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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

RENDEZVOUS PROCEDURES

APOLLO 7

FINAL

REVISION A

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MANNED SPACECRAFT CENTER
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RENDEZVOUS PROCEDURES

APOLLO 7

AS-205/101

September 27, 1968

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1.0 Purpose

This document contains the primary and backup crew procedures for the CSM 101 spacecraft rendezvous with the AS-205 S-IVB stage, in accordance with Detailed Test Objective P20.13 defined in the February 14, 1968, Mission Requirements SPD8-R-001.

The purpose of the Rendezvous Procedures Document is to provide a single source of procedures information for use in flight planning, crew training, and preparation of onboard data.

This is a control document, subject to review by all elements of the Apollo Program, and approval by the Procedures Configuration Control Board. Comments should be directed to Mr. Duane K. Mosel, Crew Safety and Procedures Branch, Flight Crew Support Division, Extension 5340.

2.0 Major Events

The AS-205/101 rendezvous exercise will begin on the second day at about 22:00 hr. with preparation for the phasing maneuver NCC1 and end with the CSM in formation flight with the S-IVB at about 30:00 hr. This time period is divided into the six segments of Section 2.0, and each is treated separately in the following paragraphs. On Figure 2-1 the locations of the most significant nominal mission events are shown in the S-IVB centered relative motion plot. The CSM attitude angles are also indicated in this figure.

2.1 NCC1 Maneuver

At 22:00 hrs. after liftoff, the CMC, IMU, and SCS will be powered up (if not already powered up) and the DAP initialized in preparation for IMU alignment and subsequent rendezvous navigation. This occurs about three revolutions prior to the NCC1 maneuver to allow sufficient time for state vector uplink and two complete night passes for coarse and fine align. State vectors for both vehicles, NCC1 burn information and the time, T (Align), that an integral number of orbits prior to TPI is reached, will be transmitted to the spacecraft by voice at 22:30 over BDA. Sunset on this orbit will occur at about 23+06 at which time the IMU orientation determination program P51 will be performed (only if the IMU had been powered down) by the CSM pilot in the LEB. If more than 10 minutes of darkness remains, a fine align (P52, nominal mode) to T (Align) will be performed. The automatic star selection and optics pointing will be used for the fine align. Sighting on a third star is planned as part of a fine align check.

At 24:00 a perigee will be reached and the ORDEAL will be initialized to the local vertical by slewing the left FDAI to the angle θ from V83 and setting the orbital rate for the altitude $\frac{H_A + H_P}{2}$, where H_A and H_P will be obtained from V82.

Throughout the mission the ORDEAL will be initialized as near to apsidal crossings as possible, to minimize effect of orbit eccentricity on FDAI error (See Reference 6.4). If the IMU had been powered down prior to the rendezvous, a PIPA bias measurement will be performed at approximately 24:12. The next sunset will occur at 24:36, at which time another fine alignment to REFSMMAT will be accomplished (assuming P52, nominal mode, completed), followed by a fine align check on a third star.

Prior to the next daylight period which begins at about 25:12 hrs., the rendezvous navigation program will be called up, the CSM maneuvered automatically to the track attitude, and, if time permits, a few SXT marks may be taken. The purpose of this exercise will be to verify that the DAP and auto-optics are tracking the target properly, and not to obtain any navigation data for post-flight analysis.

At 25:35 hrs. over BDA, an MSFN update of both state vectors and the NCC1 maneuver parameters will occur. Following this, the CMP will call the external ΔV program (P30) and the CDR will perform the EMS ΔV test and load the NCC1 ΔV magnitude into the EMS. At about 25:45, the CSM event timers will be synchronized to the NCC1 ignition time to go (V16 N35) and

the SPS thrusting program (P40) will be called. The vehicle will be maneuvered automatically to the burn attitude for a SXT/star check. A fine align to REFSMMAT and fine align check will then be performed during the darkness period prior to the NCC1 burn. The gyro-torque angles, used in this alignment, will be voiced to the MSFN for future uplink of the IMU drift compensation.

At 26:10, the CMP will leave the LEB and occupy the center seat. He will then call the SPS thrust program (P40) and automatically orient to the final burn attitude. At about 26:15 the CDR will begin preparation for SPS ignition.

The 10.1 second NCC1 maneuver will be performed at 26:25. After the ΔV's have been trimmed with the RCS to an acceptable level, the residuals will be recorded. Following the NCC1 burn, POO will be called to terminate average g.

2.2 NCC2 Maneuver

Shortly after the NCC1 maneuver, if time is available, the CMP will enter the LEB and call the rendezvous navigation program P20 The spacecraft will be maneuvered automatically to the track orientation. Upon completion of the track exercise the CMP will again move back to the center seat. At 27:05 over MIL, the MSFN will uplink NCC2 burn data and state vectors for both vehicles, as well as voice the NSR burn data. This will be followed by P30, the EMS ΔV test (if NCC2 is an SPS maneuver) and loading the NCC2 ΔV into the EMS counter. At 27:15, P40 or P41 will be called and an automatic maneuver made to the burn attitude.

NCC2 is a phase correction maneuver to place NSR at the desired trailing desplacement and altitude. If possible, it is desirable to eliminate the NCC2 maneuver. This can be done by varying the time of NSR to obtain the desired TPI TIG. If the resulting ΔH is not acceptable, the ΔH at the closest bound will be used to compute a TPI TIG. If this time falls outside the lighting constraints then the NCC2 burn is inevitable and will be calculated for a nominal ΔH and desired TPI TIG (midpoint of darkness). It will be performed with the SPS engine if larger than 0.5 sec SPS burn time.

The NCC2 burn will occur at 27:30. If the SPS is used, the CDR will trim the residual velocities to minimize errors at NSR. Residuals after trimming will be recorded. At the completion of the thrust program, the CMC idling program (P00) will again be called to terminate average g.

2.3 NSR Maneuver

The purpose of the NSR maneuver is to make the spacecraft and S-IVB orbits coelliptical. At about 27:32, after completion of NCC2, the CMP will enter the LEB, load the DAP for narrow deadband, and call P30.

The NSR ignition time and burn components will be loaded into P30 followed by the EMS test and initialization for monitoring and backup. The event timers will be set counting down to ignition time, and approximately 25 minutes before NSR the spacecraft will be manually maneuvered to the burn attitude. A fine align to REFSMMATT (P52) and an align check will be performed prior to calling the SPS thrust program (P40), 15 minutes prior to NSR, at 27:45. If time allows, a SXT/Star check will be done at this point. Ten minutes before NSR, at 27:50, the CMP will leave the LEB in preparation for the burn. NSR ignition will be approximately 28:00. Duration of the SPS burn will be nominally 8.8 seconds.

The velocity residuals will be trimmed carefully to minimize errors in the coelliptical orbit. Residuals will be recorded after trimming.

2.4 TPI Maneuver

Following the NSR maneuver, the CMP will enter the LEB and call the rendezvous navigation program (P20) and the TPI prethrust program (P34). The CSM will be automatically oriented to the track attitude. The elevation option for TPI will be selected by entering a value of 27.45 degrees. The nominal TPI time will be entered to minimize CMC interations in determining actual time of TPI. The time between TPI and TPF will be 35:00 minutes corresponding to approximately 140 degrees orbit travel. On the initial pass through P34, the event timers will be synchronized counting down to TPI. At TPI-64 minutes, 10 S-IVB sightings will be made and P34 recycled to observe the change in TPI time and total ΔV. (The threshold parameters, RMAX and VMAX, will be pad loaded to -1. Consequently, no state vector updates will be incorporated automatically. The crew must always proceed from the ΔR, ΔV display before mark incorporation.) This computed TPI TIG is then compared with the MCC-H TIG as a preliminary check of the CMC's navigation.

At TPI -48 minutes, ORDEAL will be updated to provide the best possible attitude reference for terminal phase backup.

If time permits, 5-10 S-IVB marks will be made, starting at TPI -38 minutes. The MSFN recommendation for the TPI maneuver will be transmitted to the spacecraft over ANT at 28:47. Should it be necessary, the state vectors for both the CSM and SIVB will be available, via uplink, at this time. At approximately TPI-30 minutes, the two CMC parameters; "WRENDPOS" and "WRENDVEL", will be loaded to 1000 feet and 1 fps. respectively (if they have not previously been loaded to these values). An additional 10 S-IVB marks will then be taken starting at TPI-25 minutes. After the first three marks, the W matrix will be rediagonalized to the values given above.

Throughout the coelliptical phase, whenever time permits, range and angle data from V83 or V85 will be recorded on the crew's polar plot. This will provide additional information on the status of the trajectory at TPI.

Following the end of the second set of S-IVB marks at TPI-15 minutes, the final comp-cycle in P34 will be selected. The magnitude of the resulting TPI solution will then be set into the EMS and the event timers will be resynchronized counting down to TPI. At TPI-11 minutes, the RCS thrusting program will be called and the spacecraft rotated manually in SCS pulse mode to boresight on the S-IVB using the COAS.

At TPI-8 and 5 minutes, range, range rate, and angle data will be recorded while boresighted on the target. These data will be used to enter the flight charts for determining the backup solution for TPI as explained in Section 4.1.

By approximately TPI-4 minutes the decision will be made in accordance with mission rules as to whether the PNGS TPI maneuver is usable. If the PNGS solution is used, the CSM will be auto maneuvered to the burn attitude. If the MSFN or backup chart solution is to be used, the spacecraft X-axis will be boresighted on the target and P47 will be used for thrust monitoring. In this case the solution is impulsive; the EMS would be turned on at TPI-1 minute and the CDR would begin the burn at TPI-30 seconds.

2.5 Midcourse Maneuvers

Following the TPI burn, P35 will be called, the CSM will automatically maneuver back to the track attitude, and the DAP will be configured for 0.5 degree deadband in preparation for SXT marks on the S-IVB. At approximately TPI+4 minutes, a "phoney" S-IVB mark will be made in order to bring the W matrix into synchronization with the state vectors. The update option will then be changed and 4 CSM marks made. The CMP will key ENTER at TPI+8 minutes to permit taking backup data at +9 minutes using V85 with the SXT boresighted on the S-IVB. Two more CSM updates will then be made before obtaining final backup data at 12 minutes. At 12 minutes, 30 seconds, the PROCEED from V16 N45 will be keyed which will fix the time of the midcourse maneuver at TPI+14 minutes. (The parameter "ATIGINC" will be padloaded to a value of 90 seconds.) The RCS thrust program will be utilized but the spacecraft will not be maneuvered from the track attitude.

After the first midcourse maneuver Program P35 will again be called at about TPI+15 minutes, and backup data will be recorded at 16 and 19 minutes with 2 SXT marks in between backup measurements. At 19 minutes 30 seconds, the PROCEED will be

keyed which sets the second and final midcourse at 21 minutes. Prior to the burn the spacecraft will be maneuvered to boresight on the SIVB. Program 41 will be used for the second midcourse exactly as the first.

2.6 Line of Sight Control and Braking Maneuvers

After the midcourse maneuver at TPI+21 minutes, the SIVB will be tracked using the COAS. No more SXT marks will be made after TPI+18 minutes.

When the S-IVB is boresighted in the COAS, SCS narrow deadband attitude hold will be selected, and with hands off the attitude controller, the drift of the S-IVB in the COAS reticle will be observed. By timing the drift, corrections normal to the line of sight will be obtained from flight charts and executed to maintain a collision course along an inertially fixed line.

The selection of P47 will be delayed as long as possible to minimize average g on-time, but early enough to insure all of the thrust acceleration is measured. That is, the CDR must anticipate line-of-sight thrusting by at least one minute due to the time lag in P47.

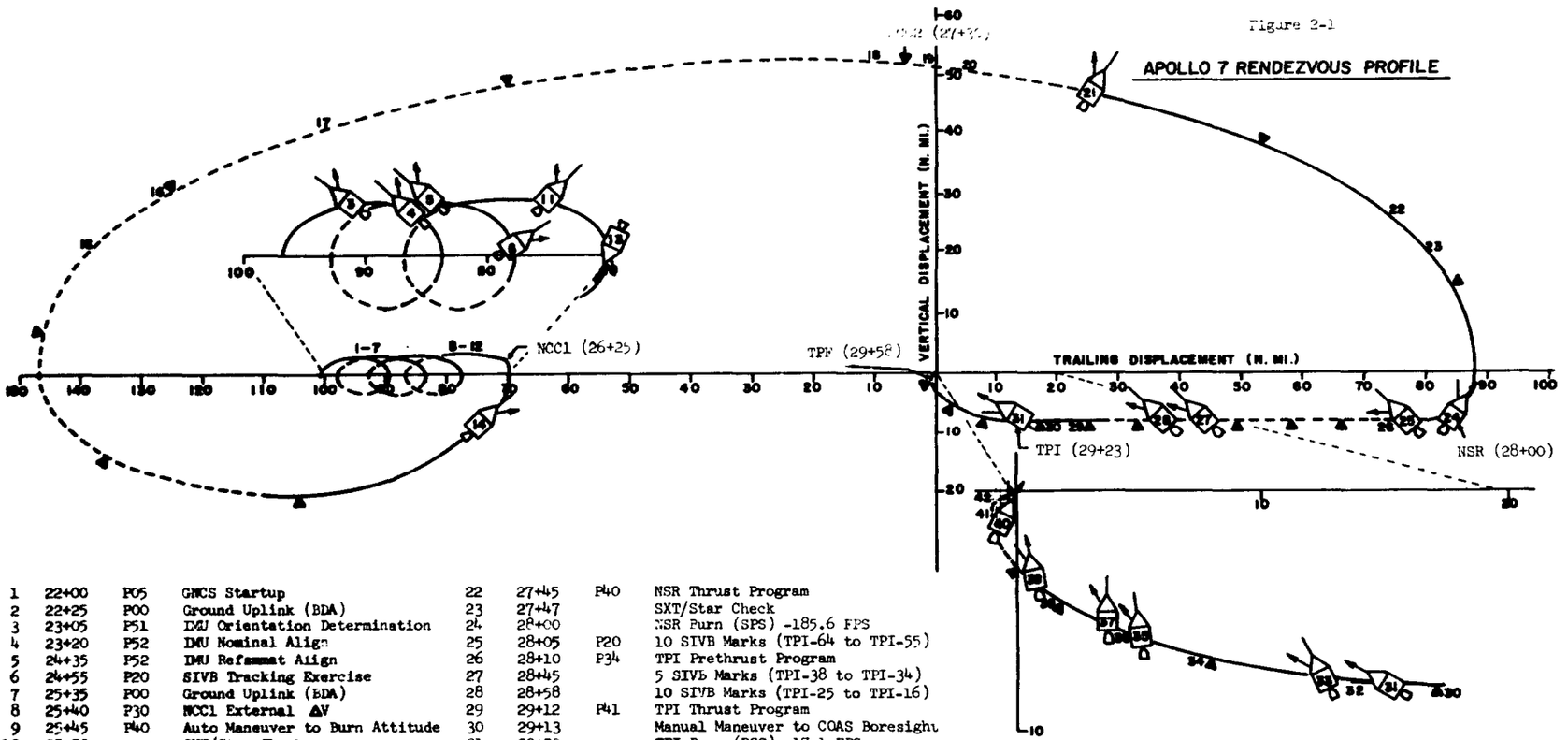
At the braking gates, range rate will be reduced to the maximum allowable values defined in the following table:

R_{NMI}	1.00	0.50	0.25	0.15
R_{MAX} FPS	25	15	10	5

MSFN targeting of NCC2/NSR will attempt to assure sunrise by the time 1 N MI range is reached. Therefore, the COAS will will be useful for estimating range and closing rate inside the braking gates. Thus a transition can be made from the DSKY display of ranging information to the visual scene. The final braking and initial formation flying will occur about 30:10 after liftoff for TPI at the nominal time.

