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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LM RENDEZVOUS PROCEDURES

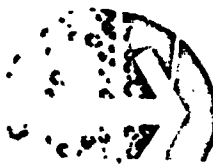
D MISSION

FINAL



REVISION A

JAN 31, 1969



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RENDEZVOUS PROCEDURES

D MISSION

AS-504/CSM-104/LM-3

January 31, 1969

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D MISSION
RENDEZVOUS PROCEDURES
LM ACTIVE

1.0 Purpose

This document contains the primary procedures for the LM-3 active rendezvous with CSM 104 spacecraft, in accordance with Detailed Test Objective P20.27, defined in the Mission Requirements SPD8-R-005, Revision 1, dated November 6, 1968.

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.

2.0 Major Events

The LM3/CSM10⁴ rendezvous occurs in the "fifth period of activities" (87 hrs to 10¹ hrs G.E.T.). The procedures in this period will be divided into segments around major activities, and discussed separately in the paragraphs of Section 2.0.

Figure 2-1 shows the LM attitude time history and the locations in time and position of the 50 major events of the nominal mission.

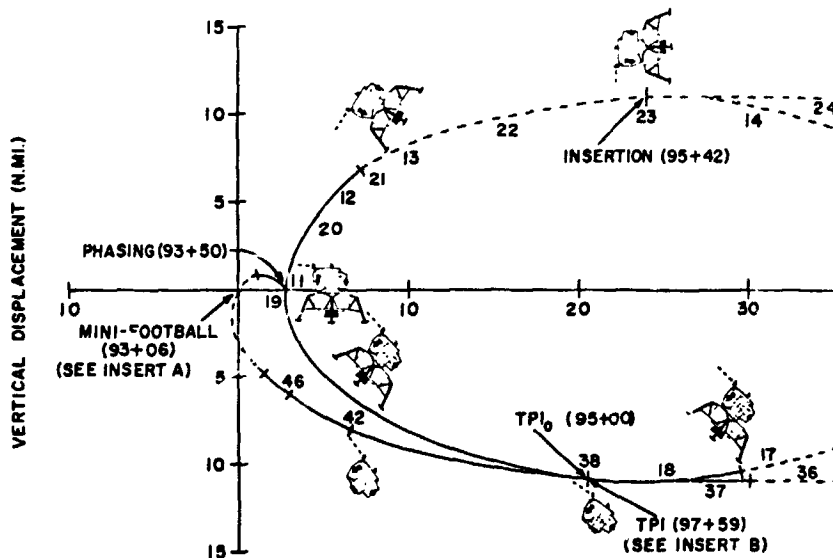


FIGURE 2-1
 "D" MISSION RENDEZVOUS PROFILE
 (CSM-CENTERED RELATIVE MOTION)

LM MAJOR EVENTS

| | | | | | |
|----|-------------|--|----|-------------|-----------|
| 1 | 92+41 | UNDOCKING | 26 | 96+04 | AGS TARG |
| 2 | 92+44 | 120 YAW RT, 90 PITCH UP | 27 | 96+15 | AGS UPDA |
| 3 | 92+50 | LM INSPECTION (360 YAW) | 28 | 96+22 | STAGE |
| 4 | 93+06 | RCS SEPARATION (CSM ACTIVE) | 29 | 96+22 | CSI THRU |
| 5 | 93+07 | AGS UPDATE AND ALIGN (R47) | 30 | 96+29 | CDM TARG |
| 6 | 93+08 | R/R CHECKOUT | 31 | 96+30-96+54 | R/R NAVIG |
| 7 | 93+15 | EXT ΔV FOR DPS PHASING (P30) | 32 | 96+57 | AGS UPDA |
| 8 | 93+18 | IMU REFSMMAT ALIGN (P52)(COAS CALIBRATION) | 33 | 97+06 | CDM THRU |
| 9 | 93+39 | AGS UPDATE AND ALIG (R47) | 34 | 97+13 | TPI TARG |
| 10 | 93+47 | LR SPUR TEST (V78) | 35 | 97+14-97+48 | R/R NAVIG |
| 11 | 93+50 | DPS PHASING (P40 AND AGS CONTROL) | 36 | 97+50 | AGS UPDA |
| 12 | 93+58 | TPI ₀ TARGETING (P34) | 37 | 97+55 | CALCULAT |
| 13 | 94+00-94+15 | R/R NAVIGATION (P20, 12 MARKS) | 38 | 97+59 | TPI THRU |
| 14 | 94+16 | LR SELF TEST | 39 | 98+04 | MCCI TARG |
| 15 | 94+28 | TPI ₀ TARGETING (P34) | 40 | 98+02-98+06 | R/R NAVIG |
| 16 | 94+30-94+48 | R/R NAVIGATION (P20, 15 MARKS) | 41 | 98+06 | CALCULAT |
| 17 | 94+51 | GO, NO GO FOR INSERTION | 42 | 98+09 | MCCI THR |
| 18 | 94+52 | IMU REFSMMAT ALIGN (P52) | 43 | 98+11 | MCC2 TAR |
| 19 | 95+20 | MONITOR CLOSE APPROACH | 44 | 98+12-98+16 | R/R NAVIG |
| 20 | 95+22 | EXT ΔV FOR DPS INSERTION (P30) | 45 | 98+20 | CALCULAT |
| 21 | 95+34 | AGS UPDATE AND ALIGN (R47) | 46 | 98+21 | MCC2 THP |
| 22 | 95+36 | LR SPUR TEST (V78) | 47 | 98+30 | BRAKING |
| 23 | 95+42 | DPS INSERTION (P40 AND AGS CONTROL) | 48 | 98+35 | STATION |
| 24 | 95+51 | CSI TARGETING (P32) | 49 | 98+47 | R/R OFF |
| 25 | 95+50-96+12 | R/R NAVIGATION (P20, 18 MARKS) | 50 | | DOCK |

FOLDOUT FRAME /

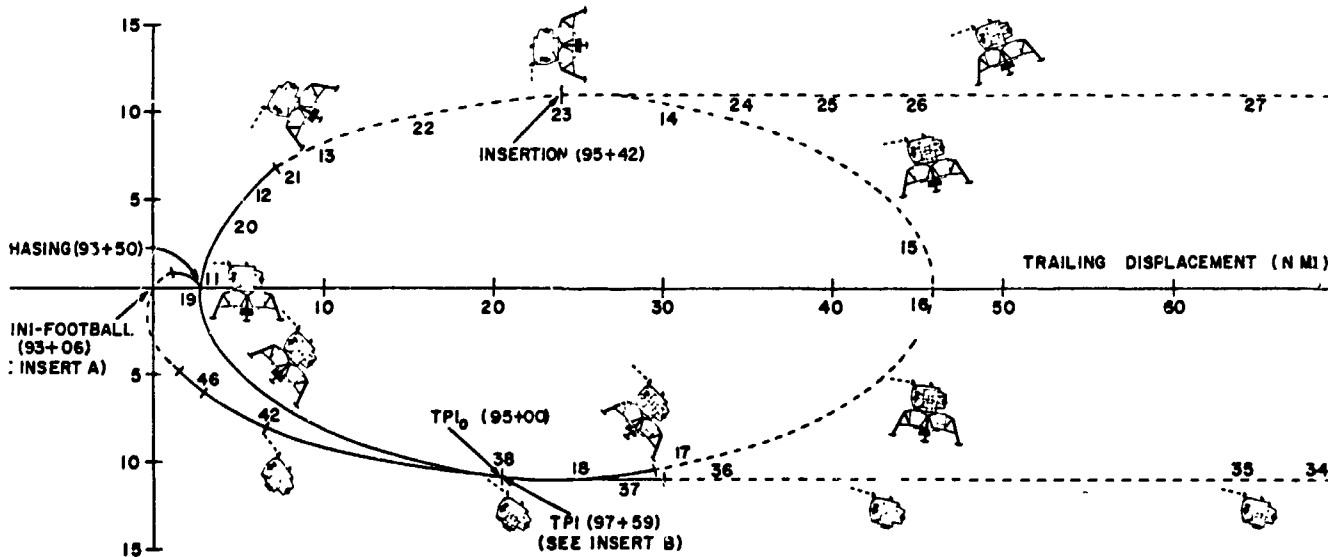
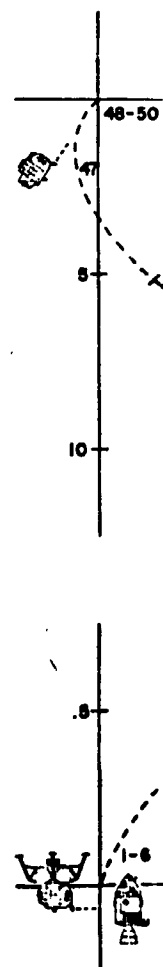


FIGURE 2-1

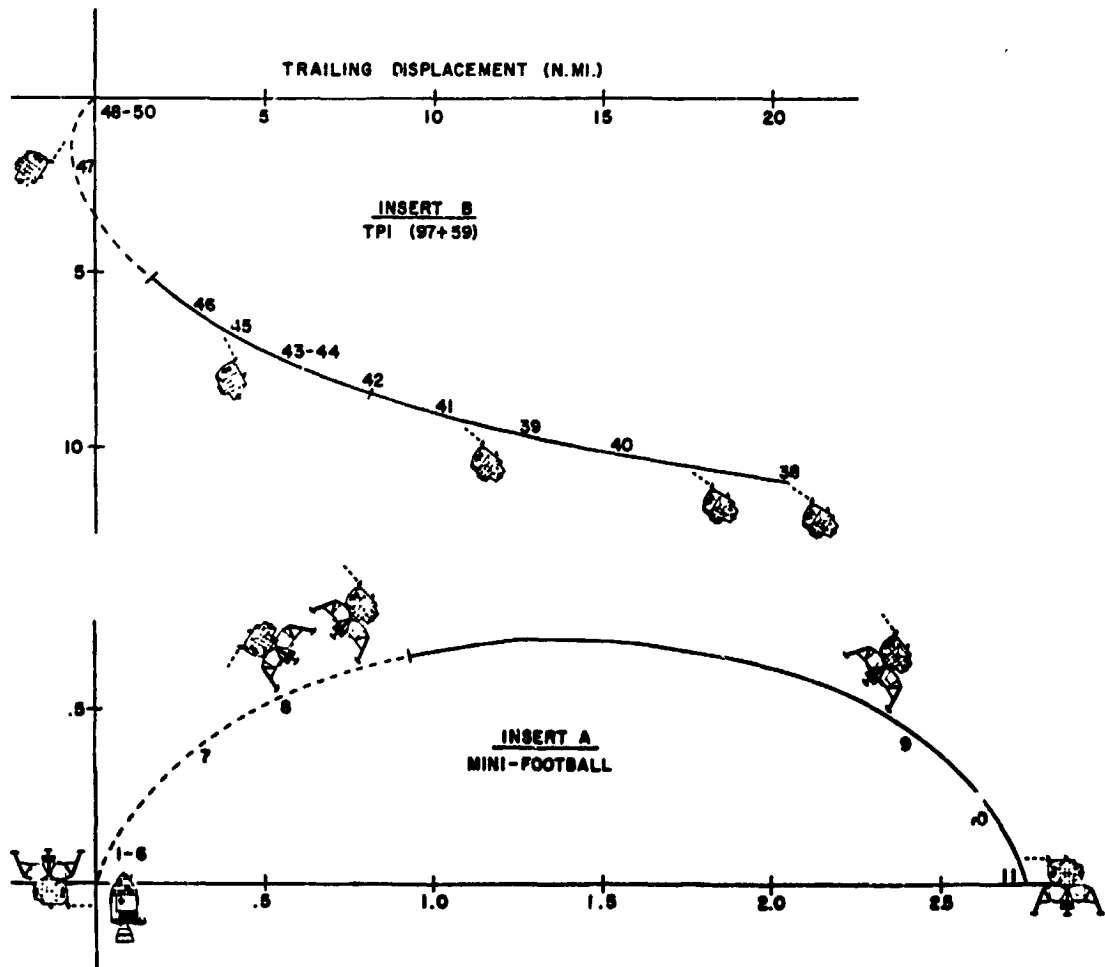
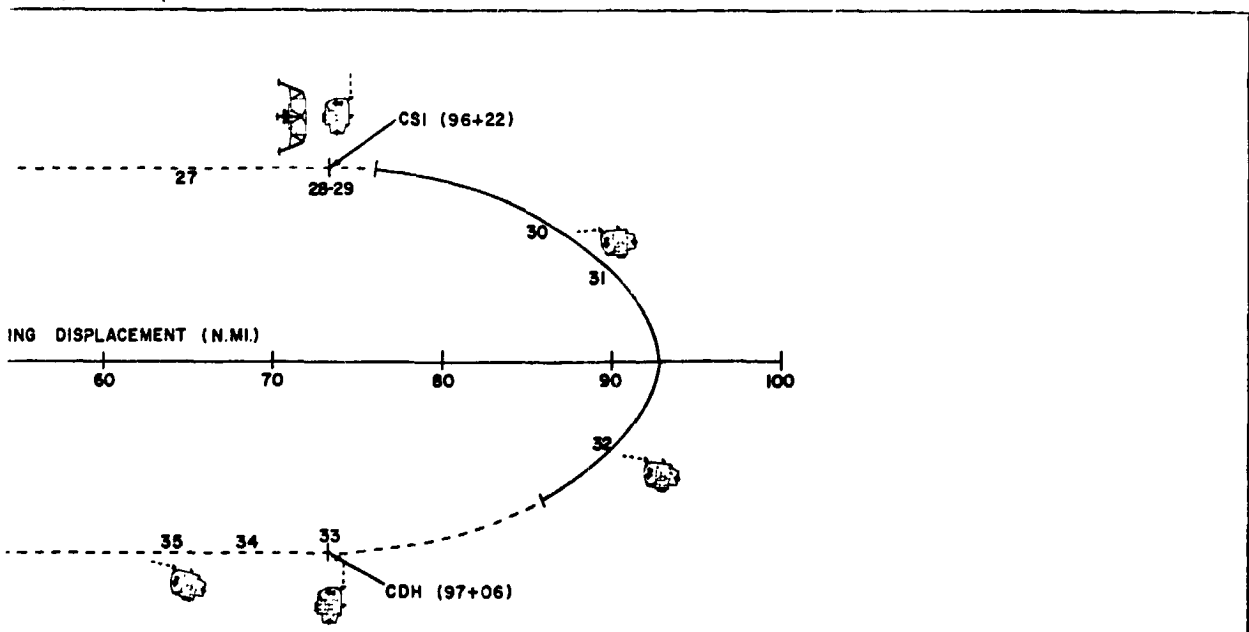
MISSION RENDEZVOUS PROFILE
(CSM-CENTERED RELATIVE MOTION)

LM MAJOR EVENTS

| | | | | |
|--------|--|----|---------------|---------------------------------------|
| -41 | UNDocking | 26 | 96+04 | AGS TARGETING |
| -44 | 120 YAW RT, 90 PITCH UP | 27 | 96+15 | AGS UPDATE AND ALIGN (R47) |
| -50 | LM INSPECTION (360 YAW) | 28 | 96+22 | STAGE |
| -06 | RCS SEPARATION (CSM ACTIVE) | 29 | 96+22 | CSI THRUSTING (P41)(APS INTERCONNECT) |
| -07 | AGS UPDATE AND ALIGN (R47) | 30 | 96+29 | CDH TARGETING (P33) |
| -08 | R/R CHECKOUT | 31 | 96+30 - 96+54 | R/R NAVIGATION (P20, 20 MARKS) |
| -15 | EXT ΔV FOR DPS PHASING (P30) | 32 | 96+57 | AGS UPDATE AND ALIGN (R47) |
| -18 | IMU REFSMMAT ALIGN (P52)(COAS CALIBRATION) | 33 | 97+06 | CDH THRUSTING (P42) |
| -39 | AGS UPDATE AND ALIGN (R47) | 34 | 97+13 | TPI TARGETING (P34) |
| -47 | LR SPUR TEST (V78) | 35 | 97+14 - 97+48 | R/R NAVIGATION (P20, 26 MARKS) |
| -50 | DPS PHASING (P40 AND AGS CONTROL) | 36 | 97+50 | AGS UPDATE AND ALIGN (R47) |
| -58 | TPI ₀ TARGETING (P34) | 37 | 97+55 | CALCULATE BU SOLUTION (TPI) |
| -94+12 | R/R NAVIGATION (P20, 12 MARKS) | 38 | 97+59 | TPI THRUSTING (P41) |
| +16 | LR SELF TEST | 39 | 98+04 | MCCI TARGETING (P35) |
| +28 | TPI ₀ TARGETING (P34) | 40 | 98+02 - 98+06 | R/R NAVIGATION (P20, 4 MARKS) |
| -94+48 | R/R NAVIGATION (P20, 15 MARKS) | 41 | 98+08 | CALCULATE BU SOLUTION (MCCI) |
| +51 | GO, NO GO FOR INSERTION | 42 | 98+08 | MCCI THRUSTING (P41) |
| +52 | IMU REFSMMAT ALIGN (P52) | 43 | 98+11 | MCCI TARGETING (P35) |
| +20 | MONITOR CLOSE APPROACH | 44 | 98+12 - 98+18 | R/R NAVIGATION (P20, 6 MARKS) |
| +22 | EXT ΔV FOR DPS INSERTION (P30) | 45 | 98+20 | CALCULATE BU SOLUTION (MCCI) |
| +34 | AGS UPDATE AND ALIGN (R47) | 46 | 98+21 | MCCI THRUSTING (P41) |
| +35 | LR SPUR TEST (V78) | 47 | 98+30 | BRAKING (P47) |
| +42 | DPS INSERTION (P40 AND AGS CONTROL) | 48 | 98+38 | STATION KEEPING |
| +8 | CSI TARGETING (P32) | 49 | 98+47 | R/R OFF |
| -96+12 | R/R NAVIGATION (P20, 18 MARKS) | 50 | | DOCK |



HOLDOUT FRAME 2



FOLDBOUT FRAME 3

1 Undocking Maneuver

By 89:50 hrs G.E.T. both crewmen have entered the LM, powered up the PGNS, IMU, and AGS, and closed the hatch in preparation for the undocking. At about 91:10 over Artigua the PGNS state vector is updated. The first rendezvous related activity begins with the docked IMU align which has been preceded by a ground uplink of the REFSMMAT into the LM Guidance Computer (LGC). The docked align is accomplished without using Program 51 and 52 procedure by manually setting the REFSMMAT flag and commanding a Verb 42 to fine align. The ICDU angles used in Verb 42 are computed from the CSM's Noun 20 and the docking ring index angle with an equation similar to that given in the AOH Vol II Section 4.9. The Rendezvous Radar antenna restraint device is released and the radar self test routine executed. Meanwhile, the CSM has begun a maneuver to the undocking attitude. LM procedures up to this point are included in the crew checklist. Undocking occurs at 92:41 with the CSM backing away to about 50 feet (giving clearance for LM maneuvers), while maintaining an inertial attitude. At this time the LM will yaw right 120 degrees and pitch up 180 degrees in order for the CSM to photograph the descent engine bell, then pitch down 90 degrees under AGS control to position the LM plus Z-axis toward the CSM.

