NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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APOLLO ENTRY SUMMARY DOCUMENT

MISSION "F"

(AS-505/106/LM-4)

FINAL COPY

March 17, 1969

MANNED SPACECRAFT CENTER
HOUSTON TEXAS

APOLLO ENTRY SUMMARY DOCUMENT

MISSION F (AS-505/106/LM-4)

PREPARED BY:

James O. Rippey
AST, Launch and Entry Procedures Section

APPROVED BY:

Dickie K. Warren
Chief, Launch and Entry Procedures Section

Paul C. Kramer
Chief, Flight Procedures Branch

for James W. Bilodeau
Assistant Chief, Flight Crew Support Division

Warren J. North
Chief, Flight Crew Support Division

Donald K. Slayton
Chairman, Crew Procedures Control Board

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1.0 INTRODUCTION

The purpose of the Entry Summary Document is to provide a single source of entry crew procedure information for use in flight planning, crew training, and preparing onboard data. The techniques contained in this document were generally derived from other documentation and are combined here to serve as a single, compact training package.

In accordance with the Flight Crew Operations Directorate CREW PROCEDURES CONTROL PLAN dated March 1968, the preliminary ESD editions are distributed for review and comment and simulator validation until 5 months prior to launch. Thereafter final ESD procedures are distributed and serve as a control document with changes subject to approval by the Crew Procedures Control Board.

Comments to this document should be directed to the Flight Procedures Branch, Flight Crew Support Division, extension 3436.

2.0 LIST OF ACRONYMS AND ABBREVIATIONS

ACCUM	Accumlator
AMP	Amplifier
ANT	Antenna
AOS	Acquisition of Signal
BBA	Backup Bank Angle
BCN	Beacon
BEF	Blunt End Forward
BETA	CMC Commanded Bank Angle
BMAG	Body Mounted Attitude Gyro
BRB	Bank Reverse Bank
CBN	Cabin
CDR	Commander
CDU	Coupling Data Unit
CKT	Circuit
CM	Command Module
CMC	Command Module Computer
CMP	Command Module Pilot
CO	Cutoff
COAS	Crew Optical Alignment Sight
COMM	Communications
CRYO	Cryogenic
CSM	Command Service Module
CTR	Counter
C/WS	Caution Warning System
DAP	Digital Auto Pilot
DET	Digital Event Pilot
DL	Drag Acceleration at Skipout
DO	Constant Drag Control Acceleration Level
DSKY	Display and Keyboard
E	DSKY Enter
ECS	Environment Control Subsystem
EI	Entry Interface
EMS	Entry Monitor System
EPS	Electrical Power Subsystem
ESS	Essential
FCSM	Flight Combustion Stability Monitor
FDAI	Flight Director Attitude Indicator
FUNC	Function
G	Acceleration in Earth Gravitational Units
G&C	Guidance and Control
GET	Ground Elapsed Time
GETI	Ground Elapsed Time of Ignition
GDC	Gyro Display Coupler
GLY	Glycol
GMBL	Gimbal
G&N, G/N	Guidance and Navigation

List of Acronyms and Abbreviations

GND	Ground
GPI	Gimbal Position Indicator
G-V	Acceleration-Velocity
HA	Height of Apogee
HE	Helium
HP	Height of Perigee
IMU	Inertial Measurement Unit
KA	Drag Acceleration necessary to initiate constant drag control
L/D	Lift to Drag Ratio
LEB	Lower Equipment Bay
LMP	Lunar Module Pilot
LOS	Loss of Signal
LV	Local Vertical, Lift Vector, Launch Vehicle
MAN	Manual
MCC	Midcourse Correction
MCC-H	Mission Control Center - Houston
MESC	Master Event Sequence Controller
MSFN	Manned Space Flight Network
MGA	Middle Gimbal Angle
MK	Mark
MNVR	Maneuver
MON	Monitor
MTR	Motor
MTVC	Manual Thrust Vector Control
N	DSKY Noun
OPT	Option, Optics
ORIEN	Orientation
O2	Oxygen
P	Pitch or CMC Program
PGA	Pressure Garment Assembly
PGNCS	Primary Guidance, Navigation and Control System
PIPA	Pulse Integrating Pendulous Accelerometer
PL	Planet
PLSS	Portable Life Support System
POSS	Possible
PRIM	Primary
PRPLNT	Propellant
PSIA	Pounds Per Square Inch Absolute
PTT	Push to Talk
PUGS	Propellant Utilization and Gaging System
PWR	Power
R	Roll or CMC Routine
R1, R2, R3	Register 1, 2, 3
RAD	Radiator
RCDR	Recorder
RCS	Reaction Control System
ROT	Altitude Rate
REFSMMAT	Reference to Stable Member Matrix

List of Acronyms and Abbreviations

REL	Relief
RET	Reentry Elapsed Time (Lunar Return Case) or Retro Elapsed Time (Earth Orbital Case). For lunar returns RET is zero at RRT. For earth orbital entries RET is zero at the deorbit burn time.
RHC	Rotational Hand Controller
RNG	Range
ROU	Routine
RRT	Reentry Reference Time (Based on MCC-H predicted time of EI to nearest second)
RSI	Roll Stability Indicator
RTGO	Range to Go
SA	Shaft Angle
SCS	Stabilization and Control System
SEC	Secondary
SECS	Sequential Events Control Subsystem
SEL	Select
SEP	Separation
SEQ	Sequential
SFT	Shaft Angle for SXTS when spacecraft is at ignition attitude
SM, S/M	Service Module
SPA	COAS Star Pitch Angle
SPS	Service Propulsion System
STBY	Standby
SXP	Star X Position (COAS)
SXT	Sextant
STS	Sextant Star
TA	Trunnion Angle
TB	Talkback Display, Time Base
TBD	To Be Determined
TERM	Terminate
TF	Time From
TFF	Time of Freefall
THBWLS	Thumbwheels
THC	Translational Hand Controller
TIG	Time of Ignition
TLI	Translunar Insertion
TM, TLM	Telemetry
TRNFR	Transfer
TVC	Thrust Vector Control
V	Velocity or DSKY Verb
VG	Velocity To Be Gained
VIO	Inertial Velocity
VL	Skipout Velocity
VM	Velocity Measured
Y	Yaw

3.0 LUNAR RETURN ENTRY TECHNIQUES

The timeline for lunar return entries is based on the recommendations found in reference 1, the simulator validated procedures in reference 2, and the mission validated procedures listed in the onboard checklist for the C Prime mission. The event times are listed in reference 3.

