Viking Mission Support

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This report summarizes Deep Space Network support for the two Viking Missions to Mars and includes the Mars orbit insertions of Vikings 1 and 2 and the landing of Viking 1. Special procedures were employed during these critical events to minimize interruptions to the telemetry data return due to spacecraft data mode and attitude changes.

I. DSN Mission Operations and Status

A. Viking Operations Activities

The significant Viking 1 Planetary and Viking 2 Cruise activities supported by the DSN during this reporting period are listed in Table 1. Included in this support was the final Operational Readiness Test (ORT-3) prior to Mars Orbit Insertion (MOI) of Viking 1.

The Approach Midcourse Maneuver (AMC) of Viking 1 was performed in two steps due to a spacecraft pressurant leak problem. The original AMC was delayed one day to June 10 with a second AMC performed on June 15. DSS 63 (Madrid) successfully supported both AMC-1 and -2.

The Viking 1 MOI was successfully supported on June 19 by Goldstone, DSS 14 with DSS 11 as backup. A Mars Orbit Trim maneuver was performed on June 21 over DSS 63, which put the Viking 1 Orbiter in the proper orbit over the prime landing site. The first site certification pictures were taken on June 22, and for the next several weeks high-rate telemetry data were received periodically by the 64-meter subnet in support of this activity. The Viking 1 landing was delayed from the scheduled July 4 date to July 20, due to landing site requirements necessitating additional trim maneuvers and additional site certification photos. The successful landing was supported by DSS 63 with the initial surface pictures played back via the orbiter relay link to DSS 63 shortly after touchdown. On July 21, the daily direct link tracks of the Viking 1 lander started with DSS 43 (Australia) supporting through July 26. Then DSS 63 began a 10-day period of direct link lander support. In the mean time, Viking 2 approach science data were being gathered and the Approach Midcourse Maneuver was supported by DSS 43 on July 27.

B. DSS Support

The tracking hours per station of the Viking spacecraft and the number of commands transmitted from each station during this reporting period are listed in Table 2.

C. Intermediate Data Record Status

The Intermediate Data Records (IDRs) are generated by merging telemetry data received in real time and telemetry data recalled post pass from the Deep Space Stations. These data are then merged in the Network Data Processing Terminal, and the resultant IDR is then delivered to the Viking Project. During this reporting period the Deep Space Network Data Record capability provided the Viking Project Data Support Group with 177 telemetry Intermediate Data Records. The average delivery time for the 177 IDRs was 16 hours after the loss of signal at the end of a scheduled track. This average delivery time is within the 24-hour delivery commitment.

II. Special Planetary Procedures

In order to maximize the quantity of telemetry data that could be delivered to the Viking Project, under adverse conditions such as orbital maneuvers that required special spacecraft orientation, a special telemetry procedure was developed and used on both Viking 1 and 2 Mars Orbit Insertions. This special procedure insures that the orbiter engineering data are not interrupted when the orbiter spacecraft telemetry mode is switched from dual to single or single to dual subcarriers. When the spacecraft telemetry mode is switched, there is a power exchange that takes place between the subcarriers, and it is this telemetry power increase or decrease which must be controlled via the input attenuators on the subcarrier demodulators.

To verify the special procedure, a test was performed at the JPL Compatibility Test Area (CTA 21) and the following results were obtained:

(1) Telemetry data bit sync loop would lose lock when the spacecraft mode was switched from single to dual subcarriers or from dual to single subcarrier and the subcarrier demodulator input attenuator was reset in the usual manner.

(2) The telemetry data bit sync loop would remain in lock, if the subcarrier demodulator input attenuation was reset prior to mode change and the reset rate was 2 dB per second or less.

A special procedure based on these results was used successfully to enhance telemetry data return during Viking propulsive and non-propulsive maneuvers.

A backup Canopus loss contingency plan to supplement the standard star procedure was made available for Viking 1 and 2 Mars Orbit Insertions. The backup Canopus loss contingency plan could provide fast and accurate spacecraft orientation data in the event of loss of Canopus lock during the critical Mars Orbit Insertion phase of the mission. Although the procedure was available, it was not utilized except for verification of X-band in and out of lock times, since both spacecraft performed in a nominal manner.

