Viking Mission Support

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This report covers the most significant Viking Mission events supported by the DSN during August and September 1976. Intermediate Data production and DSS support are also summarized for this period. Viking DSN Discrepancy Report activity for the period January 1975 through September 1976 is also included.

I. Introduction

The previous report in this series described the final preparation and testing prior to the Mars orbit insertion of Viking 1, the Mars orbit insertion, separation and landing of Viking Lander 1 (VL-1), and concluded with the Viking 2 approach maneuver on 27 July 1976. This report continues from that point and describes the sequence of events pertaining to the insertion through landing of Viking 2.

II. DSN Mission Operations Activities

A. Viking Operations Activities

Table 1 lists the significant Viking 1 and Viking 2 activities supported by the DSN during this reporting period.

The DSN supported a total of 18 significant events during this two-month period. On August 1, Viking Orbiter 1 (VO-1) was already in orbit, with Viking Lander 1 on the surface of Mars sending data daily via direct and relay links. Viking 2 was approaching Mars, 7 days away from Mars orbit insertion (MOI).

B. DSS Support

Table 2 lists the tracking hours, per station, of the Viking spacecraft and the number of commands transmitted from each station during this reporting period.

C. Intermediate Data Record Status

During this reporting period the DSN data record capability provided the Viking Project Data Support Group with 394 original telemetry Intermediate Data Records (IDR), of which 378 IDRs were delivered within the 24-hour after-loss-of-signal requirement. The average data throughput for this reporting period was 99.99 percent of the available data.

Table 3 is a breakdown of IDR production per DSS.

D. Viking Discrepancy Reports

A summary of Viking Discrepancy Reports (DR) covering the period from 1 January 1975 to 26 September 1976 is shown in Table 4.

III. DSN Special Activity Support

A. Dual Orbiter Tracking

The tracking of both Viking Orbiters by a single 64-m DSS began on August 6. Both Orbiters had been within the beamwidth of 64-m antennas for the three days prior to Mars orbit insertion of Orbiter 2, however the Viking Project chose the option of pointing the antenna at a single spacecraft in order to maximize data return. DSN predicts had shown that on August 3, a signal loss of 24 dB would result on one spacecraft while the antenna was pointed directly at the other. This loss would be reduced to just 4 dB for both spacecraft by midpoint tracking. True midpoint tracking was accomplished by using the (right ascension/declination) planetary mode of antenna drive in which hour angle (HA) and declination (dec) position coordinates are computed by inputting HA and dec for the three days beginning with the day of track. Offsets were then used to obtain midpoint tracking.

B. Viking 2 Mars Orbit Insertion

The Viking 2 MOI was successfully supported on August 7 by Madrid DSS 63 with DSS 62 as backup. The same series of events associated with MOI of Viking 1 were repeated for Viking 2. The spacecraft science subcarrier was turned off, then the spacecraft was rolled, the low-gain antenna selected, the spacecraft yawed, and then rolled again so that the high-gain antenna pointed at Earth. The high-gain antenna was then selected and the high-rate subcarrier turned on and modulated by 2 kb/s data. A loss of uplink and downlink lock occurred during the yaw turn.

A DSS exciter ramp was started a one-way light time prior to the predicted uplink loss of lock. A short insurance sweep was then executed to agree with the time at which the spacecraft was commanded back to the high-gain antenna. This tuning assured a two-way lock for MOI burn.

The MOI burn lasted approximately 39 minutes, 35 seconds, and resulted in an orbit of 27.4 hours, just 0.2 hour greater than the desired orbit. The periapsis altitude of 1519 kilometers was achieved and exceeded the desired altitude by only 19 kilometers.

Following the motor burn, the reverse order of roll, low-gain antenna, yaw, roll, and high-gain antenna took place, and an exciter ramp was accomplished to reacquire the uplink.