The preparation for lunar return entries begins at a convenient time about 30 hours before entry interface. At this time MSFN sends up all data sufficient for reentry, also an EMS entry selftest is made to assure maximum confidence in the EMS operation during entry. Thereafter various system powerups and checks are initiated as listed in section 5.1 and detailed in reference 4. Nominally, the PGNCS is up for the entire mission. However, if it is not, it is powered up at EI-7 hours in preparation for the last MCC and entry. The last MCC decision is made at about EI-6 hours for the maneuver to be performed at EI-3 hours if needed. Details of this maneuver are outlined in reference 1. After the MCC time P52 is again selected and the IMU is realigned to the REFSMMAT. If the IMU drift is within tolerance, the subsequent IMU/SCS drift check will determine if the SCS has drifted excessively. If so, the other BMAG's are selected and the IMU/SCS check repeated. This check is followed by a repeat of the EMS ΔV counter check and accelerometer bias check at EI-1 hour 15 minutes to determine if the scale factor and bias are adequate for entry monitoring. Final stowage, CM RCS preheat and pyro circuit and sequential tests are worked into this timeframe so that at EI-50 minutes the MSFN will be requested for a go to pyro arm by the crew in preparation for separation. At 45 minutes before EI the CMC update program P27 can be selected to permit update of the landing point location and the state vector. The entry PAD data, shown in section 7.0, is then voiced to the crew and recorded From this data the DET is set and started, the EMS initialized, and the RSI aligned. Prior to EI-20 minutes the crew will have strapped-in, completed their preseparation checklist, and maneuvered to the entry attitude. At this point, EI-19 minutes, the CMC entry program P61 is selected by the CMP. If there was no entry PAD data because of communication loss, the velocity and range to go from P61 is recorded and used in the EMS. At EI-15 minutes the spacecraft is pitched down and the horizon is checked against the 31.7 degree window scribe line and the FDAI attitude. If there is significant disagreement the PGNCS is suspected and the spacecraft is held on the window reference. In P62 the spacecraft is yawed 45° from this attitude and separated from the SM. After separation the CM is yawed back in plane and the horizon check repeated. At approximately EI-10 minutes the pitch attitude is within 45° of the CMC commanded attitude and P63 is entered automatically. Since the CMC DAP tries to hold local pitch attitude and the CMC is not in control the crew observes the pitch error needle unpeg and approach zero about two minutes before .05g time. This serves as a go/no go CMC

check for entry control. If the FDAI pitch error does not decrease to within $\pm 5^{o}$ at 0.05g, the PGNCS is failed and the crew flies a constant g entry mode with EMS ranging after the velocity decrease to 25,500 feet per second. If the PGNCS is acceptable the spacecraft control is placed in CMC and the CMC mode is placed in automatic. At .05g the EMS automatically starts if the EMS mode switch was positioned to automatic earlier. This will be backed up manually 3 seconds after the ground computed .05g time recorded on the entry PAD by placing the EMS mode switch in manual if it has not started automatically. At PGNCS 0.05g indication, the CMC program changes to P64 and from this point the entry is under entry DAP control.

The lunar return entry nominally is performed by the PGNCS to insure control within the overshoot and g limit lines as well as optimize the landing point accuracy. Although the high speed entry involves a rapid sequency of events there are several monitoring tasks for the crew to determine if the automatic control is performing correctly.

An entry corridor verification check is made by observing the initial slope of the EMS V-g trace between 1 and 2 g's. If the EMS indicates the need to reverse the LV orientation and the independent g meter confirms the EMS g indication, the SC is immediately oriented as a result of the EMS indication.

The EMS g indication is continuously checked during entry using the independent g meter and the PGNCS g indication as a third vote. Decisions during the first entry (P64) are critical in terms of both excessive g lines and the PGNCS is not commanding (and SC responding) to correct the situation, the PGNCS is failed.

The PGNCS go/no go check for short range targets (1200-1400 n mi) for which P65 is not used is different since there are no CMC computed skip drag (DL) and skip velocity (VL) values. The check uses the EMS scroll to determine if the PGNCS is commanding the proper roll attitude to converge the EMS g level to a predetermined PAD value (D_o) as computed by MCC-H. For the nominal target range of 1,300 nautical miles, the crew will monitor the program change from P64 to P67 at approximately EI + 3 minutes. For ranges greater than 1,400 nautical miles, the program will transfer to the Upcontrol Program, P65, when VL is between 18,000 and 25,766 feet per second and constant drag has brought the CMC predicted range to within 25 nautical miles of the target range. The P65 PGNCS go/no go check consists of determining if both the DSKY display of skipout drag (DL) and skipout velocity (VL) are within the PAD limits. In addition, the EMS scroll is monitored to determine if the trace is approaching the DL and VL values.

Throughout entry the crew monitors the spacecraft response to the CMC roll commands by observing the FDAI indications. If the commands are

apparently good and in agreement with the EMS but the spacecraft response is questionable, the crew manually takes over and flies the CMC commands.

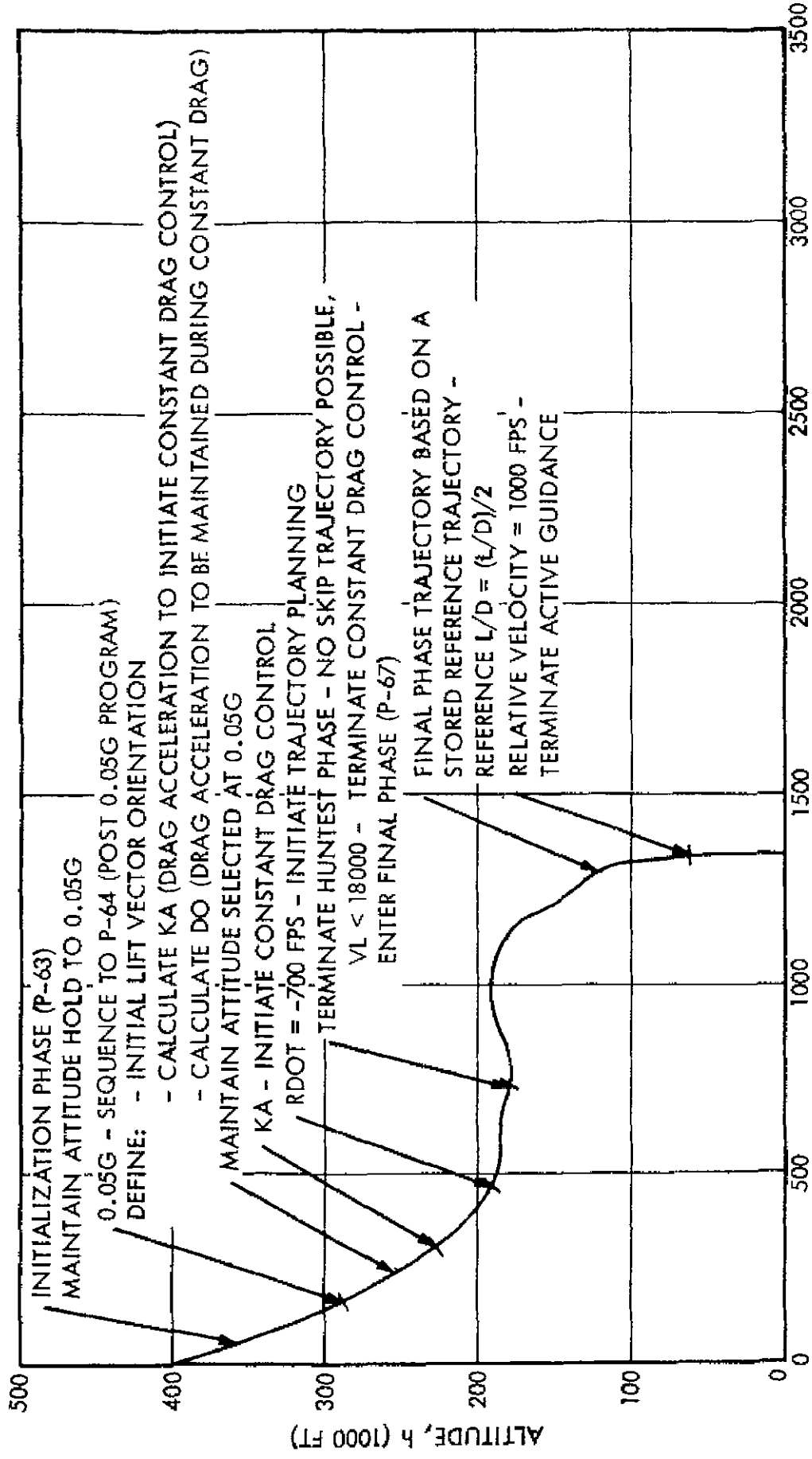
If the Upcontrol Program, P65, was entered, the program will nominally switch to the Final Entry Program, P67, for target ranges below approximately 1,800 nautical miles or to the Ballistic Program, P66, for ranges greater than approximately 1,800 nautical miles. The program transfer criteria are more precisely defined in reference 1.