A special procedure was developed and implemented to optimize data return when it became necessary to accomplish station transfers (1) during or near orbiter spacecraft periapsis, (2) under low signal conditions, or (3) because of a maneuver configuration of the spacecraft when accommodating special Mars surface photo mapping.

In order to maintain downlink receiver lock and minimize data degradation it was necessary to reduce the uplink tuning rates and optimize downlink receiver loop bandwidths. The uplink tuning rate and downlink receiver bandwidths used had to be adjusted for a number of receiver loop signal-to-noise ratios. This was accomplished by providing a table of uplink tuning rates and bandwidth combinations that could be used within specified signal level ranges.

The optimum tuning rate is available from Table 3. Depending on signal level and priority of S-band or X-band data, the optimum exciter tuning rate for maximum data return under adverse conditions could be selected.

A special modified code 1 configuration (Fig. 1) was used successfully for Mars Orbit Insertion of Viking Orbiters 1 and 2. This configuration provided complete telemetry data redundancy plus backup during the critical phase of Mars Orbit Insertion.

The modified code-1 configuration provides two independent processing streams of data being output via two (independently routed where possible) high-speed data lines. This parallel data processing concept is carried through all of the various ground data system interfaces to minimize the risk of data loss due to single-point failures.

III. DSN Support of Viking 1

A. Preseparation Checkout

DSN support of activities associated with the landing of Viking Lander 1 began on July 18, 1976 with DSS 63 supporting the separation minus 39-hour command update. The prime purpose of this command load was to prepare the mated lander for the preseparation checkout. DSS 63 was configured to code 15, the standard Orbiter–

Orbiter configuration with one Command Modulator Assembly initialized for Orbiter 1 and the other initialized for Lander 1 and mated lander commanding. The command load was successfully transmitted without incident.

The preseparation checkout occurred over DSS 43 on UTC day 201, July 19, 1976. A unique telemetry configuration was utilized during this pass in order to provide the Project with redundant data streams. During the major portion of preseparation checkout, the data rates were 1000 and 2000 bits per second. Redundant data streams were provided for these bit rates by specifying configuration code 24. This code provided two high-rate science data streams with channel 2 of Telemetry and Command Processor Alpha outputting data for the high-speed data line, and Telemetry and Command Processor Beta using channel 3 and outputting data to the wideband data line. This configuration provided dual processing channels at the station and also provided dual transmission paths to the Mission Control and Computing Center.

Following the completion of the 1000- and 2000-bit per second data, the spacecraft data rate changed to 4000 bits per second. At this data rate, channel 2 of the alpha string could no longer be used, as the rate exceeded the processing capability for this channel. At that time channel 2 of the alpha string was disabled and channel 3 enabled to provide redundant processing channels at the station with both data streams being transmitted via the wideband data line.

The non-conjoint 26-meter stations, DSS 62 (Madrid) and DSS 44 (Australia), provided backup command capability during the preseparation phase. Figure 2 shows the code 24 configuration used by DSS 43 for preseparation checkout.

B. Separation, Descent, and Landing

This phase of the landing activity was divided into two major events. The first event was the transmission of the separation "GO" command followed by the second event of separation, descent, and landing.

The telemetry configuration used by DSS 43 on the previous day for preseparation checkout (code 24) was used again for this pass.

Due to the importance of the "GO" command, special precautions were taken to insure that the command would be successfully transmitted. DSS 43 configured the two Command Modulator Assemblies for mated lander commanding. The two Telemetry and Command Processor command stacks were then loaded with "GO" commands. The prime Telemetry and Command Processor contained timed commands to be transmitted at separation minus 45 minutes while the backup Telemetry and Command Processor contained the identical commands, but untimed. The backup processor was to be used in the event problems developed in the prime string.

In addition to the commands loaded into the processor stacks, duplicate commands were also loaded into the manual buffer of each processor. These commands were to be transmitted if problems developed which would prevent transmission of the commands residing in the command stack.

A backup command capability was also provided by DSS 44. At this station the "GO" commands were loaded into the stack and manual buffer in the same way commands had been loaded in the backup string at DSS 43.