C. Mars Orbit Trim Number 1 (VO-2)

On August 9, Mars orbit trim number 1 (MOT-1) was successfully performed during the Goldstone DSS 14 view period. This trim refined the Orbiter 2 orbit and resulted in an orbit of 27.3 hours duration. The motor burn lasted 7 seconds. The burn was accomplished without the benefit of a roll, yaw, or roll turn by using the Sun-line reference technique. That is, the burn was timed for the point in the orbit in which the attitude of the Orbiter was corrected without a maneuver. This method preserved the attitude control gas supply. Although telemetry later indicated that the high-gain antenna had moved 0.4 degrees during the motor burn, due to backlash, no changes were observed in the "S" or "X" band downlinks.

D. Mars Orbit Trim Number 2 (VO-2)

On August 14, Australia DSS 43 supported MOT-2 for Viking Orbiter 2. DSS 63 provided backup support for the motor burn. This trim maneuver was to refine the orbit of Orbiter 2 with a motor burn of 3 seconds. No changes in link quantities were observed during this Sun-line maneuver. These first two maneuvers provided a new concept in site certification. Instead of synchronizing the spacecraft's periapsis with a precise point on the planet, the spacecraft was left out of sync so that its periapsis walked around the planet at 40-deg steps per day. This permitted a good examination of the 40- and 50-deg north latitude band and all proposed landing sites.

E. Mars Orbit Trim Number 3 (VO-2)

MOT-3 for Orbiter 2 took place during the DSS 14 pass on August 25, with motor burn at 17:08:45 GMT, lasting for 72 seconds. This was a zero-turn maneuver, and the telecommunications link remained in the high-rate mode, (2 kb/s and 8-1/3 b/s) during the maneuver. The only observed change during the burn was a decrease of about 0.25 dB on X-band, which would correspond to a 0.25-deg change in the high-gain antenna pointing angle. This maneuver stopped Viking 2's westward walk, changed the spacecraft's speed by 155 km/h (96 mi/h) and initiated a drift in the easterly direction toward precise coordinates for the landing site.

F. Mars Orbit Trim Number 4 (VO-2)

The resynchronization of Orbiter 2 over the Utopia landing site occurred on August 27 during the DSS 14 pass. MOT-4 again used the Sun-line maneuver procedure and no changes in the downlink were observed.

G. Viking Lander 2 Preseparation Checkout, Descent, and Landing

Network support of activities associated with the landing of Viking Lander 2 began on September 2 with DSS 43 supporting the separation minus 39-hour command update. This command load prepared the mated lander for the preseparation checkout. This command load was supported using configuration code 15. Australia DSS 44 provided backup command support for DSS 43.

Approximately nine hours later, preseparation checkout began. Spain DSS 63 supported this checkout. A special configuration was designed for the DSS 63 pass. In as much as a Lander 1 direct link was to occur during the first part of DSS 63's view period, two configurations were required. The first configuration was the standard three-spacecraft configuration for Orbiter/Lander/Orbiter, Code 30. Following the Lander direct link, a configuration was needed that would assure the receipt of the Lander 2 checkout data at JPL. Figure 1 shows the configuration used for the second half of the DSS 63 pass. This configuration provided three processing channels for Lander checkout science data. Two of these data streams were output via the wideband data line while the third was output on the high-speed data line, providing dual transmission paths. In parallel with the Lander 2 checkout data, Orbiter 1 was outputting 4 kb/s science data. Since no data channel was available at DSS 63 to process these data, they were recorded on analog tape for postpass playback if required. During the checkout, the relay subsystems were turned on and performed normally. The 10-watt UHF transmitter output power measured 10.72 watts, which was 0.44 dB above the data base value of 9.68 watts.

The Lander 2 checkout proceeded normally during the DSS 63 pass. DSS 62 provided an uplink for Viking Orbiter 2.

Spain DSS 63 supported the separation minus 9.5- and 3.5-hour command updates and the separation "GO" command during their pass on the following day, September 3. Configuration code 24 was used to support this command activity. This configuration code provided two high-rate science data streams with channel 2 of telemetry and command processor alpha outputting data to the high-speed data line while channel 3 of the Telemetry and Command Processor Assembly (TCP) beta output data for wideband data line transmission. This same configuration code had been used for support of preseparation checkout of Lander 1.