If P66 is entered, the spacecraft is automatically rolled to the liftup, heads-down attitude to permit the horizon to be viewed from the window during the second entry. The entry attitude check is made by comparing the horizon with a specified window mark. If the check fails, the crew manually maintains the entry trim attitude using the horizon view for reference. The EMS is used for ranging, since the velocity has now decreased to below 25,500 feet per second.

The EMS scroll is continuously used to monitor for excessive g conditions during the second entry. If the EMS V-g trace violates the g lines and the PGNCS is not commanding (and spacecraft responding) to correct the situation, the PGNCS is failed, and the EMS is used for ranging after its g indication has been confirmed by the independent g meter.

The entry phase is essentially over when the relative velocity of the spacecraft decreases to less than 1,000 feet per second. This is indicated in P67 when RTGO, latitude, and longitude are displayed Since very little ranging capability exists after this point, the spacecraft is oriented either full lift up or down depending on RTGO negative or positive and the crew prepares for the earth landing phase.

3.1 REENTRY GUIDANCE EVENTS



Reference 10

TRAJECTORY EVENT	TIME FROM ENTRY INTERFACE MIN.SEC
400,000 FT	00 00
ENTER S-BAND BLACKOUT	00 26
0 05 G	00·30
KA - INITIATE CONSTANT DRAG	00·52
RDOT = -700 FPS	01.20
PEAK G	01·24
P64 TO P67	02 10
EXIT S-BAND BLACKOUT	03·26
GUIDANCE TERMINATION	07 30
DROGUE DEPLOYMENT	08 33.2
MAIN DEPLOYMENT	09·22 0
TOUCHDOWN	14 15 2

L/D = 0.286
V = 36,221 R = 1350
γ = -6 48

Reference 10

3.2 SUMMARY OF MONITORING CHECKS FOR ENTRY

TIME	MONITORING TEST	PURPOSE OF TEST	EFFECT OF FAILURE
EI - 30 HR	EMS SELF TEST	• DETERMINE IF EMS SATISFACTORY TO MONITOR ENTRY • THIS TEST IS MADE AT THIS TIME BECAUSE THIS IS THE LAST POSSIBILITY TO MOVE LANDING SITE	• IF EMS IS FAILED NO TARGET RANGE GREATER THAN 1800 N MI WILL BE ALLOWED • IF ALL ACCESSABLE TARGETS HAVE BAD WEATHER A MCC BURN MUST BE MADE TO MOVE THE LANDING AREA TO AN ACCEPTABLE AREA
EI - 1 HR	EMS SELF TEST	DETERMINE IF EMS IS SATISFACTORY FOR MONITORING ENTRY	• CONSTANT G BECOMES PRIME BACKUP MODE AND RANGING WILL BE LIMITED TO 1250 N MI
EI - 17 MIN	IS THE HORIZON VISIBLE	TO DETERMINE IF IMU-HORIZON CHECK CAN BE PERFORMED	• THE IMU-HORIZON CHECK CAN NOT BE PERFORMED • THE VEHICLE SHOULD BE PITCHED TO ENTRY TRIM ATTITUDE THEN VERIFY THAT THE ATTITUDE IS THE ENTRY TRIM ATTITUDE VIA THE COAS • IF COAS STAR NOT VISIBLE, FAIL GNCS, MANEUVER TO OBTAIN STAR AND MAINTAIN INERTIAL ATTITUDE WITH COAS STAR USE EMS FOR ENTRY IF AVAILABLE
EI - 17 MIN	IMU-HORIZON CHECK WITH HORIZON ON 31 7 DEG WINDOW MARK FDAI BALLS SHOULD READ WITHIN ±5 DEG OF ATTITUDE PASSED FROM GROUND	CHECK OF IMU ALIGNMENT	• FAIL FDAI BALL NOT IN AGREEMENT WITH HORIZON CHECK ISOLATE ERROR SOURCE TO FDAI BALL OR IMU ERROR • IF SCS HAS FAILED GNCS IS GO, NO BACKUP FDAI IS AVAILABLE, AND EMS RSI IS SUSPECT FOR ENTRY MONITORING • IF IMU HAS FAILED, GNCS IS NO-GO FOR ENTRY USE EMS IF AVAILABLE
EI 15 MIN TO RET 0 05 G	CMC HORIZON CHECK MANUALLY TRACK HORIZON AND MONITOR • PITCH ERROR NEEDLE SHOULD GO TO ZERO 5 DEG AT 0 05 DEG • FDAI BALL SHOULD AGREE WITHIN ±5 DEG OF GROUND GIMBAL ANGLES AT 0 05 G AT 0 05 G TRIM HORIZON SHOULD BE AT 34 DEG MARK	CHECK OF IMU ALIGNMENT AND GUIDANCE CALCULATION OF TRIM ATTITUDE	• GNCS IS NO GO FOR ENTRY, USE EMS IF AVAILABLE
EI +30 SEC 0 05 G	CMC PROGRAM SHOULD SEQUENCE FROM P63 TO P64 AT RET 0 05 G +5 SEC	VERIFY PIPA SENSING OF G-LEVEL	• GNCS IS NO GO FOR ENTRY USE EMS IF AVAILABLE
EI - 30 SEC 0 05 G	EMS SHOULD AUTOMATICALLY INITIATE AT RET 0 05 G 3 SEC	TO VERIFY EMS SELF INITIALIZATION	MANUALLY INITIATE EMS • AT RET 0 05 G - 3 SEC • IF MANUAL INITIALIZATION UNSUCCESSFUL EMS ENTRY NO GO, USE CONSTANT-G BACKUP MODE
EI + 60 SEC	CORRIDOR VERIFICATION CHECK IF VERIFIED EMS INDICATES VIOLATION OF OFF-SET LINES DETERMINE IF CMC IS AT PROPER ATTITUDE	VERIFY INITIAL LIFT VECTOR ORIENTATION	• REVERSE INITIAL ATTITUDE - RETURN CONTROL TO CMC AT 2 0 G IF COMMANDING PROPER ATTITUDE