DSS 44 was to have been used following a failure at DSS 43. The exciter frequency at DSS 44 was chosen so that in the event of a transmitter or antenna failure at DSS 43 it would have only been necessary to turn on the transmitter at DSS 44 and tune to a new reference frequency, thus capturing the spacecraft receiver as it drifted towards its rest frequency. Command transmission could then be continued with only a slight delay.

The "GO" command was successfully transmitted by DSS 43 on July 20, 1976 using the prime transmission path.

The telemetry configuration chosen for support of separation, descent, and touchdown events was the standard two-orbiter configuration (code 15). In this configuration, both Telemetry and Command Processor strings were initialized for Orbiter 1, giving two redundant processing channels for engineering and science data. Since no commanding was anticipated during the descent phase, no special configurations or procedures were required. DSS 63 was the prime station for support of separation, descent, and touchdown.

A special procedure was used during the descent phase for telemetry processing at DSS 63. As the spacecraft began its descent and passed through the atmosphere of Mars, the 4000-bit per second data were transmitted in bursts of short duration. Between these data bursts were blocks of invalid data. In order to insure each of the 4000-bit per second bursts were processed at the station, the stations were instructed to initialize the two high-rate processing channels at the beginning of the burst data and to remain initialized even though the data appeared as noise between bursts. Testing during compatibility tests and during operational tests both prior to launch and during cruise had proven this to be a feasible plan.

The separation, descent, and touchdown events were supported flawlessly.

C. Initial Lander S-Band Direct Link Support

The first Lander direct link took place during the DSS 43 view period on July 21, 1976. The Lander had landed in the Martian evening, and the direct link took place approximately 18 hours later during the Martian morning.

For the Lander direct link support a special telemetry and command configuration had been devised. This code 61 configuration provided for redundant Lander telemetry processing channels. Redundant command capability was provided by the use of two separate high-speed data lines connected to separate Command Modulator Assemblies. The code 61 configuration is shown in Fig. 3. The figure shows prime Lander engineering and science data provided by Telemetry and Command Processor 2, channels 1 and 2.

Backup processing was provided by Telemetry and Command Processor 2, channel 3, and Telemetry and Command Processor 1, channel 2. From this configuration, Lander data were supplied via three different transmission paths over high-speed data lines 1 and 2 and the wideband data line. The configuration minimized the possibility that a single-point failure would cause a loss of data.

Lander direct link support began with the beginning of the uplink acquisition sweep. A transmitter power output level of 20 kilowatts was used. The sweep was designed to take into account the uncertainties of the Lander best lock receiver frequencies and widened to insure the acquisition of both lander receivers. A total frequency range at S-band of 135648 hertz was swept at a rate of 43.2 hertz per second. The duration of the sweep lasted 52.2 minutes. Table 4 shows the uplink/downlink sweep, and ranging parameters used during the first direct link. Since the spacecraft transmitter was not turned on until the uplink acquisition sweep had been completed, the sweep was completed in the blind without benefit of downlink lock.

Command modulation was then turned on, but commanding was delayed until the results of the commands could be verified by the downlink telemetry. Commands were selected which would not alter any spacecraft parameter but which would allow the Lander Team to verify command capability.

At approximately 2 hours and 10 minutes following the start of the uplink acquisition sweep, DSS 43 obtained lock on the downlink. A special downlink acquisition sweep for the Block IV receiver had been devised which would guarantee lock in either the one-way or two-way tracking mode. The sweep covers a range of 105,600 hertz at S-band and was swept at a rate of 4800 hertz per second. Lock was obtained on the Block IV receiver in the two-way tracking mode. Following downlink acquisition it was discovered that uplink lock on spacecraft receiver 1 had not been attained. Several minutes following downlink lock, receiver 1 was observed to go into lock. The commands sent earlier were observed to be received and processed by both spacecraft receivers through monitoring of the command segment count. Ranging data were successfully obtained during the last 10 minutes of the downlink pass. At approximately 1 hour after the downlink acquisition took place, loss of lock was observed. No anomalies, except the initial failure to lock spacecraft receiver 1, occurred during the first direct link.