The purpose of the "GO" command was explained in the previous article of this series.

All commands scheduled during the DSS 63 view period were successfully transmitted.

Spain DSS 62 provided backup command support for DSS 63.

Goldstone DSS 14 was prime for separation, descent, and landing support. DSS 11 acted as the backup command station for DSS 14.

Since all of the descent data were to be at 4000 b/s, configuration code 15 was specified. Both telemetry and command processor strings were initialized for Orbiter 2, providing dual processing channels with their outputs multiplexed onto one wideband data line.

Separation occurred at 19:39:59 GMT Earth received time on September 3. The landing sequence had been perfect up to this point; however, at 19:46:27 GMT, the X-band receiver showed a drop in received signal level and then went out of lock at 19:47:02 GMT. At the same time the S-band receivers were showing decreases in received AGC. These receivers all dropped lock at 19:47:52 GMT. Goldstone DSS 14 responded to the situation and regained S-band lock within 2 minutes at a received signal level of −169 dBm. Since this signal level was consistent with the low-gain antenna with the high-rate subcarrier on, it was assumed that the signal was not coming from a mispointed high-gain antenna. At 20:08:34 GMT, approximately 19 minutes after the downlink reacquisition, commands were sent to assure the spacecraft was on the low-gain antenna, and to select the cruise mode at 8-1/3 b/s. A round trip light time later (41 minutes) telemetry lock was established and indicated that a switchover of the attitude control system had occurred and that the spacecraft had rolled off of Vega reference by some unknown amount. Engineering data also indicated that the descending Lander-to-Orbiter real-time relay link was working and that the Lander appeared to be in good health. This mode of operation was to continue through touchdown (22:58:20 GMT) on September 3 and until approximately 07:00:00 GMT the following day.

When it was determined the spacecraft had rolled off the Vega reference, a command designated "fly back and sweep" was sent. This command would cause the spacecraft to reacquire Vega if the star was within 5 degrees of the star tracker. Vega was not acquired, indicating a roll of more than 5 degrees. Shortly afterward, commands were sent to roll the spacecraft 360 degrees to obtain a roll attitude reading. The Canopus loss contingency plan identified in the previous article of this series was used to determine the spacecraft orientation in roll axis based on the point at which the X-band signal level reached a peak. Australia DSS 43 supported this effort and obtained a rapid X-band lock, making the star mapping possible. A peak was observed of −149.06 dBm proving two things: one, that the high-gain antenna was still working, and two, that the spacecraft had rolled about 22 degrees off Vega. The Orbiter was then rolled to Vega, the high-gain antenna selected, the high-rate subcarrier turned on, and the playback of the first two Lander pictures initiated. The pictures were received without further problems.

The second received picture, which was a 310-degree panoramic survey, showed a blemish on the Lander's high-gain X-band antenna that could have been caused during landing. Since the antenna dish is a very thin honeycomb design, it was vulnerable to damage while in the stowed position during landing if a substantial shock was experienced.

H. First Lander 2 Direct Link

The first Lander 2 direct S-band link occurred on September 5 with DSS 43 supporting. Configuration code 61 was used by DSS 43 for this pass and was to be used for the first 20 Lander 2 direct links. As identified in the previous article of this series, Code 61 provides 2 processing channels for Orbiter data and 4 processing channels for Lander direct link data.

During the DSS 43 precalibrations it was determined that channel 3 of TCP beta was inoperative. This channel was assigned to process Lander 250-b/s backup data and output via the wideband data line. A decision was made to use channel 2 of the DSS 42 TCP string for this 250 b/s backup data stream. The Viking configuration permits receiver number 2 located at DSS 43 to interface with Subcarrier Demodulator Assemblies 7 and 8 at DSS 42. Two hours prior to the scheduled Lander acquisition, a problem developed with a Helios spacecraft. Australia DSS 42 was assigned to track Helios with the 250-b/s backup stream being given up. Lander acquisition occurred at 03:30:00 GMT with a signal level of −151.5 dBm, very close to the predicted level. An examination of the telemetry data indicated that the uplink sweep had acquired both Lander transponders and that the uplink signal levels for low- and high-gain antennas were nominal. Since all data streams appeared to be nominal, an assumption was made that the damage to the high-gain antenna revealed by the second lander picture was either not severe enough to degrade the communication performance or that the assumption of damage was incorrect. Because the antenna dish faces upward while stowed, it was possible that some surface material could have been thrown up onto the dish during landing and that the apparent damage was really a discoloration caused by Martian dirt. This last theory seems to be the most popular. Since the high-gain antenna surface would never again be in a position in which it could be seen by the Lander cameras, a closer examination was not possible.

