 8)

The VO-1 spacecraft continued to operate normally during this reporting period as it collected and returned to Earth weather data and Mars photos as well as relaying to Earth data from the two Viking landers.

The Survey Mission was the next phase of the Viking Mission. The Extended Mission terminated 31 May 1978, and the Continuation Mission terminated 28 February 1979. The orbiter operations in the Survey Mission terminated 31 October 1979, but the lander operations could continue through December 1990.

The objective of the Orbiter Survey Mission was to acquire high-resolution contiguous coverage, with the VIS, of a region on the planet that is likely to contain landing sites for a future Mars mission. The lander objectives were to take advantage of the unique capability of a transponder on a planet surface, to make frequent radio ranging measurements, and to conduct a long-duration monitoring of weather conditions and surface changes at the VL-1 site.

Because of pressure from Voyager and Pioneer for Network support, VO-1 was placed in a housekeeping mode, with all science instruments powered off, at the end of the Continuation Mission.

Viking Radio Science activities and experimentation continued during this reporting period. These activities include near-simultaneous lander/orbiter ranging, the general relativity experiment, and the solar corona experiment. The general relativity and solar corona experiments were conducted during the solar conjunction period of December 1978 through February 1979. Figure 5 illustrates the profile of a typical lander pass.

D. NETWORK SUPPORT

Table 1 shows Network communications support for the Viking Continuation Mission from June 1978 through 28 February 1979. Support decreased throughout the Continuation Mission, with a slight increase during the solar conjunction Radio Science activity in December and January. This reduction in overall Viking operation activity was anticipated during this period. An even further reduction in support occurred during the Viking Survey Mission. Table 2 gives the total number of commands transmitted by the Network during the Viking Continuation Mission.

E. SURVEY MISSION, MARCH - NOVEMBER 1979 (Ref. 9)

VO-1 continued to operate normally during this period, collecting and returning to Earth weather data and high-resolution surface photos, as well as relaying data from VL-2 (about 300 photos per week were returned from VO-1 during this report period). Both landers continued operating in a normal manner with VL-1 sending data directly to Earth on a weekly basis, and VL-2 sending data to VO-1, which relayed the lander data to the deep space stations.

On 6 November 1979, a Viking orbiter trim maneuver (MOT-20) officially terminated the Viking Survey Mission and the Viking Orbiter Completion Mission (VOCM) commenced. This phase of the mission was scheduled to conclude on 1 February 1980. The objectives of the VOCM were to obtain moderate-resolution photographic coverage of the Martian surface areas not previously photographed or adequately covered during earlier operations.

F. ORBITER COMPLETION MISSION, NOVEMBER 1979 - APRIL 1980 (Ref. 10)

During this period VO-1 continued to operate normally, collecting and returning weather data and moderate-resolution Mars surface photos, as well as relaying data from VL-2. VL-1 had weekly telemetry contact with the