Figure 2-1

APOLLO 7 RENDEZVOUS PROFILE



1	22+00	P05	GNCS Startup	22	27+45	P40	NSR Thrust Program
2	22+25	P00	Ground Uplink (BDA)	23	27+47		SXT/Star Check
3	23+05	P51	IMU Orientation Determination	24	28+00		NSR Burn (SPS) -185.6 FPS
4	23+20	P52	IMU Nominal Align	25	28+05	P20	10 SIVB Marks (TPI-64 to TPI-55)
5	24+35	P52	IMU Refsmmat Align	26	28+10	P34	TPI Prethrust Program
6	24+55	P20	SIVB Tracking Exercise	27	28+45		5 SIVb Marks (TPI-38 to TPI-34)
7	25+35	P00	Ground Uplink (BDA)	28	28+58		10 SIVB Marks (TPI-25 to TPI-16)
8	25+40	P30	NCC1 External ΔV	29	29+12	P41	TPI Thrust Program
9	25+45	P40	Auto Maneuver to Burn Attitude	30	29+13		Manual Maneuver to COAS Boresight
10	25+50		SXT/Star Check	31	29+23		TPI Burn (RCS) -17.1 FPS
11	25+55	P52	IMU Refsmmat Align	32	ASAP	P35	MCC1 Prethrust Program
12	26+10	P40	NCC1 Thrust Program	33	29+28		6 CSM Marks (TPI+5 to TPI+11)
13	26+25		NCC1 Burn (SPS) -208.6 FPS	34	29+36	P41	MCC1 Thrust Program
14	26+30	P20	SIVB Tracking Exercise	35	29+37		MCC1 Burn (RCS)
15	27+05	P00	Ground Uplink (MIL)	36	ASAP	P35	MCC2 Prethrust Program
16	27+10	P30	NCC2 External ΔV	37	29+40		2 CSM Marks (TPI+17 to TPI+18)
17	27+15	P40/P41	NCC2 Thrust Program	38	29+43	P41	MCC2 Thrust Program
18	27+30		NCC2 Burn (SPS/RCS)	39	29+44		MCC2 Burn (RCS)
19	27+32	P30	NSR External ΔV	40	AS REQD	P47	Thrust Monitor (LCS Control)
20	27+34		Manual Maneuver to Burn Attitude	41	29+58		TPF (RCS) -18 FPS
21	27+35	P52	IMU Refsmmat Align	42	30+10		Station Keeping

NOTE:

COAS LINE OF SIGHT
SXT LINE OF SIGHT
DENOTES ACTIVE LINE OF SIGHT
DAYLIGHT
NIGHT
10 MINUTES

GET	PCR GW	DISPLAYS/PROCEDURES	ET
		RECEIVE G8 FOR RENDEZVOUS	
		CMP ENTER NAV BAY	
		(PERFORM INITIAL	
21+50		SWITCH CHECKLIST)	
	CDR	CMC ATT-IMU	
		FDAI SCALE-5/1	
		FDAI SEL-1/2	
		FDAI SOURCE-ATT SET	
		ATT SET-GDC	
		MAN ATT(3)-RATE CMD	
		LIMIT CYCLE-OFF	
		ATT DB-MAX	
		RATE-LOW	
		DIRECT RCS-OFF	
		SCS CHAN(4)-OFF	
		SC CONT-CMC	
		CMC MODE-FREE	
		BMAG MODE(3)-RATE 2	
		DV THRUST DIRECT-OFF	
		DV THRUST(A,B)-OFF	
		SCS TVC(2)-RATE CMD	
		GMBL MOTORS(4)-OFF	
		SCS LOGIC BUS 3-ON	
		LV GUIDANCE-IU	
		IMU CAGE-OFF	
		EMS ROLL-OFF	
		.05G-OFF	
		∝/PC-PC	
		LV/SPS IND SII/SIVB-GPI	
		TVC GMBL DRIVE(2)-AUTO	
		FCSM(A,B)-RESET/OVERRIDE	
		EMS FUNCTION-OFF	
		EMS MODE-STBY	
		UP TLM(MDC)-BLOCK	
		RCS TRNFR-SM	
		PANEL 8 CB-CLOSED EXCEPT-	
		ELS BAT A AND B(2)	
		SECS ARM(2)	
		PL VENT FLT/PL	
		FLOAT BAG(3)	
		RCS LOGIC(2)	
		SPS GMBL(4)	
		TVC SERVO PWR(BOTH)-OFF	
		FDAI GPI PWR-BOTH	
		HAND CONT PWR-BOTH	
		SCS ELECT PWR-CDC/ECA	
		BMAG PWR(BOTH)-ON	
	LMP	G/N PWR-AC1	
		MN BUS TIE(2)-OFF	
		NONESS BUS-MNB	
		PANEL 5 G/N CB(10)-CLOSED	
		PANEL 229 CB-CLOSED	
		EXCEPT-MN REL PYRO(2)	
	LEB	G/N PWR,OPTICS-OFF	
		OPTICS MODE-ZERO	
		CONT SPEED-HI	
		CONT COUPLING-DIRECT	
		SCT TRUN-SLAVE TO SXT	
		CONDITION LAMPS-ON	
		UP TLM(LEB)-ACCEPT	
	LEB	PRO(UNTIL STBY LIGHT-OFF)	
22+00		RSET	
	CDR	MANEUVER S/C-SEP/HDS-UP	
	LEB	KEY V37E05E(IF IMU OFF)	
P05			
		F 50 25 00060	
	LEB	G/N PWR,IMU-ON	
		(MONITOR NB ATT LT)	
	LEB	KEY ENTER	
		F 50 07	
	LEB	KEY V37E00E	
P00			
SUNUP			
22+13			
	CDR	UP TLM(MDC)-ACCEPT	
22+25		MONITOR GND UPLINK(BDA)	
P27			
	LMP	RECORD VOICE DATA	
	CDR	UP TLM(MDC)-BLOCK	
	LEB	KEY V48E(DAP LOAD)	
22+35		F 04 46 11102 DAP	
		11111 CON-	
		B FIG	
	LEB	PRO	
		F 06 47 +00187 IX	
		+00584 IYIZ	
		+32607 WT	
	LEB	PRO	
		F 06 48 -001.06 PTRIM	
		-000.60 YTRIM	
		+0198C TLX	
	LEB	PRO	
	LEB	KEY V46E	
	LEB	KEY V62E	

```
   CDR ATT DB=MIN
       SCS CHAN(4)=A
       BMAG MODE(3)=ATT1/RATE2
       SC CONT=SCS
   LEB G/N PWR,OPTICS=ON
       ZERO OPTICS-15 SEC
       OPTICS MODE=MAN

   LEB KEY V37E51E(IF IMU OFF)
P51
23+05    F 50 25   00015
   CDR MAN ATT(P,Y)=ACC CMD
SUNDN  MONITOR FDAI
23+06
   LEB ACQ STARS IN SCT
       (AVAILABLE STARS=NUNKI,
        ALTAIR,DABIH)
   CDR MAN ATT(3)=RATE CMD
   LEB KEY ENTER
         F 51 70   STAR CODE
   LEB MARK ON STAR 1
         F 50 25   00016
   LEB KEY ENTER
23+10    F 01 70   000XX

   LEB PRO
         F 51 70   STAR CODE
   LEB MARK ON STAR 2
         F 50 25   00016
   LEB KEY ENTER
23+15    F 01 70   000XX
   LEB PRO
           06 05(ANGLE DIFF)
       (PRO=IF REQUIRED)
         F 50 07


   LEB KEY V37E52E(IF GET IS
         LESS THAN SUNUP=10 MIN)
P52
```

```
23+20    F 04 06   00005 IMU
                   00002 ORIENT
                     B   SEL
   LEB PRO
         F 06 34 +000__. TIME
                 +000__. RF
                 +0__.__ ALIGN
   CDR MANEUVER S/C=SEP/HOS-UP
   LEB PRO
         F 06 22(R,P,Y)
   LEB PRO
   CDR MONITOR FDAI AND
       NO ATT LIGHT
         F 50 25   00015
   LEB ZERO OPTICS-15 SEC
   CDR MAN ATT(P,Y)=ACC CMD
   LEB ACQ STARS IN SCT
   CDR MAN ATT(3)=RATE CMD
   LEB KEY ENTER
       (AVAILABLE STARS=FOMAL-
        HAUT,DIPHDA,ACHERNAR)

*        F 01 70   STAR CODE 1
   LEB CHECK STAR CODE 1
       OPTICS MODE=CMC
   LEB PRO
           06 92(SHAFT,TRUN)
   LEB IDENTIFY STAR 1
       OPTICS MODE=MAN
         F 51 70   STAR CODE 1
   LEB MARK ON STAR 1
23+25    F 50 25   00016
   LEB KEY ENTER
         F 01 70   STAR CODE 1

   LEB PRO
         F 01 70   STAR CODE 2
   LEB ZERO OPTICS-15 SEC
       CHECK STAR CODE 2
       OPTICS MODE=CMC
```

```
   LEB PRO
           06 92(SHAFT,TRUN)
   LEB IDENTIFY STAR 2
       OPTICS MODE=MAN
         F 51 70   STAR CODE 2
   LEB MARK ON STAR 2
         F 50 25   00016
   LEB KEY ENTER
         F 01 70   STAR CODE 2
   LEB PRO
           06 05(ANGLE DIFF)
         F 06 93(GYRO TORG ANG)
   LEB PRO
23+30    F 50 25   00014
   LEB (FOR FINE ALIGN CHECK=
        KEY ENTER,RETURN TO *,
        ZERO OPTICS AND USE
        THIRD STAR)
   LEB PRO
SUNUP    F 50 07
23+42
   LEB G/N PWR,OPTICS=OFF
   CDR ATT DB=MAX


   LEB KEY V37E00E
P00

   CDR SET ORDEAL ON FDAI 1
24+00
   LEB  KEY V82E
          F 06 44(HA,HP,TFF)
   CDR  SET ALT TO HA,HP AVG
   LEB  PRO
          F 06 32(TIME TO PER)
   LEB  PRO
   LEB  KEY V83E
          F 06 54(R,R,B)
   CDR  SLEW FDAI TO B
   LEB  PRO
```

```
   LEB MEASURE PIPA BIAS(CYI)
24+12  (IF IMU HAS BEEN POWERED
        DOWN)
   LEB  KEY V25N21E
         F 21 21(X,Y,Z PIPAS)
   LEB  SET ET=ZERO
   LEB  KEY ENTER,ENTER,
         ENTER AND V06
   LEB  KEY ENTER/START ET
   LMP  RECORD INITIAL VALUES
   LEB  KEY ENTER(AT 4+16 MIN)
   LMP  RECORD FINAL VALUES
        CALCULATE X,Y,Z PIPA
         BIAS AND VOICE TO GND


   CDR ATT DB=MIN
       BMAG MODE(3)=ATT1/RATE2
       SC CONT=SCS
   LEB G/N PWR,OPTICS=ON

   LEB KEY V37E52E
P52
24+35    F 04 06    00005 IMU
                    00003 ORIENT
                      B   SEL
       (IF P52 COMPLETED ON
        PREVIOUS NIGHT PASS)
   LEB PRO
         F 50 25   00015
   LEB ZERO OPTICS=15 SEC
   CDR MAN ATT(P,Y)=ACC CMD
SUNDN
24+36
   LEB ACQ STARS IN SCT
   CDR MAN ATT(3)=RATE CMD
   LEB KEY ENTER
       (AVAILABLE STARS=NUNKI,
        ALTAIR,DABIH,ENIF)
*        F 01 70   STAR CODE 1
   LEB CHECK STAR CODE 1
       OPTICS MODE=CMC
   LEB PRO
         06 92(SHAFT,TRUN)
   LEB IDENTIFY STAR 1
       OPTICS MODE=MAN
         F 51 70   STAR CODE 1
   LEB MARK ON STAR 1
24+40    F 50 25   00016
   LEB KEY ENTER
         F 01 70   STAR CODE 1

   LEB PRO
         F 01 70   STAR CODE 2
   LEB ZERO OPTICS=15 SEC
       CHECK STAR CODE 2
       OPTICS MODE=CMC
   LEB PRO
         06 92(SHAFT,TRUN)
   LEB IDENTIFY STAR 2
       OPTICS MODE=MAN
         F 51 70   STAR CODE 2
   LEB MARK ON STAR 2
         F 50 25   00016
   LEB KEY ENTER
         F 01 70   STAR CODE 2
   LEB PRO
         06 05(ANGLE DIFF)
         F 06 93(GYRO TORQ ANG)
   LEB PRO
24+45    F 50 25   00014
   LEB (FOR FINE ALIGN CHECK=
        KEY ENTER,RETURN TO *,
        ZERO OPTICS AND USE
        THIRD STAR)
   LEB PRO
         F 50 07
   LEB G/N PWR,OPTICS=OFF

   LEB KEY V37E00E
P00

   CDR ALIGN GDC TO IMU
       ATT DB=MAX

   CDR VERIFY GRDEAL(FDAI 1)
24+50
   LEB  KEY V82E
         F 06 44(HA,HP,TFF)
   CDR  SET ALT TO HA,HP AVG
   LEB  PRO
         F 06 32(TIME TO PER)
   LEB  PRO
   LEB  KEY V83E
         F 06 54(R,R̊,θ)
   CDR  SLEW FDAI TO θ
   LEB  PRO


   CDR BMAG MODE(3)=RATE 2
       SC CONT=CMC
       CMC MODE=AUTO
   LEB KEY V37E20E(IF NC1 RCS
        BURN NOT REQUIRED)
P20
24+55    F 04 06    00001 SV
                    00001 OPTION
                      B
   LEB G/N PWR,OPTICS=ON
       ZERO OPTICS=15 SEC
       OPTICS MODE=CMC
   LEB PRO
   CDR MONITOR MANEUVER TO
        NAV TRACK ATT(SXT)
   LEB TRACK SIVB
```

```
   LEB KEY V57E(IF DESIRED)
25+00    F 51 88
   LEB OPTICS MODE-MAN
       MARK(IF DESIRED)
   LEB OPTICS MODE CMC
       G/N PWR,OPTICS-OFF
   LEB KEY ENTER


   LEB KEY V37E00E
P00
SUNUP
25+12



   CDR UP TLM(MDC)-ACCEPT
25+35  MONITOR GND UPLINK(BDA)
P27
   LMP RECORD VOICE DATA
   CDR UP TLM(MDC)-BLOCK


   LEB KEY V37E30E
P30
25+40     F 06 33 +00026.TIG
                  +00024.DF
                  +055.00NCC1
   LEB PRO
         F 06 82 +0054.8DVXL
                 -0001.3DVYL
                 +0201.6DVZL
   LEB PRO
         F 06 42(HA,HP,DV)
   LMP COPY DV

   CDR PERFORM EMS DV TEST
        EMS FUNCTION-OFF
        CB EMS(2)-CLOSED
        EMS MODE-STBY
        EMS FUNCTION-DV SET
        LOAD +1586.8
        EMS FUNCTION-DV TEST
        (SPS LT OFF AT DV=-0.1)
        EMS MODE-STBY

   CDR EMS FUNCTION-DV SET
       LOAD VC
       EMS FUNCTION-DV

   LEB PRO
         F 16 35(TFI)
   CDR SET MDC DET              38
   LEB SET LEB DET
   LEB PRO
         F 16 45(N,TFI,MGA)
   LEB PRO
         F 50 07


   LEB KEY V37E40E              40
P40
25+45     F 06 86(VG-LV)

   LMP COMPARE WITH PAD DATA

   LEB PRO
         F 06 22(R,P,Y)

   LMP COMPARE WITH PAD DATA

   LEB PRO
         F 50 25   00203
   CDR ALIGN S/C IN ROLL
   CDR BMAG MODE(3)-RATE 2
       SC CONT-CMC
       CMC MODE-AUTO
   LEB KEY ENTER
           06 22(R,P,Y)
   CDR MONITOR MANEUVER
         F 50 19(R,P,Y)
   LEB PRO
         F 50 25   00204
   LEB G/N PWR,OPTICS-ON

   LEB PERFORM SXT/STAR CHECK
25+50   ZERO OPTICS-15 SEC     35
        OPTICS MODE-CMC
        KEY V41N51E
         F 21 92 ----•--SHAFT
                 --•---TRUN
                   B
        KEY ENTER AND OBSERVE
         OPTICS DRIVE TO STAR
        KEY RLSE
         F 50 25   00204


   CDR ATT DB-MIN
       BMAG MODE(3)-ATT1/RATE2
       SC CONT-SCS

   LEB KEY V37E52E
P52
25+55     F 04 06   00005 IMU  30
                    00003ORIENT
                      B   SEL
   LEB PRO
         F 50 25   00015
   LEB ZERO OPTICS-15 SEC
   CDR MAN ATT(P,Y)-ACC CMD
   LEB ACQ STARS IN SCT
   CDR MAN ATT(3)-RATE CMD
   LEB KEY ENTER
       (AVAILABLE STARS-SPICA,
        ALKAID,ARCTURUS)

*        F 01 70   STAR CODE 1
   LEB CHECK STAR CODE 1
       OPTICS MODE-CMC
   LEB PRO
```

```
          06 92(SHAFT,TRUN)
    LEB IDENTIFY STAR 1
        OPTICS MODE-MAN
          F 51 70    STAR CODE 1
    LEB MARK ON STAR 1
26+00    F 50 25    00016        25
    LEB KEY ENTER
          F 01 70    STAR CODE 1

    LEB PRO
          F 01 70    STAR CODE 2
    LEB ZERO OPTICS-15 SEC
        CHECK STAR CODE 2
        OPTICS MODE-CMC
    LEB PRO
          06 92(SHAFT,TRUN)
    LEB IDENTIFY STAR 2
        OPTICS MODE-MAN
          F 51 70    STAR CODE 2
SUNDN
26+05                            20
    LEB MARK ON STAR 2
          F 50 25    00016
    LEB KEY ENTER
          F 01 70    STAR CODE 2
    LEB PRO
          06 05(ANGLE DIFF)
          F 06 93(GYRO TORQ ANG)

    LMP RECORD/VOICE TO GND

    LEB PRO
          F 50 25    00014        18
    LEB (FOR FINE ALIGN CHECK-
         KEY ENTER,RETURN TO *,
         ZERO OPTICS AND USE
         THIRD STAR)
    LEB PRO
          F 50 07
    LEB G/N PWR,OPTICS-OFF
```

```
    LEB KEY V37E00E
P00

    LEB LEAVE NAV BAY


26+10                            15
    CMP KEY V37E40E
P40
          F 06 86(VG-LV)
    CMP PRO
          F 06 22(R,P,Y)
    CMP PRO
          F 50 25    00203
    CDR BMAG MODE(3)-RATE 2
        SC CONT-CMC
        CMC MODE-AUTO
    CMP KEY ENTER
          06 22(R,P,Y)
    CDR MONITOR MANEUVER
          F 50 19(R,P,Y)


26+15                            10
    LMP IGNITION PREPARATION
         MN BUS TIE(2)-ON(UP)
         S-BAND ANT-C
         SPS HE VLV TB(2)-BP
         SPS HE VLV(2)-AUTO
    CDR  CB SPS GMBL(4)-CLOSED
         DIRECT RCS-OFF
         SCS TVC(2)-RATE CMD
         TVC GMBL DRIVE(2)-AUTO

    CDR GMBL DRIVE AND TRIM CHK 9
         TVC SERV PWR 1-AC1/MNA
         TVC SERV PWR 2-AC2/MNB
         HAND CONT PWR-1
         RHC 2-ARMED
         GMBL MOTORS
```

```
         PITCH 1 - START-ON
         YAW 1 - START-ON
        THC-CW
        RHC-VERIFY NO MTVC
        GMBL MOTORS              8
         PITCH 2 - START-ON
         YAW 2 - START-ON
        CONFIRM GPI TRIM CONT
        SET GPI-PTRIM(-1.06)
                YTRIM(-0.60)
        RHC-VERIFY MTVC
        THC-NEUTRAL
        HAND CONT PWR-BOTH

    CDR ALIGN ROLL(HDS-UP)       7

    CMP KEY ENTER
          06 22(R,P,Y)
    CDR MONITOR MANEUVER
          F 50 19(R,P,Y)
    CDR MAN ATT(3)-RATE CMD
        RATE-HIGH
        DIRECT RCS-ON
        BMAG MODE(3)-ATT1/RATE2

26+20                            5
    CDR ALIGN GDC TO IMU

    CMP PRO
          F 50 25    00204
    CMP KEY ENTER                4
    CDR MONITOR GMBL DRIVE TEST
        VERIFY GPI TRIM
          06 40(TFI,VG,DVM)
    CDR VERIFY MDC DET
    CMP VERIFY VG
        CHECK C/W LAMPS
    CDR FDAI SCALE-5/5           3
        VERIFY S/C ATTITUDE
    CMP KEY V74E
```

```
   CDR DV THRUST(2)-NORM(1 MIN)
       THC-ARMED
       RHC(2)-ARMED
   CDR EMS MODE-AUTO(AT 30SEC)
   CMP MONITOR DVM
   CDR PERFORM ULLAGE(AT 15SEC)
         F 50 99(TFI,VG,DVM)
   CDR VERIFY ENGINE TRIM
   CMP KEY ENTER(AT 1SEC)
NCC1                                  0
26+25        06 40(TGO,VG,DVM)
   CDR STOP ULLAGE
       MONITOR FDAI,PC GAUGE
   LMP MONITOR VALVES OPEN
   CMP MONITOR DSKY
   CDR DV THRUST(2)-OFF(TGO=0)
         F 16 40(TGO,VG,DVM)
   LMP MONITOR VALVES CLOSED

   CDR GMBL MOTORS
        PITCH 2-OFF
        YAW 2-OFF
        PITCH 1-OFF
        YAW 1-OFF
       TVC SERVO PWR(2)-OFF
       TVC SERVO PWR(1)-OFF
       EMS MODE-STBY
   LMP PRO
         F 16 85(VG-BODY)
   CDR NULL VG'S
       THC-LOCKED

   LMP RECORD RESIDUALS

   CMP PRO
         F 06 44(HA,HP,TFF)
   CMP PRO
         F 06 32(TIME TO PER)
   CMP PRO
         F 50 07
```

```
   CMP KEY V37E00E
P00
   CMP KEY V74E

   CMP ENTER NAV BAY(IF TRACKING
        EXERCISE TO BE DONE)

   CDR CB SPS GMBL(4)-OPEN
       EMS FUNCTION-OFF
       FDAI SCALE-5/1
       RATE-LOW
       DIRECT RCS-OFF
   LMP MN BUS TIE(2)-OFF

   LEB KEY V48E(DAP LOAD)
         F 04 46    11102 DAP
                    11111 CON-
                            B  FIG

   LEB PRO
         F 06 47  +00182.IX
                  +00573.IYIZ
                  +31838.WT

   LEB PRO
         F 06 48  -001.09PTRIM
                  -000.73YTRIM
                  +02010.TLX
   LEB PRO


   CDR BMAG MODE(3)-RATE 2
26+30  SC CONT-CMC
```

```
       CMC MODE-AUTO
   LEB KEY V37E20E(IF DESIRED)
P20
         F 04 06    00001 SV
                    00010 OPTICS
                            B
   LEB G/N PWR,OPTICS-ON
       ZERO OPTICS-15 SEC
       OPTICS MODE-CMC
   LEB PRO
   CDR MONITOR MANEUVER TO
        NAV TRACK ATT(SXT)
   LEB TRACK SIVB

   LEB KEY V57E(IF DESIRED)
26+35    F 51 BB
   LEB OPTICS MODE-MAN
       MARK(IF DESIRED)
   LEB OPTICS MODE-CMC
       G/N PWR,OPTICS-OFF
   LEB KEY ENTER
SUNUP
26+42
   LEB KEY V37E00E
P00

   LEB LEAVE NAV BAY

27+00
   CDR SET ORDEAL(FDAI 1)
   CMP  KEY V82E
         F 06 44(HA,HP,TFF)
   CDR  SET ALT TO HA,HP AVG
   CMP  PRO
         F 06 32(TIME TO PER)
   CMP  PRO
   CMP  KEY V83E
         F 06 54(R,R,0)
   CDR  SLEW FDAI TO 0
   CMP  PRO
```

```
   CDR UP TLM(MDC)=ACCEPT
27+05  MONITOR GND UPLINK(MIL)
P27
   LMP RECORD VOICE DATA
       (DECISION=NCC2=RCS/SPS)
   CDR UP TLM(MDC)=BLOCK


27+10
   CMP KEY V37E30E
P30
         F 06 33 +00027=TIG
                 +00030=BF
                 +000.00NCC2
   CMP PRO
         F 06 82 +____.=DVXL
                 +____.=DVYL
                 +____.=DVZL
   CMP PRO
         F 06 42(HA,HP,DV)
   LMP COPY DV

   CDR PERFORM EMS DV TEST
        EMS FUNCTION=OFF
        CB EMS(2)=CLOSED
        EMS MODE=STBY
        EMS FUNCTION=DV SET
        LOAD +1586.8
   CDR PERFORM EMS DV TEST(SPS)
        (SPS LT OFF AT DV=-0.1)
        EMS MODE=STBY

   CDR EMS FUNCTION=DV SET
       LOAD VC
       EMS FUNCTION=DV

   CMP PRO
         F 16 35(TFI)
   CDR SET MDC DET                16
   CMP PRO
         F 16 45(N,TFI,MGA)
   CMP PRO
         F 50 07



27+15                             15
   CMP KEY V37E40E(IF SPS BURN)
P40
         F 06 86(VG=LV)

   LMP COMPARE WITH PAD DATA

   CMP PRO
         F 06 22(R,P,Y)

   LMP COMPARE WITH PAD DATA

   CMP PRO
         F 50 25   00203
   CDR ALIGN S/C IN ROLL
   CDR BMAG MODE(3)=RATE 2
       SC CONT=CMC
       CMC MODE=AUTO
   CMP KEY ENTER
         06 22(R,P,Y)
   LMP MONITOR MANEUVER
         F 50 19(R,P,Y)

27+20                             10
   LMP IGNITION PREPARATION
        MN BUS TIE(2)=ON(UP)
        SPS HE VLV TB(2)=BP
        SPS HE VLV(2)=AUTO
   CDR  CB SPS GMBL(4)=CLOSED
        DIRECT RCS=OFF
        SCS TVC(2)=RATE CMD
        TVC GMBL DRIVE(2)=AUTO

   CDR GMBL DRIVE AND TRIM CHK 9
       TVC SERV PWR 1=AC1/MNA
       TVC SERV PWR 2=AC2/MNB
       HAND CONT PWR=1
       RHC 2=ARMED
       GMBL MOTORS
        PITCH 1 = START=ON
        YAW 1 = START=ON
       THC=CW
       RHC=VERIFY NO MTVC
       GMBL MOTORS                8
        PITCH 2 = START=ON
        YAW 2 = START=ON
       CONFIRM GPI TRIM CONT
       SET GPI=PTRIM(-1.09)
               YTRIM(-0.73)
       RHC=VERIFY MTVC
       THC NEUTRAL
       HAND CONT PWR=BOTH

   CDR ALIGN S/C IN ROLL          7

   CMP KEY ENTER
         06 22(R,P,Y)
   CDR MONITOR MANEUVER
         F 50 19(R,P,Y)
   CDR MAN ATT(3)=RATE CMD
       RATE=HIGH
       DIRECT RCS=ON
       BMAG MODE(3)=ATT1/RATE2

27+25                             5
   CDR ALIGN GDC TO IMU

   CMP PRO
         F 50 25   00204
   CMP KEY ENTER                  4
   CDR MONITOR GMBL DRIVE TEST
       VERIFY GPI TRIM
         06 40(TFI,VG,DVM)
   CDR VERIFY MDC DET
```

```
   CMP VERIFY VG
       CHECK C/W LAMPS
   CDR FDAI SCALE-5/5                3
       VERIFY S/C ATTITUDE
   CMP KEY V74E

   CDR DV THRUST(2)-NORM(1 MIN)
       THC ARMED
       RHC(2)-ARMED
   CDR EMS MODE-AUTO(AT 30SEC)
   CMP MONITOR DVM
   CDR PERFORM ULLAGE(AT 15SEC)
         F 50 99(TFI,VG,DVM)
   CDR VERIFY ENGINE TRIM
