Viking Mission Support

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This report summarizes Deep Space Network support for the four Viking spacecraft during October and November 1976. The period covers the last portion of the prime mission which officially terminated on 15 November 1976 and the start of the Viking Extended Mission on that date. November also covered the Mars-Sun-Earth superior conjunction period with the rapid degradation of RF link performance resulting in the tapering off and termination of telemetry data coincident with a rapid increase in Radio Science Experiment activity. The various Radio Science Experiments are described in detail and the Computer Aided Countdown Program utilized by the tracking stations during the Viking mission is also described.

I. Viking Operations Activities

Network Operations support of Viking planetary operations continued through the period with the official end of the prime and start of the extended mission occurring on 15 November. The actual support of radio science started on a regular basis with Solar Corona and Earth Occultation Experiments beginning on 3 and 6 October, respectively. High-power transmitter (usually at 100 kW) support for the Relativity Experiment began on 3 November. High-rate telemetry support was terminated on 7 November. These conditions were established primarily because of the link degradation during the superior conjunction period and remained in effect through the end of this reporting period. Due to the nature of the radio science organization and requirements and the degradation of all data types during superior conjunction, an extra effort was required in short range planning and control of the required support. This effort was expended mainly in the production and coordination of special procedures and in the generation of the sequence of events (SOE) to be used by the Network Operations Control Team (NOCT) and supporting Deep Space Stations (DSSs). Added tracking by DSS 43 in Australia was also required, affecting support of other projects and station activities.

Other support during the period included additional Lander receiver tests utilizing DSS 63 in Spain. The special procedures required were implemented without problems during the tracks from 9 through 12 October. A special alternating ranging test was successfully supported by DSSs 61 and 63 on 17 October with Orbiter 2. The purpose of the test was to develop the procedures to be used for the Mariner Jupiter-Saturn (MJS) Project ranging support requirements.

The 64-m stations, Network Data Processing Area (NDPA), and the Ground Communications Facility (GCF) were released from Viking Modified Configuration Control (soft freeze) on 15 November. All Network facilities remained in standard configuration control throughout the period except for DSS 12 at Goldstone and DSS 63. DSS 12 was released on 3 October for Mark III Data System (MDS) reconfiguration. DSS 63 was released on 15 November for antenna bearing corrective maintenance.

A significant problem occurred during the period when DSS 14 was unable to process high-rate telemetry during the period 22 to 27 October due to Block Decoding Assembly (BDA) failures requiring special coordination of data recovery procedures. The data recovery involved shipping the analog recordings to Compatibility Test Area 21 (CTA 21) for digitization and subsequent Intermediate Data Record (IDR) production. Time was not available for this effort at DSS 14 due to tracking and station internal requirements. On 16 November a second problem occurred when DSS 14 tracking support was cancelled in order to extend the hydrostatic bearing maintenance work in progress. Viking support requirements were successfully negotiated in real time, using DSS 11.

II. Occultation and Solar Corona Support

On 1 October, Lander 1 was continuing to send data via daily direct S-band link. Lander 2 was continuing to send science data via both the relay link and direct link. Orbiter 1 was synchronized over Lander 2 and acting as a relay station. Orbiter 2 had just begun an orbital walk to begin observations of the Martian northern polar cap. Highlights of DSN support and Viking activities during this reporting period are as follows:

2 Oct — The first "grazing" Earth occultation for VO-1 occurred with no degradation observed on the downlink.

3 Oct — DSSs 14 and 43 began taking data for the Solar Corona Experiment.

4 Oct — "Grazing" Earth occultations continued for VO-1 with no degradation observed on the downlink.

5 Oct — The first "hard" Earth occultation occurred during DSS 43's pass on this date. No effects of superior conjunction on AGC or SNR had been observed.

7 Oct — The third Earth occultation occurred. It was noted that the VO-1 X-band downlink AGC increased by 3 dB when the uplink transmitter was turned off.

11 Oct — Following Earth occultation exit, VO-1 was found to be transmitting in the cruise mode at a data rate of 33.333 b/s. The Attitude Control Electronics had switched to the backup system. The CCS had erroneously responded to a loss of Sun signal during solar occultation and issued a "Sun Loss Routine."

VO-2's Infrared Thermal Mapper (IRTM) was commanded on. It had been turned off earlier due to the mirror stepping problem.

15 Oct — VO-1 Earth occultations now occurring during the DSS 63 view period.

17 Oct — An alternating range experiment during the DSS 61/63 view period for the MJS 77 Project.

A special Radio Science Coordination Voice Net for DSSs 14 and 43 was introduced for the purpose of technical information exchange between the radio science advisors and the stations. Superior conjunction effects have not yet been observed on the downlinks. Some noise has been observed on the uplink.

21 Oct — A high-gain antenna calibration for VO-2 took place during the DSS 14 pass. The DSS 14 Digital Instrumentation Subsystem (DIS) program halted during this test, causing 2 data points to be lost. AGC levels were reported by voice during the DIS outage.

26 Oct — Effects of solar conjunction are now being seen in uplink and downlink. Variations are seen in uplink AGC and downlink SNRs.

29 Oct — Severe RFI at DSS 14 caused loss of 8-kb/s data for half an hour. A message was sent to all Network stations requesting system noise temperatures be included in the post-track reports for the purpose of determining solar conjunction effects on station parameters. The data are to be taken between 4 November and 17 December 1976.

4 Nov — Message sent to all Network stations advising them of a requirement to use high-power transmitters during the time frame of 3 November to 15 December 1976. Power levels to be used are as follows:

100 kW at DSS 14

50 kW at DSSs 43 and 63

20 kW at DSSs 11, 42, and 61

Use of higher power levels decreases noise on two-way doppler and ranging.