I. Mars Orbit Trim Number 7 (VO-1)

MOT-7 took place on September 11. This trim maneuver was supported by DSS 14. It broke the orbital synchronization of Orbiter 1 and caused it to be a walk around the planet. Lander 1 began a reduced-mission phase with continuing biological experiments, weather reporting, and picture acquisitions, but with both real-time and recorded data being transmitted via the Lander to Earth by direct link only. Viking Orbiter 1 begain its walk at 12:24:34 on 11 September following an engine burn that lasted 16 seconds. The resulting orbit moved the spacecraft approximately 40 degrees east each day. The orbit was to carry VO-1 completely around the planet in 9 days continuing the walk to nearly half-way around the planet again until it reached a plane that would pass over the VL-2 location. The maneuver was successfully completed using the standard roll, yaw, roll, and burn sequence.

J. Mars Orbit Trim Number 8 (VO-1)

This trim took place on September 20 and was supported successfully by DSS 14. The burn occurred at 22:36:19 GMT Earth received time. It was a sunline maneuver with no changes observed in the downlink signal levels. This burn accomplished a fine adjustment to orbital statistics in preparation for the synchronization burn to occur on September 24.

K. Mars Orbit Trim Number 9 (VO-1)

MOT-9 synchronized VO-1 over VL-2 to permit VO-1 to become the relay station for Lander 2 data. The maneuver was completed using the Sun-line technique. One anomaly occurred during this maneuver. Upon switching to the low-gain antenna the downlink was observed to be about 1.5 dB low, with the uplink being at least 6 dB lower than predicted. Spain DSS 61 had not turned off range modulation at the required time and the observed degradation was the result of this modulation on the uplink. The trim was supported by DSS 63 and DSS 14 during an overlapping view period.

L. Pre-MOT-5 Test Burn Maneuver (VO-2)

This trim was accomplished for the primary purpose of testing VO-2's motors prior to MOT-5 to make absolutely sure everything was operational prior to MOT-5. The test trim was supported by DSS 43. Near the beginning of their pass, a hydraulic pump failure occurred preventing movement of the DSS 43 antenna. Goldstone's DSSs 12 and 14 passes were extended as long as possible, and, in addition, commands were sent to switch the spacecraft to cruise engineering only mode in the event DSS 43 could not make repairs in time for the maneuver and DSS 44 would be required to track the downlink. Australia DSS 43 managed to recover prior to the main maneuver; however, the cruise mode of telemetry was maintained.

M. Mars Orbit Trim Number 5 (VO-2)

MOT-5's purpose was to modify VO-2's orbit plane so that it could begin observations of the Martian north polar cap. This maneuver differed from the standard in that a command must be transmitted and received at the spacecraft before the motor burn would take place. The spacecraft was first rolled, yawed, and rolled on the low-gain antenna, and then the high-gain antenna was selected. A measurement of the X-band received signal level was made. A measurement below the predicted level would have indicated that the spacecraft high-gain antenna was not properly aligned and that the burn should not be attempted. The spacecraft had been previously programmed to recover from the maneuver automatically should a "GO" command not be received. The X-band downlink was found to be within tolerance and the "GO" command was transmitted. Figure 2 shows the time line associated with MOT-5. The top line indicates the ground time for DSS initiated events. The middle line shows the events when they arrive at the spacecraft or events that originate at the spacecraft. The lower line shows events occurring a round-trip light time after a ground originated event or a one-way light time after a spacecraft event.