Table 1. Viking operations activities

Date	Spacecraft	Activity
June 1–2	Viking 1	8 kbps playback
June 2–3	Viking 1	Operational Readiness Test (ORT-3) for Mars Orbital Insertion (MOI)
June 3–6	Orbiter 1	Optical Navigation Sequences (ONS)
June 4	Lander 2	Initial Computer Load (ICL) update
June 10	Viking 1	Approach Midcourse Maneuver (AMC) scheduled for June 9 postponed until June 10
June 10, 11, 13	Orbiter 1	ONS
June 10	Lander 2	ICL update
June 10–13	Lander 2	Battery Conditioning Sequence
June 14	Orbiter 1	Visual Imaging Subsystem (VIS) and Infra Red Thermal Mapper (IRTM) alignment test playback
June 15	Viking 1	AMC 2. This maneuver was required because of the continued gas regulator leakage problem
June 16	Viking 1	Start of Viking 1 approach science
June 19	Viking 1	MOI
June 21	Viking 1	Mars Orbit Trim maneuver 1
June 21	Viking 1	Started Viking 1 site certification sequence
July 8	Orbiter 1	Mars Orbit Trim maneuver 5
July 9–15	Orbiter 1	Site certification photo sequence
July 13	Orbiter 1	Mars Orbit Trim 6
July 15	Orbiter 2	Optical Navigation Sequence 2
July 18–19	Lander 1	Pre-separation checkout
July 18	Viking 2	Completed Viking 2 Optical Navigation Sequence 2
July 20	Lander 1	Touchdown and start of landed operations
July 22	Viking 2	Start Viking 2 ONS
July 24	Viking 2	ONS
July 27	Viking 2	Viking 2 Approach Maneuver performed
July 28	Viking 2	Optical Navigation Sequence 4

Table 2. DSS support

Month	DSS	Number of passes	Hours tracked	Commands transmitted
June	11	25	194.24	413
	12	15	103	0
	14	18	165.52	504
	42	22	167.36	15
	43	28	220.53	3410
	44	11	89.56	43
	61	25	232.05	399
	62	9	93.11	32
	63	29	320.43	619
June total		182	1585.80	5435
July	11	29	239.10	358
	12	7	52.27	216
	14	40	336.03	1827
	42	26	205.29	183
	43	49	349.03	1641
	44	11	76.28	0
	61	26	260.20	1354
	62	7	58.53	92
	63	43	362.14	2276
July total		238	1938.87	7947
Report total		420	3524.67	13382