6 Nov — Solar conjunction effects continue to be seen. Effects are as follows: Up to 10-dB fluctuation on uplink AGC; up to 20-dB degradation on engineering SNRs. The 26- and 64-meter stations indicate the same SNR. Downlink degraded by 2 dB.

10 Nov 2-kb/s data being received on this date showed SNR of 6 dB but had extremely high bit error rate. The Sun-Earth-probe angle on this date was 4.5 degrees. This was the last attempt for VO high-rate data.

15 Nov This was the last day of the Viking prime mission. Engineering data were still being received at an SNR of 3 dB at 26-m DSSs and 5 dB at 64-m DSSs. Bit error rate for 26-m DSSs was estimated to be 23 in 4687 bits or 0.005.

Table 1 lists the Viking DSS support during the reporting period.

III. Viking Radio Science

A very important part of the Viking prime mission has been the radio science experimentation. This activity was increased considerably during the latter part of the Viking prime mission as mentioned earlier. The specific experiments that were performed, and in many cases will continue into the Viking Extended Mission (VEM), are:

(1) Orbiter-quasar VLBI

(2) Earth occultation

(3) Solar corona

(4) General relativity

(5) Orbiter S- and X-band doppler and ranging

(6) Lander ranging

Each of these experiments is designed to provide scientists with specific data to help answer pending questions concerning the solar system and our environment. Following is a brief description of what each experiment is and to what extent it has been carried out to date, including what results have been obtained.

A. Orbiter-Quasar VLBI

During a Very Long Baseline Interferometry (VLBI) Experiment, radio signals from a spacecraft and quasar will be alternately recorded, simultaneously, at two Deep Space Stations (DSSs). The VLBI will yield precise measurements of angular separation of the two sources. The results will show precise location of the spacecraft and in turn that of Mars and Earth as well. By performing such experiments over a period of years, exact orbits can be determined and also a test of the general theory of relativity.

There have been a total of six Orbiter-Quasar VLBI passes of data acquired between DSSs 14 and 42 since Viking arrived at Mars. These passes were:

Date	Orbiter	Quasar
14 July	VO-1	OL 064.5
15 July	VO-1	OL 064.5
19 August	VO-1	P1148-00
22-23 September	VO-2	3C 279
23-24 September	VO-2	3C 279

The data from the first two passes have been processed through the Caltech VLBI correlator and appear to be of good quality.

Continued acquisition of the Orbiter-Quasar VLBI data type during the Viking Extended Mission will depend upon the resources available to plan, acquire, process, and analyze this data type.

At DSSs 14 and 42 special equipment is required to perform these VLBI functions. This equipment is listed below, and its configuration is depicted in Fig. 1.

(1) VLBI S-band receiver

(2) Hydrogen maser

(3) Viking frequency converters

(4) Mark II recorder system

(5) VLBI frequency synthesizer

B. Earth Occultations

Toward the end of the prime mission, the orbit of Orbiter 1 passed behind Mars as viewed from Earth. Thus, in early October, the Orbiter's signal was gradually cut off, or occulted by the atmosphere and later by the surface of Mars. The variations in the signal on entry and exit from occultation are used to determine Martian atmospheric and ionospheric properties. In addition, occultation measurements produce precise radii of Mars at the occultation points.

The Viking Orbiter 1 Earth occultations started on 6 October over DSS 43 (Canberra), "walked" into DSS 63 (Madrid), and ended over DSS 14 (Goldstone). This complicated sequence was the result of the Lander 2 landing site selection. Orbiter 1 was synchronized over Lander 2 during the occultation period, and since the Lander 2 site was changed, the first Earth occultations moved from the Goldstone to Canberra view period. This upset years of plans and tests of the occultation ground data system and could have resulted in the majority of the occultations occurring over Madrid, where there are no occultation open-loop receivers or recorders. However, the Radio Science Team and Viking Project finally elected to eliminate the "radio science walk," and, consequently, the occultations occurred over all three 64-m DSN stations.

There were 27 pairs of occultations. Ten exit occultations occurred over DSS 63 for which there were no coverages scheduled due to conflicting requirements, or there were only closed-loop one-way data acquired as soon as the station S- and X-band receivers were able to lock up. These 10 exits are really of no value to the experiment. In addition there were three enter occultations over DSS 63 for which there were conflicting requirements, and no closed- or open-loop occultation data were acquired. Finally, DSS 14 lost its first exit occultation due to conflicting Project requirements. Consequently, only about 75 percent of the occultations provided data. This record is very good, considering all the conflicts. The DSN and Viking Flight Team (VFT) did an excellent job in acquiring the data due to the amount of preparation that went into the planning, procedures, and occultation demonstration tests.

The first closed-loop data from DSS 43 enter occultations showed no indication of any ionosphere with the entry and exits occurring on the dark side of the planet. The atmospheric pressure and temperature profiles and the planetary radii suffer from the data noise due to the solar corona effects. The Sun-Earth-probe angle at the start of occultations was about 15 degrees.

The configuration used for occultation observations at DSSs 14 and 43 consists of the standard closed-loop system and also the open-loop system, which is the most important. The open-loop system consists of two open-loop receivers and two dedicated open-loop FR-1400 analog recorders. The open-loop system is shown in Fig. 2, and the FR-1400's track assignments are listed in Table 2.