3.2 SUMMARY OF MONITORING CHECKS FOR ENTRY (CONT'D)

TIME	MONITORING TEST	PURPOSE OF TEST	EFFECT OF FAILURE
CONTINUOUS EMS CHECK	VERIFY THAT EMS G-LEVEL IS WITHIN ± 1 0 G OF G METER	VERIFY EMS OPERATION	• IF GNCS AVAILABLE, CALL UP DSKY DISPLAY OF G-LEVEL FAIL SYSTEM NOT IN AGREEMENT WITH OTHER TWO
P64-P65	CONTINUOUS EMS-CMC CHECK VERIFY THAT THE EMS V G TRACE DOES NOT VIOLATE OFF-SET AND ONSET LINES WITH THE CMC NOT COMMANDING 180 ± 15 DEG (OFFSET) OR 0 ± 15 DEG (ONSET)	VERIFY PROPER ENTRY TRAJECTORY	• GNCS NO GO - COMPLETE ENTRY WITH EMS
P64	MONITOR THAT CMC IS COMMANDING PROPER ATTITUDE TO CONVERGE EMS G-LEVEL TO DO	VERIFY PROPER ENTRY TRAJECTORY	• GNCS NO GO - COMPLETE ENTRY WITH EMS
P64	VERIFY SEQUENCING TO P65 OR P67	VERIFY GNCS	• GNCS NO GO - COMPLETE ENTRY WITH EMS
P65	VL, DL CHECK VERIFY THAT CMC VALUE FOR VL IS WITHIN ±800 FPS AND DL IS WITHIN ±0 6 G OF GROUND VALUES AND THAT 18000 VL VSAT	VERIFY CMC PLANNED REFERENCE TRAJECTORY	• GNCS NO GO - COMPLETE ENTRY WITH EMS
P65	VERIFY THAT EMS V, G TRACE APPROACHES P65 VALUES OF VL DL WITHOUT VIOLATING OFFSET LINES	VERIFY ENTRY TRAJECTORY	• GNCS NO GO FOR ENTRY USE EMS IF AVAILABLE
P66	VERIFY WITH HORIZON THAT CM IS IN PROPER TRIM ATTITUDE FOR SECOND ENTRY	VERIFY TRIM ATTITUDE	• GNCS NO GO FOR SECOND ENTRY - USE EMS RANGING
P67	VERIFY EMS V, G TRACE DOES NOT VIOLATE G ONSET LINES WITHOUT CMC COMMANDING 0 - 15 DEG	VERIFY ENTRY TRAJECTORY	• GNCS NO GO - COMPLETE ENTRY WITH EMS

Reference 10

3.3 MONITORING WITHOUT EMS G-METER PRIMARY MONITORING DEVICE

APPLICABLE PROGRAM	MONITORING TEST	REASON FOR TEST	EFFECT OF FAILURE
P64-65	IF GNCS COMMANDS A 90 DEG BANK ANGLE FOR MORE THAN 1 COMPUTER CYCLE (2 SECONDS) THE G LEVEL FROM THE G METER SHOULD READ ≥ 5 4 G DURING THOSE CYCLES (GNCS |ROLLC| ≤ 90.0 DEG FOR G LEVEL > 5.4 G)	DETECT LARGE ACCELEROMETER ERROR	GNCS NO-GO, FLY CONSTANT G BACKUP MODE
P64	VERIFY GNCS IS COMMANDING CORRECT BANK ANGLE TO CONVERGE G LEVEL TO GNCS CONSTANT DRAG VALUE, DO	VERIFY PROPER TRAJECTORY CONTROL	GNCS NO-GO, FLY CONSTANT G BACKUP MODE
P65	VERIFY THAT GNCS VL - DL SOLUTION IS WITHIN PAD LIMITS	VERIFY PROPER P65 END CONDITIONS	GNCS NO-GO, FLY CONSTANT G BACKUP MODE
P67	VERIFY THAT GNCS ROLLC IS 0 ± 15 DEG FOR DRE < -9.0	VERIFY P67 TRAJECTORY CONTROL	GNCS NO-GO, FLY CONSTANT G BACKUP MODE

Reference 10

4.0 EARTH ORBITAL DEORBIT AND ENTRY TECHNIQUES

As outlined in reference 5, a nominal PGNCS entry from earth orbit is based on a preparation time of 2 hours and 40 minutes, including 2 night passes. This time includes approximately 20 minutes before the first night pass after the CMC update and PAD data have been received. This time also includes approximately 20 minutes after the second night pass to allow sufficient time to prepare for retrofire after the IMU fine alignment It has been determined coarse alignment accuracy is adequate for retrofire and entry and undoubtedly other functions could be omitted depending on the circumstances for the decision to reenter. Described herein are the nominal earth orbital entry procedures with pertinent comments on system validation for real time acceptance decisions.

After the entry decision is made the crew transfers the PGNCS from the standby to the operate mode and receives a CMC update with P27. Next, the maneuver PAD update is voiced up and the initial entry mode is determined. During the initial night pass the IMU orientation is established using P51 star sightings to obtain a REFSMMAT. The preferred orientation option in P52 is then selected to coarse align the IMU using the desired entry REFSMMAT determined by MCC-H. The GDC is now aligned to the IMU in preparation for an IMU/SCS drift check. If the GDC indicates the SCS drift rate exceeds 10 degrees per hour in any axis the check is repeated on the other BMAG's to establish if the GDC or just the single set is unusuable. Various sytem checks as listed in section 5.1 are performed as necessary consistent with the timeline dictates of the major activities Included in these checks are the EMS self-tests and the ΔV counter test. The latter requires the spacecraft be placed in drifting flight with the function switch in the ΔV position. If the counter registers a change of more than 25 feet per second within 100 seconds the scroll and counter are unreliable for monitoring the deorbit burn and entry ranging. If the EMS self-test fails and time does not allow further analysis a 55/55 BRB entry is planned as the PGNCS backup entry mode. After completion of these checks the entry PAD is provided by MCC-H The crew then selects the external ΔV program P30 and the appropriate deorbit thrusting program P40 or P41. During this period, which includes the final night pass, P52 may be selected to verify the IMU alignment. Since the retro attitude has been computed so that a window mark coincides with the horizon at GETI, this serves as the conclusive check on the PGNCS. At 5 minutes before retrofire the attitude check is made by verifying that the 12 degree scribe line is within 3 degrees of the horizon If not, the PGNCS has failed and the SCS is used for attitude reference and the ΔV counter for burn duration control. Since the SCS attitude was aligned to the IMU, a realignment is necessary. This is accomplished by manually maneuvering the spacecraft to maintain the 24 degree window mark on the horizon and releasing the GDC align button at TIG - 2 minutes.

Upon completion of the burn the ΔV residuals are burned to within 0.2 feet per second. If the PGNCS, ΔV counter, or estimated burn duration are in disagreement it must be established whether sufficient velocity has been supplied to put the landing point in the footprint. The PGNCS data will be used if it is confirmed by one other source, if not the ΔV counter will be used if it is confirmed by the burn duration time. If additional ΔV is necessary the data is available to the crew on an onboard chart found in Section 8.0.