   CMP KEY ENTER(AT 1SEC)
NCC2                                 0
27+30       06 40(TGO,VG,DVM)
   CDR STOP ULLAGE
       MONITOR FDAI,PC GAUGE
   LMP MONITOR VALVES OPEN
   CMP MONITOR DSKY
   CDR DV THRUST(2)-OFF(TGO=0)
         F 16 40(TGO,VG,DVM)
   LMP MONITOR VALVES CLOSED

   CDR GMBL MOTORS
        PITCH 2-OFF
        YAW 2-OFF
        PITCH 1-OFF
        YAW 1-OFF
       TVC SERVO PWR(2)-OFF
       TVC SERVO PWR(1)-OFF
       EMS MODE-STBY
   CMP PRO
         F 16 85(VG-BODY)
   CDR NULL VG'S
       THC-LOCKED

   LMP RECORD RESIDUALS
```

```
   CMP PRO
         F 06 44(HA,HP,TFF)
   CMP PRO
         F 06 32(TIME TO PER)
   CMP PRO
         F 50 07
   CMP KEY V37E00E
P00
   CMP KEY V74E

   CMP ENTER NAV RAY

   CDR CB SPS GMBL(4)-OPEN
       EMS FUNCTION-OFF
       FDAI SCALE-5/1
       RATE-LOW
       DIRECT RCS-OFF
   LMP MN BUS TIE(2)-OFF

   LEB KEY V48E(DAP LOAD)
         F 04 46    11102 DAP
                    11111 CON-
                            FIG
   LEB PRO
         F 06 47   +00182.IX
                   +00573.IYIZ
                   +31838.WT
   LEB PRO
         F 06 48   -001.09PTRIM
                   -000.73YTRIM
                   +02010.TLX
```

```
   LEB PRO

   LEB KEY V37E30E
P30
         F 06 33   +00027.TIG
                   +00059.0F
                   +056.00NSR
   LEB PRO
         F 06 82   -0087.8DVXL
                   +0000.4DVYL
                   -0163.8DVZL
   LEB PRO
         F 06 42(HA,HP,DV)
   LMP COPY DV

   CDR PERFORM EMS DV TEST
        EMS FUNCTION-OFF
        CB EMS(2)-CLOSED
        EMS MODE-STBY
        EMS FUNCTION-DV SET
        LOAD +1586.8
        EMS FUNCTION-DV TEST
        (SPS LT OFF AT DV=-0.1)
        EMS MODE-STBY

   CDR EMS FUNCTION-DV SET
       LOAD VC
       EMS FUNCTION-DV

   LEB PRO
         F 16 35(TFI)
   CDR SET MDC DET                   27
   LEB SET LEB DET
   LEB PRO
         F 16 45(N,TFI,MGA)
   LEB PRO
         F 50 07
```

```
   CDR ATT DB-MIN
       BMAG MODE(3)-ATT1/RATE2
       SC CONT-SCS
       MAN ATT(P)-ACC CMD
       MANEUVER TO BURN ATT
       MAN ATT(3)-RATE CMD
   LEB G/N PWR,OPTICS-ON

27+35                                  25
   LEB KEY V37E52E
P52
         F 04 06    00005 IMU
                    00003 ORIENT
                      B    SEL
   LEB PRO
         F 50 25    00015
   LEB ZERO OPTICS-15 SEC
   CDR MAN ATT(P,Y)-ACC CMD
SUNDN
27+36                                  24
   LEB ACQ STARS IN SCT
   CDR MAN ATT(3)-RATE CMD
   LEB KEY ENTER
       (AVAILABLE STARS-
        FOMALHAUT,DIPHDA,ACH-
        ERNAR)

*        F 01 70    STAR CODE 1
   LEB CHECK STAR CODE 1
       OPTICS MODE-CMC
   LEB PRO
           06 92(SHAFT,TRUN)
   LEB IDENTIFY STAR 1
       OPTICS MODE-MAN
         F 51 70    STAR CODE 1
   LEB MARK ON STAR 1                  22
         F 50 25    00016
   LEB KEY ENTER
         F 01 70    STAR CODE 1
```

```
   LEB PRO
         F 01 70    STAR CODE 2
   LEB ZERO OPTICS-15 SEC
       CHECK STAR CODE 2
       OPTICS MODE-CMC
   LEB PRO
           06 92(SHAFT,TRUN)
   LEB IDENTIFY STAR 2
       OPTICS MODE MAN
         F 51 70    STAR CODE 2
   LEB MARK ON STAR 2
27+40    F 50 25    00016          20
   LEB KEY ENTER
         F 01 70    STAR CODE 2
   LEB PRO
           06 05(ANGLE DIFF)
         F 06 93(GYRO TORQ ANG)
   LEB PRO
         F 50 25    00014          18
   LEB (FOR FINE ALIGN CHECK-
        KEY ENTER,RETURN TO *,
        ZERO OPTICS AND USE
        THIRD STAR)
   LEB PRO
         F 50 07


27+45                                  15
   LEB KEY V37E40E
P40
         F 06 86(VG-LV)

   LMP COMPARE WITH PAD DATA

   LEB PRO
         F 06 22(R,P,Y)

   LMP COMPARE WITH PAD DATA

   LEB PRO
```

```
         F 50 25    00203
   CDR ALIGN S/C IN ROLL
   CDR BMAG MODE(3)-RATE 2
       SC CONT-CMC
       CMC MODE-AUTO
   LEB KEY ENTER
           06 22(R,P,Y)
   CDR MONITOR MANEUVER
         F 50 19(R,P,Y)

   LEB PERFORM SXT/STAR CHECK
        ZERO OPTICS-15 SEC        13
        OPTICS MODE-CMC
        KEY V41N91E
         F 21 92   ___.__ SHAFT
                   __.___ TRUN
                     B
        KEY ENTER AND OBSERVE
         OPTICS DRIVE TO STAR
        KEY RLSE
         F 50 19(R,P,Y)

   LEB G/N PWR,OPTICS-OFF
27+50                                  10
   LEB LEAVE NAV BAY

   LMP IGNITION PREPARATION
        MN BUS TIE(2)-ON(UP)
        S-BAND ANT-D
        SPS HE VLV TB(2)-BP
        SPS HE VLV(2)-AUTO
   CDR  CB SPS GMBL(4)-CLOSED
        DIRECT RCS-OFF
        SCS TVC(2)-RATE CMD
        TVC GMBL DRIVE(2)-AUTO

   CDR GMBL DRIVE AND TRIM CHK 9
        TVC SERV PWR 1-AC1/MNA
        TVC SERV PWR 2-AC2/MNB
        HAND CONT PWR-1
```

```
        RHC 2-ARMED
        GMBL MOTORS                    8
         PITCH 1 - START-ON
         YAW 1 - START-ON
        THC-CW
        RHC-VERIFY NO MTVC
        GMBL MOTORS
         PITCH 2- START-ON
         YAW 2 - START-ON
        CONFIRM GPI TRIM CONT
        SET GPI-PTRIM(-1.09)
               YTRIM(-0.73)
        RHC-VERIFY MTVC
        THC-NEUTRAL
        HAND CONT PWR-BOTH

    CDR ALIGN ROLL(HDS-DOWN)           7

    CMP KEY ENTER
           06 22(R,P,Y)
    CDR MONITOR MANEUVER
          F 50 19(R,P,Y)
    CDR MAN ATT(3)-RATE CMD
        RATE-HIGH
        DIRECT RCS-ON
        BMAG MODE(3)-ATT1/RATE2

27+55                                  5
    CDR ALIGN GDC TO IMU

    CMP PRO
          F 50 25   00204
    CMP KEY ENTER                      4
    CDR MONITOR GMBL DRIVE TEST
        VERIFY GPI TRIM
           06 40(TFI,VG,DVM)
    CDR VERIFY MDC DET
    CMP VERIFY VG
        CHECK C/W LAMPS
    CDR FDAI SCALE-5/5                 3
```

```
        VERIFY S/C ATTITUDE
    LEB KEY V74E

    CDR DV THRUST(2)-NORM(1 MIN)
        THC-ARMED
        RHC(2)-ARMED
    CDR EMS MODE-AUTO(AT 30SEC)
    CMP MONITOR DVM
    CDR PERFORM ULLAGE(AT 15SEC)
          F 50 99(TFI,VG,DVM)
    CDR VERIFY ENGINE TRIM
    CMP KEY ENTER(AT 1SEC)
NSR                                    0
28+00       06 40(TGO,VG,DVM)
    CDR STOP ULLAGE
        MONITOR FDAI,PC GAUGE
    LMP MONITOR VALVES OPEN
    CMP MONITOR DSKY
    CDR DV THRUST(2)-OFF(TGO=0)
          F 16 40(TGO,VG,DVM)
    LMP MONITOR VALVES CLOSED

    CDR GMBL MOTORS
         PITCH 2-OFF
         YAW 2-OFF
         PITCH 1-OFF
         YAW 1-OFF
        TVC SERVO PWR(2)-OFF
        TVC SERVO PWR(1)-OFF
        EMS MODE-STBY
    CMP PRO
          F 16 85(VG-BODY)
    CDR NULL VG'S
        THC-LOCKED

    LMP RECORD RESIDUALS

    CMP PRO
          F 06 44(HA,HP,TFF)
    CMP PRO
```

```
          F 06 32(TIME TO PER)
    CMP PRO
          F 50 07
    CMP KEY V37E00E
P00
    CMP KEY V74E

    CMP ENTER NAV BAY

    CDR CB SPS GMBL(4)-OPEN
        EMS FUNCTION-OFF
        FDAI SCALE-5/1
        RATE-LOW
        DIRECT RCS-OFF
    LMP MN BUS TIE(2)-OFF

    LEB KEY V48E(DAP LOAD)
          F 04 46    11102DAP
                     11111CON-
                       B  FIG
    LEB PRO
          F 06 47  +00177.IX
                   +00563.IYIZ
                   +31124.WT
    LEB PRO
          F 06 48(P,Y TRIM,TLX)
    LEB PRO

    CDR BMAG MODE(3)-RATE 2
        SC CONT-CMC
```

```
      CMC MODE-AUTO
28+05
   LEB KEY V37E20E
P20
         F 04 06    00001 SV
                    00001 OPTION
                          B
   LEB G/N PWR,OPTICS-ON
       ZERO OPTICS-15 SEC
       OPTICS MODE-CMC
   LEB PRO
   CDR MONITOR MANEUVER TO
        NAV TRACK ATT(SXT)


28+10
   LEB KEY V37E34E
P34
         F 04 06    00003 TPI
                    00002 DATA
                      B   OPT
   LEB KEY V25N37E
         F 21 37  +00029.TIG
                  +00023.DF
                  +000.00TPI
   LEB KEY RLSE
         F 04 06(TPI DATA OPT)
   LEB PRO
         F 06 55       B  ELEV
                  +027.45ANG
                         B
   LEB PRO
         F 06 39  +00000. DT
                  +00035.TRANS
                  +000.00
SUNUP
28+12
   LEB PRO
         F 06 37(TIG DF TPI)
   LEB PRO
         F 06 58(DVTPI,HP,DVTPF)
   LEB PRO
         F 16 35(TFI)
   CDR SET MDC DET                69
   LEB SET LEB DET
   LEB PRO
28+15    F 16 45(N,TFI,0)

   LEB KEY V57E
         F 51 BB
   LEB OPTICS MODE-MAN
28+19                              64
   LEB MAKE 10 SIVB MARKS-1/MIN
       (OPTICS MODE-CMC/CHK SV)
   LEB OPTICS MODE-CMC
28+29                              54
   LEB KEY ENTER
         F 16 45(N,TFI,0)

28+30
   LEB KEY V32E-RECYCLE           52
         F 06 37(TIG DF TPI)


   LEB PRO
         F 06 58(DVTPI,HP,DVTPF)
   LEB PRO
         F 16 35(TFI)
   CDR SET MDC DET                49
   LEB SET LEB DET
   LEB PRO
         F 16 45(N,TFI,0)


   CDR SET ORDEAL(FDAI 1)
28+35                              48
   LEB  KEY V82E
         F 06 44(HA,HP,TFF)

   CDR  COMPARE WITH GND HA,HP
      SET ALT TO GND HA,HP AVG
   LEB  PRO
         F 06 32(TIME TO PER)
   LEB  PRO
         F 16 45(N,TFI,0)
   LEB  KEY V83E
         F 06 54(R,Ṙ,θ)
   CDR  BORESIGHT ON HORIZON
        SLEW FDAI TO DSKY THETA
        COMPARE WITH 346 DEG
   LEB  PRO
         F 16 45(N,TFI,0)

   LEB KEY V58E
   LEB BORESIGHT ON TGT(SXT)

28+40                              43
   LEB  KEY V85E
         F 06 53(R,Ṙ,Q)
   LMP  COPY R,Ṙ,Q(POLAR PLOT)
   LEB  PRO
         F 16 45(N,TFI,0)

28+45                              38
   LEB KEY V74E


   LEB KEY V57E
         F 51 BB
   LEB OPTICS MODE-MAN
   LEB MAKE 5 SIVB MARKS-1/MIN
       (OPTICS MODE-CMC/CHK SV)
28+47                              36
   LMP RECORD VOICE TPI DATA

   LEB OPTICS MODE-CMC
28+50                              33
```

```
   LEB KEY ENTER
         F 16 45(N,TFI,0)

   LEB KEY V74E


   LEB IF W#1,000/1 =

         LOAD W=1,000/1
         KEY V24N01E
         KEY 2000E
         KEY 47E
         KEY 20E      00047
                      00020
                      02000
         KEY RLSE
          F 16 45(N,TFI,0)

   CDR ALIGN GDC TO IMU
   LMP S-BAND ANT-B

   LEB KEY V57E
28+55    F 51 BB
   LEB OPTICS MODE-MAN
28+58
   LEB MAKE 3 SIVB MARKS-1/MIN
       (OPTICS MODE-CMC/CHK SV)
   LEB KEY ENTER
         F 16 45(N,TFI,0)

29+01
   LEB KEY V86E

   LEB KEY V57E
         F 51 BB
   LEB MAKE 7 SIVB MARKS-1/MIN
SUNDN  (OPTICS MODE-CMC/CHK SV)
29+05
   LEB OPTICS MODE-CMC
   LEB G/N PWR,OPTICS-OFF
29+08                                  15
   LEB KEY ENTER
         F 16 45(N,TFI,0)

   LEB  KEY V85E                       14
         F 06 53(R,R,Q)
   LMP  COPY R,R,Q(POLAR PLOT)
   LEB  PRO
29+10    F 16 45(N,TFI,0)              13
   LEB PRO
         F 06 37(TIG OF TPI)
   LEB PRO
         F 06 58(DVTPI,HP,DVTPF)

   CDR EMS MODE-STBY
       EMS FUNCTION-DV SET
       LOAD DV
       EMS FUNCTION-DV

   LEB PRO
         F 16 35(TFI)
   CDR CHECK MDC DET                   12
   LEB CHECK LEB DET
   LEB PRO
         F 16 45(N,TFI,MGA)
   LEB PRO
         F 50 07


   LEB KEY V37E41E                     11
41
         F 04 06    00004 AXIS
                    00001 CODE
                       B

   CDR BMAG MODE(3)-ATT1/RATE2
       SC CONT-SCS
       MAN ATT(P)-ACC CMD
       BORESIGHT ON TGT(COAS)          10
       MAN ATT(3)-RATE CMD
       MAN ATT(P,Y)-MIN IMP

   LEB PRO
         F 06 85(VG-BODY)
   LEB PRO                             14
         F 06 22(R,P,Y)
   LEB PRO
         F 06 86(VG-LV)

   LMP COPY/COMPARE WITH GND

   LEB PRO
         F 50 25   00203

   LEB  KEY V83E
         F 06 54(R,R,0)
   CDR  BORESIGHT ON TGT(COAS)          9
29+15
   LMP  COPY 0(TFI-8MIN)                8

   CDR  BORESIGHT ON TGT(COAS)          6
   LMP  COPY R,R,0(TFI-5MIN)            5

        CALCULATE BACKUPS

   LEB  PRO
         F 50 25   00203

   CDR BMAG MODE(3)-RATE 2
       MAN ATT(3)-RATE CMD
       SC CONT-CMC
       CMC MODE-AUTO
   LEB KEY ENTER                        4
         06 22(R,P,Y)
   CDR MONITOR MANEUVER
         F 50 19(R,P,Y)

29+20                                   3
   LMP COMPARE TPI SOLUTIONS
```

```
   LEB PRO BEFORE TFI=30SEC      1
       F 06 85(VG=BODY)
   CDR EMS MODE=AUTO(AT 30SEC)

       F 16 85(AT 13SEC)
   LMP TLM INPUTS=HIGH

TPI
   CDR NULL VG'S AT TFI=0        0
29+23
   LMP TLM INPUTS=LOW
   LEB PRO
       F 06 44(HA,HP,TFF)
   LEB PRO
       F 06 32(TIME TO PER)
   LEB PRO
       F 50 07
   LEB KEY V16N40E
       F 16 40(TFI,VG,DVM)
   LMP RECORD DVM
   LEB KEY RLSE
       F 50 07
   CDR EMS FUNCTION=OFF
       EMS MODE=STBY
       BMAG MODE(3)=RATE 2
       SC=CONT=CMC
       CMC MODE=AUTO
   LEB KEY V37E35E
P35
       F 16 35(TIME FROM INT)

   CDR MONITOR MANEUVER TO      59
       NAV TRACK ATT(SXT)

   LEB PRO
       F 16 45(N,TF=INT,0)


   LEB KEY V48E(LOAD 0.5 DB)
29+25   F 04 46   11102DAP     58
```

```
                  11111CON=
                    8  FIG
LEB PRO
     F 06 47(IX,IYIZ,XT)
LEB PRO
     F 06 48(P,Y TRIM,TLX)
LEB PRO
     F 16 45(N,TF=INT,0)


LEB G/N PWR,OPTICS=ON
    ZERO OPTICS=15 SEC

LEB KEY V57E
     F 51 BB
LEB MAKE 1 PHONEY SIVB MARK
LEB OPTICS MODE=CMC          56
LEB KEY ENTER
     F 06 49(DEL R,DEL V,B)
LEB KEY V32E(REJECT UPDATE)
     F 16 45(N,TF=INT,0)
LEB RESET ALARM LIGHTS

LEB KEY V81E

LEB KEY V57E
     F 51 BB
LEB OPTICS MODE=MAN
LEB MAKE 4 CSM MARKS=1/MIN 55
29+30  (OPTICS MODE=CMC/CHK SV)
LEB KEY ENTER(ET=52MIN)      52
     F 16 45(N,TF=INT,0)

LEB AFTER LAST MARK PRO=
    CESSED=KEY V85E
     F 06 53(R,R,Q)
LEB  BORESIGHT ON TGT(SXT)
LMP  COPY Q(ET=51MIN)        51
LEB  PRO
     F 16 45(N,TF=INT,0)
```

```
LEB KEY V57E
     F 51 BB
LEB MAKE 2 CSM MARKS         50
LEB OPTICS MODE=CMC
LEB KEY ENTER(ET=49MIN)      49
     F 16 45(N,TF=INT,0)

LEB AFTER LAST MARK PRO=
    CESSED=KEY V85E
     F 06 53(R,R,Q)
LEB  BORESIGHT ON TGT(SXT)
29+35
LMP  COPY R,R,Q(ET=48MIN)    48
    CALCULATE BACKUPS
LEB  PRO
     F 16 45(N,TF=INT,0)

LEB PRO(ET=47+30MIN)
     F 16 45(N,TFI,MGA)
LEB PRO
     F 16 59(DVMD,TFI,DVTPF)
LEB PRO
     F 50 07


LEB KEY V37E41E              47
P41
     F 04 06(AXIS CODE)
LEB PRO
     F 06 85(VG=BODY)
LEB PRO
     F 06 22(R,P,Y)
LEB PRO
     F 06 86(VG=LV)
LEB PRO
     F 50 25   00203
LEB PRO
     F 50 19(R,P,Y)
```

```
   LEB PRO BEFORE ET=46+30MIN
         F 06 85(VG=BODY)

   LMP COMPARE SOLUTIONS

         F 16 85(AT 13SEC)
   LMP TLM INPUTS=HIGH

MCC1
   CDR NULL VG'S(ET=46MIN)          46
   LMP TLM INPUTS=LOW
   LEB PRO
         F 06 44(HA,HP,TFF)
   LEB PRO
         F 06 32(TIME TO PER)
   LEB PRO
         F 50 07
   LEB KEY V16N40E
         F 16 40(TFI,VG,DVM)
   LMP RECORD DVM
   LEB KEY RLSE
         F 50 07
   LEB KEY V37E35E
P35
         F 16 35(TIME FROM INT,
   LEB PRO
         F 16 45(N,TF=INT,C)

   LEB KEY V48E(LOAD 0.5 DB)
         F 04 46   11102DAP
                   11111CON=
                     B  FIG
   LEB PRO
         F 06 47(IX,IYIZ,AT)
   LEB PRO
         F 06 48(P,Y TRIM,TLX)
   LEB PRO
         F 16 45(N,TF=INT,C)

   LEB KEY V85E                     45
         F 06 53(R,R̊,Q)
   LEB  BORESIGHT ON TGT(SXT)
   LMP  COPY Q(ET=44MIN)            44
   LEB  PRO
         F 16 45(N,TF=INT,C)

   LEB KEY V57E
         F 51 88
   LEB OPTICS MODE=MAN
   LEB MAKE 2 CSM MARKS             43
SJNUP
29+41
   LEB KEY ENTER(ET=42MIN)          42
         F 16 45(N,TF=INT,C)

   LEB AFTER LAST MARK PRO=
       CESSED=KEY V85E
         F 06 53(R,R̊,Q)
   LEB  BORESIGHT ON TGT(SXT)
   LMP  COPY R,R̊,Q(ET=41MIN)        41
        CALCULATE BACKUPS
   LEB  PRO
         F 16 45(N,TF=INT,C)

   LEB OPTICS MODE=CMC
       G/N PWR,OPTICS=OFF
   LEB KEY V56E

   LEB PRO(ET=40+30MIN)
         F 16 45(N,TFI,MGA)

   CDR BMAG MODE(3)=ATT1/RATE2
       SC CONT=SCS
       MAN ATT(P)=ACC CMD
       BORESIGHT ON TGT(CSAS)
       MAN ATT(3)=RATE CMD

   LEB PRO
         F 16 59(DVMD,TFI,DVTPF)

   LEB PRO
         F 50 07

   LEB KEY V37E41E                  40
P41
         F 04 06(AXIS CODE)
   LEB PRO
         F 06 85(VG=BODY)
   LEB PRO
         F 06 22(R,P,Y)
   LEB PRO
         F 06 86(VG=LV)
   LEB PRO
         F 50 25   00203
   LEB PRO
         F 50 19(R,P,Y)

   CDR BORESIGHT ON TGT(CSAS)

   LEB PRO BEFORE ET=39+30MIN
         F 06 85(VG=BODY)

   LMP COMPARE SOLUTIONS

         F 16 85(AT 13SEC)
   LMP TLM INPUTS='IGH

MCC2
   CDR NULL VG'S(ET=39MIN)          39
   LMP TLM INPUTS=LOW
   LEB PRO
         F 06 44(HA,HP,TFF)
   LEB PRO
         F 06 32(TIME TO PER)
   LEB PRO
         F 50 07
   LEB KEY V16N40E
         F 16 40(TFI,VG,DVM)
   LMP RECORD DVM
```

```
   LEB KEY RLSE
         F 50 07
   LEB KEY V37E00E
P00
   LEB KEY V74E
29+45

   CDR EMS FUNCTION=DV
       LOCK THC
   LEB KEY V37E47E/WHEN REQUIRED
P47
         F 16 83(DV=BODY)
   CDR COMP LT=OFF/THC ARMED
       ATT DB=MIN IF NORMAL
        LOS RATES ARE LOW
   LEB KEY V60E AS REQUIRED

   LEB KEY V83E
         F 06 54(R,Ṙ,θ)          36

   CDR EMS MODE=AUTO
   LMP TLM INPUTS=HI/LOW.
        BEFORE/AFTER TRANSLATION
   CDR REMOVE NORMAL LOS
        RATES AS PER CHARTS
   LMP RECORD N40 DVM

   CDR BRAKING GATES=
        R=1.0 NM/RDOT TO 25FPS
        R=0.5 NM/RDOT TO 15FPS
        R=0.25NM/RDOT TO 10FPS
30+00   R=1000FT/RDOT TO  5FPS

30+10
   CDR STATION KEEPING
```