The pattern of occultations for the first phase is shown in Fig. 3. This phase ran from 1 October to 1 November. The next phase begins on 16 January 1977 over DSSs 63 and 14. The first phase involved Orbiter 1 only. The next segment will utilize only Orbiter 2 in a similar manner. A more detailed look at Orbiter 2's occultations will be discussed in future articles.

The analog data recorded during these occultation passes were forwarded to the Compatibility Test Area (CTA 21) via the DSN's Network Information Center (NIC). The configuration (refer to Fig. 4) of CTA 21 at the Jet Propulsion Laboratory includes special equipment to support the analog-to-digital conversion of Viking occultation data recorded at the 64-meter stations. Analog occultation tapes received at CTA 21 contain recordings of both S- and X-band data from receivers operated in both the open-loop and closed-loop modes. The closed-loop receiver data can consist of up to 16 parameters which are digitized in pairs. A single occultation could result in analog tapes containing 22 minutes of entry and exit data from the open-loop receivers and 22 minutes of closed-loop receiver data. Digitization of all analog data by CTA 21 would require approximately 12 to 15 hours. However, typical requirements during the prime mission have been on the order of 4 hours digitization time for each occultation. In addition to the occultation data conversion support, CTA 21 provides a backup capability for analog-to-digital conversion of Viking telemetry data. During the prime mission a combined total of 38 occultation and telemetry analog tapes, resulting in 63 digital tapes, were processed by CTA 21.

C. Solar Corona

As Mars and Earth approached superior conjunction on 24 November, radio signals from the Viking spacecraft passed close to the Sun and were gradually affected by the influence of the solar corona. Signal variations, using dual-frequency downlinks, will provide new information on regions close to the Sun.

Eight days of intensive solar corona data were acquired from 3 through 10 October to check out the solar corona data acquisition process and also to get useful solar corona data at a Sun-Earth-probe angle of about 15 degrees. These data were acquired from DSSs 14 and 43 using Orbiter 1, Orbiter 2, and Lander 2. Data were acquired in two modes: a multiple spacecraft-single station mode, and a single spacecraft-dual station mode. Both closed-loop data (4 streams of 10 per second data for 2 hours) and open-loop data were acquired. The open-loop receivers at DSS 14 were operated in two modes: a mode to collect dual S-band data from two orbiters using Synthesizer Local Oscillator (SYNLO) predictions, and a mode to collect S- and X-band data from one orbiter using Programmed Local Oscillator (PLO) predictions. This week of successful operations provided the experience and data needed to design the solar corona passes during the solar conjunction period.

The configurations at DSSs 14 and 43 differ somewhat, in that DSS 14 uses a PLO at certain times, as described above. These differences in configurations are shown for comparison in Figs. 5 and 6. Table 3 also lists the different modes DSS 14 can operate in due to this addition. The track assignments are the same as for occultation (see Table 2) except that only tracks 1, 2, 4, and 6 are used.

Fortunately for the Solar Corona Experiment, there will be extensive periods of one-way tracking of the "second" orbiter during the General Relativity Experiment. Since one-way S- and X-band data are not corrupted by the uplink solar corona scintillations, the Solar Corona Experiment can get all the data they can use without the usual conflict between the Relativity and Solar Corona Experimenters. Solar corona observations started again on 2 November and have been scheduled through 11 January 1977. Both digital and analog tapes from DSS 14 and analog tapes of the open-loop receiver will be available. Closed-loop S- and X-band doppler data from the two-way orbiter used for the General Relativity Experiment will also be useful for the Solar Corona Experiment even though it suffers from uplink solar corona scintillations.

D. General Relativity

Because signals are affected by the Sun's gravitational field, a precise solar gravitational time-delay test of the general relativity theory will be performed. These tests can have a major impact on fundamental physical laws and on studies of the evolution of the universe.

In September the Viking Project reviewed and approved the proposed Radio Science Team General Relativity Time Delay Experiment. This experiment proposal is based upon the use of lander ranging with simultaneous orbiter ranging for solar corona charged-particle calibrations. The period of time covered by the simultaneous lander and orbiter ranging extends from 3 November through 9 December. In addition, near-simultaneous lander and orbiter ranging before and after this time period is used as an essential part of the General Relativity Experiment data base, to solve for planetary ephemerides errors and as part of the radio science lander location and Martian pole location and dynamics experiment.

Experience during the Viking prime mission has shown that the ranging system (the planning, sequencing, data acquisition, and processing) does not operate in a hands-off mode. Due to various reasons, including Lander 1 direct link receiver failure, Orbiter 2-Lander 2 separation anomaly, Lander 2 Traveling Wave Tube Amplifier (TWTA) 1 failure, and several operational procedural errors, only about 25 percent of the near-simultaneous lander and orbiter ranging passes that were scheduled actually acquired good near-simultaneous orbiter and lander ranging. As a consequence of this poor record, and the Helios experience during the solar conjunction period, a real-time radio science ranging team was organized and started into operation near the end of October. One of the first problems observed by the real-time ranging team was a degradation in the ranging signal-to-noise ratio from Lander 2. This foretold the ultimate failure of TWTA 1, which resulted in a reduction in the amount of ranging coverage available from Lander 2 (both in length of ranging period and number of periods) which resulted in a revision of the whole General Relativity Experiment plan.

As of 10 November 1976, there have been four attempts to acquire simultaneous lander and orbiter ranging from DSSs 14 and 43. The first pass with Lander 1 on 3 November experienced a Mu 2 ranging machine failure that was corrected in time for the next day's pass, which was successful. The two passes with Lander 2 on 8 and 9 November were successful. The real-time ranging team has been able to monitor and correct many operational errors which, if they were not caught, would have resulted in lost ranging data. If this success rate continues, the General Relativity Experiment should be able to achieve its objectives. However, the solar corona effects will become much more severe as we approach solar conjunction on 25 November.