Table 3. Recommended uplink tuning rates

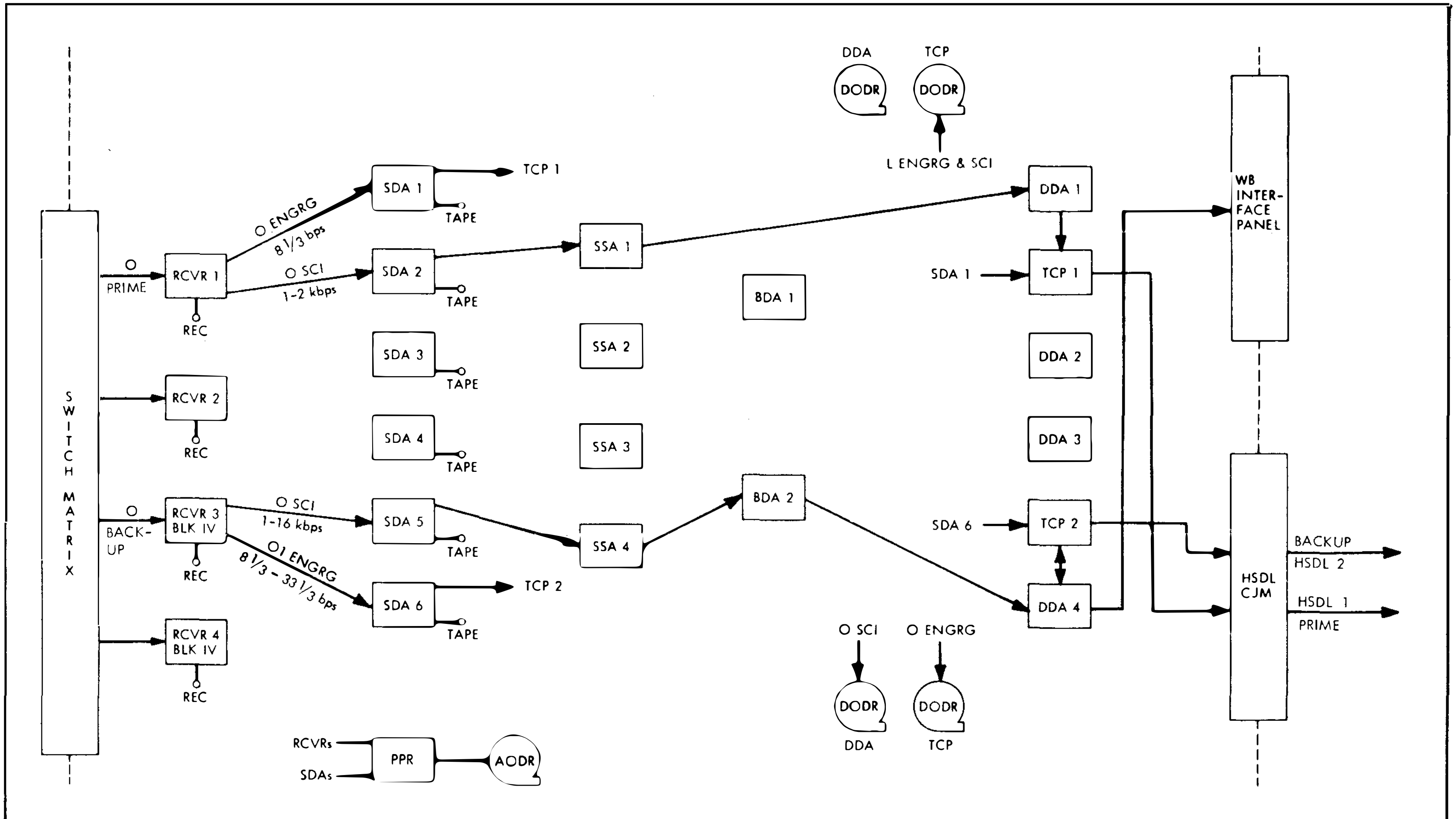
Downlink signal level, dBm	10-Hz bandwidth		30-Hz bandwidth	
	S-band tuning rate, Hz/s	X-band tuning rate, Hz/s	S-band tuning rate, Hz/s	X-band tuning rate, Hz/s
−138 to −143	1.50	0.41	10.90	3.00
−143 to −148	1.25	0.34	9.10	2.50
−148 to −153	0.75	0.20	6.30	1.73
−153 to −158	0.50	0.14	1.50	0.40
−158 to −160	0.30	0.08	0.38	0.10
−160 to −163	0.19	0.05	—	—
−163 to −165	0.06	0.016	—	—

Table 4. Lander 1 initial acquisition: DSS 43, SOL 1

Uplink Acquisition Sweep	
Transmitter on	05:10:00 UTC
Transmitter power	20 kW
Frequency	44022494.0 Hz
Start tuning (Time 0)	05:10:40 UTC
Tune to	44020604.0 Hz
Tuning rate (rate 0)	—0.9000 Hz/s
Time (time 1)	05:45:40 UTC
Tune to TSF	44021540.0 Hz
Tuning rate (rate 1)	+0.9000 Hz/s
Stop tuning (time 2)	06:03:00 UTC
Command modulation on	06:03:29 UTC
Range modulation on	07:20:20 UTC
Sweep duration	52 min 20 s
Downlink Acquisition Sweep	
Start sweep	07:10:00 UTC
Sweep upper limit	44753046.55 Hz
Sweep lower limit	44751846.55 Hz
Sweep rate	100 Hz/s
Ranging Parameters	
Enter acquisition directive	07:20:40 UTC
T1	38 s
T2	9 s
T3	0 s
Round trip light time	38 min 5 s
Components	15

Notes: a. Receiver VCO $\approx$ 23.8625 MHz. Bias receiver frequencies according to actual measurements.

b. Receiver to be swept in acquisition mode with ATZ (acquisition trigger at zero-beat) enabled.