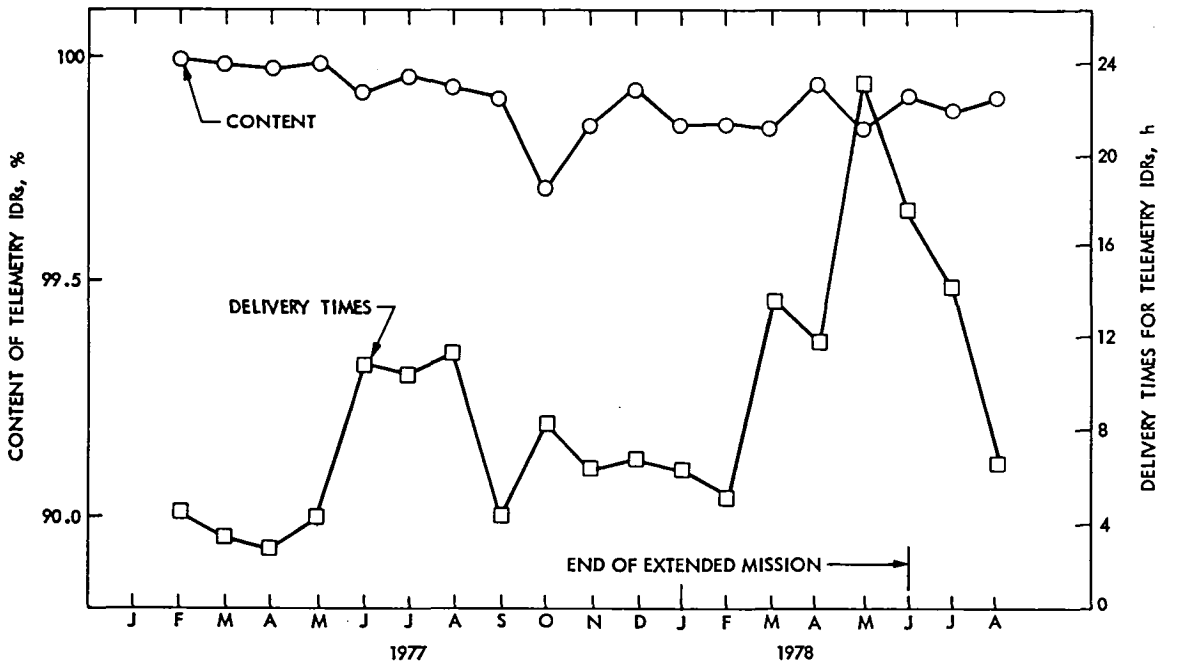

Figure 4. Viking Telemetry IDR Performance

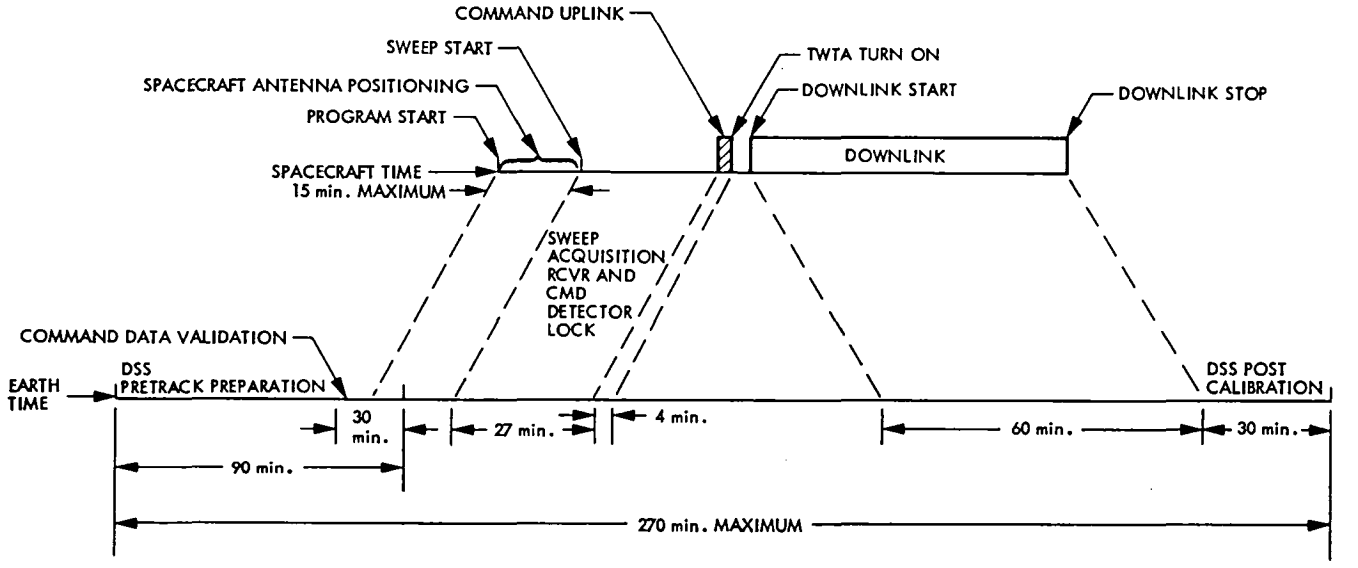

Figure 5. Typical Lander Pass

Table 1. DSN Viking Continuation Mission Communications Support

DSS	1978							1979												1980		
	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
11	1[a] 1[b]	2 13	–	1 3	–	–	1 2	–	8 32	5 14	2[a] 14[b]	4 31	2 11	3 17	–	1 6	1 3	2 11	–	2 15	3 15	3 21
12	–	–	–	–	–	4 20	2 5	7 20	20 145	8 23	2 6	2 5	2 13	1 3	–	–	–	–	–	–	–	3 15
14	34 242	14 89	13 85	3 12	9 48	13 51	13 29	23 45	3 4	1 8	–	–	–	6 33	22 91	15 65	12 62	8 64	6 52	2	7 49	–
42	–	2 9	1 3	–	4 22	–	6 23	6 19	8 39	4 15	5 19	4 20	2 10	–	1 5	2 10	–	–	–	–	–	–
43	46 346	51 449	23 135	28 188	27 181	17 116	23 188	26 122	12 49	1 8	6 31	–	–	6 40	1 5	1 1	1 6	–	2 13	2 8	1 8	2 17
44	3 17	–	3 11	–	–	–	1 5	1 2	–	1 4	–	1 4	–	1 3	4 18	–	3 12	–	–	–	–	1 5
61	–	–	1 5	–	–	–	1 8	3 19	2 7	1 3	–	3 10	1 4	1 4	–	–	–	–	–	–	–	1 11
62	3 33	1 7	1 9	–	–	–	1 8	3 9	–	2 7	1 6	–	–	–	2 2	1 4	–	–	–	6 41	3 20	2 10
63	41 343	40 291	16 130	21 157	18 114	22 130	23 130	8 53	4 7	1 7	1 5	2 12	1 10	13 50	29 131	27 105	19 104	15 119	16 142	2 14	11 101	17 158
Total	128 982	110 858	58 378	53 360	58 365	56 317	71 398	78 289	57 283	24 89	17 81	16 82	8 48	31 150	59 252	47 191	36 187	25 194	24 207	14 78	25 193	29 237

[a]Number of tracks; the summation of all Viking spacecraft tracked.

[b]Track time: scheduled station support in hours.

a/b

Table 2. Number of Commands Transmitted During the Viking Continuation Mission

DSS	1978							1979		
	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
11	6	0	–	0	–	–	0	0	1111	3
12	–	–	–	–	–	1	0	17	531	3
14	1214	870	562	0	2	694	149	0	0	4
42	0	0	0	–	0	–	0	0	1006	458
43	1567	791	7	70	252	648	1914	1141	419	8
44	0	–	30	–	–	–	332	0	–	0
61	0	–	0	–	–	–	0	15	0	0
62	960	0	683	–	–	–	0	15	–	5
63	2451	2984	2073	4988	3376	2690	8	53	3	4
Total	6198	4645	3355	5058	3630	4032	2403	1241	3070	485

ground tracking stations. Meteorology data and imaging were part of this telemetry stream. New GFC equipment was installed during this period, and a plan was developed to convert the Viking data block to the new format.