MOT-5 was performed flawlessly. The motor burn lasted 5 minutes and produced a velocity change of 343 m/s. It changed the orbit inclination from 55.3 degrees to 75 degrees. The walk will change 30 degrees per day with a planned resynchronization over VL-2 to take place after 16 revolutions on October 18. VO-1 will then be released to start a second walk during solar conjunction. It will resync over VL-1 sometime in mid-November.

IV. Conclusion

With two spacecraft in orbit and two spacecraft landed, all returning extremely large amounts of data daily, the Viking Mission would have to be considered one of the most successful on record. It is also gratifying to note that during this exceptionally high activity period, with the DSN being utilized to near 100 percent capability continuously, the loss of data due to network hardware failures has been insignificant. This has been made possible, to a large degree, by utilizing 64-meter DSS "failure mode" configurations that were designed to optimize the data processing capabilities at a station in the event of a single-point failure in any telemetry stream. These configurations were described in detail in previous articles in this series. Another factor that contributed to the excellent network performance was the use of the DSS Computer Assisted Countdown, which will be described in the next report.

Table 1. Viking Operations Activities

Date	Spacecraft	Activity
1. Aug. 3	Viking 1	Station keeping trim maneuver
2. Aug. 6	Vikings 1 & 2	First simultaneous tracking of 2 VOs by one DSS
3. Aug. 7	Viking 2	MOI
4. Aug. 9	Viking 2	MOT-1
5. Aug. 14	Viking 2	MOT-2
6. Aug. 25	Viking 2	MOT-3
7. Aug. 27	Viking 2	MOT-4
8. Sept. 2	Viking 2	Preseparation checkout
9. Sept. 3	Viking 2	Separation, descent & touchdown
10. Sept. 4	Viking 2	First direct link
11. Sept. 11	Viking 1	MOT-7
12. Sept. 18	Viking 1	First solar occultation
13. Sept. 20	Viking 1	MOT-8
14. Sept. 24	Viking 1	MOT-9
15. Sept. 25	Viking 1	Lunar occultation
16. Sept. 28	Viking 1	Ground Communications Facility 7.2 kb/s high-speed data line test
17. Sept. 29	Viking 2	Pre-MOT 5 test burn maneuver
18. Sept. 30	Viking 2	MOT-5

Table 2. Station support for Viking

DSS	Tracks[a]	Hours tracked	Commands transmitted
August			
11	30	229:35	2
12	6	42:55	0
14	69	494:34	2248
42	27	242:53	1440
43	69	571:21	3094
44	7	56:55	0
61	31	305:24	3511
62	9	83:45	438
63	62	541:52	2318
Total (monthly)	310	2569:14	13,051
September			
11	29	216:14	1430
12	6	45:24	6
14	72	486:59	1205
42	34	304:02	1532
43	69	584:59	2685
44	11	91:29	4
61	29	269:36	1028
62	7	98:29	332
63	81	536:10	1495
Total (monthly)	338	2633:22	9717
Report total	648	5202:36	22,768

[a]The number of tracks includes the number of passes, each of which includes one, two, or three spacecraft simultaneously.

Table 3. IDR production

DSS	Total original	Delivered in 24 hours	Delivered late
14	127	126	1
43	128	122	6
63	139	130	9

Table 4. Viking Discrepancy Report summary, 1 January 1975–26 September 1976

Resolution	Deep Space Station										Deep Space Network	Ground Communication Facility	Network Data Processing Area	Network Operations Control Area	Total	%
	11	12	14	42	43	44	61	62	63	71						
Station Dependent	55	47	188	45	118	22	37	25	141	16	7	34	133	72	940	79.8
Station Independent	6	7	21	8	10	1	2	4	18	1	10	9	76	30	203	17.2
Other or Unavoidable	3	2	3	0	1	0	0	1	0	1	14	5	1	3	34	2.8
Total DRs Closed	64	56	212	53	129	23	39	30	159	18	31	48	210	105	1177	
Total DRs Generated	66	56	221	53	139	23	39	30	167	18	32	48	224	113	1229	
DRs Opened as of 26 Sept. 76	2	0	9	0	10	0	0	0	8	0	1	0	14	8	52	