E. Orbiter S- and X-Band Doppler and Ranging

Since November 1975, when the X-band transponders on the orbiters were turned on, several hundred S- and X-band doppler and ranging passes of excellent data have been acquired during cruise and planetary operations. During planetary operations, tracking data taken near periapsis have enhanced the accuracy of determining the Martian gravity field and local gravity anomalies. This will be accomplished through elimination of error sources by use of dual-frequency S- and X-band tracking. The gravity field definition provides information on the mass, internal structure density and mass distribution, geological processes, and the evolution of Mars. These data have been extremely useful in evaluating the new X-band system performance, monitoring solar flares and solor corona noise, and for the charged-particle calibration of doppler and ranging data. Four data types, i.e., S- and X-band doppler and ranging, have been compared and yielded the same charged-particle results. Namely, S- and X-band differential doppler. S-band DRVID, X-band DRVID, and S-X band range yield the same change of total electron content during recent high solar activity passes. This demonstrates the performance of the DSN S- and X-band doppler and ranging system beyond any reasonable doubt.

F. Lander Ranging

By acquiring lander doppler and ranging data along with near-simultaneous ranging from the lander and orbiter, much knowledge will hopefully be gained concerning Martian polar properties and lander position. Specifically, these data will be used for Radio Science Lander location, and Martian pole location, and dynamics experiment. The near-simultaneous ranging (see Fig. 7) from the lander and orbiter from the same DSS have been requested to eliminate the effects for differential charged-particle differential station location errors for stations located on different continents.

The power of the lander doppler and ranging data has been demonstrated by the navigation and radio science use of the small amounts of data to solve for very accurate lander locations and pole directions. Efforts will continue during the extended mission to improve on the quality and quantity of lander and near-simultaneous orbiter ranging for the radio science lander position and Martian pole location and dynamics experiment. Hopefully, this experiment will yield knowledge about changes in the Martian spin rate and Martian pole precession and mutation. These would be important results for understanding Martian dynamics and internal structure.

In addition, lander and near-simultaneous orbiter ranging can be used for another test of general relativity: a dynamic test as contrasted to the time delay test discussed earlier. This dynamic test of general relativity will require lander and orbiter ranging over the lifetime of the landers and orbiters.

Therefore, the lander ranging and near-simultaneous orbiter ranging are the most unique and probably the most important radio science data to be collected on the Viking project.

IV. Viking Computer-Aided Countdown Program

The Computer-Aided Countdown (CAC) Program DXI-5140-TP was developed by personnel of the Madrid Deep Space Station (DSS 62) within its "DSN Engineering Program," with the assistance of the DSN System Support Group. Work on the program began in March 1975; however, due to heavy workload associated with preparations for Viking launch and tracking support, it was not completed until March 1976. During the month of March the program was evaluated and software acceptance testing was performed.

The program combines tasks previously performed by other test software programs, shortening the time required to support station precalibrations, and thus making more effective use of station time.

The program provides for a centralized verification of station performance in four important areas:

(1) Telemetry System performance

(2) Command System performance

(3) Doppler performance

(4) Planetary Ranging Assembly countdown performance

The program was written for a typical 64-meter DSS with the ability of testing six telemetry channels, two command processors, and Block III S-band, and Block IV S- and X-band doppler. For 26-meter DSSs the program is capable of testing four telemetry channels, two command processors, and Block III S-band doppler.

The software was designed with the flexibility of accommodating all possible Viking telemetry rates, Orbiter and/or Lander commanding, and any combination of Block III, Block IV, S-band, X-band doppler processing.

The CAC Program was first used by the DSN in April 1976. The months of April and May were designated as a trial and training period. During this period the three levels of computer-aided countdowns were exercised, while DSS personnel became familiar with the program and developed procedures for its optimum use. Table 4 defines the CAC level by station and identifies the options of each. Beginning on 1 June 1976 the level 1 computer-aided countdowns were committed at all Network stations supporting Viking.

The level 1 CACs were continued throughout the Viking prime mission and into the Viking Extended Mission. The level 2 CAC will become the prime countdown level with the option of using level 1 for passes in which a critical event is scheduled. Table 5 identifies the results of the level 1 CACs during two months of continuous use.

Acknowledgment

The authors would like to thank J. P. Brenkle of the Viking Radio Science Team for his contributions to this article.

Table 1. Viking support

Period	DSS	Tracks	Track time	Commands
September	11	29	216:14	1430
	12	6	45:21	6
	14	72	487:59	1205
	42	35	315:42	1532
	43	68	578:06	2685
	44	11	91:29	4
	61	29	261:13	1078
	62	7	59:37	332
	63	83	557:52	438
		340	2613:33	8660
October	11	32	212:43	1515
	12	0	0:0	0
	14	77	413:57	1292
	42	32	351:08	2776
	43	85	787:16	2967
	44	1	4:51	0
	61	31	251:52	2676
	62	5	35:36	319
	63	79	590:02	1524
		342	2647:25	13069
November 1–15	11	18	103:36	339
	12	0	0	0
	14	30	167:18	403
	42	11	113:43	444
	43	36	327:16	1963
	44	0	0	0
	61	17	133:49	0
	62	2	15:40	0
	63	24	181:01	143
		138	1042:23	3292

Table 2. FR-1400 recorder configuration for DSSs 14 and 43 (dedicated recorders for occultation data)