Post burn entry preparation requires EMS initialization, RSI alignment and pre-separation functions. The crew then selects the initial entry program P61 and records the displays as a check against PAD data Upon completion of these checks P62 is entered. The crew manually orients the spacecraft to the separation attitude and yaws 45^{o} to insure against possible CM SM recontact. After separation the spacecraft is maneuvered to the reentry trim attitude which places the horizon on the 31.7^{o} window mark at EI. Shortly thereafter in P62 the entry DAP is activated and P63 initiated. During this time MCC-H has computed a postburn update and it is voiced to the crew if different from preburn values. The EMS scroll and range counter will be adjusted accordingly if time permits A final PGNCS check prior to .05g may be monitored at this time. With the CMC mode in free and the manual attitude pitch in acceleration command while the horizon reference is held, the pitch error needle will decrease to zero as EI is reached. At RET 0.05g, the EMS mode switch is turned to manual, the entry 0.05-g switch and EMS roll switch are turned on, and the spacecraft control switched to CMC to begin DAP control. At the PGNCS 0.05-g indication, the program change from P63 to P64 is monitored and the time voice recorded. At this time the EMS range counter check is made during the 10 second period following EMS 0.05g. During this period the counter should count down 40 ± 10 nautical miles. At PGNCS 0.2-g indication the change from P64 to P67 is monitored and the display may be held by keying VERB in order to record the initial downrange error display and compare it to the PAD value. The PGNCS has failed if the two do not agree within ± 100 nautical miles. In the event P67 has not appeared when both the g-meter and the scroll indicate greater than 0.5g, the PGNCS has similarily failed. In either failure the SCS is used for attitude reference with an EMS entry. If the checks agree the crew remains with automatic DAP for the remainder of the entry.

The entry phase is essentially over when the relative velocity of the spacecraft decreases to less than 1000 feet per second. This is indicated in P67 when RTGO, latitude, and longitude are displayed. Since very little ranging capability exists after this point, the spacecraft is oriented either full lift up or down depending on RTGO negative or positive and the crew prepares for the earth landing phase.

4.1 Typical Retrofire and Entry Sequence of Events

Decision to reenter

P27 (CMC update)

Retrofire PAD update

Entry mode decision

P51 (IMU orientation determination) during first dark period

P52 (IMU coarse alignment)

EMS checks

Entry PAD update

P30 (external ΔV)

P40 (SPS thrust)

P52 (IMU fine alignment) during second dark period

P40 (SPS thrust)

Ignition attitude check

Retrofire

P61

P62

CM/SM separation

P63

Postburn PAD update

Entry attitude check

P64 (begin DAP control at 0.05g)

P67 (PGNCS go/no go check at 0.2g)

4.2 Retrofire and Entry Alternatives

System failure	Failure before committed to nominal GETI (before nom GETI -3 mins)	Failure after committed to nominal GETI (after nom GETI -3 mins)	Failure after committed to ballistic reentry (after delayed GETI -5 mins)
PGNCS	SCS burn at nominal GETI and EMS entry	SCS burn at nominal GETI and EMS entry	----------
PGNCS and EMS	Delay* GETI for SCS burn and (90/90) BRB ballistic entry	SCS burn at nominal GETI and (55/55) BRB entry	Delay GETI for SCS burn and (90/90) BRB ballistic entry
PGNCS and all onboard attitude reference	Delay** GETI for horizon monitor burn and rolling ballistic entry	Horizon monitor burn and rolling ballistic entry	Horizon monitor burn and rolling ballistic entry

*If voice communications fail, proceed with nominal GETI and use (55/55) BRB entry.

**If voice communications fail, proceed with nominal GETI and use rolling ballistic entry.

5 0 DETAILED ENTRY PROCEDURES

In order to combine similar procedures that are common to lunar return entries and earth orbit entries the following procedures are divided into categories that allow a minimum of duplicity. This provides a smaller training package and more closely resembles the onboard crew checklist when comparison is necessary.

5.1 Entry Preparations for Supercircular and Earth Orbital Entries

The entry preparations are combined in these procedures and steps peculiar to either supercircular or earth orbital entries are labeled accordingly. The time listings in this section are applicable to only supercircular entries since the earth orbital entry timeline is a function of several variables as described in section 4.0 and reference 5.

5.1 (Continued)

VEHICLE PREPARATION

1		INITIAL STOWAGE COMPLETED
2		CMC & ISS START UP
3		SCS POWER UP
4		P51 - IMU ORIENTATION
5		LOAD DAP V48E 11102, 01111, PRO, PRO, PRO
6	-06:00h	LAST MCC DECISION
7	-05:35h	NO COMM - P52 & NAV SIGHTINGS NOMINAL - P23/37 ONBOARD COMPARISON
8		DON MAE WESTS & FOOT RESTRAINTS
9		VHF AM A - SIMPLEX
10	-04:30h	P27 (SV,REFSMMAT), MNVR & ENTRY PAD UPDATES
11	-04:15h (__:__:__)	P52 - IMU REALIGN (OPTION 1)
12		P37 (NO COMM ONLY)
13		ECS CKS 02 SUPPLY REFILL ECS Monitor Ck EVAP H2O CONT (2) vlvs - AUTO SUIT HEAT EXCH SEC GLY - FLOW
14		EPS CKS #1, 3, 4 (5 if req'd)
15		SPS CK (If req'd)
16		RCS CKS SM RCS Monit Ck CM RCS Monit Ck
17		C&W SYS CK
18		CMC SELF CK

19 DSKY COND LT TEST

20 -03:45h MIDCOURSE MANEUVER
P30 - EXT ΔV
-03:15h P40/41 - SPS/RCS THRUSTING
-03:00h MIDCOURSE (#7) BURN

21 NO COMM NAV SIGHTINGS

22 MNVR TO ENTRY ATT (Supercirc only)
V62E

22A V49E

22B F 06 22 DESIRED FINAL GMBL ANGLES (.01°)
LOAD ENTRY ATT PAD ANGLES
PRO

22C F 50 18 REQ MNVR TO FDAI RPY ANGLES (.01°)
(AUTO) SC CONT - CMC
BMAG MODE (3) - RATE 2
CMC MODE - AUTO
PRO
(MAN) SC CONT - SCS
MNVR to 22E

22D 06 18 AUTO MNVR TO FDAI RPY ANGLES (.01°)

22E F 50 18 REQUEST TRIM (.01°)
(TRIM) Go to 22C
(BYPASS) ENTR

23 -2:00hr BORESIGHT & SXT STAR CHECK
OPT MODE - CMC
OPT ZERO - OFF

V41 N91E

F 21 92 SHAFT, TRUN (.01°,.001°)
Load SXTS angles

41 OPTICS DRIVE

CHECK SXT STAR
OPT ZERO - ZERO
CHECK BORESIGHT STAR (If avail)

24 -01:35h **P52 - IMU REALIGN**

Record gyro torquing angles
R _____
P _____
Y _____
If >1°, recycle P52
If confirmed, use SCS for EMS entry

25(__:__:__) **GDC ALIGN**

If drift >10°/hr, change rate source

26 **FINAL STOWAGE**

OPTICS (except for hybrid)
ORDEAL
GLY TO RAD SEC - BYPASS (verify)
Cool pnl installed
Y-Y struts (2) extended
Stow Data Box R-12