2.2 RCS Separation Maneuver

The LM is placed in AGS attitude hold (pitch, roll) and a yaw rate of approximately 1 degree/second is commanded with AGS minimum impulses. This yaw rate is held for 360 degrees, so that the CSM can visually inspect all legs of the LM landing gear and descent engine bell. When the LM plus Z-axis is again pointed at the CSM, the yaw rate is stopped and the LM enters PGNS attitude hold and begins station keeping. The attitudes of both vehicles during the inspection have been established to provide illumination of the LM surface from reflected sunlight.

At 93:05:45 the CSM performs a 5 feet/second radially downward burn to allow safe separation from the LM during IMU alignment prior to the phasing burn. The LM crew accomplishes Target Delta V (Verb 84) to update the LGC with the maneuver just accomplished by the CSM.

Phasing Maneuver

Rendezvous radar acquisition using Verb 41 Noun 72 (lock-on option) is checked by manually maneuvering to point the LM plus Z-axis at the CSM and designating the antenna to the plus Z-axis. After determining that the radar is locked on the main lobe, the tape meter is calibrated using rendezvous radar self test (Verb 62). After lock-on is accomplished and radar operation verified, the radar antenna is positioned clear of the AOT field of view and turned off. While awaiting sunset, External Delta V (Program 30) is loaded with the parameters of the phasing burn and the event timer is set counting down to this maneuver.

A REFSMMAT alignment (Program 52) is performed just prior to sunset using the center forward detent position. Manual star selection is used with automatic vehicle maneuvering. Before terminating Program 52, the COAS is calibrated for future use. The rendezvous radar is turned on and an AGS state vector update and AGS alignment is accomplished followed by an AGS external Delta V targeting.

The landing radar (LR) is activated and placed in the proper configuration for a LR spurious test (Routine 77). This test is started with a Verb 78 prior to descent propulsion system (DPS) thrusting and terminated by a Verb 79 after the DPS thrusting.

The sequence of the phasing burn is started with selection of Program 40. This program will be used to monitor the maneuver which is executed under AGS control. LM guidance is switched to AGS control at about 3 minutes prior to ignition, after insuring that the ATT CONT switches are in PULSE. Configuring the ATT CONT switches in PULSE prior to switching GUID CONT from PGNS to AGS assures that unexpected high maneuver rates are not commanded by the AGS. AGS attitude error signals are displayed on the FDAI needles when the MODE CONT switch is placed to AUTO and are nulled with AGS pulses. When these errors are nulled, the ATT CONT switches are placed to MODE CONT which enables AGS auto steering. The ABORT button is depressed, manual ullage is initiated, and the burn is executed under AGS control. Upon thrust termination, the PGNS residuals are nulled with RCS thrusting.

+ TPI₀ Targeting

When range has opened to 19,000 feet, rendezvous radar tracking with LGC updating is initiated. Program 34 (TPI) is called and targeted for a possible abort from the equi-period. The program is recycled to compute a solution for resetting the event timer. The AGS is targeted for the PGNS computed TPI time based on the LGC elevation angle option. There are few Guidance and Navigation tasks during the next several minutes except for maintaining the LM plus Z-axis coarsely aligned with the CSM using radar error needles or the COAS. This time will be spent making systems checks and accomplishing test objectives.

Final computation of TPI₀ is accomplished 14 minutes prior to ignition. The TPI₀ solution is evaluated and the onboard GO, NO GO decision is made about 94:51.

2.5 1.U Alignment and Close Approach to CSM

If the insertion maneuver is to be executed, the rendezvous radar antenna is driven from the AOT field of view and is turned off so that it will not drift back into the field of view. A REFSMMAT alignment (Program 52) is then accomplished between 94:50 and 95:08. After completion of the alignment, the rendezvous radar is turned on and an automatic radar lock on is performed in preparation for monitoring the close approach to the CSM (about 2.8nm). The inertial angular rate of the line of sight to the CSM is also monitored to insure that the trajectory is not intercepting.

6 Insertion Maneuver

When the radar indicates the range is increasing, PGNS External Delta V (Program 30) is loaded with the parameters of the insertion burn and the event timer is set counting down. The AGS is updated, aligned, and targeted in external delta V prior to the maneuver.

DPS Thrusting (Program 40) is called and the auto maneuver under PGNS control to the burn attitude is enabled. This burn is executed under automatic PGNS control with AGS monitoring.

2.7 CSI Maneuver

At about 95:49, CSI targeting is accomplished using Program 32 and AGS. Some iteration on the CDH apsis (1st or 2nd) may be required to obtain a solution from both PGNS and AGS. Prestaging checks are begun at about CSI -5 minutes to insure readiness to stage just prior to CSI. Radar updating is terminated 1.4 minutes prior to CSI and the final solution computed. This solution is recorded and transmitted to the ground and CSM. A CSI chart solution is calculated to validate the "G" mission procedures. The AGS is updated, aligned, and targeted in external delta V with the CSI solution to be burned. An automatic maneuver to the thrusting attitude is done under PGNS control (Program 41) and last minute prestaging systems checks are accomplished. The descent stage is jettisoned at ignition. RCS thrusting is started on time, and ascent fuel is used through the interconnect system to supplement RCS fuel usage.

.8 CDH Maneuver

Program 33 is selected after the CSI burn and the AGS absolute time of CDH is loaded from the PGNS. The LGC is updated with radar marks as in other prethrust sequences, and a solution is computed. A CDH chart solution is calculated 7 minutes prior to TIG. The AGS is updated, aligned, and targeted in external delta V with the CDH solution to be burned. An automatic maneuver to the thrust attitude is performed, and CDH thrusting is done with the Ascent Propulsion System (APS) using Program 42.

2.9 TPI Maneuver

Radar tracking is initiated after the CDH maneuver and updating of the LGC continued. Terminal Phase targeting is done in Program 34, and in the AGS. Radar updates are entered into the AGS, taking marks approximately every three minutes. Both systems are targeted to have a node occur at intercept. Backup measurements are made at the appropriate times. The AGS is aligned, updated, and retargeted in external delta V mode with the solution to be used for TPI. The TPI maneuver is accomplished in attitude hold, using RCS thrusting along the plus Z-axis with the thrust direction established with the COAS.

.10 Midcourse Corrections (MCC)

The midcourse program (Program 35) is assumed to have ATIGINC =3 minutes. (ATIGINC is the constant that determines time between selecting final computation cycle and the midcourse maneuver time).

MCC 1

Program 35 is entered immediately after TPI, and radar track reinitiated. Backup measurements are made and MCC chart solutions obtained.

MCC 1 is made to occur at TPI plus 10 minutes in the PGNS by proceeding from display "Verb 16 Noun 45" at TPI plus 7 minutes. The backup solution is valid for TPI plus 10 minutes.

If MCC 1 is to be executed, Program 41 is selected to burn the components with RCS. No maneuver to a "preferred" thrust attitude will be made. (LM plus Z-axis will remain pointed at the CSM after TPI until docking.)

MCC 2

MCC 2 occurs at TPI plus 22 minutes by keying STBY at TPI plus 19 minutes. A backup chart solution is obtained at TPI plus 20 minutes. The maneuver is executed as MCC 1.

2.11 Braking

In preparation for braking, the DAP is checked to verify narrow deadband is selected. Program 20 is terminated at 18,000 ft but the radar is kept in AUTO TRACK to provide radar range and range rate displayed on the tape meter. Average "G" is turned on prior to braking, and attitude hold is selected. The braking schedule is followed as contained in section 3.

3.0 Nominal Mission Procedures

The procedures included in this section do not specify which crewmember, Commander or IM Pilot, performs each listed task. These need not be specified since the following basic rules define which crewmember performs each task. These rules are:

COMMANDER (CDR):

1. All attitude changes, whether manual or automatic, will be accomplished by the CDR.
2. The operation of the DSKY during thrust programs (P40, P41, P42, P47) will be done by the CDR. Actual manipulation of the Translation Thrust Control Assembly (TTCA) need not be always done by the CDR, but in most cases will be.
3. Operation of the rendezvous and landing radar will be done by the CDR.
4. The CDR will operate all other systems accessible to only his crew station.

LM PILOT (LMP) TASKS:

1. AGS operation.
2. DSKY operation will be done by the LMP except when keyboard entries affect the control of spacecraft attitude or thrusting.
3. Backup data logging and chart calculations.
4. All logging of maneuver solutions and systems performance.
5. The LMP will operate all other systems accessible to only his crew station.

These general rules are guidelines only, and may be deviated from by the LM crew if they develop more efficient Task assignments.

The abbreviations used herein are consistent with those in the AOH. However, in order to condense and simplify the procedures so that they are representative of onboard data, a number of additional shorthand conventions have been used. To allow the unfamiliar reader to understand the procedures contained in this section, the following explanations are included:

1. AGS - A single asterisk is employed to denote those procedures involving operations to be performed on the DEDA. The three number group following an asterisk specifies DEDA address. An "R" following the address group indicates the address is to be read out. A five digit group behind the "R" indicates a nominal or expected display. If the three number address group is followed by a + or - sign, a data load is indicated. When a single digit follows the +, addition of 4 zeros behind this digit is assumed. Once used, these conventions are easily handled and save considerable space.

2. PGNS - The verb-noun addresses in the PGNS are indicated to the left of the procedures column. An "F" is used to indicate a flashing display, or absence of an "F" a static display. To the right of the verb-noun, on the same line, are the contents of the three data registers. If numeric quantities appear, the DSKY should be correspondingly made to agree by executing a V21, V22, or V23 and performing a data load. The procedure of blanking and loading registers is not included since it is repeated often and is highly familiar to the crews.

EXAMPLE: F 06 33 94:39:46 TIG DPS SEP

Expanded, this means; Load flashing verb 06 noun 33 with the quantity 94 hours, 39 minutes and 46 seconds; the time of ignition of the descent engine separation maneuver.

Procedurally, this is done by keying verb 25 enter, loading +00094 in register 1, +00039 in register 2, and +04500 in register 3.

If numeric quantities do not follow the verb-noun, it is indicated that a computed or information quantity is being displayed via the DSKY. If nominal values are listed for possible comparison, they appear in parentheses.

EXAMPLE: F 06 42 HA HP ΔV

Expanded, this means; Flashing verb 06 noun 42 has computed height of apogee in register 1, height of perigee in register 2, and velocity to be gained in register 3.

. TIME - The numbers in the left hand column preceded by a + or - indicate "event timer" time referenced to an event. Minus indicates event timer counting down to a future event. Periodically, this same column contains the nominal mission ground elapsed times (G.E.T.) in parentheses. Asterisks following the event time indicate a time critical event which should be accomplished to the nearest second.

ASSUMPTIONS

- 1 TRANSFER COMPLETE
- 2 SYSTEMS CHECKS COMPLETE
- 3 PGNS ACTIVATED
- 4 AGS ON AND SELF TESTED
- 5 RCS PRESSURIZATION AND TEST FIRING COMPLETE
- 6 RNDZ RDR SELF TEST COMPLETE.
- 7 DAP LOAD (01002)
- 8 IMU ALLIGNED
- 9 LGC IN P88
- 10 V76E (PGNS PULSE)

GUID CNT-AGS
 MODE SEL-LDG RADAR
 RNG/ALT M8N-RNG/RNGRT
 RATE ERR M8N-RNDZ RDR(CDR)
 ATTITUDE M8N-PGNS(CDR)
 RATE ERR M8N-CMPTR(LMP)
 ATTITUDE M8N-AGS(LMP)
 SHFT/TRUN-+50
 X-POINTER-HI MULT
 RADAR TEST SW-OFF
 ENG GMBL-ENABLE
 ENG ARM-OFF
 X-TRANSL-2JETS
 BAL CPL-8N
 DEADBAND-MIN
 ATT CNT-PULSE(3)
 MODE CNT-ATT H8LD
 THR8T/JET-JET
 IMU-8N
 R/R MODE-LGC
 TTCA/TRANSL(CDR)-ENABLE
 ACA/4JET(CDR)-ENABLE
 TTCA/TRANSL(LMP)-ENABLE
 ACA/4JET(LMP)-ENABLE

(92:41)
 WHEN CLEAR OF CSM
 GUID CNT-AGS
 DEFLECT ACA OUT OF DETENT
 ATT CNT-M8DE CNT(3)
 YAW RIGHT 120DEG (RATE CMD)
 FITCH UP 180 DEG (2 DEG/SEC
 (CSM PHOTO OF DPS BELL)
 PITCH DN 90 DEG (2 DEG/SEC)
 (CSM IN FWD WINDOW)

(92:49)
 ATT CNT(YAW)-PULSE
 YAW 360 DEG FOR INSPECTION
 (APPROX 1 DEG/SEC)

GUID CNT-PGNS
 ATT CNT(YAW)-MODE CNT
 KEY V77E (WHEN YAW=0)
 GUID CNT-AGS

-7
 LM ACTIVE STA KEEP UNTIL
 AFTER CSM RCS SEP.
 GUID CNT-PGNS

F 06 54 R,RD8T,THETA
 *304R THETA
 SET 8RDEAL
 PR8
 DSKY BLANKS

***** MINI-F88TBALL *****

F 06 84 KEY V84E (TGT AV)
 0AVX 0AVY +0005.0AVZ
 PR8

F 06 33 93:05:45 TIG RCS SEPARATION

100 (23:00) OBSERVE CSM DETAIL...
 TGT AV'S CONFIRMED BY CSM
 PR0 (TGT AV IN CSM SV)
 KEY V80E
 KEY V76E (PGNS PULSE)
 B0RESIGHT 0N CSM WITH C0AS.