Track	Data					Mix ratio[a]
	IRIG channel	Function	VCO center freq, kHz	Deviation percentage	Deviation voltage, volts	
1		Speedlock	Direct			1:1
		Voice	13.50	±40.0	±5	
2		S-band OLR Digitizing tone	108/432[b]	±40.0	±1	1:1
3	9	RCVR 3 AGC	3.90	± 7.5	±5	1:1
	10	RCVR 3 SPE	5.40	± 7.5	±5	1:1
	11	RCVR 4 AGC	7.35	± 7.5	±5	1:1
	12	RCVR 4 SPE	10.50	± 7.5	±5	1:1
	13	RCVR 3 DAGC	14.50	± 7.5	±1	1:1
	15	RCVR 3 DPE	30.00	± 7.5	±5	1:1
	17	RCVR 4 DAGC	52.50	± 7.5	±1	1:1
	20	RCVR 4 DPE	124.00	± 7.5	±5	1:1
4		NASA time	13.50	±40.0	±5	1:1
		Speedlock	Direct			
5	9	RCVR 1 AGC	3.90	± 7.5	±5	1:1
	10	RCVR 1 SPE	4.50	± 7.5	±5	1:1
	11	RCVR 2 AGC	7.35	± 7.5	±5	1:1
	12	RCVR 2 SPE	10.50	± 7.5	±5	1:1
	13	RCVR 1 DAGC	14.50	± 7.5	±1	1:1
	15	RCVR 1 DPE	30.00	± 7.5	±5	1:1
	17	RCVR 2 DAGC	52.50	± 7.5	±1	1:1
	20	RCVR 2 DPE	124.00	± 7.5	±5	1:1
6		X-band OLR Digitizing tone	108/432[b]	±40.0	±1	1:1
7		NASA time	13.50	±40.0	±5	1:1
		Speedlock	Direct			

[a]The input to each recorder track will be adjusted to 2.8 volts p-p.

[b]Use the 108.0-kHz VCO when recording solar corona data and the 432.0-kHz VCO when recording occultation data.

Table 3. DSS 14 solar corona local oscillator configuration model

Mode	OLR configuration to be selected	Local oscillator source	Setting, MHz	
			5100B synthesizer 1	5100B synthesizer 2
1[a]	S/S	SYN	≈23	≈23
	S/X	SYN	≈46	NA
2	S/X	SYN	≈46	30.00135
3	S/S	PLO	NA	NA
4	S/S	PLO	NA	30.00135
5	S/X	PLO	NA	NA
6	S/X	PLO	NA	30.00135

[a]Fail safe mode. To be selected for unmodified OLR operation.

Table 4. CAC options

DSS	CAC level	Time, hours	Options
14 43 63	1	6	2 hours of full DSS testing followed by a built-in 2.5-hour hold (or rectification). Then 1.5 hours of retest and data transfer test.
	2	3	2 hours of full DSS testing followed by a 1-hour retest and data transfer test.
42 61	1	4.5	1.5 hours of full DSS testing followed by a 2-hour built-in hold. Then a 1-hour retest and data transfer test.
	2	2.5	1.5 hours of full DSS testing followed by a 1-hour retest and data transfer test.
11 12 44 62	1	3	1.5 hours of full DSS testing followed by a 0.5-hour built-in hold. Then a 1-hour retest and data transfer test.
	2	2.5	1.5 hours of full DSS testing followed by a 1-hour retest and data transfer test.
	3	1.5	1 hour of full DSS testing followed by 0.5 hour of data transfer test.

Table 5. CAC performance

Performance	Number of passes			
	DSS 14	DSS 43	DSS 63	Total
64-m CAC scheduled for 6-channel support	50	36	57	143
Station green after full DSS testing	38	30	50	118
Equipment anomalies corrected during built-in hold	8	3	6	17
Equipment anomalies corrected during testing and built-in hold	2	3	2	7
DSS unable to support 6 channels at the end of the CAC due to equipment anomalies	2	0	2	4

Conclusions: 1. DSSs were red for 6-channel support prior to the built-in hold 17.5 percent of the passes.