4.0 Backup Techniques

The purpose of this section is to describe the methods by which the rendezvous maneuvers will be monitored onboard and define techniques for completing the mission in the event of PNGS malfunction. It is not an objective of this document to specify the circumstances under which the rendezvous will be terminated or the systems performance limits that will require alternate maneuver solutions to be used. These factors will be controlled through the Apollo Data Priority Coordination Meetings, and the Mission Rules Documents.

Two general requirements exist for Guidance and Control backup techniques. The first requirement is for assessment of system performance during apparently normal operation. This monitoring function is carried out during translation by observing critical parameters such as attitude errors, vehicle rates and V_G, and during determination of maneuvers by independent calculations of the V_G's. The second requirement for back-up is for taking over either attitude or translation control using alternate systems and/or targeting when an obvious failure occurs. The techniques for monitoring are treated in section 4.1.

For purpose of failure procedures development the G & N system is considered to be comprised of three major subsystems:

(a) Optics

(b) IMU

(G) CMC

Techniques for completing the mission for each of the above failures are presented in sections 4.2, 4.3, and 4.4. It is assumed that since no onboard targeting capability exists for maneuvers prior to TPI,

backup for any PNGS failure prior to NSR will be to use the SCS and EMS to complete the maneuvers through NSR, or to terminate the maneuver sequence, which ever is specified in the mission rules.

Because of the number of possible failure modes, procedures will be developed only for total failure of the subsystems listed above. Partial failures wherein some performance can be realized from the failed system will be handled by the crew utilizing whatever data can be salvaged by combining the primary and backup techniques.

4.1 PNGS Monitoring

The NCC1, NCC2, and NSR maneuvers will be targeted by the MSFN and can not be determined onboard. Monitoring for these maneuvers therefore consists of observing the SPS start sequence attitude errors, attitude rates, and other parameters and manual backup of engine shutdown using the EMS ΔV counter. If PNGS fails to start the SPS, the SCS will be used. Subsequent to NSR, range and target elevation data will be called as time permits by the CSM pilot in the LEB calling V85 with the SXT boresighted on the SIVB. The data will be plotted by the LM Pilot on the SIVB centered relative motion graph shown in Figure 4.1. This information will be valuable to determine qualitatively the ellipticity of the CSM orbit, TPI arrival time, magnitude of TPI maneuver, and approach angle. PNGS targeting of the TPI and midcourse maneuvers will be monitored by the use of the flight charts shown as Figures 4-2, 4-3, and 4-5. These charts will be used to determine maneuver components along the line of sight to the SIVB, normal to the line of sight inplane, and out of plane. The TPI chart will be used in the monitoring mode as follows:

(a) After the last SIVB mark prior to TPI, the Event Timers will be set counting down to TPI ignition.

(b) At TPI-8 minutes, with the COAS boresighted on the SIVB, elevation angle from V83 will be recorded. This angle will be recorded by the LM pilot on Figure 4-2 in the block labeled "MONITOR COMP" in the space next to θ_8.

(c) At TPI-5 minutes, θ_5 is recorded in the space above θ_8 and range and range rate from V83 are recorded in the spaces provided within the same block.

(d) With θ_5 and R_5 as inputs the lower left graph in Figure 4-2 will be used to read $\dot{R}_{REQ}$ which will be logged in the space provided below $\dot{R}_5$.

(e) The difference between $\dot{R}_5$ and $\dot{R}_{REQ}$ then represents the component of TPI ΔV along the line of sight to the SIVB.

(f) Subtracting θ_8 from θ_5 will define $\Delta\theta$. Entering the lower right graph with θ_5, progressing horizontally to the value of $\Delta\theta$, and moving vertically to R_5 in the upper right graph will determine the inplane component of the TPI ΔV normal to the line of sight.

(g) The two components of TPI will be recorded in the maneuver block under the lable "CHART" for comparison with the MSFN and PNGS solutions labeled "GND" and "DSKY" respectively.

By the above process the monitoring solution for the midcourse maneuvers will be determined utilizing Figures 4-3 and 4-5.*

A summary of the monitoring data required and time of acquisition relative to TPI follows:

MONITORING DATA

DATA	UNITS	SOURCE	TIME-MIN					
			TPI		MCC1		MCC2	
Range	.01 NMI	V 83		-5		12		19
Range Rate	.1 FPS	V 83		-5		12		19
Elevation Angle	.01 DEG	V 83	-8	-5	9	12	16	19

* Since MCC1 is to be performed the navigation tracking attitude, an additional chart (Figure 4-4) must be utilized. Knowing the trunnion angle, one can use this chart to convert the X-axis line-of-sight velocity components, calculated by the MCC1 flight chart (Figure 4-3), into the appropriate components at the navigation tracking attitude.

4.2 Optics Failure

Failure of the Optics subsystem degrades performance of the G & N system by preventing SXT alignment of the IMU and state vector updates by SIVB marks. Thus all translation maneuvers would be degraded by attitude errors and PNGS targeting for TPI and midcourse corrections would be based on MSFN uplink vectors. The technique for IMU alignment in case of optics failure will be to utilize the backup alignment programs (P53 and P54) using the COAS for star sightings. The alignment accuracy will be enhanced if the COAS bias errors can be determined on the first mission day prior to G & N power down. Therefore, it is planned during the first 9 hours of the mission to do the Inflight COAS calibration as defined in section 4.11.7 of reference 6.4.

The method for determining the TPI maneuver will be as follows: After NSR the SCS pulse mode will be selected and the commander will control attitude to maintain wings level and boresight the COAS on the SIVB. The event timer will be set to 32 minutes and holding, awaiting the start of the TPI backup sequence. The CSM pilot will monitor elevation angle from V83 and when 20.0 degrees is reached, the event timer will be started counting up. This will establish the time of TPI and the measurements 5 and 8 minutes prior to the burn. Use of the TPI chart (Figure 4-2) will be similar to that for monitoring as defined in section 4.1, except that range data will not be used. Rather the value of ΔV_{FWD} will be obtained from the right edge scale on the upper right graph of Figure 4-2.

Midcourse maneuver data will be obtained in the same manner as for TPI. Midcourse charts and maneuver times will be the same as for PNGS monitoring; however, simulations have shown that an additional midcourse

after TPI is required to control arrival time for large trajectory errors. The chart for this additional correction is shown as Figure 4-9.

A summary of the backup data required for optics failure and time of acquisition relative to TPI follows:

OPTICS FAIL BACKUP DATA

DATA	UNITS	SOURCE	TIME FROM TPI - MIN							
			TPI		B/U MC		MCC1		MCC2	
Elevation Angle	.01 DEG	V 83	-8	-5	3	6	9	12	16	19

4.3 CMC Failure

The effect of a failed CMC would be to remove all PNGS attitude and translation control capability as well as targeting for the terminal phase maneuvers. For CMC failure prior to NSR the SPS under SCS control will be used through NSR if the mission is continued. The TPI maneuver will be accomplished by the following method:

(a) After NSR the ORDEAL will be initialized by slewing the FDAI to -15 degrees while the COAS is boresighted on the horizon.

(b) The SIVB will be tracked at the top of the COAS reticle using SCS pulse mode and the event timer will be started counting up from 52:00 minutes when the FDAI reaches 15 degrees. At this time the control will be switched to SCS attitude hold.

(c) At 55:00 minutes the SIVB elevation angle on the COAS will be called out by the commander and recorded by the LM pilot in the space labeled α in the "FAILURES" block.

(d) The LMP then determines $\Delta\theta$ by adding 7 degrees to α and θ_5 by adding 27 degrees to α.

(e) The graphs on the right side of Figure 4-2 will be used as described in section 4.2 to determine the TPI maneuver components along and normal to the line of sight. Since no ΔV can be measured in the body Z axes for this failure mode, the up/down component will be converted to burn time using the scale at the top of Figure 4-2. The forward component

will be loaded into the EMS and all components executed at 30 seconds on the event timer.

The above process will be repeated for each of the three midcourse maneuvers, except that the burns will be executed at the impulsive burn times. The data required are as follows:

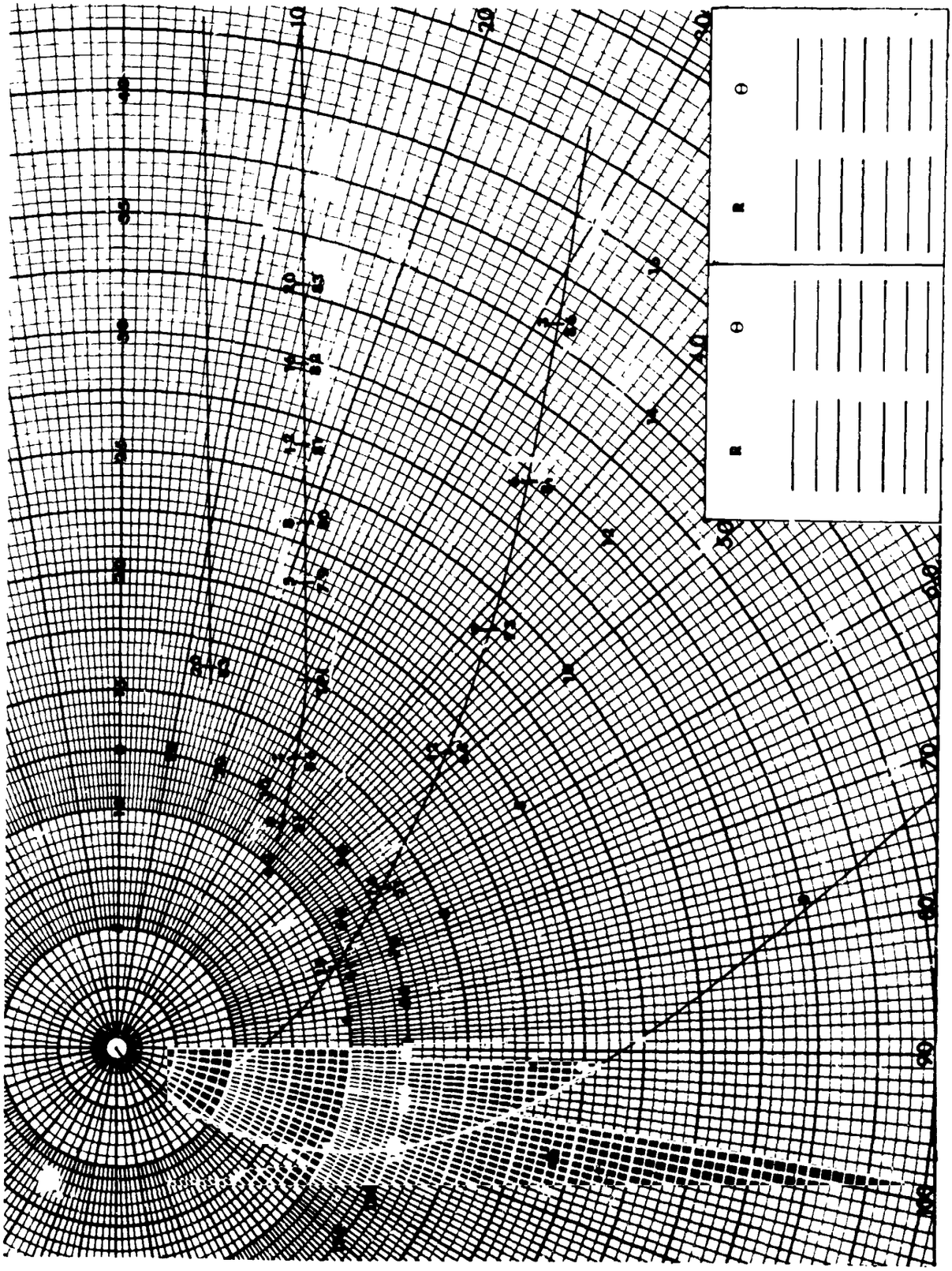
CMC/IMU FAIL BACKUP DATA

DATA	UNITS	SOURCE	TIME FROM TPI - MIN							
			TPI		B/U MC		MCC1		MCC2	
Elevation Angle	DEG	ORDEAL	-8			6		12		19
ΔElevation Angle	.1 DEG	COAS		-5		6		12		19

4.4 IMU Failure

Loss of the IMU results in loss of PNGS attitude and translation as for CMC failure. However, if the failure is close to TPI or a mid-course, a valid solution for the upcoming maneuver might be available. Otherwise the techniques will be identical to those of section 4.3.