Code	Spacecraft	Receiver	Data Type	SDA	SSA	BDA	DDA	TCP
1 Modified	Orbiter Prime	1	Engrg	1	0	0	0	1
			Sci	2	1	0	1	
	Orbiter Backup	3	Sci	5	4	2	4	2
			Engrg	6	0	0	0	

Fig. 1. Modified planetary configuration, Orbiter–Orbiter—code 1

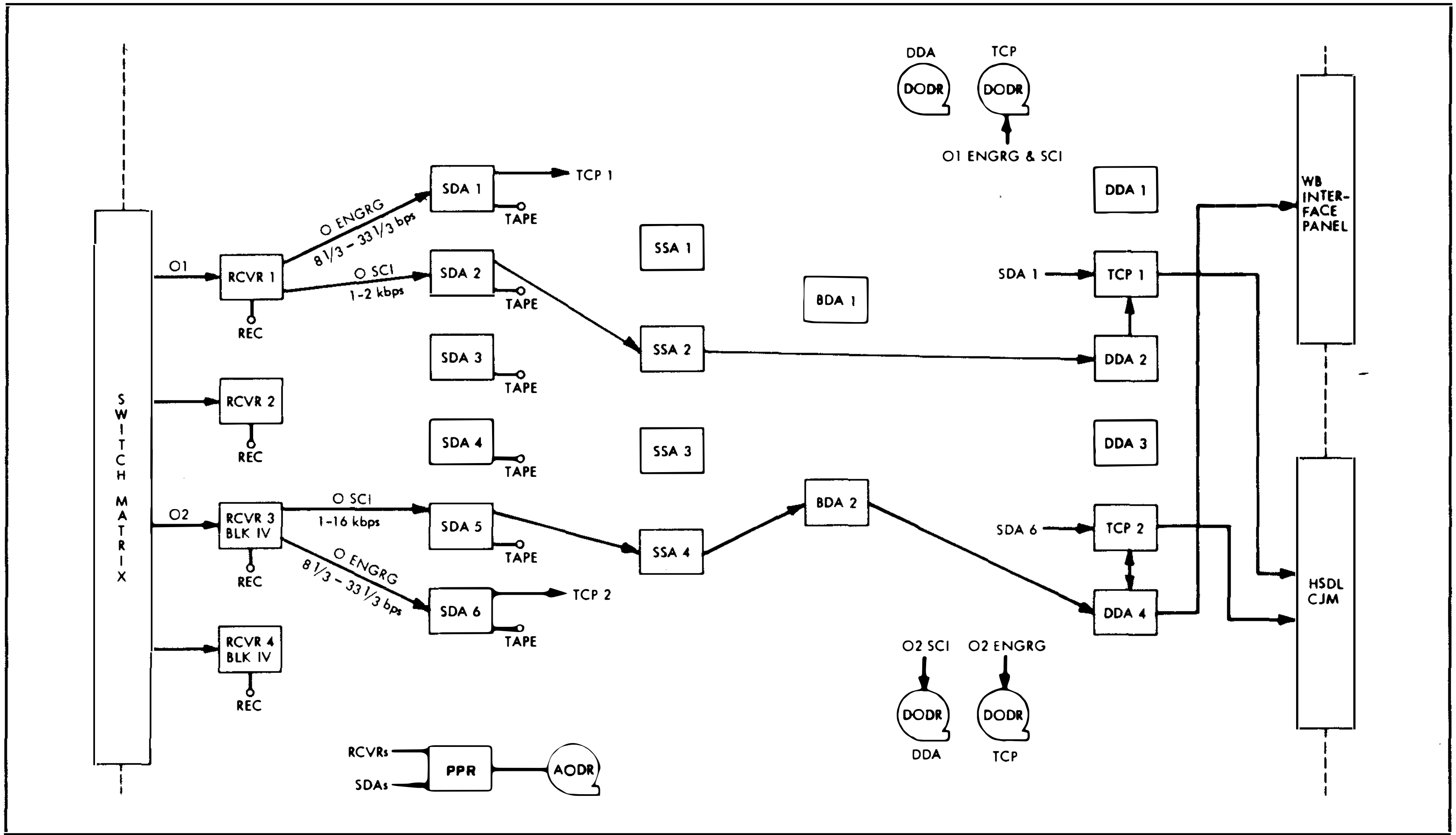
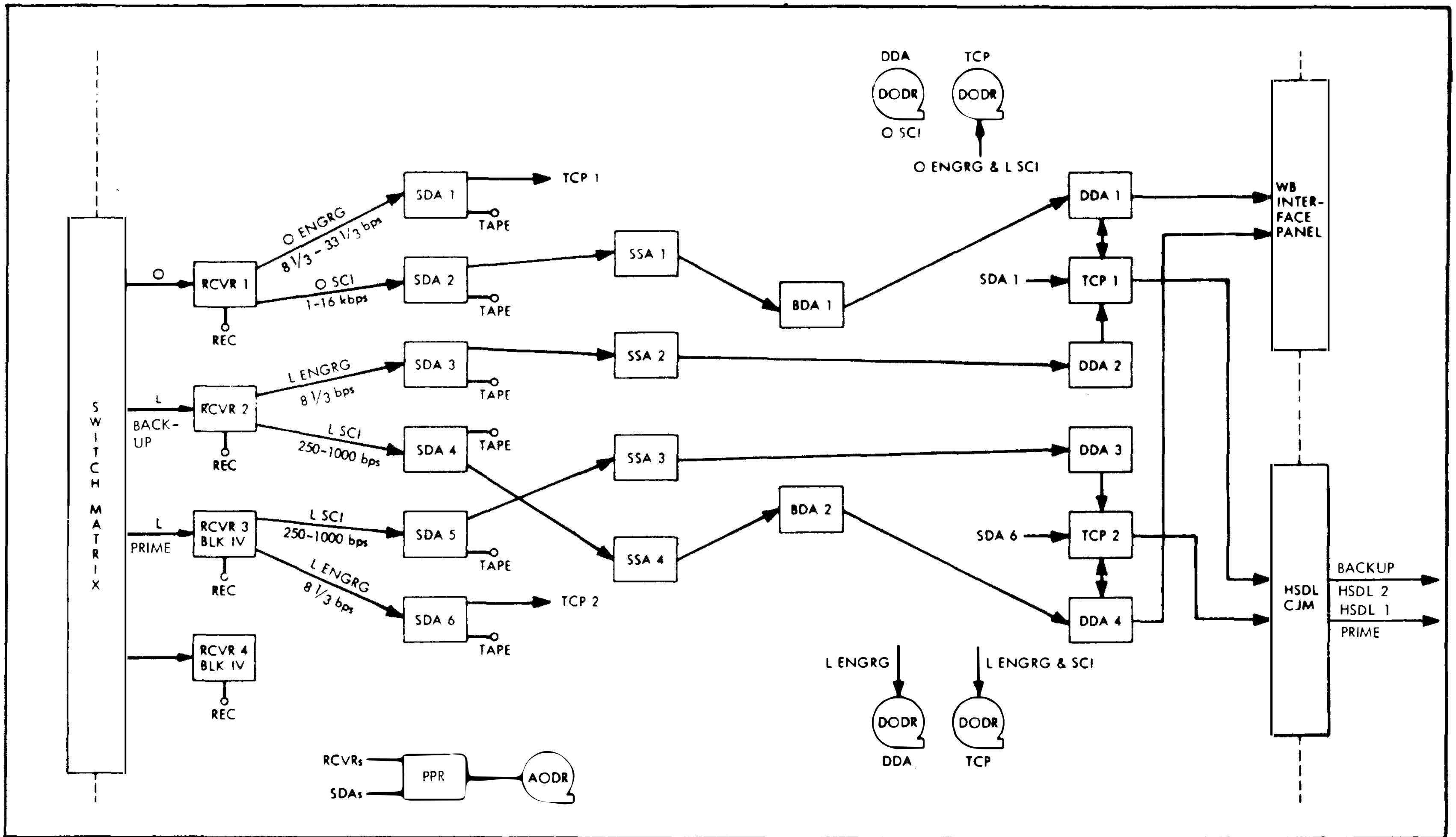


Fig. 2. Orbiter–Orbiter—code 24



Code	Spacecraft	Receiver	Data Type	SDA	SSA	BDA	DDA	TCP
61	Orbiter	1	Engrg	1	0	0	0	1
			Sci	2	1	1	1	
	Backup Lander	2	Engrg	3	2	0	2	
			Sci	4	4	2	4	2
	Prime Lander	3	Sci	5	3	0	3	
			Engrg	6	0	0	0	

Fig. 3. Standard planetary configuration, Orbiter–Orbiter–Lander—code 61