2. DSSs were red for 6-channel support prior to AOS 2.8 percent of the passes.

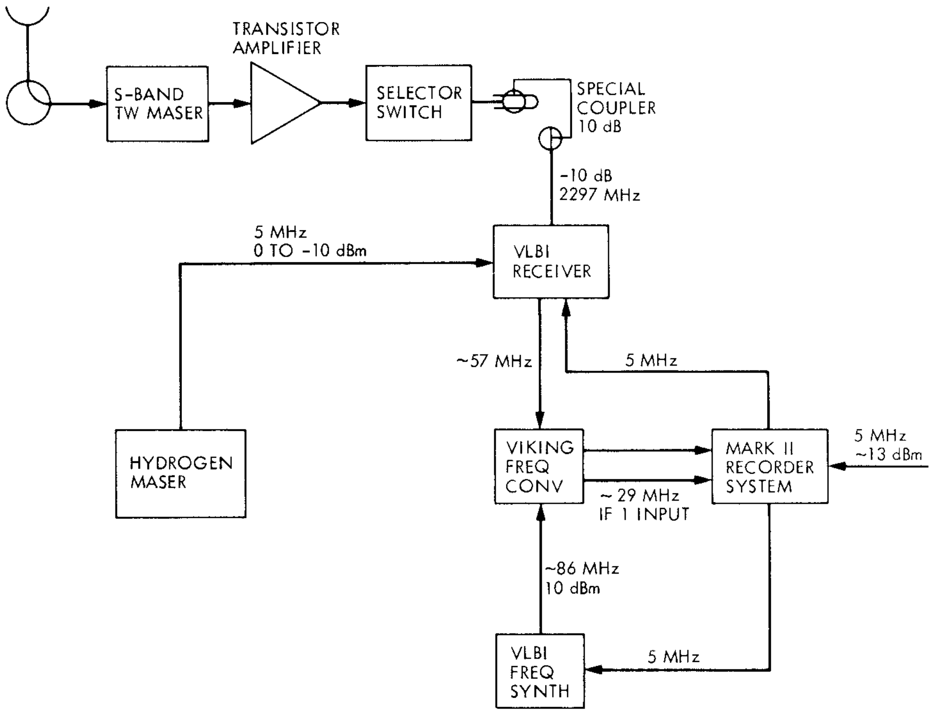

Fig. 1. VLBI configuration for DSSs 14, 42, and 43

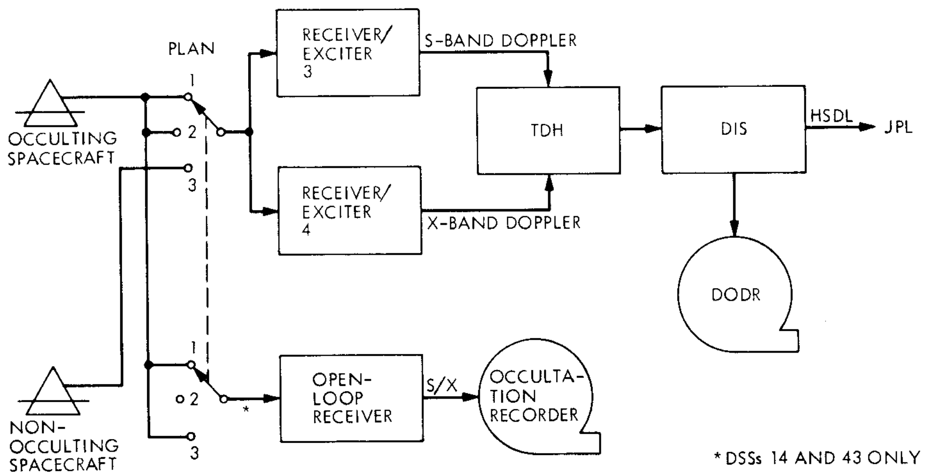

Fig. 2. Occultation configuration