Figure 4-1



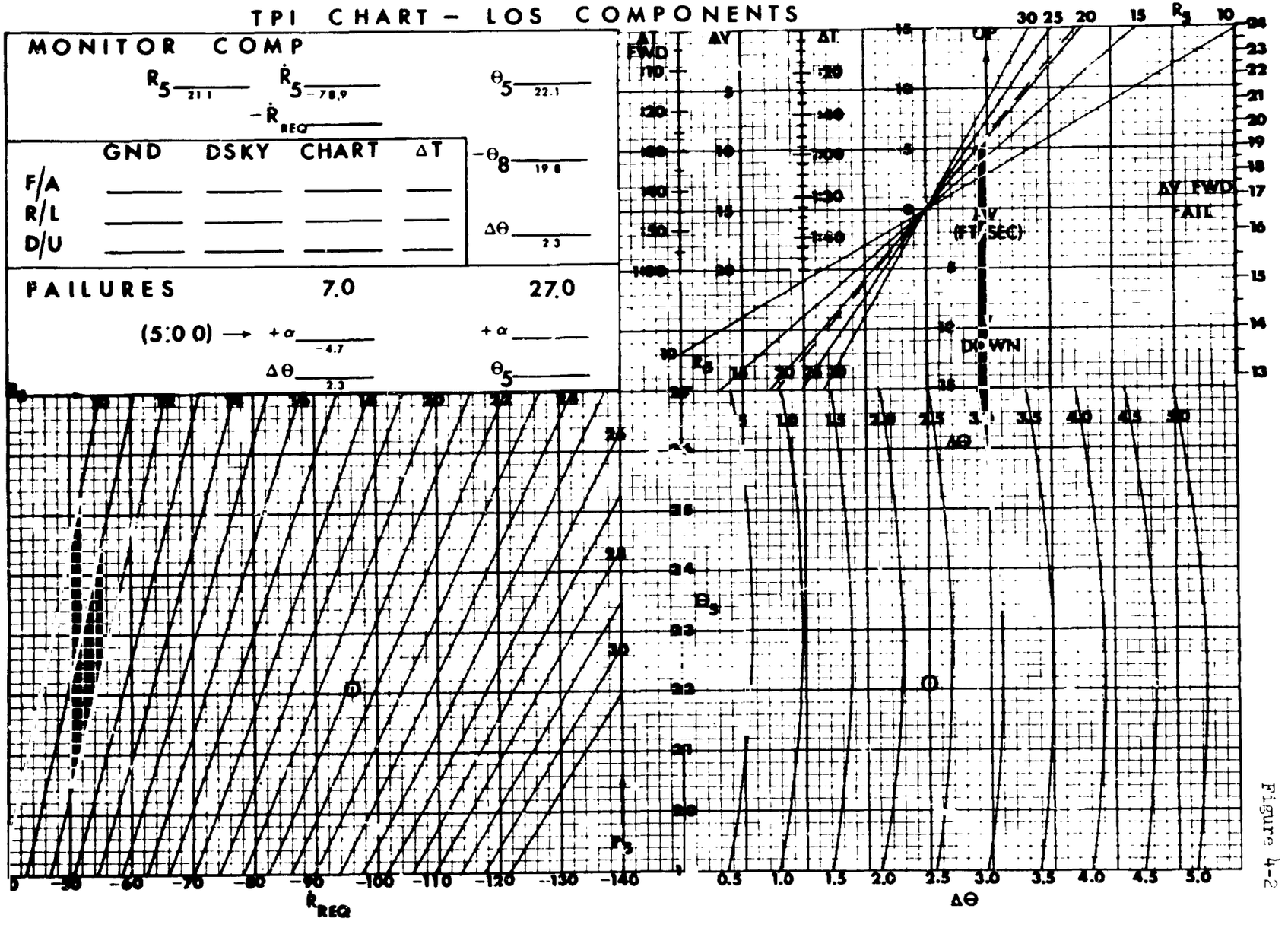

TPI CHART – LOS COMPONENTS
MONITOR COMP
R_5 21.1
$\dot{R}_5$ −78.9
$-\dot{R}_{REQ}$
θ_5 22.1
$-\theta_8$ 19.8
$\Delta\theta$ 2.3
GND DSKY CHART ΔT
F/A
R/L
D/U
FAILURES 7.0 27.0
(5:00) → +α −4.7
$\Delta\theta$ 2.3
+α
θ_5
ΔT FWD
ΔV
ΔT
ΔV FWD FAIL
UP
DOWN
ΔV (FT/SEC)
R_5
θ_5
$\dot{R}_5$
$\Delta\theta$
$\dot{R}_{REQ}$
$\Delta\theta$

Figure 4-2

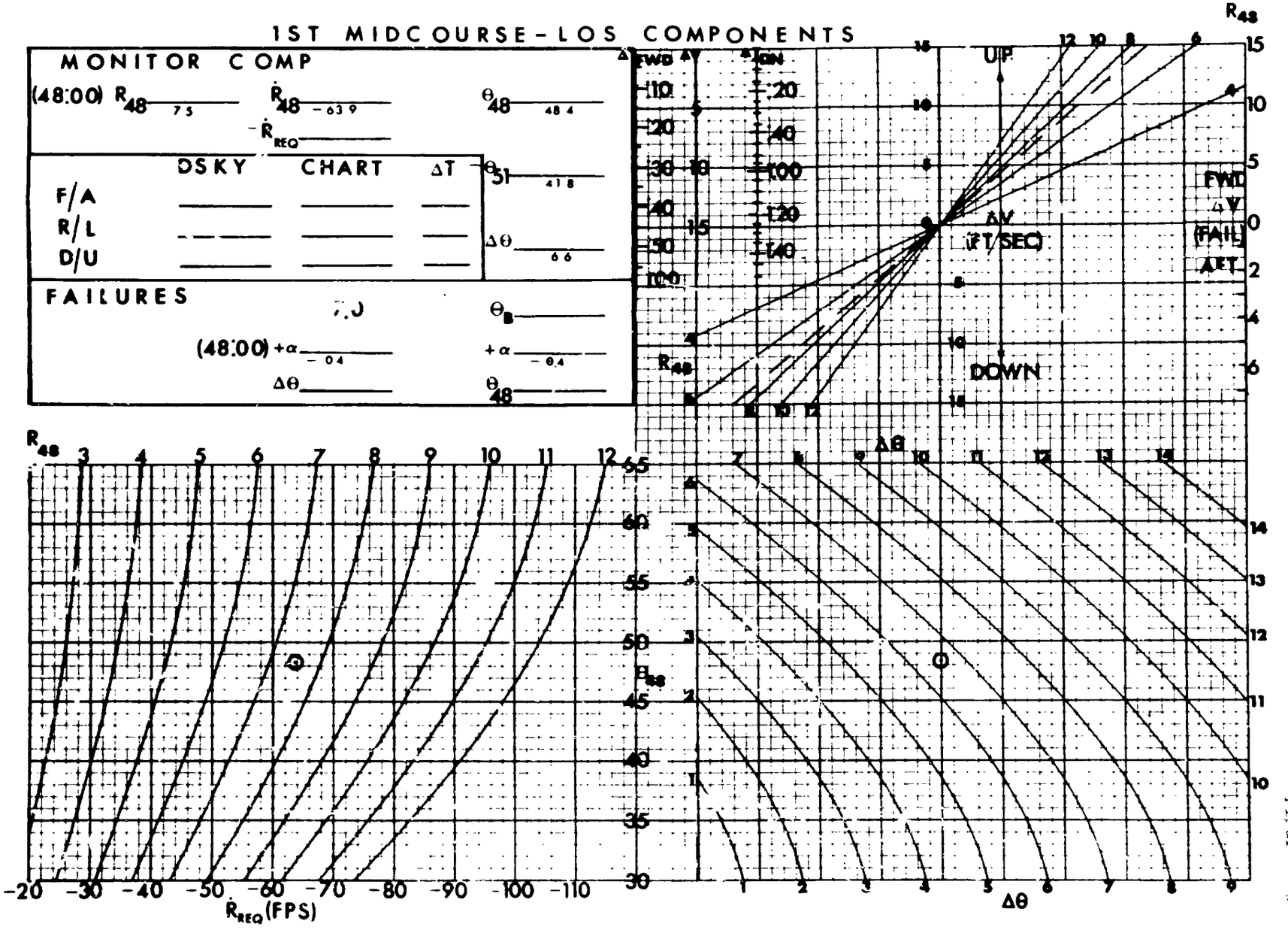

1ST MIDCOURSE-LOS COMPONENTS
MONITOR COMP
(48:00) R_{48} 7.5
$\dot{R}_{48}$ -63.9
$\dot{R}_{REQ}$
θ_{48} 48.4
DSKY CHART ΔT
F/A
R/L
D/U
θ_{51} 41.8
Δθ 6.6
FAILURES
(48:00) +α -0.4
+α -0.4
Δθ
θ_{48}
θ_B
R_{48}
$\dot{R}_{REQ}$ (FPS)
FWD
AFT
UP
DOWN
ΔV (FT/SEC)
FWD ΔV (FAIL) AFT
Δθ