(93:07) KEY V47E (AGS UPDATE)
 F 06 16 GET 0F AGS 0 TIME
 *414+1 UPDATE AGS
 PR0
 *414R (00000 COMPLETE)
 F 50 16 D0WNLINK COMPLETE
 PR0
 (WAIT 32 SECONDS)
 *400+3 AGS ALIGN
 DSKY BLANKS

-57 KEY V63E
 (PGNS M0DE 2 ERR NEEDLES)
 CB AC BUS A RNDZ RDR-CLOSE
 (WAIT 30 SECONDS)
 CB PGNS RNDZ RDR-CLOSE

(93:08) R/R CHECK0UT
 B0RESIGHT 0N CSM WITH C0AS.
 TEST M0NIT0R RNDZ RDR-AGC
 SHFT/TRUN-+5
 R/R M0DE-LGC
 *507+0
 *400+2 RADAR ACQUISITION
 KEY V41N72E (R/R DESIGNATE)
 F 21 73 +0000TRUN +0000CSHFT

AS-504/CSM-104/LM-3
 3.
 PREPARED BY FPRB/CF24

16 72 M0NIT0R SHFT/TRUN ANGLES
 (+0000TRUN +0000SHFT)
 VERIFY DSKY WITH FDAI
 KEY REL

-49 KEY V83E
 VERIFY R/R L0CK0N G80D
 F 06 54 READ R,RD0T,THETA
 PR0

KEY V62E
 F 04 06 00004 00001
 PR0

F 16 72 +XXX,XX +XXX,XX
 PR0

F 16 78 XXXXX.XR XXXXX.XRD0T
 VERIFY TAPE METER WITH DSKY
 KEY V34E (TERMINATE)

(MANUALLY BREAK L0CK)
 R/R M0DE-SLEW
 SLEW RATE SW=L0
 (SLEW D0W0N 30 DEG.)
 R/R M0DE-LGC

KEY V41N72E (R/R DESIGNATE)
 F 21 73 +000.00TRUN -077.00SHFT
 F 04 06 00006 00002
 PR0

41 (C0ARSE ALIGN VERB)
 KEY V16N72E

16 72 M0NIT0R SHFT/TRUN ANGLES
 (000.00TRUN +283.00SHFT)
 VERIFY DSKY WITH FDAI

4.
 1/31/69

CB AC BUS A RNDZ RDR-0PEN

***** PHASING *****

(93:15) KEY V44E
KEY V37E30E (EXT AV)
F 06 33 93:50:04 TIG DPS PHASING
PR8
F 06 82 0AVX 0AVY -0085.CAVZ
PR8
F 06 42 HA HP AV
PR8
F 16 45 0 TFI MGA

-36 SET ET TO DPS PHASING
PR8
F 37 88

(93:18) KEY 52E (ALIGN)
F 04 06 00001 00003 (REFSMAT)
PR8
F 50 25 00015 SELECT STAR 1
CB AOT LAMP-CLOSED
ENTR

-34 F 01 70 002DE LOAD STAR 1
PR8
F 50 18 FDAI ANGLES (R60)
M8DE C8NT-AUT8
PR8 (AUT8 MAN)
06 18
F 50 19 FDAI ANGLES TRIM MANEUVER
PR8 (TRIM NOT REGD)
F 01 71 002DE
PR8

5.

AS-504/CSM-104/LM-3

PREPARED BY FPR8/CF24

F 54 71 MANEUVER WITH RCS PULSES
AND MARK 1ST STAR
PR8

F 01 70 002DE LOAD 2ND STAR
PR8

F 50 18 FDAI ANGLES
M8DE C8NT-AUT8
PR8 (AUT8 MAN)

06 18
F 50 19 FDAI ANGLES TRIM MANEUVER
PR8 (TRIM NOT REGD)

-27 F 01 71 002DE
PR8

M8DE C8NT-ATT HOLD
MANEUVER WITH PGNS PULSES
AND MARK 2ND STAR
PR8 (MARKS COMPLETE)

F 54 71

F 06 05 ANGLE DIFFERENCE
PR8

F 06 93 GYRO TORQUE ANGLES (XX.XXX)
PR8

BEYOND THIS POINT
ACCOMPLISH CBAS CALIBRAT-
ION TO THE EXTENT POSSIBLE
BY TIG MINUS 14.

F 50 25 GC014
PR8 (CBAS CALIBRATION)
F 50 25 00015 SELECT STAR 1
ENTR

6.

1/31/69

PRB
 F 50 18 FDAI ANGLES (R60)
 M8DE C8NT-AUT8
 PR8 (AUT8 MANEUVER)
 06 18
 F 50 19 FDAI ANGLES TRIM MANEUVER
 PR8 (TRIM N8T REGD)
 -18 F 01 71 00SDE
 8BSERVE STAR IN C8AS, WHEN
 ATTITUDE ERRORS ARE ZERO
 MARK AZ-EL ANGLE 8N C8AS
 DIAGRAM.
 PR8
 F 06 87 AZ-EL CALIB ANGLES
 PR8
 KEY V34E (TERMINATE)
 -14 CB A8T LAMP-8PEN
 KEY V37E88E
 KEY V47E (AGS UPDATE)
 F 06 16 GET 8F AGS 0 TIME
 *+14+1 UPDATE AGS
 PR8
 *+14R (00000 COMPLETE)
 F 50 16 D8WNLINK COMPLETE
 PR8
 (WAIT 32 SECONDS)
 *+00+3 AGS ALIGN
 *+11+0 DPS ENG SELECT
 *+00+1 GUIDANCE STEERING
 (93:36) CB AC BUS A RNDZ RDR-CL8SE
 (WAIT 30 SECONDS)

F 04 00 00000 00000
 PR8
 F 06 18 FDAI ANGLES
 PR8
 F 50 18 FDAI ANGLES
 PR8
 06 18 FDAI ANGLES
 F 50 19 FDAI ANGLES TRIM MANEUVER
 PR8
 CB PGNS LR-CL8SE
 R/R M8DE-SLEW
 N8 TRK LT-8N
 KEY V76E (PGNS PULSE)
 M8DE C8NT-ATT H8LD
 88RESIGHT 8N CSM WITH C8AS.
 (PGNS PULSE M8DE)
 SLEW RADAR NEEDLES T8 (0.0)
 MAX SIGNAL STRENGTH.
 R/R M8DE-AUT8 TRACK
 N8 TRK LT-8UT
 RATE ERR M8N-LDG RDR/CMPTR
 (93:46)
 KEY V37E40E (DPS THRUSTING)
 F 50 18 FDAI ANGLES
 M8DE C8NT-ATT H8LD
 ENTR (MANUAL MANEUVER)
 F 50 19 FDAI ANGLES TRIM MANEUVER
 PR8
 KEY V06N86E (AV'S LV)
 L8AD AGS EXT AV
 *+10+5 EXT AV
 *+50+00001AVX +51+0AVY
 *+52+00085AVZ L8AD
 88LUTION IN AGS.

-7

-3

7.

8.

COMPLETE.
KEY RELEASE
KEY V78E (LR SPUR TEST)

THR0T/JETS(CDR)-THR0T
THR0T(CDR)-SET MIN THRUST
ENG GMBL-0FF
THR C0NT SW-MAN
MAN THR0T-CDR
X-TRANSL-2JETS
ENG ARM-DES
ATT C0NT-PULSE(3)
M0DE C0NT-AUT0
GUID C0NT-AGS

KEY V77E (ATT H0LD)
PR0 (RYPASS TRIM)
F 50 25 00203 (AUT0 THR0 REQUEST)
ENTR (AUT0 N0T DESIRED)
06 40 TFI VG AVM
*500R00085. AVX

-2 DEADBAND-MIN (C0NFIRM)
(WHEN ERR0RS ARE 0.)
TRIM AGS ERR0RS T0 0.
ATT C0NT-M0DE C0NT(3)
-:35 DSKY BLANKS

START ET COUNTING UP AT 0
-:08 C0MMAND +X TRANSLATION
WITH TTCA.
REQUEST ENG 0N
ENG GMBL-ENABLE
F 99 40

0(93:50:04) A00RT-DEPRESS (ENG 0N)
ENTR (BYPASS PGNS ENG 0N)
F 16 40 TFC VG AVM
M0NIT0R THRUST INDICAT0R

9.

AS-504/CSM-104/LM-3

PREPARED BY FPRB/CF24

10.

1/31/69

(AFTER 15 SEC ENG 0N)

CAUTION: BE PREPARED TO DEPRESS ENG
STOP IN EVENT LATE CUTOFF.

M0DE C0NT-ATT H0LD
A00RT-RESET
ENG ARM-0FF
PR0

F 16 85 AV'S-00DY
NULL AV'S WITH RCS
*500R 501R 502R (C0PY)
GUID C0NT-PGNS
KEY V76E
RATE ERR M0N-RNDZ RADAR
PR0

F 37 8B
KEY V79E (TERMINATE SPUR)
KEY 00E

CB PGNS LR-0PEN

***** TPIO TPIO TPIO *****

IF PGNS FAILURE 0CCURS
BETWEEN 93:50 AND 94:45,
SEE APPENDIX 1 FOR A00RT

R/R M0DE- LGC
KEY V95E (N0 UPDATE)
KEY V37E20E (R>19,000FT)
F 50 18 FDAI ANGLES
ENTR (MANUAL MANEUVER)

KEY V80E (UPDATE LM SV)

F 05 09 00525 (P8SSIRLE ALARM)
PR8
F 06 05 ATHETA B B(AFTER ALARM)
PR8 (ACCEPT ANGLE DATA)

(93:58) KEY V37E34E (TPIC)
F 06 37 95:00:00 TIG 0F TPI0
PR8
F 06 55 B +027.50 +130.0C
PR8
F 16 45 MKS TFI =00001

(94:03) WHEN MARKS = 5, RECYCLE.
+15(APPR0X) KEY V32E RECYCLE
F 06 37 TIG 9F TPI
F 06 58 HP AVTPI AVTPF (COPY)
PR8

+18 MARKS RESUME
F 06 59 AV'S-L0S (COPY)
PR8
F 16 45 MKS TFI -00001

+19 *10+3 TPI SEARCH
*311-032.50 AT TRANS
*313+050.00 AT TPI
*410+4 (WHEN TFI = 50.00)
*303R THETA AT TPI(027.50)
*267R AV TPI (COMPARE PGNS)
*371R AV TOTAL
PR8 (FINAL CO P CYCLE)
F 06 37 TIG 0F TPI

+26 TRANSMIT TIG 0F TPI TO CSM
FOR LOADING IN P34.

11.

AS-504/CSM-104/LM-3

PREPARED BY FPRB/CF24

F 06 81 AV'S-LV (COPY)
PR8
F 06 59 AV'S-L0S (COPY)
PR8
F 16 45 MKS TFI MGA

SET ET COUNTING DOWN
PR8
F 37 88

SET W-MATRIX TO 1 MR.
KEY V24N01E
KEY 2002E
KEY 1014E
KEY 1014E
KEY V04NC1E
KEY 2002E
VERIFY R1, R2=01014

KEY V37E00E (P00)
KEY V62E
PR8

F 04 06 00004 00001

F 16 72 +XXX.XX +XXX.XX
PR8

F 16 78 XXXXX.XR XXXXX.XRD0T
VERIFY TAPE METER WITH DSKY
KEY V37E00E
DSKY BLANKS

(94:16) PERFORM LR SELF TEST

CB PGNS LR=CL0SE
RNG/ALT M0N=ALT/ALT RT

12.

1/31/69

RADAR TEST SW-000
 LDG ANT SW-DES
 X-POINTERS (READ)
 .VZA =+200FPS(PEGGED UP)
 .VYA =+200FPS(PEGGED RT)
 ALT/ALT RATE METER (READ)
 .ALT =8263FT (N8M)
 LDG ANT SW-HOVER
 ALT/ALT RATE METER (READ)
 .ALT =7981FT
 .ALT RT =+49FPS
 SET RADAR TEST MONITOR T8:
 .ALT XMTR =3.5V
 .VEL XMTR =3.78V

KEY V62E
 F 04 06 00004 00002
 PR8
 F 16 66 08280FT ANT P8S(C0001)
 F 16 67 VXA=-00247, VYA=+00929,
 VZA=+00665FPS
 KEY V37E00E

LDG ANT SW-AUTO
 KEY V61E
 (WAIT 24 SECONDS)

KEY V62E
 F 04 06 00004 00002
 PR8
 F 16 66 08280FT ANT P8S(C0002)
 KEY V37E00E
 LDG ANT SW-DES
 (WAIT 10 SECONDS)
 LDG ANT SW-AUTO
 RADAR TEST SW-0FF

(94:25)

CB PGNS LR-0PEN

13.

AS-50*/CSM-10*/LM-3

PREPARED BY FPR8/CF24

KEY V37E20E
 F 50 18 FDAI ANGLES
 ENTR (MANDAL MANEUVER)
 F 50 19 FDAI ANGLES TRIM MANEUVER
 PR8 (TRIM N8T REQUIRED)
 DSKY BLANKS
 VERIFY R/R LOCKON G88D

(94:28)
 KEY V37E34E (TPIO FINAL)
 F 06 37 95:00:00 TIG 8F TPI8
 PR8
 F 06 55 B +027.50 E +130.00
 PR8
 F 16 45 MKS TFI -00001
 KEY V76E (PGNS PULSE)
 M8DE CNT-ATT H8LD

RECEIVE G8 FR8M GROUND

WH'N MARKS = 4, RECYCLE.
 KEY V93E (REINIT W MATRIX)
 KEY V32E RECYCLE
 F 06 37 TIG 8F TPI (C8PY)
 PR8

F 06 58 HP ΔVTPI ΔVTPF (C8PY)
 PR8
 F 06 59 ΔV'S-L8S (C8PY)
 PR8
 F 16 45 MKS TFI -00001

-26 SET ET COUNTING DOWN

WHEN MARKS = 6, RECYCLE.
 -20(APPR8X) KEY V32E RECYCLE
 F 06 37 TIG 8F TPI (C8PY)
 PR8
 F 06 58 HP ΔVTPI ΔVTPF (C8PY)
 PR8
 F 06 59 ΔV'S-L8S (C8PY)

14.

1/31/69

*410+3 TPI SEARCH ROUTINE
*311+032.50 AT TRANS
*313+016.00 TFI TPI
*410+4 (WHEN ET=-16)
*303R THETA AT TPI
*267R AV TPI (COMPARE PGNS)
*371R AV TOTAL
COPY GND TPI SOLUTION

-16

PR0 (FINAL COMP CYCLE)
TIG TPI
TRANSMIT TIG OF TPI TO CSM
FOR LOADING IN P34.

-14

PR0
F 06 58 HP AVTPI AVTPF
PR0
F 06 81 AV'S-LV

PR0
F 06 59 AV'S-L0S
PR0

F 16 45 MKS TFI MGA

-10 RESET ET (IF REOD)

PR0
F 37 88

(94:51) KEY 00E (P00)
ON BOARD G0,N0 G0
KEY V47E (AGS UPDATE)
F 06 16 GET OF AGS 0 TIME
*414+1 UPDATE AGS
PR0

15.

AS-504/CSM-104/LM-3

PREPARED BY FPRB/CF24

*400+3 AGS ALIGN

IF ABORTING FOR A RADAR OR
A NBN G+N FAILURE,
SEE APPENDIX 2 FOR ABORT

-9 KEY V41N72E (R/R DESIGNATE)
F 21 73 +000.00TRUN -077.00SHFT
F 04 06 00006 00002 CONTINJ0US
PR0

41 (CBARSE ALIGN VERB)
KEY V16N72E
16 72 MONITOR SHFT/TRUN ANGLES
(000.00TRUN +283.00SHFT)

CB PGNS RNDZ RDR=0PEN
CB AC BUS A RNDZ RDR=0PEN

(94:52) KEY V44E
F 04 06 00001 00003 (REFSMAT)
PR0
F 50 25 00015 SELECT STAR 1
CB A8T LAMP-CLOSED
ENTR

-7 F 01 70 002DE LOAD STAR 1
PR0
F 50 18 F0AI ANGLES
MODE CONT-AUTO

16.

1/31/69


```

PR0 (AUTO MANEUVER)
06 18 FDAI ANGLES TRIM MANEUVER
F 50 19 PR0 (TRIM NOT REGD)

F 01 71 002DE
(94:56) PR0
M0DE C0NT-ATT H0LD
MANEUVER WITH RCS PULSES
AND MARK 1ST STAR
F 54 71 PR0

-2 F 01 70 002DE LOAD 2ND STAR
PR0
F 50 18 FDAI ANGLES
M0DE C0NT-AUT0
PR0 (AUTO MANEUVER)

06 18 FDAI ANGLES TRIM MANEUVER
F 50 19 PR0 (TRIM NOT REGD)

F 01 71 002DE
PR0
M0DE C0NT-ATT H0LD
MANEUVER WITH PGNS PULSES
AND MARK 2ND STAR
F 54 71 PR0

F 06 05 ANGLE DIFFERENCE
PR0
F 06 93 GYRO TORQUE ANGLES
PR0

-57 F 50 25 00014

```

```

*****
IF TIME PERMITS CHECK
ALIGNMENT WITH THIRD STAR
*****

```

17.

AS-504/CSM-104/LM-3

PREPARED BY FPRB/CF24

18.