In January the orbiter science instruments were shut down, and the spacecraft continued to use the low-gain antenna due to the lack of a significantly bright star to maintain high-gain antenna pointing. In February the spacecraft was returned to normal operations.

On 6 November 1979 VL-1 became a separate mission, called the Lander Monitor Mission (LMM). The objective of the LMM was to obtain ranging data from the surface of Mars. Meteorology and imaging data were also returned on a periodic basis. Throughout the LMM the spacecraft was operated in an autonomous mode on programs that were previously stored in its onboard computer.

VO-1 was occulted by Mars for about 23 minutes every 24 hours. Network instruments operating on the radio signals received during the occultation entry and exit provided new information on several atmospheric fluctuations at the 5-km level, correlation of ionospheric plasma temperature with solar activity, and improved knowledge of several Martian topographic features.

G. LANDER MONITOR MISSION, NOVEMBER 1979 - APRIL 1980 (Ref. 11)

Both VL-1 and VL-2 remained in the automatic mode, performing repetitive observations on 37-day cycles. Only one command load was required for each lander during the entire period. The inorganic analysis continued to provide data on its final surface sample. Radio Science investigation included occultation experiments, local gravity anomaly observations, and Earth-to-spacecraft ranging. An intermittent failure in the VL-2 Data Storage Memory was probably a thermal problem aggravated by the high temperatures during the Martian summer.

GLOSSARY

VO-1	Viking Orbiter 1
VO-2	Viking Orbiter 2
VL-1	Viking Lander 1
VL-2	Viking Lander 2
CCS	Computer Command Subsystem
VCM	Viking Continuation Mission
IDR	Intermediate Data Records
LCAM	Lander Continuation Automatic Mission
MCCC	Mission Control and Computing Center
CPA	Command Processor Assembly
VIS	Visual Imaging System
GCF	Ground Communications Facility
OCM	Orbiter Completion Mission
LMM	Lander Monitor Mission
DODR	Digital Original Data Record
VOCM	Viking Orbiter Completion Mission

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