Figure 4-3

MCC1 ΔV CONVERSION TO NAV FLACH AXIS

LINE-OF-SIGHT

ΔV_{F-A} _____

ΔV_{U-D} _____

ΔV_{total} _____

57.0

$-A_{trunnion}$ _____

$A_{rotation}$ _____

$A_{total\ \Delta V}$ _____

$-A_{rotation}$ _____

$A_{track\ \Delta V}$ _____

TRACK

ΔV_{F-A} _____

ΔV_{U-D} _____

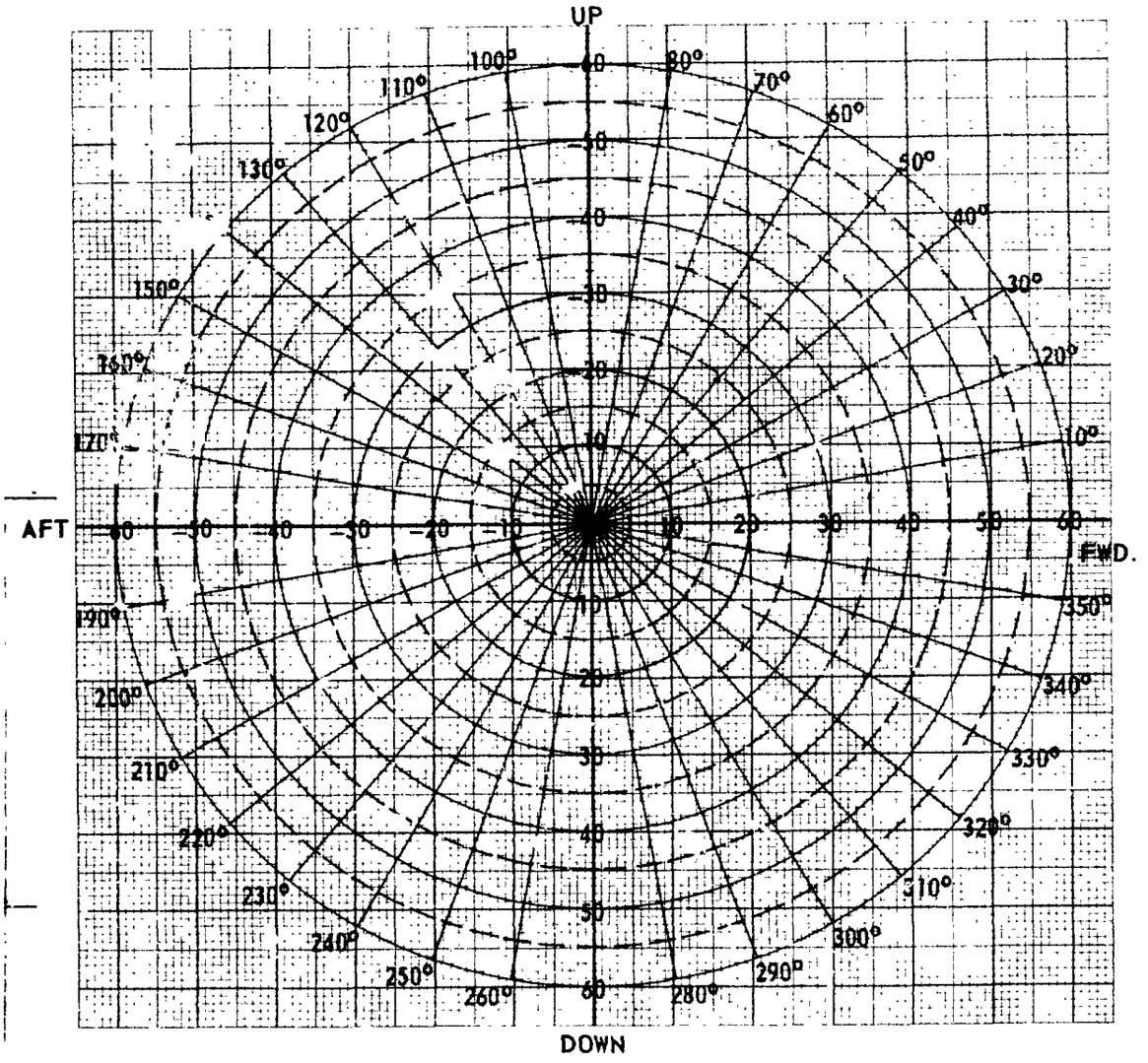


Figure 4-4

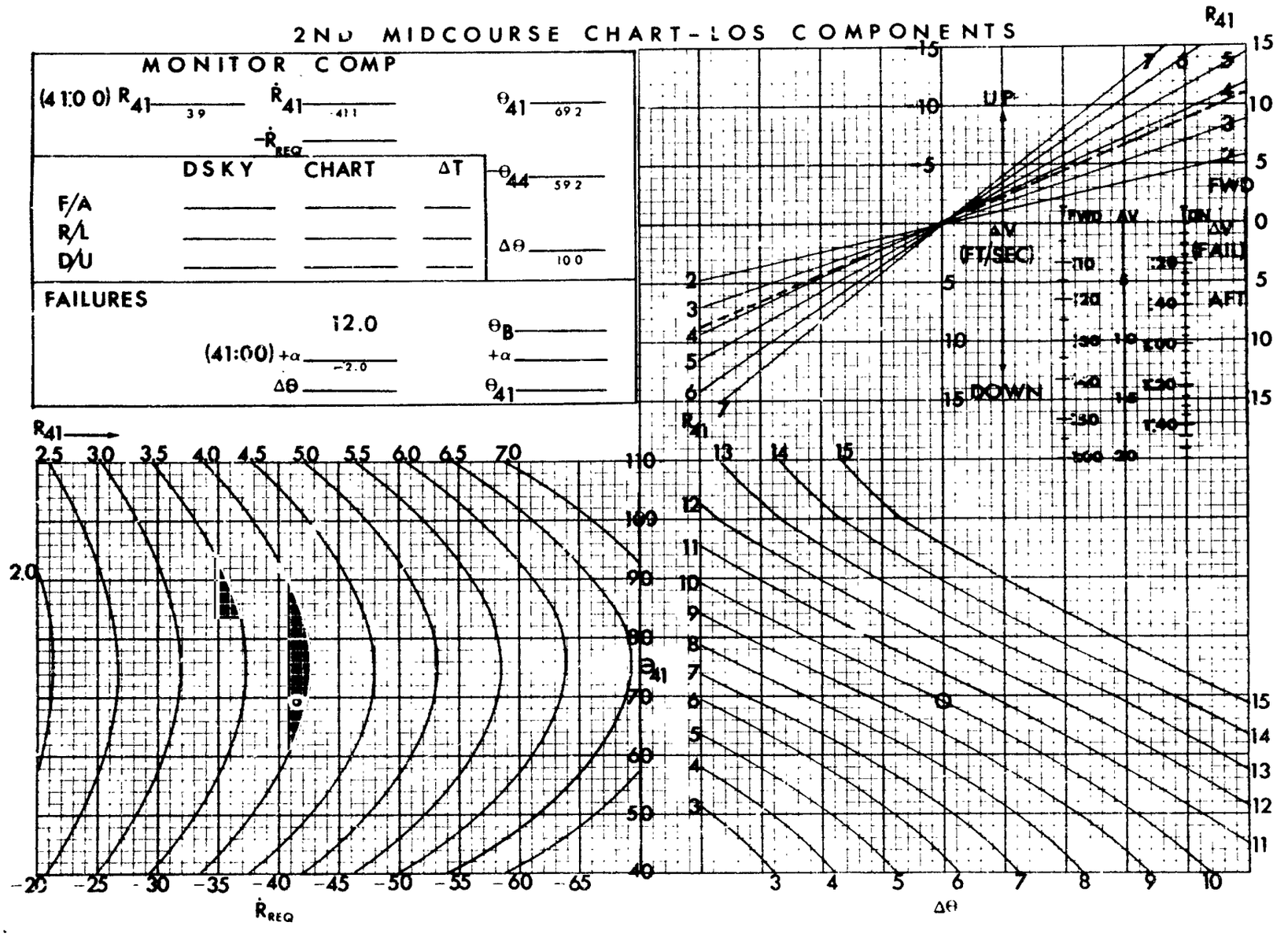

2ND MIDCOURSE CHART-LOS COMPONENTS
MONITOR COMP
(41:00) R_{41} 39
$\dot{R}_{41}$ -411
θ_{41} 692
$-\dot{R}_{REQ}$
DSKY CHART ΔT
F/A
R/L
D/U
θ_{44} 592
Δθ 100
FAILURES
12.0
(41:00) +α -2.0
θ_B
+α
Δθ
θ_{41}
R_{41}
2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0
2.0
-20 -25 -30 -35 -40 -45 -50 -55 -60 -65
$\dot{R}_{REQ}$
110 100 90 80 70 60 50 40
θ_{41}
UP
DOWN
ΔV (FT/SEC)
FWD AV
ΔV (FAIL)
FWD
AFT
3 4 5 6 7 8 9 10
Δθ
15 14 13 12 11 10 9 8 7 6 5 4 3 2

Figure 4-5

OUT OF PLANE - LINE OF SIGHT RATE CHART

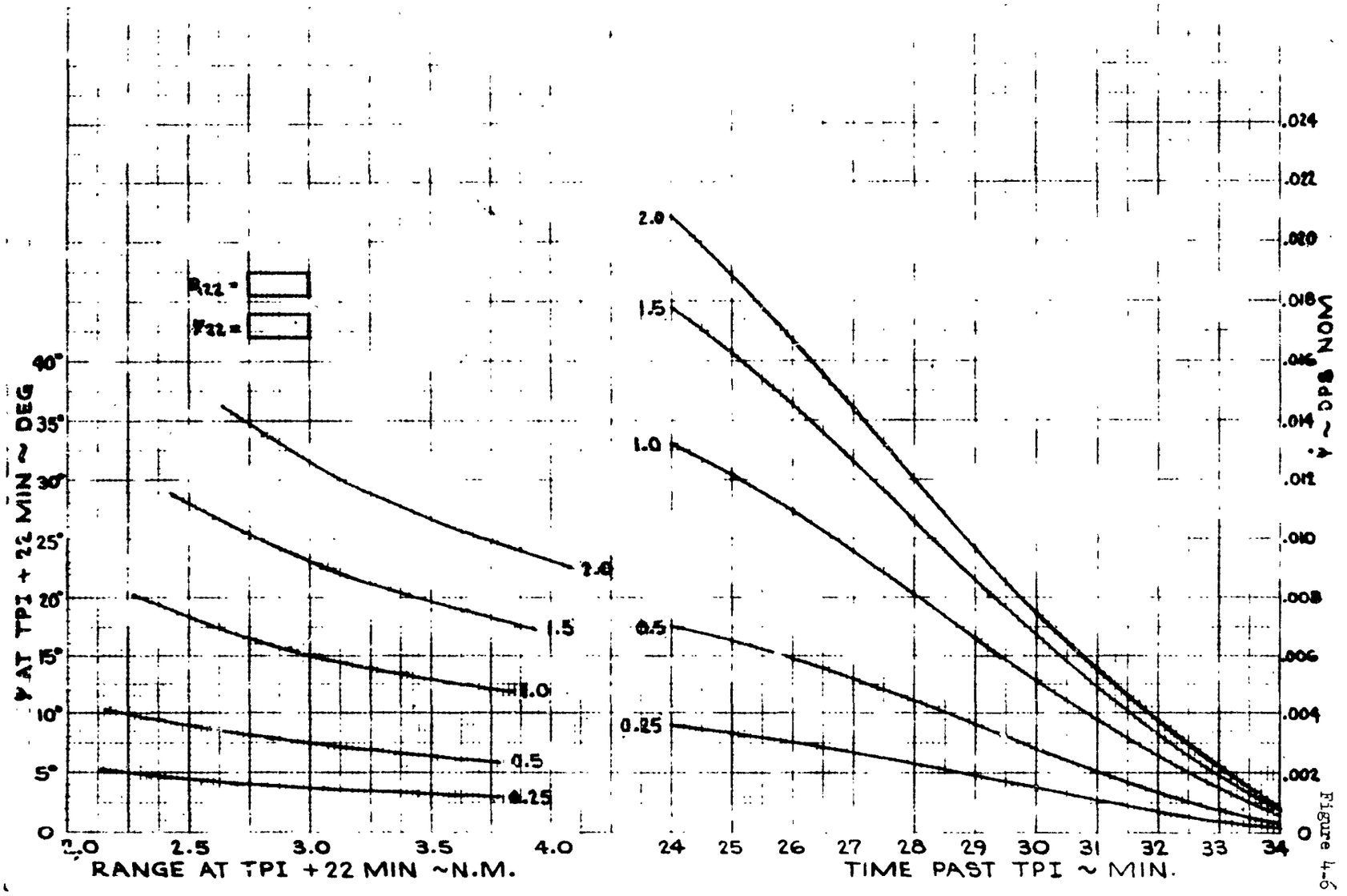


Figure 4-6

LINE-OF-SIGHT RATE CHART

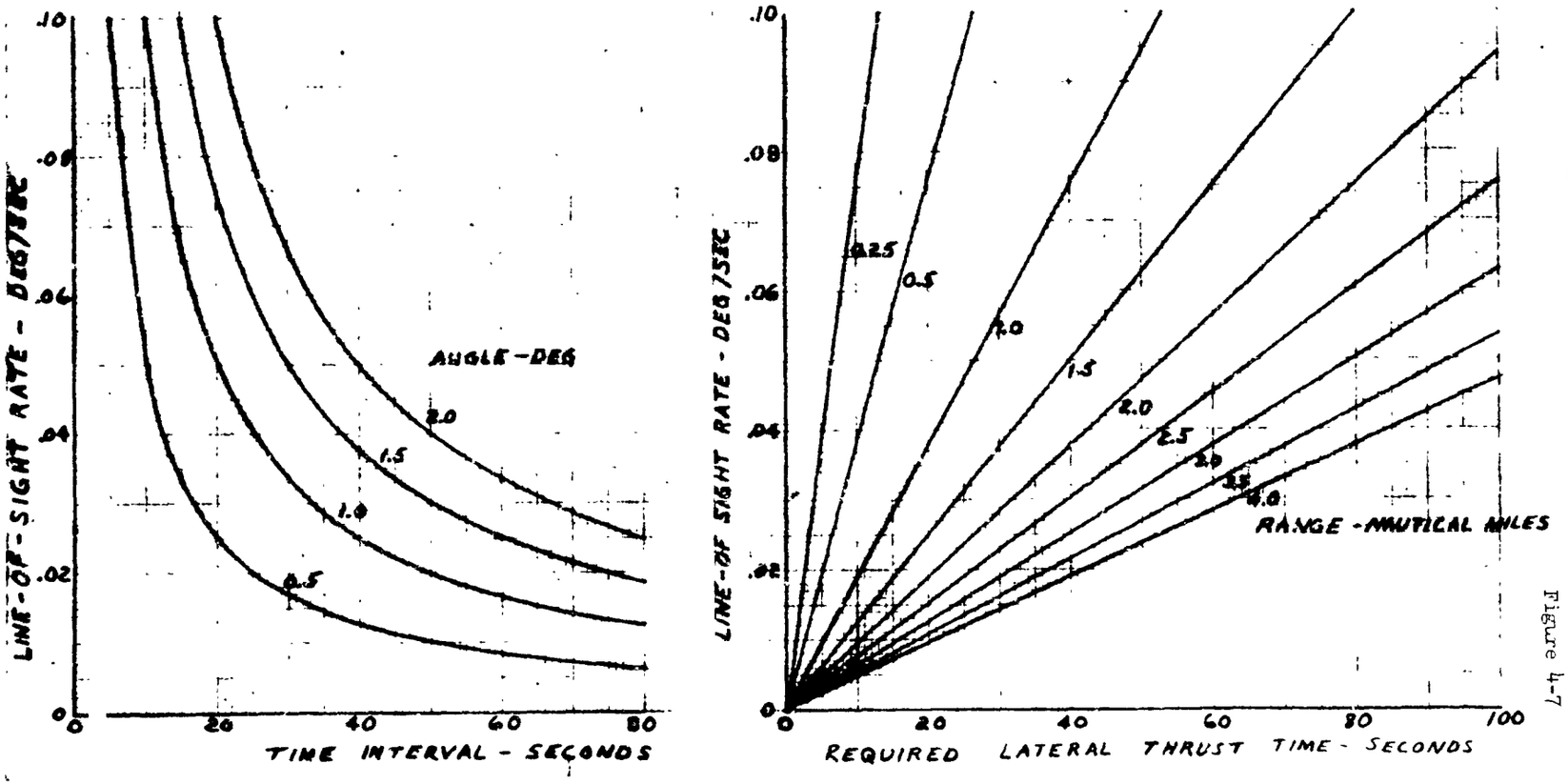
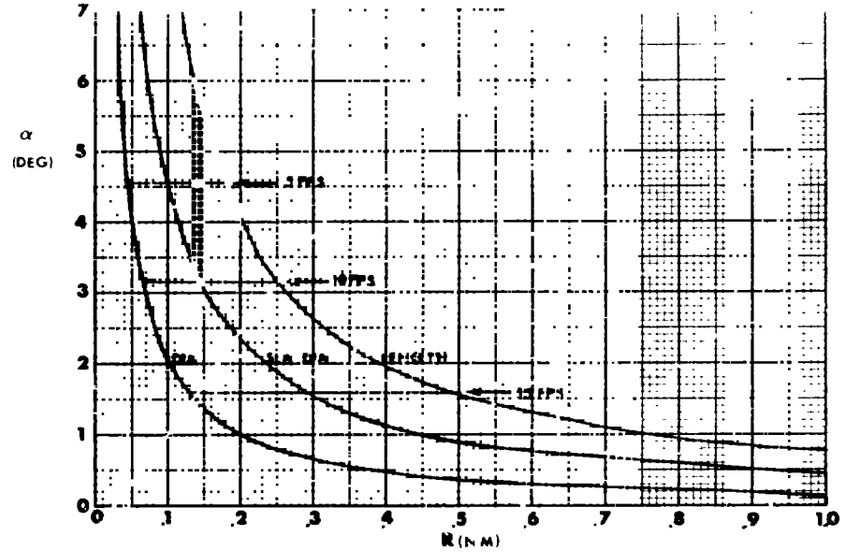


Figure 4-7

BRAKING

TIME	R	$\dot{R}$	θ
38:00	2.85	−33.0	81.03
37:00	2.54	−30.3	85.33
36:00	2.25	−28.0	89.78
35:00	1.98	−25.8	94.36
34:00	1.74	−24.0	99.03
33:00	1.51	−22.4	103.76
32:00	1.29	−21.2	108.50
31:00	1.09	−20.2	113.23
30:00	.89	−19.5	117.89
29:00	.70	−19.0	122.48
28:00	.52	−18.7	126.95
27:00	.33	−14.7	131.29