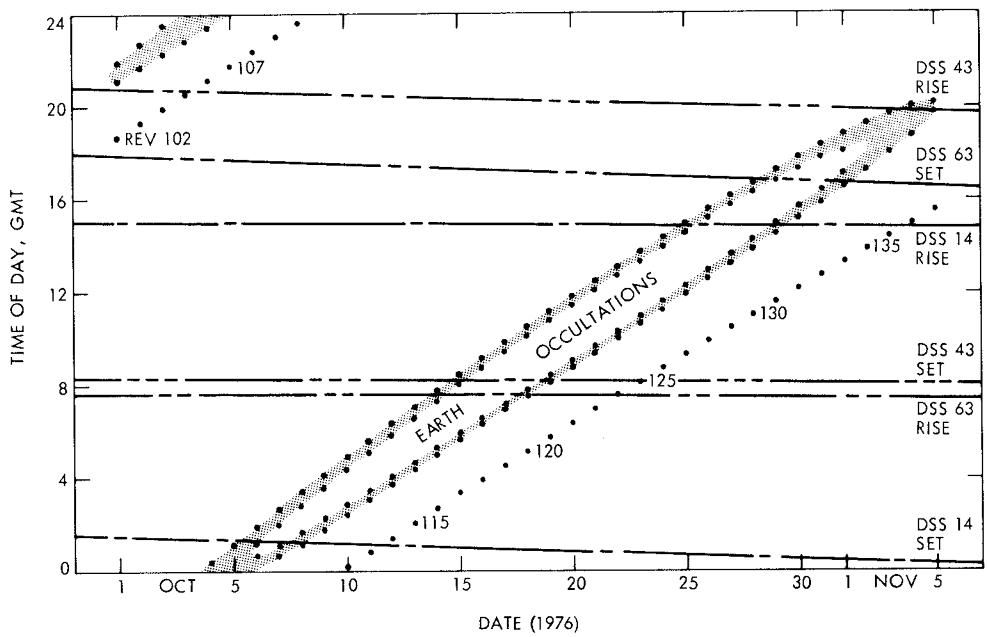

Fig. 3. VO-1 Earth occultations

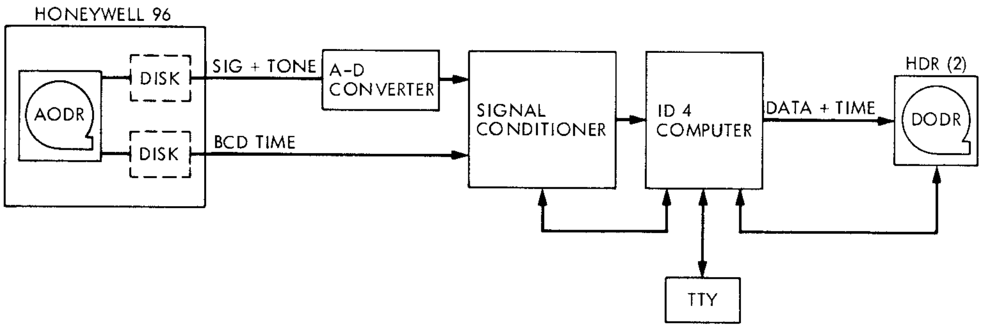

Fig. 4. Simplified block diagram of typical digitizing configuration

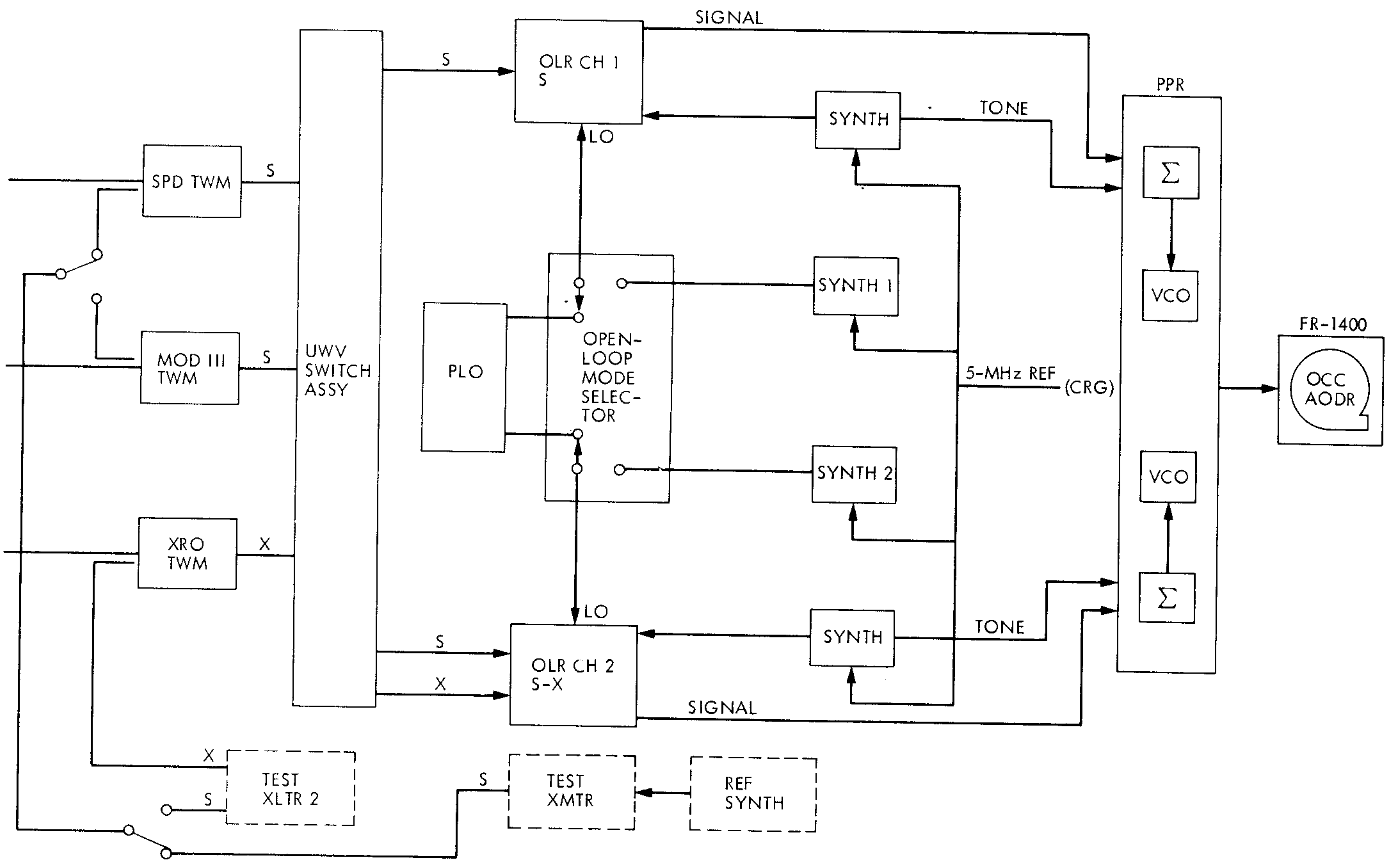