1/31/69

```

ENTR (NO CHECK)
CB ABT LAMP-OPEN
F 37 BB

```

```

KEY V47E (AGS UPDATE)
F 06 16 GET 0F AGS 0 TIME
*414+1 UPDATE AGS
PR0
*414R (00000 COMPLETE)
F 50 16 DOWNLINK COMPLETE
PR0
(WAIT 32 SECONDS)
*400+3 AGS ALIGN

```

***** INSERTION *****

```

CB AC BUS A RNDZ RDR-CLOSE
(WAIT 30 SECONDS)
CB PGNS RNDZ RDR-CLOSE

```

```

(95:09) KEY V95E (NO UPDATE)
F 50 18 KEY V37E20E (ACQUIRE RADAR)
M0DE C0NT-AUT0
PR0 (AUTO MANEUVER)

```

```

06 18 FDAI ANGLES TRIM MANEUVER
F 50 19 PR0 (TRIM NOT REQUIRED)
M0DE C0NT-ATT H0LD
DSKY BLANKS
VERIFY R/R LOCKON G00D
KEY V80E (UPDATE LM SV)

```

```

(95:20) MONITOR RANGE ON TAPE METER
WHEN RANGE < 19,000FT
KEY V95E INHIBIT SV UPDATE

```

F 06 33 KEY V37E30E (EXT AV)
95:41:48 TIG INSERTION
PR0
F 06 82 +0039.9AVX 0AVY CAVZ
PR0
F 06 42 HA HP AV
PR0
F 16 45 MKS TFI MGA

-18 RESET ET COUNTING DOWN
WHEN MARKS = 6, PROCEED.
PR0
-12 F 37 88

-8 KEY 00E (P00)
KEY V47E (AGS UPDATE)
F 06 16 GET 9F AGS 0 TIME
+14+1 UPDATE AGS
PR0
+14R (00000 COMPLETE)
F 50 16 DOWNLINK COMPLETE
PR0
(WAIT 32 SECONDS)
+00+3 AGS ALIGN
+11R 00000 (CONFIRM)
+00+1 GUIDANCE STEERING

-7 CB PGNS LR-CLOSE

(95:35) KEY V77E (ATT HOLD)
KEY V37E40E
MODE CONT-AUTO

19.

AS-50*/CSM-10*/LM-3

PREPARED BY FPRB/CF24

KEY VUON06E (AV'S LV)
L8AD AGS EXT AV
+10+5 EXT AV
+450+000+0AVX +51+0AVY
+452+0AVZ

SOLUTION IN AGS.
KEY RELEASE
KEY V78E (LR SPUR TEST)

THR0T/JETS(CDR)-THR0T
THR0T(CDR)-SET MIN THRUST
THR CONT SW-MAN
MAN THR0T-CDR
X-TRANSL-2JETS
ENG ARM-DES

-4 F 50 19 FDAI ANGLES TRIM MANEUVER
PR0 (TRIM NOT REQD)
+07+0 WHEN MANEUVER IS
COMPLETE.

F 50 25 00203 (AUTO THR0T REQUEST)
ENTR (AUTO NOT DESIRED)
-3 06 40 TFI VG AVM
+COMPARE AGS ATT ERRORS
+500R+00040. AVX
-:35 DSKY BLANKS

-:8 MONITOR ULLAGE
F 99 40 REQUEST ENG 0N
ENG GMBL-ENABLE
0(95:41:48) PR0 F0R ENG 0N ENABLE
06 40 TFC VG AVM
MONITOR THRUST INDICATOR

CAUTION: BE PREPARED TO DEPRESS ENG
STOP IN EVENT LATE CUTOFF.

20.

1/31/69

F 16 40 TFC VG ΔVM
ENG ARM=OFF
PRB

F 16 85 ΔV'S-BODY
NULL ΔV'S WITH RCS
THRBT/JETS(CDR)-JETS
KEY V79E (TERMINATE SPUR)
PRB

F 37 BB

CB PGNS LR-OPEN

***** CSI CSI CSI *****

IF PGNS FAILURE OCCURS
BEYOND THIS POINT,
SEE APPENDIX 3 FOR ABORT

IF A RADAR FAILURE OCCURS,
LM TARGETS CSI AND CDH
WITH P30 AND EXECUTES
BURNS AS PER NOMINAL PRB-
CEDURES, CSM IS ACTIVE
FOR TPI AND TPF.

KEY V95E (NO UPDATE)
KEY V37E20E

F 50 18 FDAI ANGLES
MODE CONT-AUTO
PRB (AUTO MANEUVER)

06 18

F 50 19 FDAI ANGLES TRIM MANEUVER

21.

AS-50Δ/CSM-10Δ/LM-3

PREPARED BY FPRB/CF2Δ

DSKY BLANKS
VERIFY R/R LOCKON G88D
KEY V80E (UPDATE LM SV)

(95:51) KEY V37E32E

F 06 30 96:22:00 TIG 0F CSI
PRB

F 06 55 Δ00001 N Δ027.50 E
PRB

F 06 37 98:02:21 TIG 0F TPI
(WITH 3 MIN TIME BIAS)
PRB

F 16 45 MKS TFI -00001

-34 SET ET COUNTING DOWN

KEY V76E (PGNS PULSE)
MODE CONT-ATT HOLD

-30* COPY RD8T FROM TAPE METER
FOR BU'S

WHEN MARKS = Δ, RECYCLE.
KEY V93E (REINIT W MATRIX)

F 06 50 ΔH ΔT-CSI/CDH ΔT-CDH/TPI
PRB

F 06 81 ΔV'S-LV(CSI) (COPY)
PRB

F 06 82 ΔV'S-LV(CDH) (COPY)
PRB

F 16 45 MKS TFI Δ00001

NOTE: MANUAL ITERATION FOR FINDING
THE PROPER APSIDAL XING MAY BE REQD

WHEN MARKS = Δ, RECYCLE.

22.

1/31/69

PRB
 F 06 82 ΔV'S-LV(CDH) (COMPARE)
 PRB
 F 16 45 MKS TFI -00001

 WHEN RANGE IS > 50.8 N.M.
 KEY V37E00E (P00)
 KEY V62E
 F 04 06 00004 00001
 PRB
 F 16 72 +XXX.XX +XXX.XX
 PRB
 F 16 78 XXXXX.XR XXXX.XRD8T
 VERIFY TAPE METER WITH DSKY
 KEY V37E00E

 KEY V37E20E
 F 50 18 FDAI ANGLES
 MADE CNT-AUT8
 PRB (AUTO MANEUVER)
 06 18
 F 50 19 FDAI ANGLES TRIM MANEUVER
 PRB (TRIM N8T REQIRED)
 DSKY BLANKS
 VERIFY R/R LACK8N GR8D

 KEY V37E32E
 F 06 30 96:22:00 TIG 8F CSI
 PRB
 F 06 55 FIRST APSIDAL XING.
 +00001 N +027.50 E
 PRB
 F 06 37 98:02:21 TIG 8F TPI
 (WITH 3 MIN TIME BIAS)
 PRB
 F 16 45 MKS TFI -00001

(96:04)
 *2/D+J8C0U AGS CSI TIME
 *277+479.3 AGS TPI TIME
 *605+10250 TPI ANGLE CODE
 *416+0 1ST APSIDAL
 *417+1
 *410+1 CSI ROUTINE
 *457R CHECK < 2FPS
 *463R ALT RATE (COPY)
 *313R TFI CSI
 COMPARE 313 WITH E.T.
 *456R ΔVCSI COPY
 *371R ΔVCDH COPY
 *276R ABS TIME CDH(0426.5)
 *411+0 RCS ENGINE
 *450R ΔVX 452R ΔVZ

 KEY V48E (DAP LOAD)
 F 01 46 DAP CONFIGURATION (02002)
 PRB
 F 06 47 LM WT CSM WT
 KEY V34E (TERMINATE)
 F 16 45 MKS TFI -00001

 PRB (FINAL COMP CYCLE)
 -14 F 06 50 ΔH ΔT-CSI/CDH ΔT-CDH/TPI
 PRB
 F 06 81 ΔV'S-LV(CSI) (COPY)
 PRB
 KEY V90E
 -12 F 06 16 LOAD CSI TIME
 PRB
 F 06 90 Y,YD8T,PSI
 (COPY YD8T AT CSI)
 PRB

-10* 2 FPS, LOAD -YD8T IN R2.
COPY RANGE AND R88T FROM
TAPEMETER FOR BU'S

PR8
F 06 82 ΔV'S-LV(CDH) (COPY)
PR8
F 16 45 MKS TFI MGA
PR8
F 37 BB
KEY 00E (POO)

-8 PERFORM PRESTAGE CHECKS.
COMPARE AGS AND PGNS
C88RD SOLUTION WITH GND
TRANSMIT TGT ΔV'S TO CSM
AND SYNC COUNTDOWN.

(96:15) KEY V47E (AGS UPDATE)
F 06 16 GET 8F AGS 0.
*414+1 UPDATE AGS SV
PR8
F 50 16 DOWNLINK COMPLETE
PR8
(WAIT 32 SECONDS)
*400+3 AGS ALIGN
*400+1 GUIDANCE STEERING

-6 KEY V77E (ATT HOLD)
KEY V37E41E
F 50 18 FDAI ANGLES
M8DE C88NT-AUT8
PR8 (AUT8 MANEUVER)
06 18

-5 KEY V06N86E (ΔV'S LV)
LOAD AGS EXT ΔV

25.

AS-50*/CSM-10*/LM-3

PREPARED BY FPR8/CF24

*450, 451, 452-LOAD THE
COMPONENTS OF SOLUTION
TO BE EXECUTED.
KEY RELEASE

-3 F 50 19 BYPASS TRIM
PR8 (TRIM NOT REGD)
*407+0 WHEN MANEUVER IS
COMPLETE.
ED: MASTER ARM-8N
THR8T/JET(CDR)-JET
X-TRANSL-4JETS

-2 16 85 ΔV'S-88DY
*COMPARE AGS ATT ERR8RS
*500R ΔVX (COMPARE)
-:35 DSKY BLANKS

F 16 85

-0 STAGE SW-FIRE
ED: MASTER ARM SW-8FF

(96:22:00) NOMINAL (37-8ΔVX)
BURN +X WITH TTCA

ASC FEED 2-8PEN (SYS A-B)
CHECK ASC FUEL AND 8XID
FLAGS 8PEN. (SYS A-B)
MAIN 88V (SYS A AND B)-CL8S
MAIN 88V (SYS A AND B)-8PEN
(BEFORE THRUST TERMINATION)
ASC FEED 2-CLOSE (SYS A-B)
(BEFORE THRUST TERMINATION)
NULL REMAINING ΔV'S
*500RΔVX 501RAVY 502RΔVZ
PR8

F 37 88

26.

1/31/69

```

(96:26) KEY V37E20E
F 50 18 FDAI ANGLES
MODE CONT-AUTO
PR8 (AUTO MANEUVER)

06 18
F 50 19 FDAI ANGLES TRIM MANEUVER
PR8 (TRIM NOT REQUIRED)
DSKY BLANKS
VERIFY R/R LOCKON G89D
KEY V80E (UPDATE LM SV)

(96:29) KEY V76E (PGNS PULSE)
MODE CONT-ATT HOLD

-54 F 06 31 TIG 9F CDH (97:06:28)
KEY V25E
(ADD 1 MIN 45 SEC BIAS)
PR8
F 16 45 MKS TFI -00001

-37 SET ET TO TFI CDH

(96:30) WHEN MARKS = 4, RECYCLE.
KEY V93E (REINIT W MATRIX)
KEY V32E RECYCLE
-35 (APPROX) F 06 50 AHCDH ATCDH/TPI ATTP1/TPI
PR8
F 06 81 AVCDH-LV (COPY)
PR8
F 16 45 MKS TFI -00001
*10+2 CDH ROUTINE
*276+ABS TIG CDH (426.5)
(PG'S COMPUTED TIG CDH)
*267R AV CDH (COPY)

(96:26) FOR BU'S
COPY RD8T FROM TAPE METER
FOR BU'S

-18*
-14 PR8 (FINAL COMP CYCLE)
F 06 50 AHCDH ATCDH/TPI ATTP1/TPI
PR8
F 06 81 AV'S-LV (COPY)

-12 KEY V90E
LOAD CDH TIME
PR8
F 06 16
F 06 90 Y,YD8T,PSI
(COPY Y AND YD8T AT CDH)
PR8
F 16 45 MKS TFI -00001
IF YD8T FROM V90 WAS > THAN
2 FPS, LOAD -YD8T IN R2.

PR8
F 16 45 MKS TFI MGA
PR8
F 37 88 KEY 00E (POO)

C88RD SOLUTION WITH GND
TRANSMIT TGT AV'S TO CSM
AND SYNC COUNTDOWN.

(96:57) KEY V47E (AGS UPDATE)
F 06 16 GET 8F AGS 0
*14+1 UPDATE AGS
PR8
*14R (00000 COMPLETE)

```

27.

28.

AS=504/CSM=104/LM=3

PREPARED BY FPRB/CF24

1/31/69

F 50 16 URMNLINK COMPLETE
PR8

(WAIT 32 SECONDS)
*400+3 AGS ALIGN
*400+1 GUIDANCE STEERING
*411+1 APS THRUST

KEY V83E (R, RD8T, THETA)
SET 8RDEAL
PR8

7 COPY RD8T FR8M TAPE METER
FR8 BU'S

(97:01) KEY V77E (ATT HOLD)
KEY V37E42E (APS THRUSTING)
F 50 18 FDAI ANGLES
MODE C8NT-AUT8
PR8 (AUTO MANEUVER)
06 18

4 KEY V06N86E (AV'S LV)
LOAD AGS EXT AV
*410+5 EXT AV
*45C, 451, 452-LOAD THE
COMPONENTS OF SOLUTION
T9 BE EXECUTED.
KEY RELEASE

*3 F 50 19 FDAI ANGLES TRIM MANEUVER
PR8 (TRIM NOT REQD)
*407+0 WHEN MANEUVER IS
COMPLETE.
*COMPARE AGS ATT ERR8FS
*500R AVX (COMPARE)

06 40 TFI VG AVX
*35 DSKY BLANKS

*:05 F 99 40 REQUEST ENG 8N
ENG ARM-ASC

29.

AS-504/CSM-104/LM-3

PREPARED BY FPR8/CF24

0(97:06:28) NOMINAL (37.9AVX)
PR8 (F8R ENG 8N)
06 40 TFC VG AVX
F 16 40 TFC VG AVX
ENG ARM-8FF

F 16 85 PR8
NULL REMAINING AV'S
*500R4VX 501R4VY 502R4VZ
PR8

F 37 88

***** TPI TPI *****

IF A RADAR FAILURE HAS
OCCURRED, MAINTAIN Z-AXIS
POINTING AT CSM WITH A
PULSE MODE, COMPUTE A
NORMAL TO LOS SOLUTION AT
TPI AND MIDCOURSES WITH
BACK-UP CHARTS.

*56 KEY V95E (NO UPDATE)

KEY V37E20E
F 50 18 FDAI ANGLES
MODE C8NT-AUT8
PR8 (AUTO MANEUVER)

06 18
F 50 19 FDAI ANGLES TRIM MANEUVER
PR8 (TRIM NOT REQUIRED)
DSKY BLANKS

VERIFY R/R LOCK8N G88D
KEY V80E (UPDATE LM SV)

30.

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F 06 55 B +027.50 E +130.00
PRB
F 16 45 MKS TFI -00001

KEY V76E (PGNS PULSE)
MODE CNT-ATT HOLD

(97:18) WHEN MARKS = 4, RECYCLE.
KEY V93E (REINIT W MATRIX)
KEY V32E RECYCLE
-42 (APPROX) F 06 37 TIG 9F TPI (COPY)
PRB

F 06 58 HP ΔVTPI ΔVTPF (COPY)
PRB

F 06 55 ΔV'S-L9S (COPY)
PRB

F 16 45 MKS TFI -00001

-38 SET ET COUNTING DOWN

-37 +415+1 316+R

-34 +415+1 316+R

-33 (APPROX) WHEN MARKS = 6, RECYCLE.
KEY V32E RECYCLE
F 06 37 TIG 9F TPI (COPY)
PRB

F 06 58 HP ΔVTPI ΔVTPF (COPY)
PRB

F 06 59 ΔV'S-L9S (COPY)
PRB

F 16 45 MKS TFI -00001

+40+0 405+0 406+0
+41+1 RCS THRUST
+415+1 316+R

-32

31.

AS-50*/CSM-10*/LM-3

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BOOK INDICATED
+415+1 316+R
+267R ΔV TPI (COMPARE PGNS)
+371R ΔV TOTAL

COPY GND TPI SOLUTION

WHEN MARKS = 12, RECYCLE.