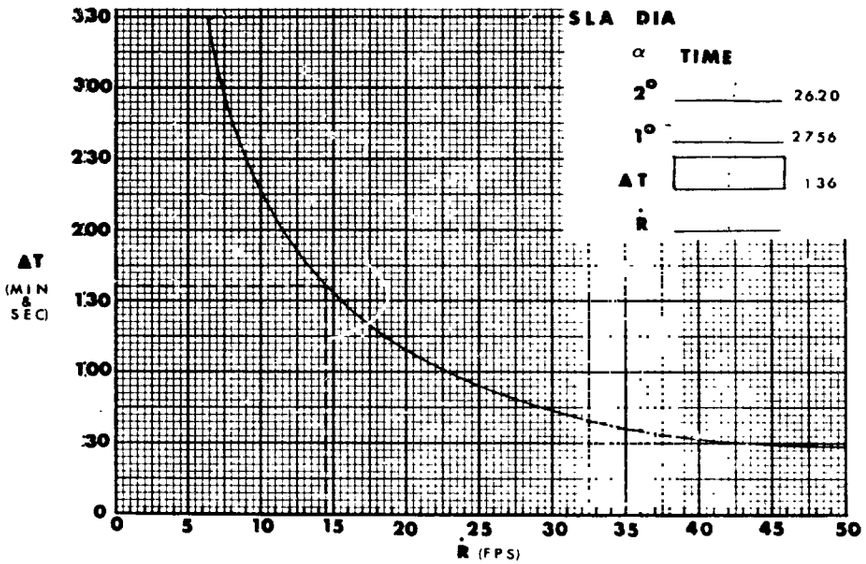


Figure 4-8

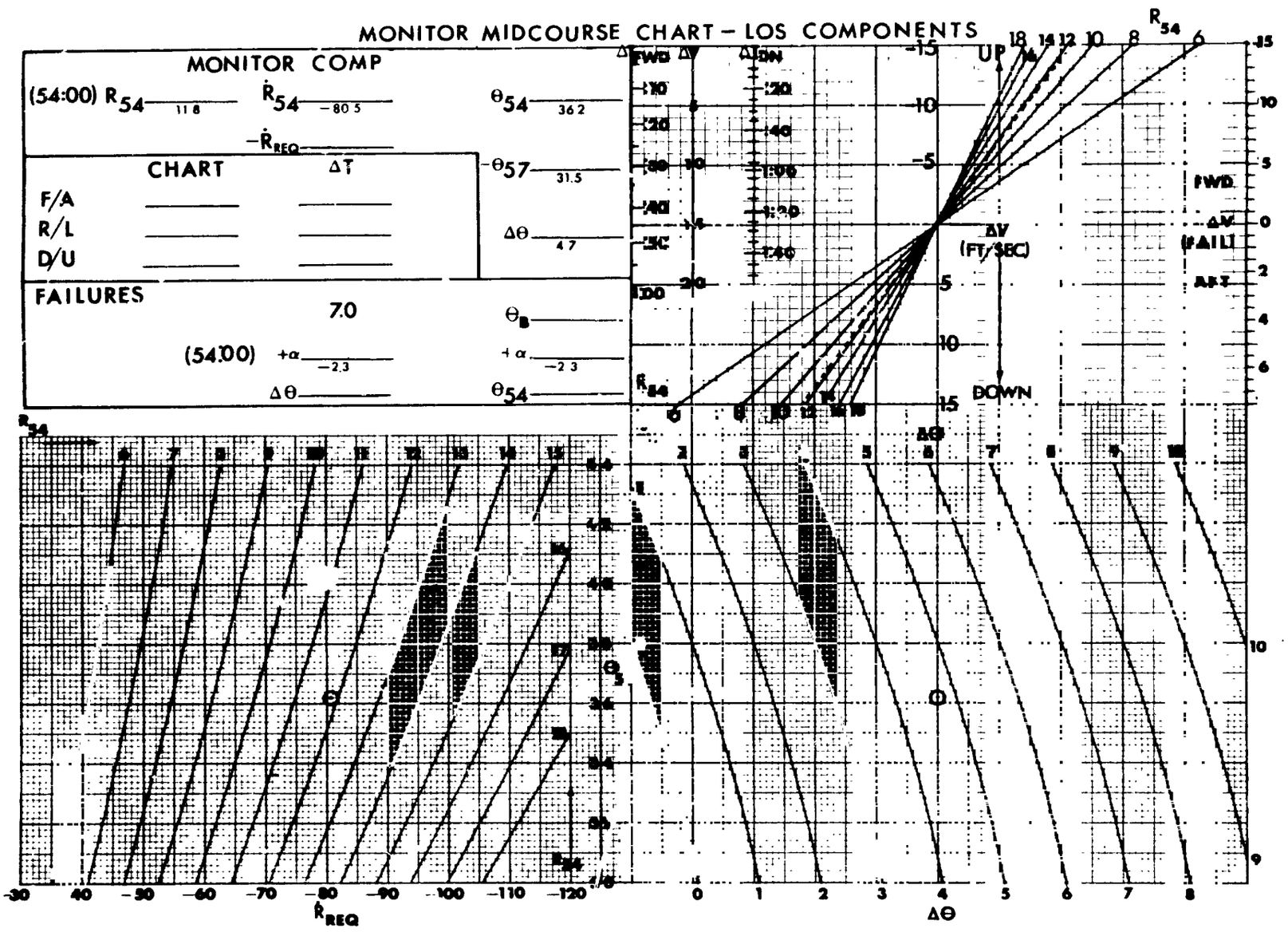

MONITOR MIDCOURSE CHART – LOS COMPONENTS
MONITOR COMP
(54:00) R54 11.8
Ṙ54 −80.5
θ54 36.2
−ṘREQ
CHART
ΔT
F/A
R/L
D/U
θ57 31.5
Δθ 4.7
FAILURES
7.0
(54:00) +α −2.3
+α −2.3
Δθ
θ54
θB
R54
ΔV (FT/SEC)
UP
DOWN
FWD
AFT
ṘREQ
Δθ

Figure 4-9

RENDEZVOUS FAILURE PROCEDURES

OPTICS FAILURE

CDR S/C Control SW - SCS
THC - Neutral
Man ATT SW - Roll - R/C
Pitch - R/C
Yaw - R/C
Limit Cycle SW - OFF
ATT Deadband SW - Min
Rate SW - Low
SCS Channel SW - Roll A/C - OFF
Roll B/C - ON
Pitch - ON
Yaw - ON
BMAG Mode SW - Roll, Pitch, Yaw - Att 1 Rate 2

FDAI Scale SW - 5/1
FDAI Select SW - 1
FDAI Source SW - ATT SET
ATT SET SW - IMU
CMC ATT SW - IMU

CMP Proceed through P34
Key V37E00E

PLATFORM FAILURE

CDR S/C Control SW - SCS
THC - Neutral
Man ATT SW - Roll - R/C
Pitch - Min Imp
Yaw - R/C
Limit Cycle SW - OFF
ATT Deadband SW - Min
Rate SW - Low
SCS Channel SW - Roll A/C - OFF
Roll B/D - ON
Pitch - ON
Yaw - ON
BMAG Mode SW - Roll, Pitch, Yaw - Att 1 Rate 2
Set Attitude Set Wheels -
0^{o} - Roll
0^{o} - Pitch
0^{o} - Yaw

FDAI Scale SW - 5/1
FDAI Select SW - 1
FDAI Source SW - ATT SET
ATT SET SW - GDC
CMC ATT SW - IMU

CMP Proceed through P34
CDR Pitch S/C Down - Boresight on horizon.
Establish Roll Reference
Pitch S/C UP - Verify yaw references with target
Press GDC Align
Pitch S/C Down - Boresight on horizon.
CMP Key V37E00E

COMPUTER FAILURE

CDR S/C Control SW - SCS
THC - Neutral
Man ATT SW - Roll - R/C
Pitch - Min Imp
Yaw - R/C
Limit Cycle SW - OFF
ATT Deadband SW - Min
Rate SW - Low
SCS Channel SW - Roll A/C - OFF
Roll B/D - ON
Pitch - ON
Yaw - ON
BMAG Mode SW - Roll, Pitch, Yaw - Att 1 Rate 2

FDAI Scale SW - 5/1
FDAI Select SW - 1
FDAI Source SW - ATT SET
ATT SET SW - IMU
CMC ATT SW - IMU

Pitch S/C Down - Boresight on horizon.

OPTICS FAILURE

(28:35)

CDR Set ORDEAL
Key V83E
Set Alt to Gnd HA, HP Avg
PWR SW - Earth
FDAI 1 SW - Orb Rate
FDAI 2 SW - Orb Rate
Slew Up/Down to DSKY R3

CMP PRO

CDR Zero FDAI-1 Error Needles with ATT SET
FDAI Select SW - $\frac{1}{2}$
ATT SET SW - GDC
GDC Align - Press until FDAI 2 ALIGNS
Man Att SW - Roll, Pitch, Yaw - Min Imp
Boresight on Target

CMP Key V83E

CDR Set ET to 8:00 Down

(8:00)

CDR,CMP When Θ = 20.0° Start ET

CDR Pitch S/C Down to 1.5° on ball
PRO
Call P41

(6:30)

Proceed to body ΔV components

LMP Copy ΔV

PLATFORM FAILURE

(28:35)

CDR Set ORDEAL

Set Alt to Gnd HA, HP Avg
PWR SW - Earth
FDAI 1 SW - Orb Rate

Slew Up/Down to Θ_{BALL}=345.7°

Yaw Man Att SW - Min Imp

Pitch S/C Up - Place Target at Top of Reticle

Set ET to 8:00 Down

(8:00)

When Θ_{BALL} is 15.0°, Start ET,
Pitch and Yaw Man Att SW - R/C

COMPUTER FAILURE

(28:35)

CDR Set ORDEAL

Set Alt to Gnd HA, HP Avg
PWR SW - Earth
FDAI 1 SW - Orb Rate
FDAI 2 SW - Orb Rate
Slew Up/Down to Θ_{BALL}=345.7°

Zero FDAI-1 Error Needles with ATT SET
FDAI Select SW - $\frac{1}{2}$
ATT SET SW - GDC
GDC Align - Press until FDAI 2 ALIGNS
Yaw Man Att SW - Min Imp

Pitch S/C Up - Place Target at Top of Reticle

Set ET to 8:00 Down

(8:00)

When Θ_{BALL} is 15.0°, Start ET,
Pitch and Yaw Man Att SW - R/C

OPTICS FAILURE

CDR Boresight on Target
CMP Key V37E00E, V83E

(5:00)

LMP Copy R, R, θ
Calculate Up/Down, Fwd/Aft ΔV (Use Computer or Nominal R)

CDR EMS Function SW - DV Set
EMS Mode SW - STBY
Load ΔV FWD on counter
EMS Function SW - DV

CMP PRO

(2:00)

Key V37E47E

(1:00)

CDR EMS Mode SW - Auto
SCS Channel SW - Roll A/C-ON
Man Att SW - Roll, Pitch Yaw - R/C

(00:30)

Thrust to obtain desired ΔV on DSKY Display

CMP PRO, Key V37E00E
CDR SCS Channel SW - Roll A/C - OFF

PLATFORM FAILURE

(5:00)

CDR Read ∝ in Reticle and θ_{BALL}
LMP Compute Up/Down Thrust Time and Forward ΔV (Use Computer or Nominal R)
CMP Key V37E41E

CMP,LMP Proceed to LOCAL VERTICAL DISPLAY OF ΔV - Copy
CDR Boresight on Target & Roll S/C + 7° (Right)
EMS Function SW - DV Set
EMS Mode SW - STBY
Load ΔV FWD on Counter
EMS Function SW - DV
CMP Key V37E00E

CDR EMS Mode SW - Auto
SCS Channel - Roll A/C - ON

(00:30)

Thrust Forward to Zero EMS counter and Up/Down for computed time
SCS Channel SW - Roll A/C - OFF

COMPUTER FAILURE

(5:00)

CDR Read ∝ in Reticle and θ_{BALL}
LMP Compute Up/Down Thrust Time and Forward ΔV (Use Nominal R)
CDR Boresight on Target & Roll S/C + 7° (Right)

EMS Function SW - DV Set
EMS Mode SW - STBY
Load ΔV FWD on counter
EMS Function SW - OFF, DV

EMS Mode SW - Auto
SCS Channel SW - Roll A/C - ON

Thrust Forward to Zero EMS counter and Up/Down for computed time
SCS Channel SW - Roll A/C - OFF

OPTICS FAILURE

CDR Boresight on Target
Man Att SW - Pitch, Yaw - Min Imp
CMP Key V83E
(57:00)
LMP Copy θ
CDR EMS Mode SW - STBY
EMS Function SW - OFF, DV
CMP PRO
(55:00)
Key V37E47E, V83E
(54:00)
LMP Copy R, $\dot{R}$, θ
Compute Up/Down Forward/Aft ΔV (Use Nominal or Computer R)
CMP PRO
EMS Mode SW - Auto
CDR SCS Channel SW - Roll A/C - ON
Man Att SW - Pitch, Yaw - R/C
Thrust to obtain desired ΔV on DSKY display ASAP
CMP PRO, Key V37E00E
SCS Channel SW - Roll A/C - OFF

PLATFORM FAILURE

CDR Roll S/C to 0° Att
Man Att SW - Pitch, Yaw - Min Imp
Place TGT at Top of Reticle
(57:00)
Man Att SW - Pitch, Yaw - R/C
EMS Mode SW - STBY
EMS Function SW - OFF, DV
(54:00)
CDR Read α and θ_{BALL}
Compute Up/Down Thrust Time and FWD/AFT ΔV (Use Nominal R)
CDR SCS Channel SW - Roll A/C - ON
Roll S/C + 7° (Right)
EMS Mode SW - AUTO
Thrust Up/Down for computed times and Fwd/Aft to obtain desired ΔV on EMS ASAP
SCS Channel SW - Roll A/C - OFF

COMPUTER FAILURE

CDR Roll S/C to 0° Att
Man Att SW - Pitch, Yaw - Min Imp
Place TGT at Top of Reticle
(57:00)
Man Att SW - Pitch, Yaw - R/C
EMS Mode SW - STBY
EMS Function SW - OFF, DV
(54:00)
CDR Read α and θ_{BALL}
Compute Up/Down and FWD/AFT ΔV (Use Nomonal R)
SCS Channel SW - Roll A/C - ON
Roll S/C + 7° (Right)
EMS Mode SW - Auto
Thrust Up/Down for computed times and Fwd/Aft to obtain desired ΔV on EMS ASAP
SCS Channel SW - Roll A/C - OFF

OPTICS FAILURE

CDR Boresight on Target
Man Att SW - Pitch, Yaw - Min Imp
CMP Key V83E
(51:00)
IMP Copy Θ

EMS Mode SW - STBY
EMS Function SW - OFF, DV
CMP PRO

(49:00)
Key V37E47E, V83E
(48:00)
LMP Copy R, Ṙ, Θ

Compute Up/Down, FWD/AFT ΔV (Use Nominal or Computer R)

CMP Press Key Release

PRO
EMS Mode SW - Auto
CDR SCS Channel SW - Roll A/C-ON
Man Att SW-Pitch, Yaw - R/C
Thrust to obtain desired ΔV on DSKY Display ASAP
CMP PRO, Key V37E00E
CDR SCS Channel SW - Roll A/C - OFF

PLATFORM FAILURE

CDR Roll S/C to 0° Att
Place TGT at Top of Reticle
Man Att SW - Pitch, Yaw - Min Imp
(51:00)
CDR Man Att SW - Pitch, Yaw - R/C

EMS Mode SW - STBY
EMS Function SW - OFF, DV

(48:00)
CDR Read α and Θ_{BALL}
LMP Compute Up/Down Thrust Time and FWD/AFT ΔV (Use Nominal R)

CDR SCS Channel SW - Roll A/C - ON
Roll S/C + 7° (Right)
EMS Mode SW - Auto
Thrust Up/Down for Computed Time and FWD/AFT to obtain desired ΔV on EMS ASAP

SCS Channel SW - Roll A/C - OFF

COMPUTER FAILURE

CDR Roll S/C to 0° Att
Place TGT at Top of Reticle
Man Att SW - Pitch, Yaw - Min Imp
(51:00)
CDR Man Att SW - Pitch, Yaw - R/C

EMS Mode SW - STBY
EMS Function SW - OFF, DV

(48:00)
CDR Read α and Θ_{BALL}
LMP Compute Up/Down Thrust Time and FWD/AFT ΔV (Use Nominal R)

CDR SCS Channel SW - Roll A/C - ON
Roll S/C + 7° (Right)
EMS Mode Sw - Auto
Thrust Up/Down for Computed Time and FWD/AFT to obtain desired ΔV on EMS ASAP

SCS Channel SW - Roll A/C - OFF

OPTICS FAILURE

CDR Boresight on Target
Man Att SW - Pitch, Yaw - Min Imp

CMP Key V83E

(44:00)

LMP Copy Θ

CDR EMS Mode SW - STBY
EMS Function SW - OFF, DV

CMP PRO

(42:00)

Key V37E47E, V83E

(41:00)

LMP Copy R, $\dot{R}$, Θ

Compute Up/Down, FWD/AFT ΔV (Use Nominal or Computer R)

CDR EMS Mode SW - Auto
SCS Channel SW - Roll A/C - ON
Man Att SW - Pitch, Yaw - R/C
Thrust to obtain Desired ΔV on DSKY Display ASAP

PLATFORM FAILURE

CDR Roll S/C to 0° Att
Boresight on Target
Man Att SW - Pitch, Yaw - Min Imp

(44:00)

CDR Man Att SW - Pitch, Yaw - R/C

EMS Mode SW - STBY
EMS Function SW - OFF, DV

(41:00)

Read α and Θ_{BALL}

LMP Compute Up/Down Thrust Time and FWD/AFT ΔV (Use Nominal R)

CDR EMS Mode SW - Auto
SCS Channel SW - Roll A/C - ON
Roll S/C + 7° (Right)
Thrust Up/Down for Computed Time and FWD/AFT to obtain desired ΔV on EMS ASAP

COMPUTER FAILURE

CDR Roll S/C to 0° Att
Boresight on Target
Man Att SW - Pitch, Yaw - Min Imp

(44:00)

CDR Man Att SW - Pitch, Yaw - R/C

EMS Mode SW - STBY
EMS Function SW - OFF, DV

(41:00)

Read α and Θ_{BALL}

LMP Compute Up/Down Thrust Time and FWD/AFT ΔV (Use Nominal R)

CDR EMS Mode SW - Auto
SCS Channel SW - Roll A/C - ON
Roll S/C + 7° (Right)
Thrust Up/Down for Computed Time and FWD/AFT to obtain desired ΔV on EMS ASAP

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