Fig. 5. Simplified open-loop system block diagram for DSS 14

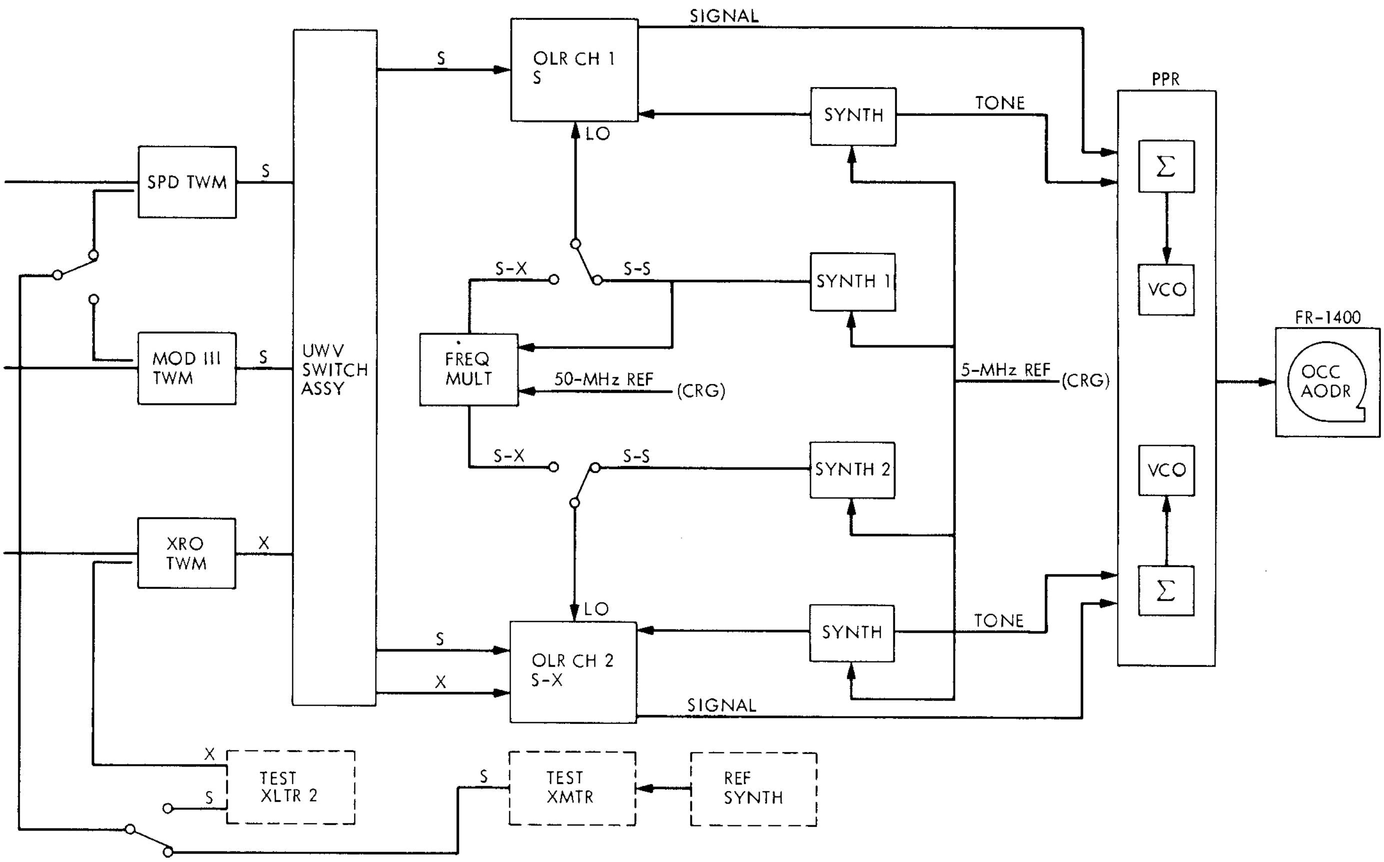

Fig. 6. Simplified open-loop system block diagram for DSS 43

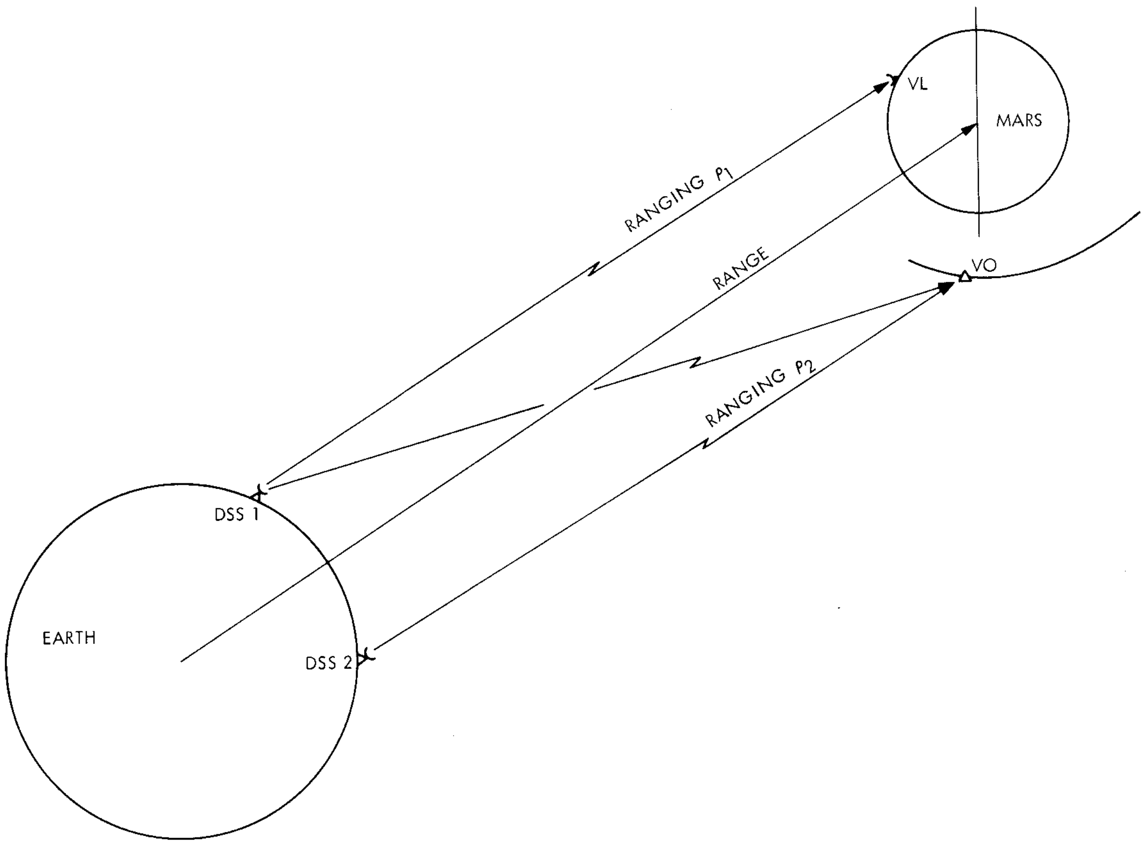

Fig. 7. Near-simultaneous lander/orbiter ranging