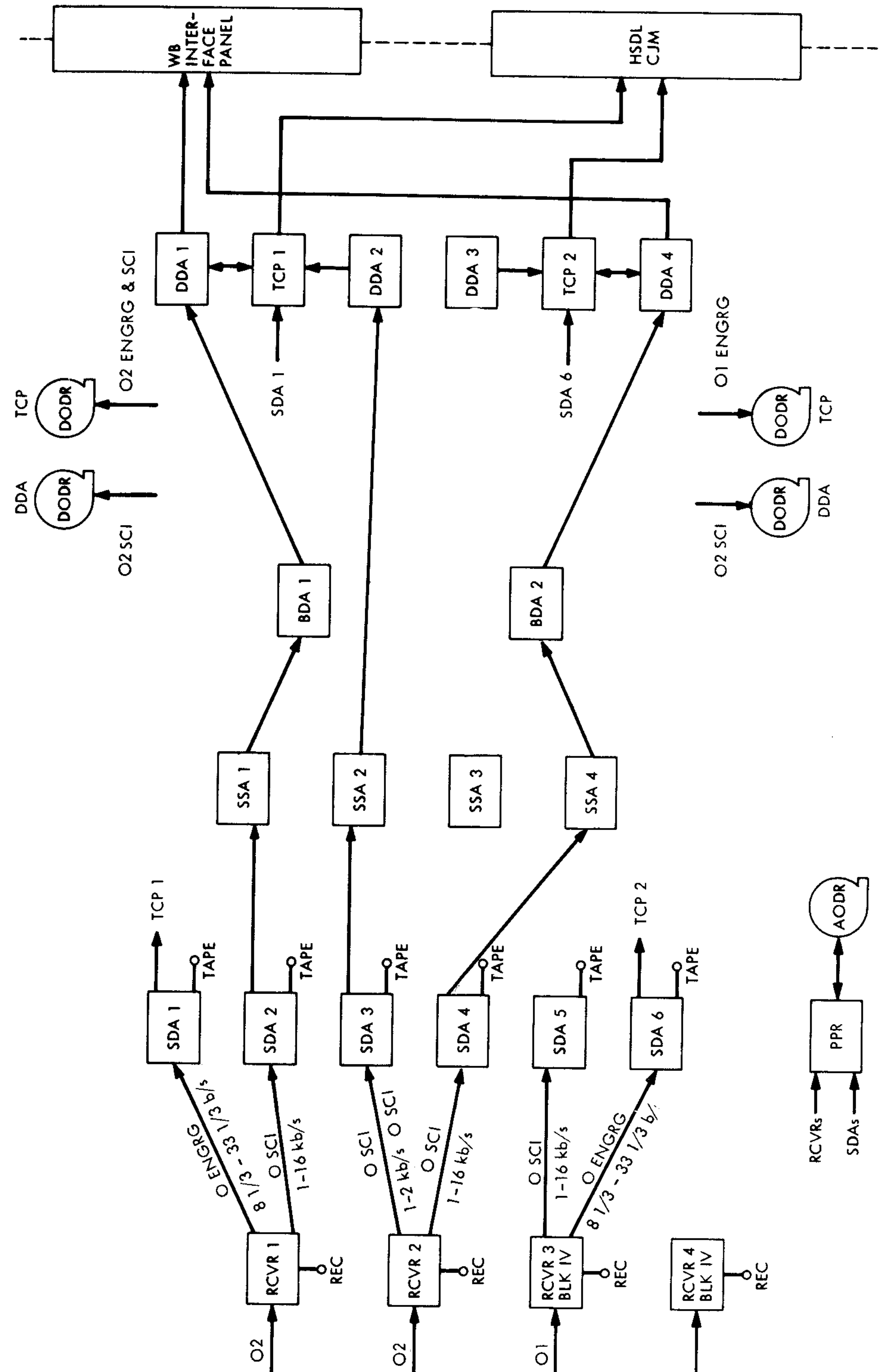

Fig. 1. DSS 63 VO-2 preseparation checkout configuration