KEY V32E (RECYCLE)

-27 (APPROX) F 06 37 TIG 9F TPI (COPY)
PRB

F 06 58 HP ΔVTPI ΔVTPF (COPY)
PRB

F 06 59 ΔV'S-L9S (COPY)
PRB

F 16 45 MKS TFI -00001

-26 +415+1 316+R

-23 +415+1 316+R

-20 +415+1 316+R

-17 +415+1 316+R 503-RD8T

+313+016.00 TFI TPI

-16 +410+4 (WHEN ET = -16)

+303R THETA AT TPI (COPY)

+267R ΔV TPI (COMPARE PGNS)

+371R ΔV TOTAL (COPY)

-14 PRB (FINAL COMP CYCLE)

-11 F 06 37 TIG TPI

TRANSMIT TIG 9F TPI TO CSM

FOR LOADING IN P34.

PRB

F 06 58 HP ΔVTPI ΔVTPF (COPY)
PRB

F 06 81 ΔV'S-LV (COPY)
PRB


```

-3 KEY V06N86E (ΔV'S LV)
LOAD AGS EXT ΔV
*410+5 EXT ΔV
*450, 451, 452=LOAD
COMPONENTS OF SOLUTION
TO BE EXECUTED.
KEY RELEASE

-2 F 50 19 FDAI ANGLES TRIM MANEUVER
PR0 (TRIM NOT RECD)
*407+0 WHEN MANEUVER IS
COMPLETE.
16 85 ΔV'S=BODY
*500R ΔVX (COMPARE)
*35 DSKY BLANKS

F 16 85 ΔV'S=BODY
NOMINAL (21.8ΔVX)
*0(97:59:21) BURN +Z WITH TTCA
+0:00 SET ET COUNTING UP

NULL REMAINING ΔV'S
*500RΔVX 501RΔVY 502RΔVZ
PR0
F 37 88 KEY 00E (P00)
KEY V93E
(REINITIALIZE W MATRIX)

***** 1ST MC CORRECTION *****

KEY V37E20E
F 50 18 FDAI ANGLES
ENTR (MANUAL MANEUVER)
F 50 19 FDAI ANGLES TRIM MANEUVER
PR0 (TRIM NOT REQUIRED)
34.
1/31/69

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-9 PR0
F 16 45 MKS TFI MGA
RESET ET (IF RECD)
PR0
F 37 88 KEY 00E (P00)

(97:50) KEY V47E (AGS UPDATE)
F 06 16 GET 9F AGS 0 TIME
*414+1 UPDATE AGS
PR0
*414R (00000 COMPLETE)
F 50 16 D8WNLINK COMPLETE
PR0
(WAIT 32 SECONDS)
*400+3 AGS ALIGN
*304R COPY TGT LOS ANGLE
COPY CSM SOLUTION FOR TPI
COMPARE ONBOARD SOLUTIONS
TRANSMIT TO CSM AND GND
SOLUTION TO BE BURNED
SYNC COUNTDOWN WITH CSM

-8* *304R COPY TGT LOS ANGLE
COPY CSM SOLUTION FOR TPI
COMPARE ONBOARD SOLUTIONS
TRANSMIT TO CSM AND GND
SOLUTION TO BE BURNED
SYNC COUNTDOWN WITH CSM

-5* *304R COPY TGT LOS ANGLE
COPY R, RD0T FROM TAPE METER
FOR BU'S.
(97:55) CALCULATE BU SOLUTION
KEY V77E
KEY 41E
F 50 18 FDAI ANGLES
MODE CNT=ATT HOLD
ENTR (MANUAL MANEUVER)
33.
AS-504/CSM-104/LM-3
PREPARED BY FPRB/CF24

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(98:04)

KEY V37E35E

F 16 45 MKS TFI -00001

+11 F 16 45 MKS TFI -00001

KEY 35E
WHEN MARKS = 1, KEY V93E.
(REINITIALIZE W MATRIX)

+5* *304R C8PY TGT L8S ANGLE

+7 *404+0 405+0 406+C
PR8 (COMP MC FOR TPI +10)

F 06 81 4V'S-LV (C8PY)
PR8

+17* *304R C8PY TGT L8S ANGLE

F 06 59 4V'S-L8S

*404+0 405+0 406+0

+8* *304R C8PY THETA,R,RD8T

+19 PR8 (COMP MC FOR TPI +22)
F 06 81 4V'S-LV (C8PY)
PR8

(98:09) COMPUTE BU MC CORRECTION

PR8

F 16 45 MKS TFI MGA

PR8

F 37 8B

IF 1ST MC SMALL, SKIP
P41 AND RECALL P35.

+20* *304R C8PY THETA,R,RD8T

(98:20) COMPUTE BU MC CORRECTION

+9 KEY 41E

F 50 18 FDAI ANGLES

ENTR (MANUAL MANEUVER)

F 50 19 BYPASS TRIM

PR8 (TRIM NOT REGD)

16 85 4V'S-B8DY

COMPARE PGNS AND BU'S

KEY V77E

+9:25 DSKY BLANKS

KEY V77E

+10 F 16 85 NULL 4V'S WITH RCS

KEY V76E

PR8

35.

AS-504/CSM-104/LM-3

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F 37 88 PR8
KEY 00E (P00)
KEY V37E47E (AVERAGE G)
BLANK FOR 1 MIN
F 16 83 AV'S
KEY V62E
F 04 06 00004 00001
PR8
F 16 72 +XXX.XX +XXX.XX
PR8
F 16 78 XXXXX.XR XXXXX.XRD8T
VERIFY TAPE METER WITH DSKY

(98:30) KEY V77E (ATT H8LD)
BRAKING: 30FPS - 6000FT
20FPS - 3000FT
10FPS - 1500FT
5FPS - 500FT

RENDEZVOUS

D8CK

37.

AS=504/CSM=104/LM=3

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4.0 Abort Procedures

Three specific abort procedures are defined in this document in addition to the abort provisions inherent in the Nominal Mission Procedures. Reference is made to these in the Nominal Mission Procedures as Appendices 1, 2, and 3. Appendix 1 contains the PGNS failure abort procedures for TPI₀ through TPF. Appendix 2 defines the complete Guidance and Navigation (G&N) procedures for executing TPI₀ through TPF when aborting for failures other than G&N. Appendix 3 contains procedures for completing the remainder of the mission following a PGNS malfunction after the insertion maneuver.

PHASING

CB AC BUS A RNDZ RDR-CLOSE
(WAIT 30 SECONDS)
CB PGNS RNDZ RDR-CLOSE

ATT CNT-PULSE(3)
*400+2 RADAR ACQUISITION
MODE CNT-AUTO
PULSE TO NULL AGS ERRORS
POINT Z-AXIS IN DIRECTION
OF CSM.
MODE CNT-ATT HOLD
ATT CNT-MODE CNT(3)
SLEW R/R ANT TO 0.0 9N F0AI
VERIFY MAX SIGNAL STRENGTH
R/R MODE-AUT9 TRACK
NA TRK LT-8FF
COMPARE R/R ERR NEEDLES
WITH C0AS, IF CSM VISIBLE.
ATT CNT-PULSE(3)

***** TPIG TPIO *****

*10+3 TPI SEARCH ROUTINE
*311+032.50 AT TRANS
*313+0+0.00 TFI TPI
*303R L0S ANGLE IN 40 MIN
*10+4 (WHEN 303R=+027.50)
*313R TFI TPI

-40 SET ET COUNTING DOWN

-39 *15+1 316+R
-36 *15+1 316+R

39.

AS-50*/CSM-10*/LM-3

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-20
-27
-24
-23
-21
-18
-15

*10+1 316+K
*15+1 316+R
*15+1 316+R
*303R (MONITOR L0S ANGLE)
*15+1 316+R
*15+1 316+R
*15+1 316+R 503*RD0T
*303R (+027.50)

(IF TPI ANGLE HAS CHANGED)
(RETARGET AGS)
*10+3 TPI SEARCH
*313+013.00 TFI TPI
*303R L0S IN 13 MIN
*10+4 (WHEN 303R=+027.50)
*267R ΔV TPI (+00022.)
*371R ΔV TOTAL (+00050.)
COPY AGS SOLUTION THEN,
LOAD GROUND SOLUTION IN
EXTERNAL DELTA V

-13

8 *304R COPY TGT L0S ANGLE

-5* *304R COPY TGT L0S ANGLE

COPY R AND RD0T FROM TAPE
METER FOR BU'S

CALCULATE BU SOLUTION

*40+0 405+0 406+0
(IF BU'S BURNED, MONITOR ΔV
APPLIED WITH 470 471 472)

*3

MODE CNT-AUTO
*400+2 Z-AXIS GUIDANCE
*507+ STEERING
PULSE TO NULL AGS ERRORS
ATT CNT-MODE CNT(3)

40.

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SET ET COUNTING UP AT U

***** 1ST MC CORRECTION *****

MODE CONT-ATT HOLD (WHEN
502 IS LESS THAN 415)
NULL REMAINING AV'S
500R AVX 501R AVY 502R AVZ
ATT CONT-PULSE(3)

5* 304R COPY TGT LOS ANGLE
8* 304R COPY THETA,R,RD0T

CALCULATE BU MC CORRECTION

404+C 405+0 406+C
(IF BU'S BURNED, MONITOR AV
APPLIED WITH 47C 471 472)
400+0 ATT HOLD

***** 2ND MC CORRECTION *****

10 ATT CONT-MODE CONT(3)
NULL AV'S WITH RCS
500R AVX 501R AVY 502R AVZ
ATT CONT(3)-PULSE

17* 304R COPY TGT LOS ANGLE
20* 304R COPY THETA,R,RD0T

41.

AS-504/CSM-104/LM-3

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ATT CONT-MODE CONT(3)