27 -01:15h **EMS CHECK**

EMS FUNC - OFF
cb EMS (2) - close
EMS MODE - STBY
EMS FUNC - EMS TEST 1 (wait 5 sec)
EMS MODE - NORMAL (wait 10 sec)
  Check ind lts - off
  RANGE ind - 0.0
  Slew hairline over notch
    in self-test pattern
EMS FUNC - EMS TEST 2 (wait 10 sec)
  .05G lt - on (all others out)
EMS FUNC - EMS TEST 3
  .05G lt - on
  RSI Lower lt - on (10 sec later)
  Set RANGE counter to 58 nm±0.0
EMS FUNC - EMS TEST 4
  .05G lt - on (all others out)
  G-V trace within pattern to lwr rt
    corner @9G
  RANGE ind counts down to 0±0.2
EMS FUNC - EMS TEST 5
  .05G lt - on
  RSI upper lt - on (10 sec later)
  RANGE ind - 0.0
  Scribe traces vertical line 9g to
    0.22±0.1
ALIGN SCROLL TO ENTRY PATTERN (on
  37K ft sec line)
EMS FUNC - RNG SET
  G-V scroll assy traces vert. line
    0.22g to 0±0.1
EMS MODE - STBY

28 ΔV TEST (Deorbit only)

EMS FUNC - ΔV SET/VHF RNG
SET ΔV ind to 1586.8 fps
EMS MODE - NORMAL
EMS FUNC - ΔV TEST
SPS THRUST LT - on/off (10 sec)
ΔV ind stops at -0.1 to -41.5
EMS MODE - STBY

29 PRIMARY WATER EVAP ACTIVATION

GLY EVAP H2O FLOW - AUTO
GLY EVAP STM PRESS - AUTO
PRI ECS GLY PUMP - AC1

30 -01:10h CM RCS PREHEAT

Note: If sys test mtr 5c,d,6a,b,c,d all read 3.9 vdc (28°F) or more, omit preheat
cb RCS LOGIC (2) - close
CM RCS LOGIC - ON
UP TLM CM - BLOCK (verify)
cb CM RCS HTRS (2) - close
CM RCS HTRS - ON (LMP Confirm)
(20 min or til lowest rdg is 3.9 vdc) (Monitor Manf press for press drop)

31 (__:__:__) FINAL GDC DRIFT CK (If req'd)

If drift >10°/hr, Suspect GDC. Do not use RSI & FDAI #2

32 -00:50m TERM. CM RCS PREHEAT

UP TLM CM - BLOCK (verify)
CM RCS HTRS - OFF
CM RCS LOGIC - OFF

33 SYSTEMS TEST PANEL CONFIGURATION

SYS TEST METER - 4B
RNDZ XPNDR - OPERATE
CM RCS HTRS - OFF
WASTE H2O DUMP - OFF
URINE DUMP - OFF

34 LEB LIGHTING - OFF

35 SEC WATER EVAP ACTIVATION

GLY To RAD SEC vlv - BYPASS
SEC COOL EVAP - EVAP
SEC COOL PUMP - AC2

36 PYRO BATT CK

cb PYRO A SEQ A - close (verify)
cb PRYO B SEQ B - close (verify)
DC IND - PYRO BAT A(B)
*If PYRO BAT A(B) < 35 vdc *
cb PYRO A(B) seq A(B) - open
PYRO A(B)BAT BUS A(B)TO PYRO
*MN BUS TIE - close *
cb MNA BAT C - close
cb MNB BAT C - close
DC IND - MNB
PNL 8 - All cb's closed except:
PL VENT - open (verify)
FLOAT BAG (3) - open (verify)
DOCKING PROBE (2) - open (verify)
EDS BAT (3) - open (verify)
CM RCS HTRS (2) - open

37 CM RCS ACTIVATION

cb SECS ARM (2) - close (verify)
cb SECS LOGIC (2) - close (verify)
SECS LOGIC (2) - ON
MSFN confirm GO for PYRO ARM(if poss)
SECS PYRO ARM (2) - ARM
CM RCS PRPLNT 1&2 - ON
CM RCS PRESS - ON
RCS Ind sw - CM1, then 2
He PRESS 3700-4400 psia
MANF PRESS 287-302 psia
SECS PYRO ARM (2) - SAFE
SECS LOGIC (2) - OFF

38 -00:45m P27 & ENTRY PAD UPDATE

Go To Entry Checklist
Supercirc - pg 23
Hybrid - pg 29
Normal Deorbit - pg 35

5.2 SUPERCIRCULAR ENTRY

1 SET DET (up, to EI)

2 EMS INITIALIZATION
SET RNG TO PAD DATA RNG
EMS FUNC - Vo SET
Slew Scroll to Pad Data VIO
EMS FUNC - ENTRY

3 RSI ALIGNMENT
FDAI SOURCE - ATT SET
ATT SET - GDC
EMS ROLL - on (up)
GDC ALIGN PB - PUSH & HOLD
YAW Tw - Position RSI thru
45° & back to LIFT UP
GDC ALIGN PB - Release
EMS ROLL - OFF
Align GDC to IMU

4 CM RCS RING A CK
RCS TRNFR - CM
cb CM RCS LOGIC MNB - open
AUTO RCS SEL MNB (6) - OFF
SC CONT - SCS
Test Ring A Thrusters
SC CONT - CMC
RCS TRNFR - SM
AUTO RCS SEL (12) - MNA/MNB
(liftoff config)
cb CM RCS LOGIC MNB - close

5 OPTICS PWR - OFF
CMP to COUCH

30:00m (-30·00) MN BUS TIE (2) - ON
TAPE RCDR - REWIND

6 35·00m (-25·00)

SEPARATION CK LIST

TVC SERVO PWR 1 - AC1/MNA
cb ELS (2) - close (verify)
PRIM GLY TO RAD - BYPASS (pull)
PLSS O2 vlv - FILL
O2 SM SUPPLY vlv - OFF
CAB PRESS REL vlv (2) - NORM
GMBL MTRS (4) - START
ABORT SYS PRPLNT - RCS CMD (verify)
SM RCS PRIM PRPLNT (4) - ON
VHF AM (A&B) - OFF
HI GAIN ANT PWR - OFF
FC PUMPS (3) - OFF
Verify single suit compr oper,
loads balanced
FC 2 MN A&B - OFF
S BD PWR AMP - LOW
cb ECS RAD CONT/HTR (2) - open
cb WASTE H2O/URINE DUMP HTRS (2) - open
cb HTRS OVLD (2) - open
POT H2O HTR - OFF
CAB FAN (2) - OFF
GLY EVAP TEMP IN - MAN
SEC COOL EVAP - RESET
SEC COOL PUMP - off (ctr)

MNVR TO CM/SM SEP P, R ATT

SC CONT - SCS
CMC MODE - FREE
MNVR TO PAD ATT
R _____(0°)
P _____
Y _____(0°)

SUPERCIRCULAR ENTRY (Continued)