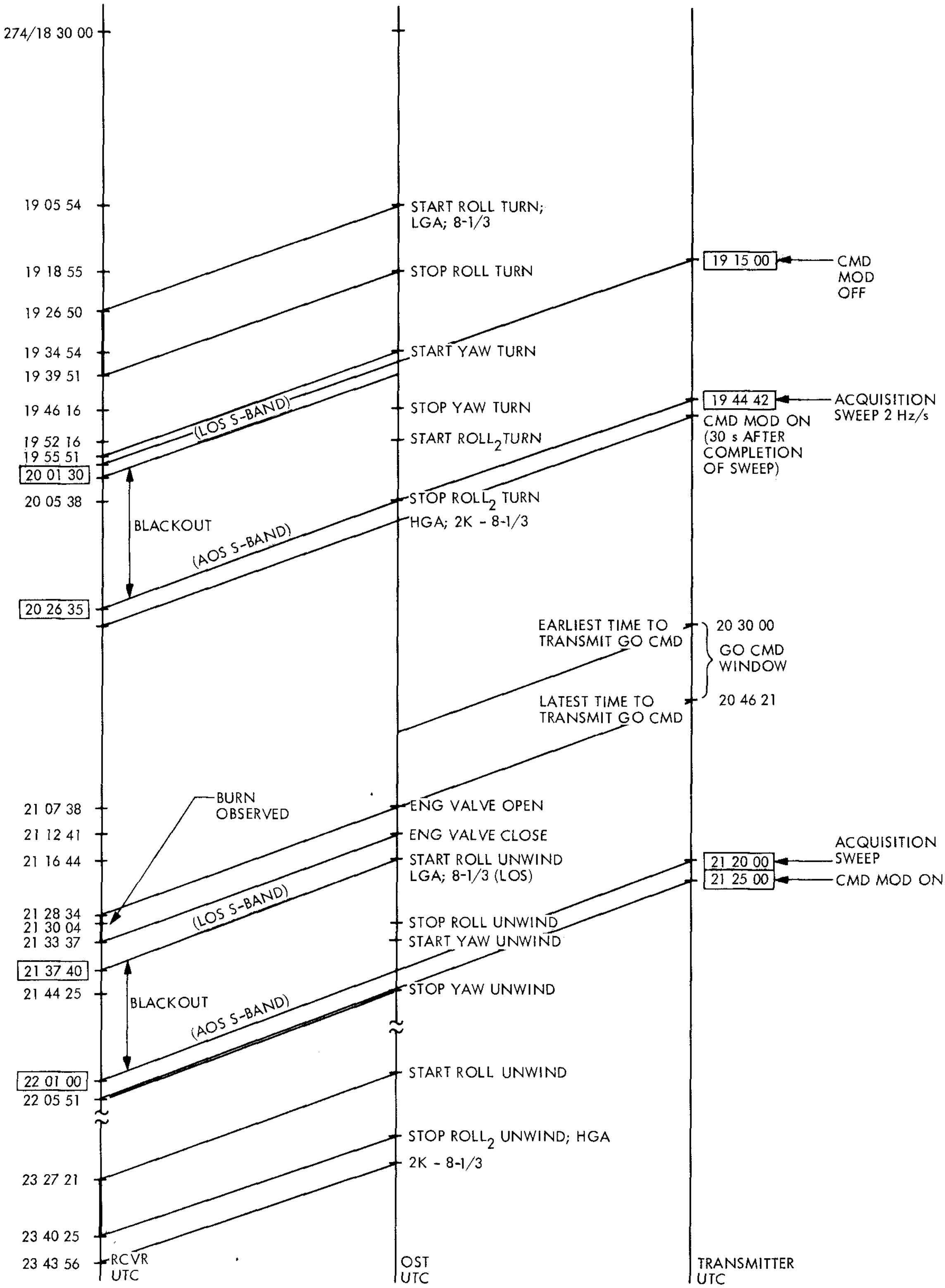

Fig. 2. VO-2 MOT-5 (plane change) summary