NULL AV'S WITH RCS
ATT CONT-PULSE(3)

22

404+0 405+0 406+0
MONITOR BRAKING AV VIA 470,
471, AND 472.

BRAKING:
30FPS-6000FT
20FPS-3000FT
10FPS-1500FT
5FPS- 500FT

RENDEZVOUS

D8CK

42.

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APPENDIX C PDK ABOOK

PERFORM PRESTAGE CHECKS

***** TPIO TPIO TPIO *****

IF A RADAR FAILURE OCCURS
BEYOND THIS POINT,
MAINTAIN Z-AXIS POINTING
AT CSM WITH PULSE MODE,
COMPUTE A NORMAL TO LOS
SOLUTION AT TPI AND
MIDCOURSES WITH BACK-JP
CHARTS.

-8* *30R COPY TGT LOS ANGLE

COPY CSM SOLUTION FOR TPI
COMPARE ONBOARD SOLUTIONS
TRANSMIT TO CSM AND GND
SOLUTION TO BE BURNED.
SYNC COUNTDOWN WITH CSM

-5* *30R COPY TGT LOS ANGLE

COPY R AND RDOT FROM TAPE
METER FOR BU'S

CALCULATE BU SOLUTION

-4* KEY V37E*1E (RCS THRUSTING)

F 50 18 FDAI ANGLES
KEY V77E
MODE CONT-ATT HOLD
ENTR (MANUAL MANEUVER)

43.

AS-50*/CSM-10*/LM-3

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-3
KEY V06N86E (ΔV'S LV)
LOAD AGS EXT ΔV
*410+5 EXT ΔV
*450, 451, 452-LOAD
COMPONENTS OF SOLUTION
TO BE EXECUTED.
KEY RELEASE

F 50 19 BYPASS TRIM
PRB (TRIM NOT REQD)
*407+0 WHEN MANEUVER IS
COMPLETE.

-2 ED: MASTER ARM SW-0N

16 85 ΔV'S-88DY
*500R ΔVX (COMPARE)
*35 DSKY BLANKS

STAGE SW-FIRE
ED: MASTER ARM SW-0FF

-0 F 16 85
(94:59) BURN +Z WITH TTCA

+0:00 SET ET COUNTING UP

NULL REMAINING ΔV'S
*50CRΔVX 501RΔVY 502RΔVZ
PRB

F 37 BR

KEY 00E (P00)
KEY V93E
(REINITIALIZE W MATRIX)

***** 1ST MC CORRECTION *****

44.

F 50 19 BYPASS TRIM
PR0 (TRIM NOT REQUIRED)
DSKY BLANKS
VERIFY R/R LOCKEN GOOD

KEY V37E35E
F 16 45 MKS TFI -00001

+5* *304R COPY TGT LOS ANGLE

+7 *404+0 405+0 406+C
PR0 (COMP MC FOR TPI +10)
F 06 81 AV'S-LV (COPY)

F 06 59 AV'S-L0S

+8* *304R COPY THETA,R,RD0.

COMPUTE BU MC CORRECTION

PR0
F 16 45 MKS TFI MGA
PR0
F 37 BB

IF 1ST MC SMALL, SKIP
F41 AND RECALL P35.

+9 KEY 41E
F 50 18 FDAI ANGLES
F 50 19 ENTR (MANUAL MANEUVER)
16 85 BYPASS TRIM
PR0 (TRIM NOT REQD)
16 85 AV'S-B0DY
COMPARE PGNS AND BU'S
KEY V77E

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AS-504/CSM-104/LM-3

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F 37 BB
FKU

***** 2ND MC CORRECTION *****

+11 KEY 35E
F 16 45 MKS TFI -00001

WHEN MARKS = 1, KEY V93E.
(REINITIALIZE W MATRIX)

+17* *304R COPY TGT LOS ANGLE

*404+0 405+0 406+0
PR0 (COMP MC FOR TPI +22)
F 06 81 AV'S-LV (COPY)

F 06 59 AV'S-L0S

F 16 45 MKS TFI MGA

PR0
F 37 BB

+20* *304R COPY THETA,R,RD0T

COMPUTE BU MC CORRECTION

KEY 41E
F 50 18 FDAI ANGLES
F 50 19 ENTR (MANUAL MANEUVER)
16 85 BYPASS TRIM
PR0 (TRIM NOT REQD)
16 85 AV'S-B0DY
COMPARE PGNS AND BU'S

46.

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→21:25 DSKY BLANKS

→22 F 16 85 NULL ΔV C WITH RCS
KEY V76E
PR8

F 37 8B
KEY 00E (P88)

F 16 83 ΔV'S
KEY V37E47E (AVERAGE G)
BLANK FOR 1 MIN

F 04 06 00004 00001
KEY V62E
PR8

F 16 72 +XXX.XX +XXX.XX
PR8

F 16 78 XXXXX.XR XXXXX.XRD8T
VERIFY TAPE METER WITH DSKY

KEY V77E (ATT HOLD)
BRAKING: 30FPS - 6000FT
20FPS - 3000FT
10FPS - 1500FT
5FPS - 500FT

RENDEZV8US

D8CK

47.

AS-504/CSM-104/LM-3

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48.

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DEL 10 17 1 521

CB AC BUS A RNDZ RDR=CL0SE
(WAIT 30 SECONDS)
CB PGNS RNDZ RDR=CL0SE

ATT C9NT=PULSE(3)
R/R M9DE=SLEW
*507+0
*400+2 RADAR ACQUISITION
RATE ERR M9N-CMPTR(LMP)
PULSE T8 NULL AGS ERR8RS
PRINT Z-AXIS IN DIRECTION
OF CSM.
DEADBAND-MIN
M9DE C9NT-ATT H9LD
ATT C9NT=M9DE C9NT(3)
RATE ERR M9N-RNDZ RDR(CDR)
SLEW R/R ANT T8 C.0 9N FDAI
VERIFY MAX SIGNAL STRENGTH
R/R M9DE=AUT8 TRACK
N9 TRK LT=8FF
COMPARE R/R ERR NEEDLES
WITH C9AS, IF CSM VISIBLE.
DEADBAND-MAX

***** CSI CSI CSI *****

*275+382.0 AGS CSI TIME
*277+479.3 AGS TPI TIME
*605+10250 TPI ANGLE C9DE
*416+0.1ST APSIDAL
*417+1
*410+1 CSI ROUTINE

49.

AS=50+CSM=10+LM=3

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50.

*456R AVCSI C9PY
*371R AVCDH C9PY
*276R ABS TIME CDH(0+26.5)
*411+0 RCS ENGINE
*450R AVX +52R AVZ

C9PY R9BT FR9M TAPE METER
F9R BU'S
C9PY R9BT FR9M TAPE METER
F9R BU'S
C9PY RANG. AND R9BT FR9M
TAPEMETER F9R BU'S

30

20

10

PERFORM PRESTAGE CHECKS

*16

ATT C9NT=PULSE(3)
M9DE C9NT=AUT8

*411+0 RCS SELECT
*410+5 EXT AV
*450+AVX +51+AVY +52+AVZ
(LOAD GND CSI SOLUTION)

*10

*400+1 GUIDANCE STEERING
PULSE T8 NULL AGS ERR8RS
DEADBAND-MIN
TRIM AGS ERR8RS
ATT C9NT=M9DE C9NT(3)
*407+0 WHEN MANEUVER IS
COMPLETE.
*500R+VX

*2

ED: MASTER ARM=9N

ED: MASTER ARM=OFF

SET ET COUNTING UP AT 0.

0(96:22)

BURN +X WITH TTCA
 ASC FEED 2-OPEN(SYS A-B)
 CHECK ASC FUEL AND OXID
 FLAGS OPEN. (SYS A-B)
 MAIN S0V (SYS A-B)=CLOSE
 MAIN S0V (SYS A-B)=OPEN.
 (BEFORE THRUST TERMINATION)
 ASC FEED 2-CLOSE (SYS A-B)
 (BEFORE THRUST TERMINATION)
 NULL REMAINING AVIS
 *500R4VX 501R4VY 502R4VZ

***** CDH CDH CDH *****

ATT CONT-PULSE(3)
 *400+2 RADAR ACQUISITION
 PULSE TO NULL AGS ERRORS
 POINT Z-AXIS IN DIRECTION
 OF CSM.

M0DE CONT-ATT HOLD
 ATT CONT-M0DE CONT(3)
 SLEW R/R ANT TO 0.0 SN F0A1
 VERIFY MAX SIGNAL STRENGTH
 R/R M0DE-AUT0 TRACK
 N0 TRX LT-OFF
 DEADBAND-MAX

*410+2 CDH ROUTINE
 *276+0+26.5 ABS TIME CDH
 *313R TFI CDH
 *411+1 APS SELECT

037 SET ET TO TFI CDH

51.

AS-504/CSM-104/LM-3

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*37UK4V LUM

COPY GROUND SOLUTION

029* COPY RD0T FROM TAPE METER FOR BU'S

018* COPY RD0T FROM TAPE METER FOR BU'S

*263R4VY CDH 0PV COPY
*450R4VX 452R4VZ COPY

07* COPY RD0T FROM TAPE METER FOR BU'S

CALCULATE BU CDH
COMPARE SOLUTIONS

*410+5 EXT 4V
 *450, 451, 452-LOAD
 GROUND SOLUTION FOR CDH.

05 ATT CONT-PULSE(3)
 *400+1 GUIDANCE STEERING
 M0DE CONT-AUT0
 PULSE TO NULL AGS ERRORS
 DEADBAND-MIN
 TRIM ERRORS
 ATT CONT-M0DE CONT(3)
 *407+0 WHEN MANEUVER IS
 COMPLETE.
 *500R4VX

014 MONITOR VLLAGE
 0(97:06:28) AB0RT STAGE-DEPRESS

SET ET COUNTING UP AT 0.

52.

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ABORT STAGE-RESET

***** TPI TPI TPI *****

*5 ATT CNT-PULSE(3)
 *400+2 RADAR ACQUISITION
 MODE CNT-AUTO
 PULSE TO NULL AGS ERRORS
 POINT Z-AXIS IN DIRECTION