41:00m (-19:00) P61 - ENTRY PREP

1 V37E 61E

* 05 09 01427 - ROLL REVERSED*
* 05 09 01426 - IMU UNSAT *

2 F 06 61 IMPACT LAT, LONG, HDS UP/DN (+/-)
PRO (.01°,fps,±00001)

3 F 06 60 GMAX,VPRED,GAMMA EI (.01°,fps,.01°)
Record
GMAX _____
V400K _____
GAMMA EI _____
PRO

4 F 06 63 RTOGO (.1nm) _____ PAD _____
VIO (fps) _____ PAD _____
TFE(min-sec) _____
Compare with MSFN for PGNS GO/NO GO
If NO COMM, Set RTOGO & VIO in EMS
& initialize
(ACCEPT) PRO
(RECALC) V32E To 4

P62 - CM/SM SEP & PRE-ENTRY MNVR
CAUTION: Call No EXT Verbs In P62

5	F 50 25	00041 REQUEST CM/SM SEP
		SC CONT - SCS/FREE
	43:00m	COMPARE PITCH ATT WITH PAD DATA (within 5°)
	(-17:00)	YAW - 45° OUT-OF-PLANE (LEFT)
		RATE - HIGH
		ATT DB - MIN
		MAN ATT (3) - RATE CMD
		BMAG MODE (3) - ATT1/RATE 2
		MN BUS TIE (2) - ON (verify)
		PRIM GLY TO RAD - BYPASS (verify)
		CM RCS LOGIC - ON (verify)
		SECS LOGIC (2) - on (up)
		SECS PYRO ARM - ARM
	45:00m	CM/SM SEP (2) - ON
	(-15:00)	CSM/LM FNL SEP (2) - on (up) (verify)
		C&W MODE - CM
		RCS TRNFR - CM
		CM RCS MANF PRESS - 287-302 psia
		CM RCS LOGIC - OFF
		SECS PYRO ARM (2) - SAFE
		Monitor VMA/B:
		If <25 vdc go to EMERG
		POWERDOWN pg E/6-1
	50:00m	AUTO RCS SEL A/C ROLL (4) - OFF
	(-10:00)	AUTO RCS SEL CM 2(6)-OFF
		AUTO RCS SEL CM 1(6)-MNA
		YAW back to 0°
		PITCH TO HORIZ TRACK ATT
		ROLL - 0° (LIFT UP)
		PITCH - 400K Horiz Mark (31.7°)
		YAW - 0°
		ATT DB - MAX
		MAN ATT PITCH - ACCEL CMD
		EMS DATA - Verify
		EMS FUNC - ENTRY (verify)
		EMS MODE - NORMAL
		cb SPS P&Y (4) - open
		MAINT HORIZ TRK
		PRO (Act ENTRY DAP)
6	F 06 61	IMPACT LAT,LONG,HDS/DN (.01°,.01°,-00001)
		PRO
7	POSS 06 22	FINAL ATT DISP, RPY (.01°)
		(Only if X-axis beyond 45° of Vel vector)

P63 - ENTRY INIT

8 06 64 G,VI,RTOGO (.01G,fps,.1nm)
FDAI SCALE - 50/15
ROT CONTR PWR DIR (both) - MNA/MNB
TAPE RCDR - CMD RESET/HBR/FWD
58·00m HORIZ CK
(-02:00) Pitch error needle goes toward zero approaching .05G time
MAN ATT (PITCH) - RATE CMD
If CMC is GO:
BMAG MODE (3) - RATE 2
SC CONT - CMC/AUTO

* If DAP NO GO *
* SC CONT - SCS *
* FLY BETA *
* If CMC NO GO: *
* SC CONT - SCS *
* FLY EMS *

P64 - ENTRY POST .05G

9 RTOGO AT .05G AGREES WITH EMS-verify
HORIZ CK
.05G Lt - ON (EMS START)
.05G time
(+0__:__) * No EMS START within 3 sec: *
(__·__:__) * EMS MODE - BACKUP/VHF RNG *

.05G sw - on (up)
EMS ROLL - on (up)
06 68 BETA, VI, HDOT (.01°,fps,fps)
Compare RSI & FDAI
If CMC or PAD cmds Lift DN,
MNVR Lift DN
EMS GO/NO GO
G-V Plot within limits
Rng ctr dwn 60±7 during 10 sec period
Monitor G-meter for convergence with pad data (Do)
(V<27K fps) Go to 13

P65 - ENTRY - UP CONT (V>27K fps)

10 F 16 69 BETA (.01°) _____
DL (.01G) _____ PAD _____
VL (fps) _____ PAD _____

* IF NO AGREEMENT: *
* SC CONT - SCS *
* FLY EMS *

PRO

11 06 68 BETA,VI,HDOT (.01°,fps,fps)
(V<VL+500 fps & RDOT Neg) Go To 13

P66 - ENTRY - BALLISTIC (D<DL)

12 06 22 DESIRED GMBL ANGLES RPY (.01°)
Monitor horiz ±12° of 31.7° mark

P67 - ENTRY - FINAL PHASE (0.2G)

13 06 66 BETA,CRSRNG ERR,DNRNG ERR
(.01°,.1nm,.1nm)
KEY VERB
Record DNRNG ERR _____
KEY RLSE
Monitor lift vector on RSI & FDAI

16 67 RTOGO,LAT,LONG (Vrel=1000fps)
(.1nm,.01°,.01°)
SC CONT - SCS
RTOGO NEG - LIFT UP
RTOGO POS - LIFT DOWN
Monitor altimeter

Go To EARTHLANDING pg 45

5.3 G&N HYBRID DEORBIT

VEHICLE PREP COMPLETE

P30 - EXTERNAL ΔV

1 V37E 30E

2 F 06 33 GETI
(ACCEPT) PRO (hr,mın,.0lsec)
(REJECT) LOAD DESIRED GETI

3 F 06 81 ΔVX,Y,Z (LV) (.1fps)
(ACCEPT) PRO
(REJECT) LOAD DESIRED GETI

4 F 06 42 HA,HP,ΔV (.1nm,.1fps)
Record ΔV _____
(ACCEPT) PRO
(REJECT) Reselect P30 or P27. Load new param.

5 F 16 45 M,TFI,MGA (marks,mın-sec,.01°)
*MGA -00002· ıf *
* IMU not alıgned*

SET DET
PRO

6 F 37 00E

7 SEPARATION CK LIST
PRIM GLY TO RAD - BYPASS (Pull)
PLSS 02 vlv - FILL
02 SM SUPPLY vlv - OFF
CAB PRESS REL vlv (2) - NORM
cb ELS (2) - close
cb SECS ARM (2) - close
cb SECS LOGIC (2) - close (verıfy)
AUTO RCS SEL CM (12) - MNA or MNB
(lıftoff confıg)
ROT CONTR PWR NORM 1&2 - AC/DC
ABORT SYS PRPLNT - RCS CMD
SM RCS PRIM PRPLNT (4) - OPEN
VHF AM (A&B) - OFF