 BF CSM.
 MODE CNT-ATT HBLD
 ATT CNT-MODE CNT(3)
 SLEW R/R ANT TO C.O 9N FDAJ
 VERIFY MAX SIGNAL STRENGTH
 R/R MODE-AUTO TRACK
 NO TRK LT-OFF
 ATT CNT-PULSE(3)

*6 *10+3 TPI SEARCH ROUTINE
 *311+032.50 AT TRANS
 *313+040.00 TFI TPI
 *303R LOS ANGLE IN 40 MIN
 *10+4 (WHEN 303R+027.50)
 *313R TFI TPI

*40 SET ET COUNTING DOWN
 *15+1 316+R
 *15+1 316+R
 *15+1 316+R
 *15+1 316+R
 *15+1 316+R
 *15+1 316+R
 *303R (MONITOR LOS ANGLE)

53.

AS-50*/CSM-10*/LM-3

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(IF TPI ANGLE HAS CHANGED)
(RETARGET AGS)

*10+3 TPI SEARCH ROUTINE
 *313+013.00 TFI TPI
 *303R LOS IN 13 MIN
 *10+4 (WHEN 303R+027.50)
 *267R ΔV TPI (+00022.)
 *371R ΔV TOTAL (+00050.)
 COPY AGS SOLUTION THEN,
 LOAD GROUND SOLUTION IN
 EXTERNAL DELTA V

-13

*304R COPY TGT LOS ANGLE
 *304R COPY TGT LOS ANGLE

8

COPY R AND RDOT FROM TAPE
 METER FOR BU'S

5

CALCULATE BU SOLUTION

*40+0 405+0 406+0
 (IF BU'S BURNED, MONITOR ΔV
 APPLIED WITH 470 471 472)

MODE CNT-AUTO
 *400+2 Z-AXIS GUIDANCE
 *507+1 STEERING
 PULSE TO NULL AGS ERRORS
 ATT CNT-MODE CNT(3)
 *502R ΔVZ (ΔVTPI)
 BURN ΔZ WITH TTCA

*3

(97:59:21)

SET ET COUNTING UP AT 0

54.

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MODE CNT=AH WHEN 502<+5
NULL REMAINING AV'S
*500RΔVX 501RΔVY 502RΔVZ

+22

ATT CNT=MODE CNT(3)
NULL AV'S WITH RCS
ATT CNT=PULSE(3)

***** 1ST MC CORRECTION *****

ATT CNT=PULSE(3)

+5* *30R COPY TGT LOS ANGLE

+8* *30R COPY THETA,R,RDΘT

CALCULATE BU MC CORRECTION

*40+0 405+0 406+C
(IF BU'S BURNED, MONITOR ΔV
APPLIED WITH 47C 471 472)

+10 *400+0 ATT HBLD
ATT CNT=MODE CNT(3)
NULL AV'S WITH RCS
*500RΔVX 501RΔVY 502RΔVZ

ATT CNT=PULSE(3)

***** 2ND MC CORRECTION *****

+17* *30R COPY TGT LOS ANGLE

+20* *30R COPY THETA,R,RDΘT

CALCULATE BU MC CORRECTION

*40+0 405+0 406+C
(IF BU'S BURNED, MONITOR ΔV
APPLIED WITH 470 471 472)

55.

AS-50Δ/CSM-10Δ/LM-3

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56.

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*40+0 405+0 406+0
MONITOR BRAKING ΔV VIA 470,
471, AND 472.

BRAKING:
30FPS=6000FT
20FPS=3000FT
10FPS=1500FT
5FPS= 500FT

RENDEZVOUS

DECK

5.0 Backup Charts

Backup chart solutions are calculated at CSI, CDH, TPI, MCC 1 and MCC 2. At CSI and CDH the charts are exercised as a validation of the F and G mission rendezvous procedures. At TPI and the midcourses they are second in priority to the LM PNGS solutions.

5.1 CSI Chart

The CSI chart solution is based on a Maclaurin's expansion of four variables for the delta V at CSI (range rate at 30, 20, and 10 minutes prior to CSI and range 10 minutes prior to CSI). The coefficients are determined by the simultaneous solution of several expansions, each representing a dispersed trajectory prior to CSI.

5.2 CDH Chart

The CDH chart solution utilizes the sinusoidal time history of range rate variations from coellipticity and relative velocity errors from coellipticity. Range rate data for the CDH chart are taken 29, 18, and 7 minutes prior to CDH.

5.3 TPI and MCC Charts

The TPI charts solve for the relative position and velocity at TPI resolved into normal and along the line-of-sight (LOS) coordinates. The measured relative state is differenced with the required state conditions for intercept in 130 degrees of orbit travel. Information required for the TPI charts is the elevation of the LOS from local horizontal (θ) at eight and five minutes prior to TPI, plus range and range rate five minutes prior to TPI. In a similar manner the midcourse charts maintain the time of TPI consistent with the TPI maneuver. Data are taken for the midcourses five and eight minutes after TPI for MCC 1 and 17 and 20 minutes after TPI for MCC 2. The same measurement sequence as used at TPI is used for both midcourse corrections.

CSI
BACK-UP TABLE
(NEXT PAGE)

| | | | | | | | |
|-------|-------|-------|-------|-------|-------|-------|-------|
| 87. | 87. | 87. | 87. | 87. | 87. | 87. | 87. |
| -72.8 | 104.7 | 104.7 | 104.7 | 104.7 | 104.7 | 104.7 | 104.7 |
| -73.7 | 105.9 | 105.9 | 105.9 | 105.9 | 105.9 | 105.9 | 105.9 |
| -74.5 | 107.1 | 107.1 | 107.1 | 107.1 | 107.1 | 107.1 | 107.1 |
| -75.3 | 108.3 | 108.3 | 108.3 | 108.3 | 108.3 | 108.3 | 108.3 |
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| -77.0 | 110.7 | 110.7 | 110.7 | 110.7 | 110.7 | 110.7 | 110.7 |
| -77.8 | 111.9 | 111.9 | 111.9 | 111.9 | 111.9 | 111.9 | 111.9 |
| -78.7 | 113.1 | 113.1 | 113.1 | 113.1 | 113.1 | 113.1 | 113.1 |
| -79.5 | 114.4 | 114.4 | 114.4 | 114.4 | 114.4 | 114.4 | 114.4 |
| -80.4 | 115.6 | 115.6 | 115.6 | 115.6 | 115.6 | 115.6 | 115.6 |
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| -82.9 | 119.2 | 119.2 | 119.2 | 119.2 | 119.2 | 119.2 | 119.2 |
| -83.7 | 120.4 | 120.4 | 120.4 | 120.4 | 120.4 | 120.4 | 120.4 |
| -84.5 | 121.6 | 121.6 | 121.6 | 121.6 | 121.6 | 121.6 | 121.6 |
| -85.4 | 122.8 | 122.8 | 122.8 | 122.8 | 122.8 | 122.8 | 122.8 |
| -86.2 | 124.0 | 124.0 | 124.0 | 124.0 | 124.0 | 124.0 | 124.0 |
| -87.1 | 125.2 | 125.2 | 125.2 | 125.2 | 125.2 | 125.2 | 125.2 |
| -87.9 | 126.4 | 126.4 | 126.4 | 126.4 | 126.4 | 126.4 | 126.4 |
| -88.7 | 127.6 | 127.6 | 127.6 | 127.6 | 127.6 | 127.6 | 127.6 |
| -89.6 | 128.8 | 128.8 | 128.8 | 128.8 | 128.8 | 128.8 | 128.8 |
| -90.4 | 130.0 | 130.0 | 130.0 | 130.0 | 130.0 | 130.0 | 130.0 |
| -91.2 | 131.2 | 131.2 | 131.2 | 131.2 | 131.2 | 131.2 | 131.2 |
| -92.1 | 132.4 | 132.4 | 132.4 | 132.4 | 132.4 | 132.4 | 132.4 |
| -92.9 | 133.6 | 133.6 | 133.6 | 133.6 | 133.6 | 133.6 | 133.6 |
| -93.7 | 134.8 | 134.8 | 134.8 | 134.8 | 134.8 | 134.8 | 134.8 |
| -94.5 | 136.0 | 136.0 | 136.0 | 136.0 | 136.0 | 136.0 | 136.0 |
| -95.4 | 137.2 | 137.2 | 137.2 | 137.2 | 137.2 | 137.2 | 137.2 |
| -96.3 | 138.4 | 138.4 | 138.4 | 138.4 | 138.4 | 138.4 | 138.4 |
| -97.1 | 139.6 | 139.6 | 139.6 | 139.6 | 139.6 | 139.6 | 139.6 |
| -97.9 | 140.8 | 140.8 | 140.8 | 140.8 | 140.8 | 140.8 | 140.8 |
| -98.8 | 142.0 | 142.0 | 142.0 | 142.0 | 142.0 | 142.0 | 142.0 |
| -99.6 | 143.2 | 143.2 | 143.2 | 143.2 | 143.2 | 143.2 | 143.2 |
| 88. | 88. | 88. | 88. | 88. | 88. | 88. | 88. |
| -2.9 | -57.4 | -57.4 | -57.4 | -57.4 | -57.4 | -57.4 | -57.4 |
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| -3.1 | -58.7 | -58.7 | -58.7 | -58.7 | -58.7 | -58.7 | -58.7 |
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| -3.8 | -64.6 | -64.6 | -64.6 | -64.6 | -64.6 | -64.6 | -64.6 |
| -3.8 | -65.3 | -65.3 | -65.3 | -65.3 | -65.3 | -65.3 | -65.3 |
| -3.9 | -65.9 | -65.9 | -65.9 | -65.9 | -65.9 | -65.9 | -65.9 |
| -4.0 | -66.6 | -66.6 | -66.6 | -66.6 | -66.6 | -66.6 | -66.6 |
| -4.1 | -67.3 | -67.3 | -67.3 | -67.3 | -67.3 | -67.3 | -67.3 |
| -4.2 | -67.9 | -67.9 | -67.9 | -67.9 | -67.9 | -67.9 | -67.9 |
| -4.2 | -68.6 | -68.6 | -68.6 | -68.6 | -68.6 | -68.6 | -68.6 |
| -4.3 | -69.2 | -69.2 | -69.2 | -69.2 | -69.2 | -69.2 | -69.2 |
| -4.4 | -69.9 | -69.9 | -69.9 | -69.9 | -69.9 | -69.9 | -69.9 |
| -4.5 | -70.6 | -70.6 | -70.6 | -70.6 | -70.6 | -70.6 | -70.6 |
| -4.6 | -71.2 | -71.2 | -71.2 | -71.2 | -71.2 | -71.2 | -71.2 |
| -4.6 | -71.9 | -71.9 | -71.9 | -71.9 | -71.9 | -71.9 | -71.9 |
| -4.7 | -72.5 | -72.5 | -72.5 | -72.5 | -72.5 | -72.5 | -72.5 |
| -4.8 | -73.2 | -73.2 | -73.2 | -73.2 | -73.2 | -73.2 | -73.2 |
| -4.9 | -73.9 | -73.9 | -73.9 | -73.9 | -73.9 | -73.9 | -73.9 |
| -5.0 | -74.5 | -74.5 | -74.5 | -74.5 | -74.5 | -74.5 | -74.5 |
| -5.1 | -75.2 | -75.2 | -75.2 | -75.2 | -75.2 | -75.2 | -75.2 |
| -5.2 | -75.8 | -75.8 | -75.8 | -75.8 | -75.8 | -75.8 | -75.8 |
| -5.3 | -76.5 | -76.5 | -76.5 | -76.5 | -76.5 | -76.5 | -76.5 |
| -5.4 | -77.1 | -77.1 | -77.1 | -77.1 | -77.1 | -77.1 | -77.1 |
| -5.4 | -77.8 | -77.8 | -77.8 | -77.8 | -77.8 | -77.8 | -77.8 |
| -5.5 | -78.5 | -78.5 | -78.5 | -78.5 | -78.5 | -78.5 | -78.5 |

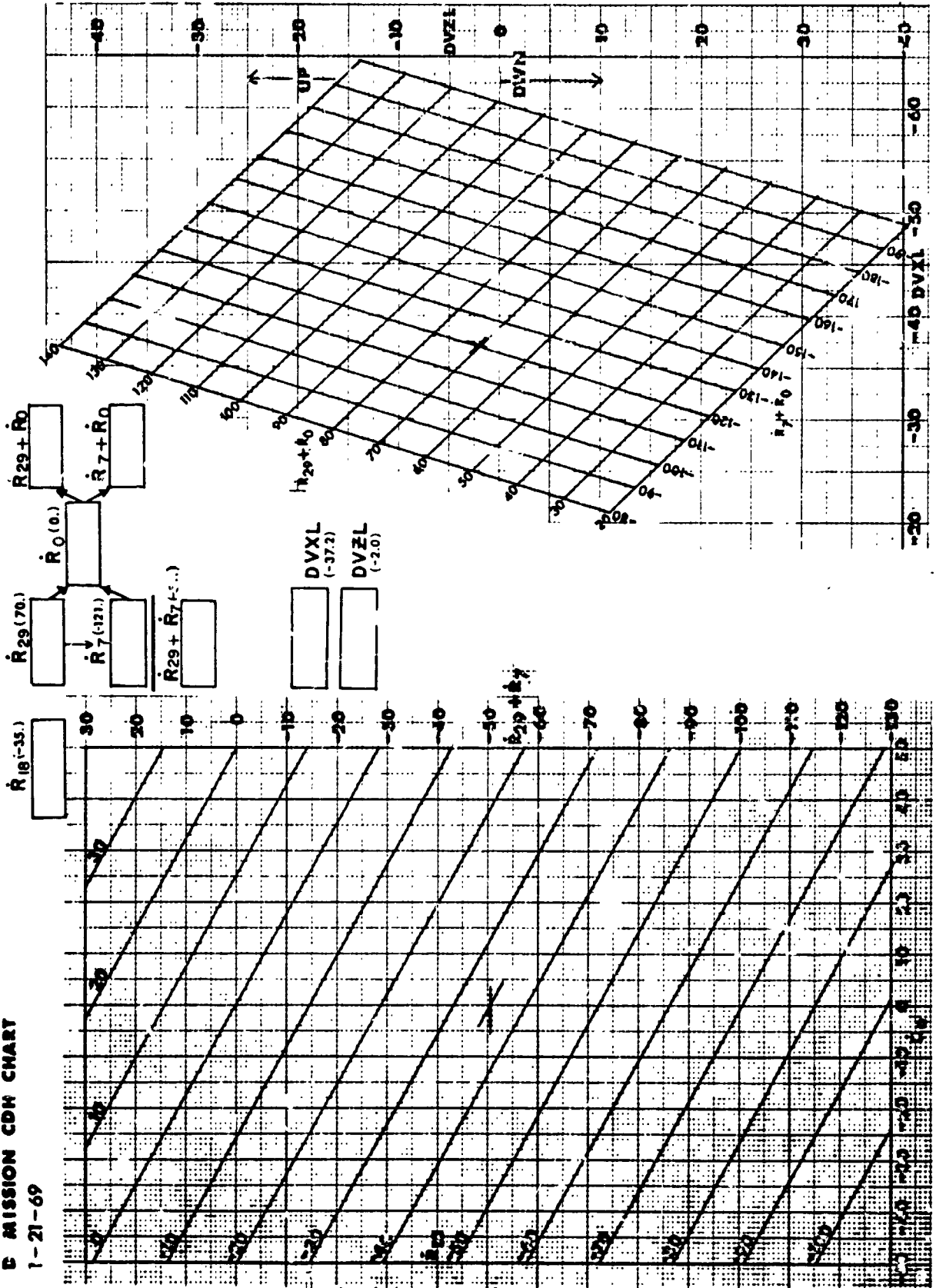
CSI BACK-UP TABLE: MISSION D

| R ₃₀ | F ₃₀ | R ₂₀ | F ₂₀ | R ₁₀ | F ₁₀ | R ₁₀ | G ₁₀ |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 120. | -100.4 | 120. | 144.4 | 120. | -79.1 | 68. | -5.5 |
| 121. | -101.3 | 121. | 145.6 | 121. | -79.8 | 69. | -5.6 |
| 122. | -102.1 | 122. | 146.9 | 122. | -80.4 | 70. | -5.7 |
| 123. | -103.0 | 123. | 148.1 | 123. | -81.1 | 71. | -5.8 |
| 124. | -103.8 | 124. | 149.3 | 124. | -81.8 | 72. | -5.9 |
| 125. | -104.6 | 125. | 150.5 | 125. | -82.4 | 73. | -5.9 |
| 126. | -105.5 | 126. | 151.7 | 126. | -83.1 | 74. | -6.0 |
| 127. | -106.3 | 127. | 152.9 | 127. | -83.7 | 75. | -6.1 |
| 128. | -107.1 | 128. | 154.1 | 128. | -84.4 | 76. | -6.2 |
| 129. | -108.0 | 129. | 155.3 | 129. | -85.1 | 77. | -6.3 |
| 130. | -108.8 | 130. | 156.5 | 130. | -85.7 | 78. | -6.4 |
| 131. | -109.7 | 131. | 157.7 | 131. | -86.4 | 79. | -6.4 |
| 132. | -110.5 | 132. | 158.9 | 132. | -87.0 | 80. | -6.5 |
| 133. | -111.3 | 133. | 160.1 | 133. | -87.7 | 81. | -6.6 |
| 134. | -112.2 | 134. | 161.3 | 134. | -88.4 | 82. | -6.7 |
| 135. | -113.0 | 135. | 162.5 | 135. | -89.0 | 83. | -6.8 |
| 136. | -113.8 | 136. | 163.7 | 136. | -89.7 | 84. | -6.8 |
| 137. | -114.7 | 137. | 164.9 | 137. | -90.3 | 85. | -6.9 |
| 138. | -115.5 | 138. | 166.1 | 138. | -91.0 | 86. | -7.0 |
| 139. | -116.3 | 139. | 167.3 | 139. | -91.7 | 87. | -7.1 |

| (NOM) | (NOM) | (NOM) |
|-------------------------------|-------------------------------|--|
| R ₂₈ ----- (113.5) | R ₃₀ ----- (113.2) | F ₃₀ ----- (-94.8) |
| R ₃₂ ----- (112.8) | R ₁₀ ----- (116.2) | F ₁₀ ----- (-76.6) |
| | R ₁₀ ----- (62.2) | G ₁₀ ----- (- 50) |
| | | F ₃₀ + F ₁₀ + G ₁₀ ----- (-176.4) |
| | | R ₂₀ ----- (114.7) |
| | | F ₂₀ ----- (138.3) |
| | | ΔV _{CSI} ----- (-38.1) |

E MISSION CDH CHART

1-21-69



'D' MISSION

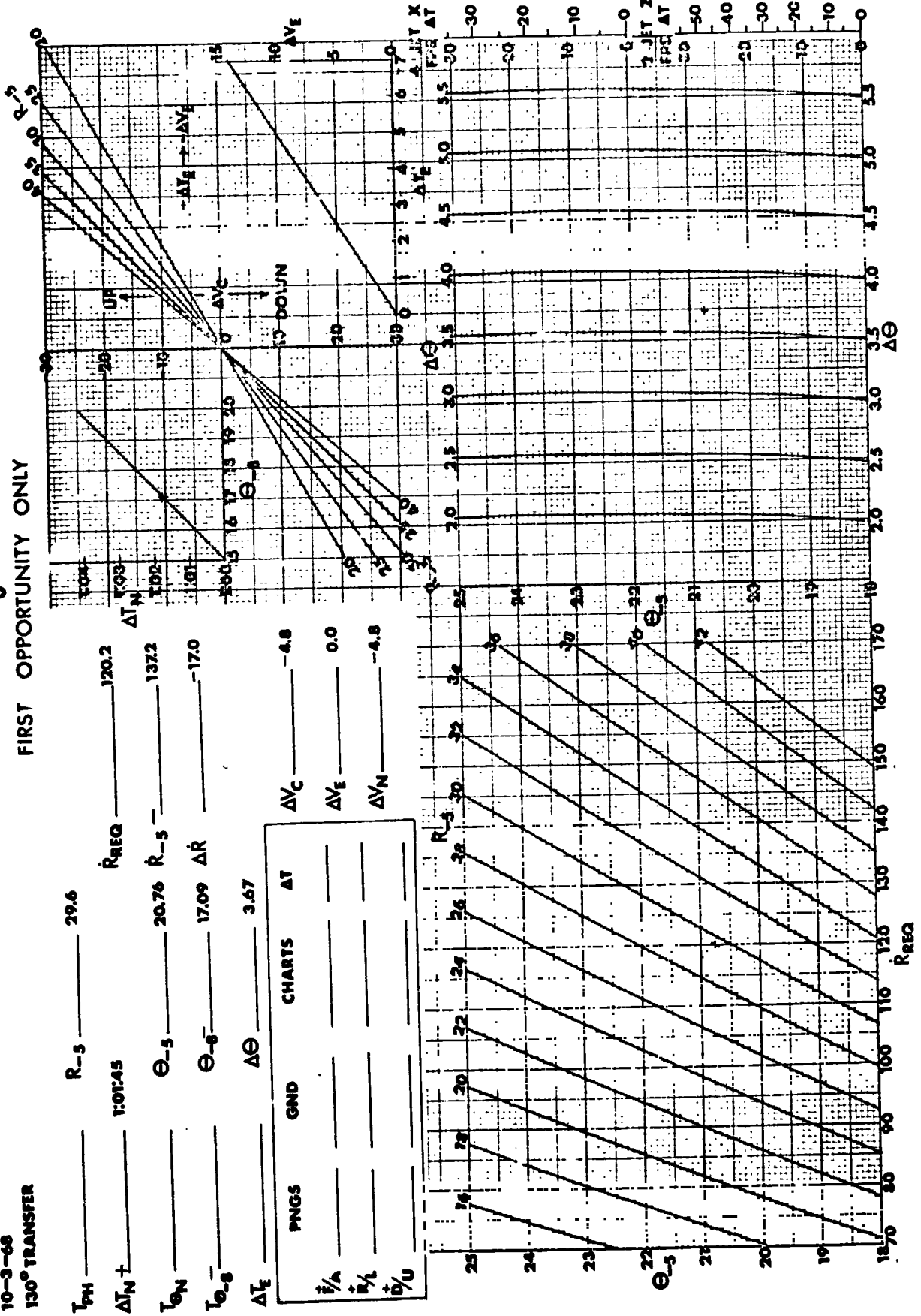
TPI0

FIRST OPPORTUNITY ONLY

10-3-68
130° TRANSFER

T_{PH} _____ R_{-5} _____ 29.6
 ΔT_N _____ 1:01:45 R_{REQ} _____ 120.2
 $T_{\Theta N}$ _____ Θ_{-5} _____ 20.76 R_{-5} _____ 137.2
 $T_{\Theta S}$ _____ Θ_{-6} _____ 17.09 ΔR _____ -17.0
 ΔT_E _____ $\Delta \Theta$ _____ 3.67

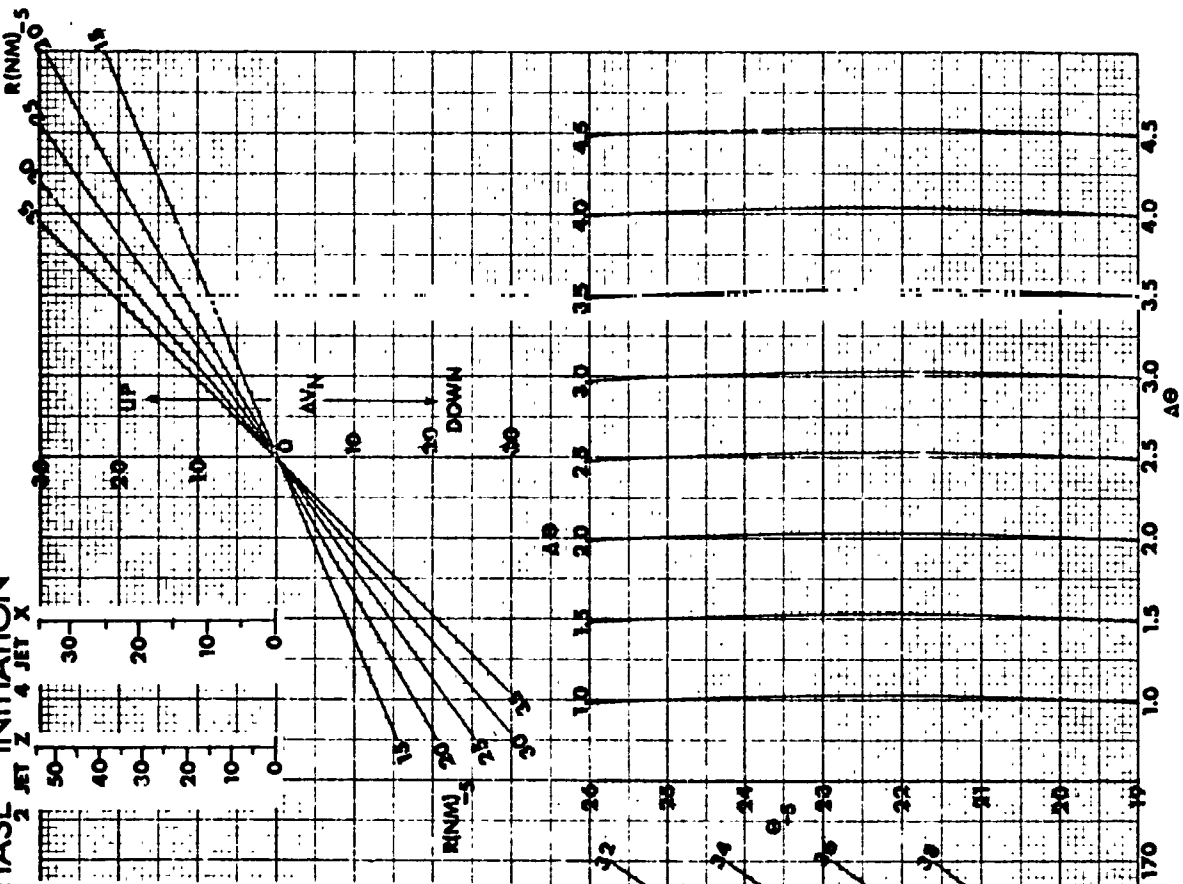
| PNGS | GND | CHARTS | ΔT |
|-------------|-------|--------|-------------------------|
| \bar{r}/A | _____ | _____ | ΔV_C _____ -4.8 |
| \bar{r}/L | _____ | _____ | ΔV_E _____ 0.0 |
| \bar{D}/U | _____ | _____ | ΔV_N _____ -4.8 |



"D" MISSION

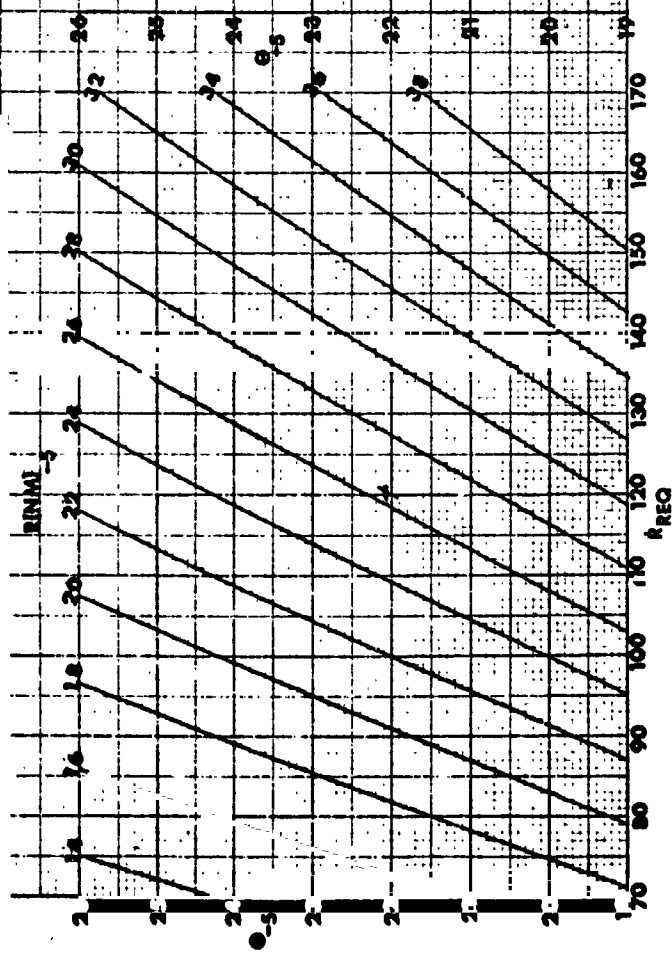
LM-120 CSAR-130
130 DEGREE TRANSFER
9-17-68

TERMINAL PHASE INITIATION



R_{REQ} _____ 120.7
 R_{-5} _____ 98.9
 ΔR _____ 21.8
 $\Delta \theta$ _____ 2.39

| PRIGS | GND | CHARTS |
|-------------------------|-------|--------|
| $\frac{+}{-} F/A$ _____ | _____ | _____ |
| $\frac{+}{-} R/L$ _____ | _____ | _____ |
| $\frac{+}{-} D/U$ _____ | _____ | _____ |



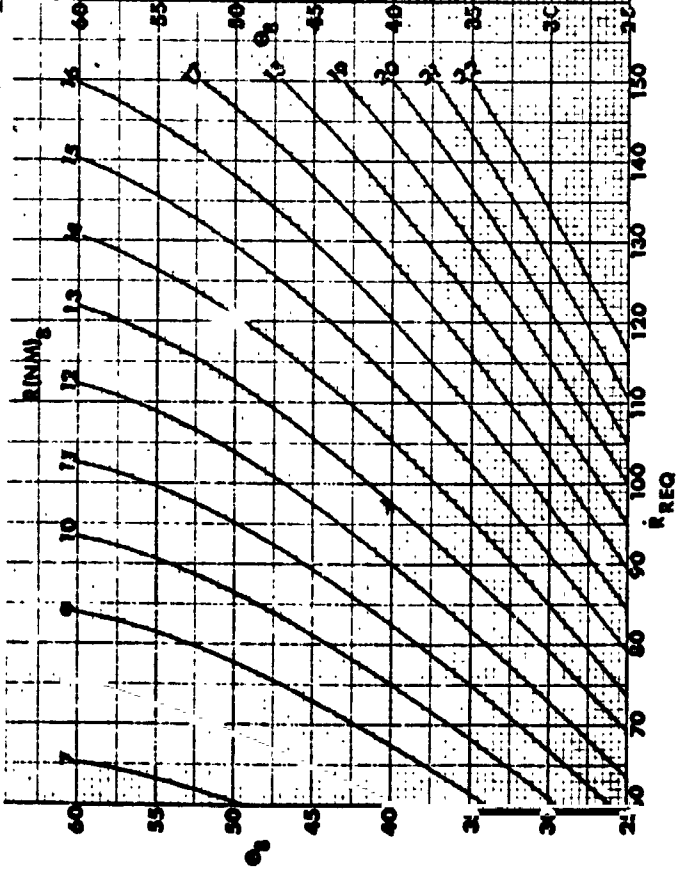
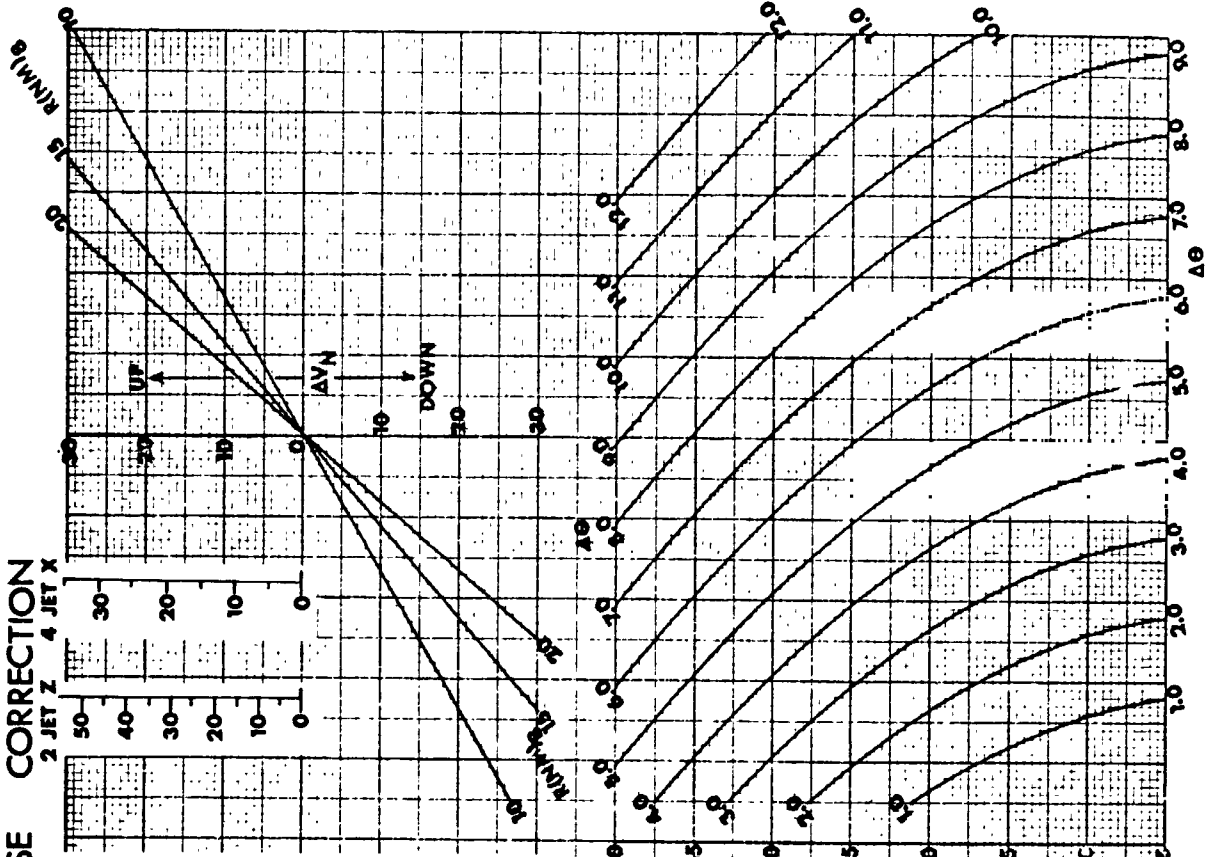
LM-120 CSM-130
130 DEGREE TRANSFER
9-17-68

MISSION

FIRST MIDCOURSE CORRECTION

Θ_8 _____ R_{REQ} _____ 97.4
 Θ_5 _____ R_8 _____ 12.90 R_8 _____ 97.4
 $\Delta\Theta$ _____ 34.86 ΔR _____ 0.0
 $\Delta\Theta$ _____ 5.38

| PNGS | GND | CHARTS |
|------------------|-------|--------|
| γ/A _____ | _____ | _____ |
| R/L _____ | _____ | _____ |
| D/U _____ | _____ | _____ |

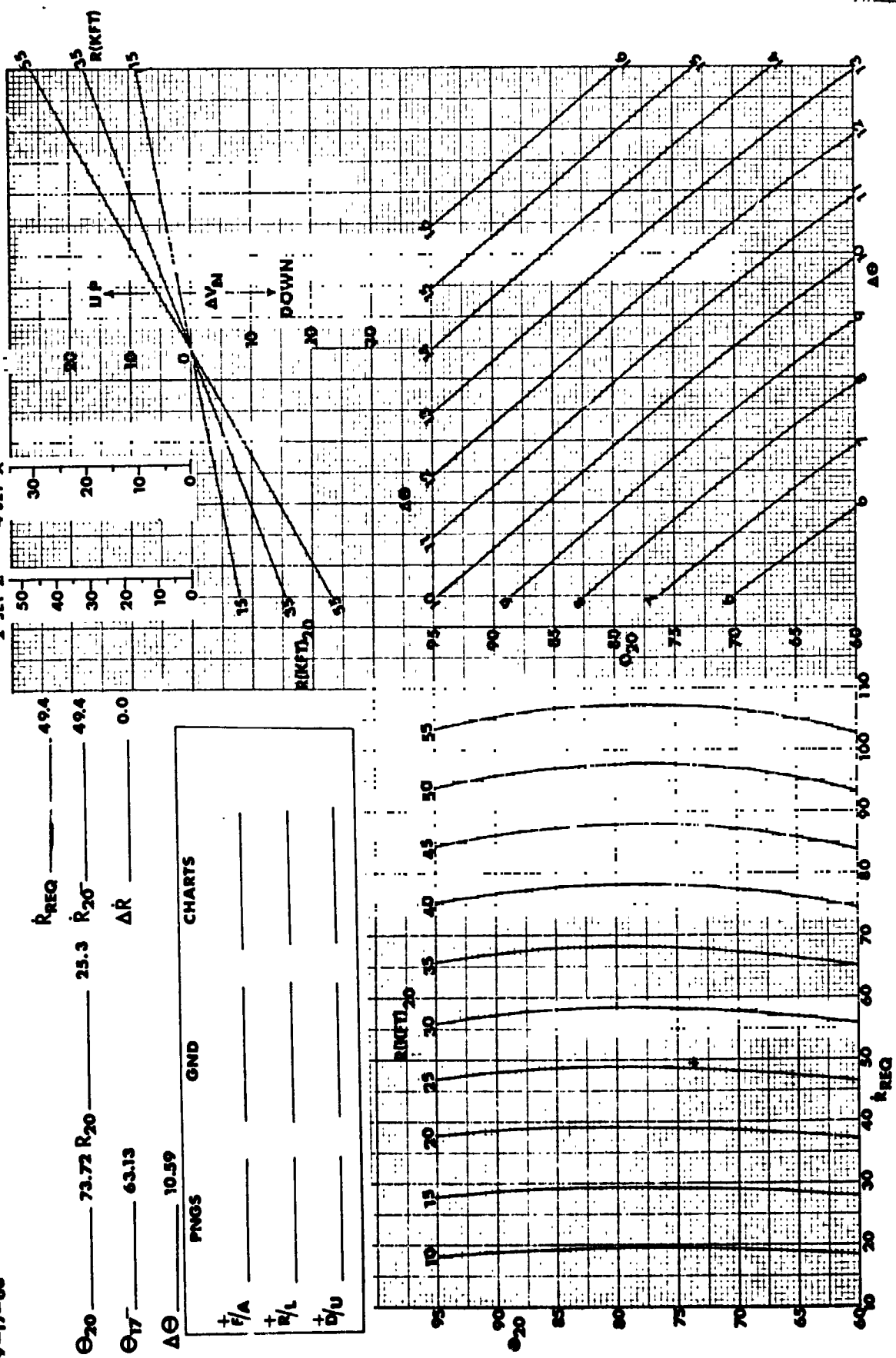


LJ-120 CSM-130
130 DEGREE TRANSFER
9-17-68

SECOND MIDCOURSE CORRECTION

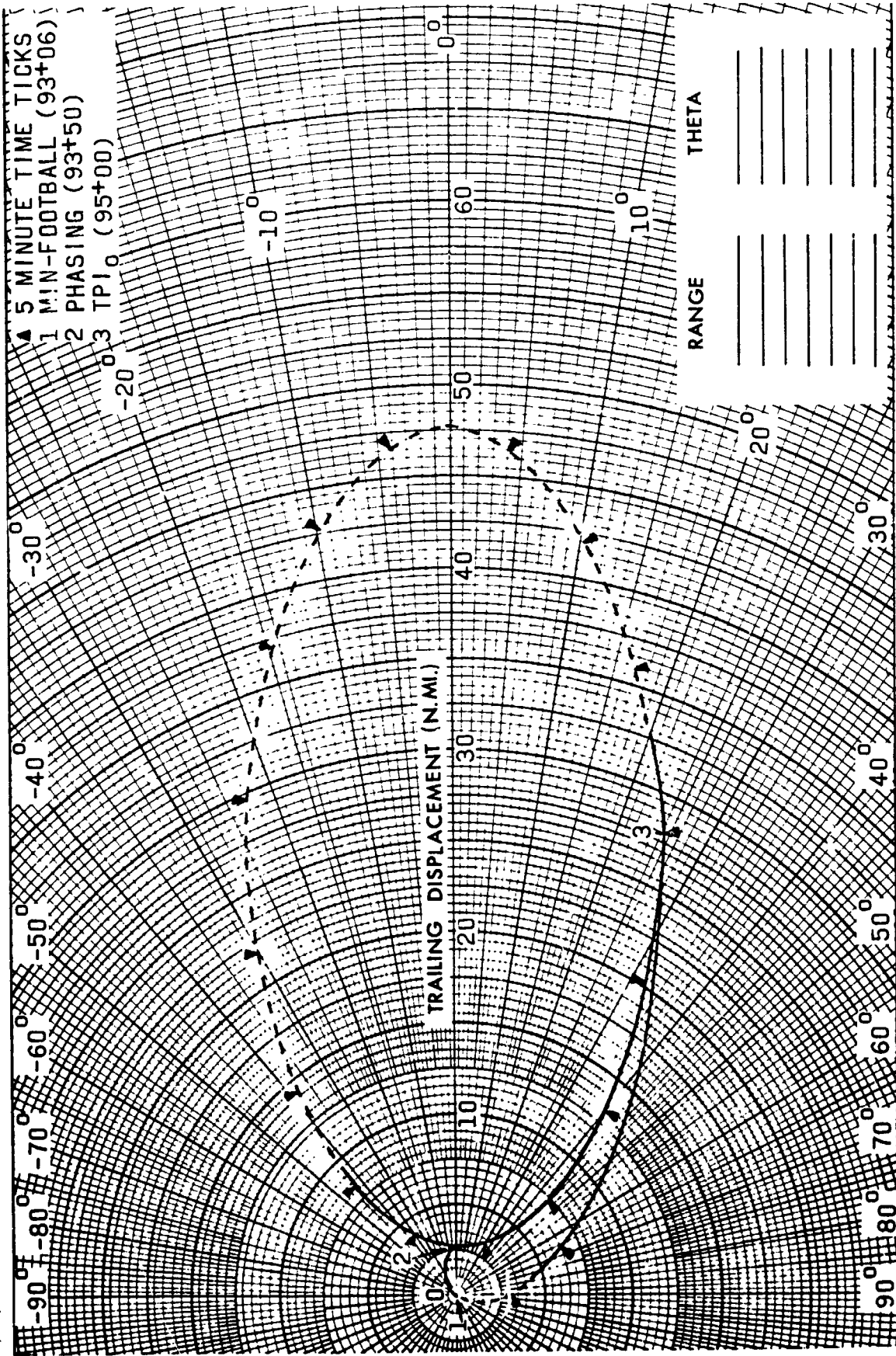
R_{REQ} _____ 49.4
 R_{20} _____ 25.3
 ΔR _____ 0.0
 Θ_{20} _____ 73.77
 Θ_{17} _____ 63.13
 $\Delta \Theta$ _____ 10.59

| PINGS | GND | CHARTS |
|-------------|-------|--------|
| + F/A _____ | _____ | _____ |
| + R/L _____ | _____ | _____ |
| + D/U _____ | _____ | _____ |

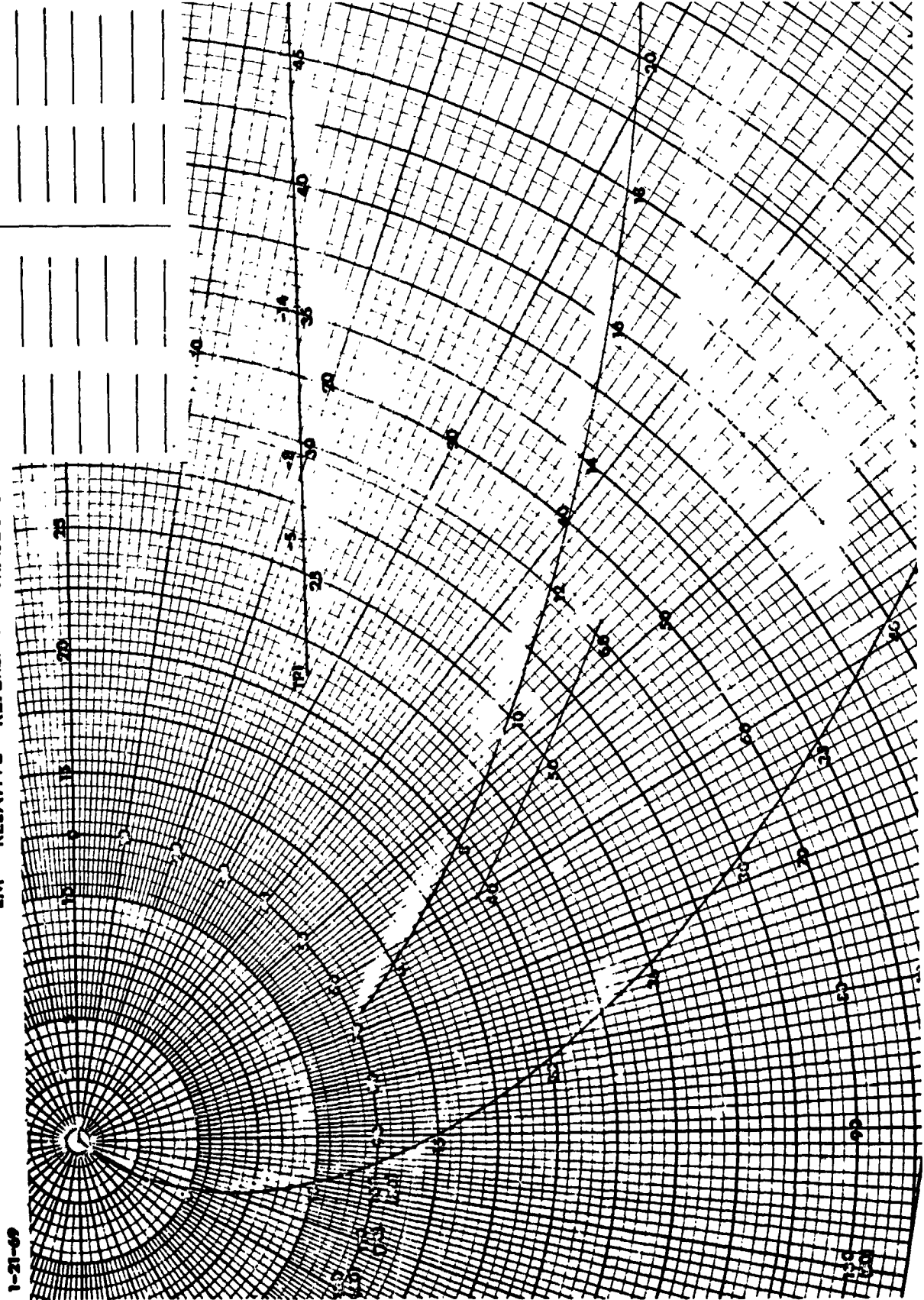


LM FOOTBALL REFERENCE TRAJECTORY

1/22/69



LM RELATIVE REFERENCE TRAJECTORY



1-21-69

1-21-69

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6.0 References

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- 6.3 Guidance System Operations Plan, Sundance, Volume II, MIT R-557, dated July 1968.
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