8 CMP to Couch

9		MNVR TO PAD BURN ATT LOAD DAP BMAG MODE (3) - RATE 2 SC CONT - CMC/AUTO ATT DB - MIN MAN ATT(3) - RATE CMD	
10		V62E	
11		V49E	
12	F 06 22	DESIRED FINAL GMBL ANGLES LOAD MNVR PAD GMBL ANGLES PRO	(.01°)
13	F 50 18	REQ MNVR TO FDAI RPY ANGLES (AUTO) PRO (MAN) SC CONT - SCS BMAG MODE (3) - RATE 2 MNVR To 15	(.01°)
14	06 18	AUTO MNVR TO FDAI RPY ANGLES	(.01°)
15	F 50 18	REQ TRIM TO FDAI RPY ANGLES (TRIM) Go to 13 (BYPASS) ENTR	(.01°)
16		CHECK BORESIGHT & SXT STARS OPT MODE - CMC OPT ZERO - OFF	
17		V41 N91E	
18	F 21 92	SHAFT,TRUN Load SXTS angles	(.01°,.001°)
19	41	OPTICS DRIVE Check SXT STAR OPT ZERO - ZERO Check BORESIGHT STAR (if avail)	
20		V25 N17E Load Pad Data GMBL Angles for CM BURN ATT ATT SET tw - SET to PAD DATA GMBL ANGLES for CM BURN ATT	(.01°)

21 PWR REDUCTION

HGA PWR - OFF
FC PUMPS (3) - OFF
Verify single suit compr oper, loads balanced
FC 2 MN A&B - OFF
S BD PWR AMP - LOW
cb ECS RAD CONT/HTR (2) - open
cb WASTE H2O/URINE DUMP HTRS(2)- open
cb HTRS OVLD (2) - open
POT H2O HTR - OFF
CAB FAN (2) - OFF
GLY EVAP TEMP IN - MAN
MN BUS TIE (2) - ON
TVC SERVO PWR 1 - AC1/MNA
GMBL MTR (4) - START

P41 - RCS THRUSTING

22 V37E 41E

23 F 50 18 REQ MNVR TO LCL HORIZ (HDS ON) (.01°)
(AUTO) BMAG MODE (3) - RATE 2
SC CONT - CMC/AUTO
PRO To 24
(MAN/DAP) BMAG MODE (3) - RATE 2
SC CONT - CMC/HOLD
V62E
MNVR To 25

24 06 18 AUTO MNVR TO FDAI RPY (.01°)

25 F 50 18 REQ TRIM TO LCL HORIZ (.01°)
ALIGN SC ROLL
(AUTO TRIM) PRO To 24
(BYPASS) ATT DB - MIN
RATE - LOW
MAN ATT (3) - RATE CMD
BMAG MODE (3) - ATT1/RATE 2
ENTR

55:00m

26 06 85 VGX,Y,Z (.1fps)
RECHECK BORESIGHT STAR
TRANS CONTR PWR - on (up)
EMS MODE - STBY (verify)
EMS FUNC - ΔV SET/VHF RNG
SET ΔV for SM BURN _____
EMS FUNC - ΔV
S BD ANT - OMNI C
SECS LOGIC (2) - ON
MSFN confirm Go for PYRO ARM
SECS PYRO ARM (2) - ARM
CM RCS LOGIC - ON (verify)

59·25

27 DSKY BLANKS

59:30

28 16 85 VG X,Y,Z (AVE G ON) (.1fps)
RHC's & THC - ARMED
LIMIT CYCLE - OFF
TAPE RCDR - CMD RESET/HBR
EMS MODE - NORMAL

00·00

29 F 16 85 REQ NULL VG X,Y,Z (.1fps)
BURN EMS ΔV CTR TO ZERO
RESET DET & COUNT UP
If SM ONLY burn go to step 32
THC - LOCKED
SC CONT - SCS/FREE
RATE - HIGH
PRIM GLY To RAD - BYPASS (verify)
MN BUS TIE (2) - ON (verify)
CM/SM SEP (2) - on (up)
CSM/LM FNL SEP (2) - on (up) (verify)
C&W MODE - CM
RCS TRNFR - CM
CM RCS LOGIC - OFF
Monitor VM A/B·
If <25 vdc, go to EMERG
POWER DOWN Pg E/6-1
V63E

* If CMC NO GO: *
* FDAI SOURCE - ATT SET *
* FDAI SEL - 1 or 2 *
* ATT SET - GDC *

MAN ATT PITCH - ACCEL CMD
FDAI SCALE - 5/5
MNVR TO CM BURN ATT (NULL ERR NEEDLES)
R 0°
P _____
Y 0°

30 CM RCS BURN
RHC #1-Continuous Pitch Down
RHC #2-Module Pitch to null needles
BURN VGZ TO ZERO
* If only 1 RHC *
* Pulse ± P=5° from retro att.*
* Maintain rates <3°/sec *

31 BURN COMPLETION AT:
ΔV CTR= _____ or DET= _____

V82E

32 F 16 44 HA,HP,TFF (.1nm,min-sec)
Check HP·
If > Pad data, continue burn
until < Pad
PRO

33 F 16 85 VGX,Y,Z (.1fps)
Read VG residuals to MSFN
(HYBRID) PRO to 34
(SM ONLY BURN)
PRO
F 37 00E ____

EI-15:00 V37E 47E
F 16 83 ΔVX,Y,Z (.1fps)
SC CONT - SCS/FREE
MAN ATT (PITCH) - RATE CMD
RATE - HIGH
PRIM GLY To RAD - BYPASS (verify)
MN BUS TIE (2) - ON (verify)
CM/SM SEP (2) - ON
CSM/LM FNL SEP (2) - on (up) (verify)
C&W MODE - CM
RCS TRNFR - CM
CM RCS LOGIC - OFF
SECS PYRO ARM (2) - SAFE

PRO
Monitor VMA/B:
If <25 vdc go to EMERG
POWER DOWN

34 F 37 00E

PCM BIT RATE - LOW
ATT DB - MAX
EMS MODE - STBY
EMS FUNC - OFF

Go To EARTH ORBIT ENTRY, pg 40

8			SPS THRUSTING PREP CYCLE CRYO FANS SPS GAGING - ACl (verify) PUG MODE - NORM (verify) BMAG MODE (3) - RATE 2 ΔV CG - CSM CMC MODE - FREE AUTO RCS SEL (16) - MNA or MNB (liftoff config) SC CONT - CMC/AUTO	
9			MNVR TO PAD BURN ATT V62E	
10			V49E	
11	F	06 22	DESIRED FINAL GMBL ANGLES LOAD MNVR PAD GMBL ANGLES PRO	(.01°)
12	F	50 18	REQ MNVR TO FDAI RPY ANGLES (AUTO) PRO (MAN) SC CONT - SCS MNVR to 14	(.01°)
13		06 18	AUTO MNVR TO FDAI RPY ANGLES	(.01°)
14	F	50 18	REQ TRIM TO FDAI RPY ANGLES (TRIM) Gò to 12 (BYPASS) ENTR	(.01°)
15			BORESIGHT STAR CHECK	
16			V37E 40E OPT PWR - OFF	
17	F	50 18	REQUEST MNVR TO FDAI RPY ANGLES (AUTO) BMAG MODE (3) - RATE 2 SC CONT - CMC/AUTO PRO to 18 (MAN/DAP) BMAG MODE (3) - RATE 2 SC CONT - CMC/HOLD MNVR to 19 (MAN/SCS) SC CONT - SCS MNVR to 19	(.01°)

5.4 NORMAL DEORBIT

VEHICLE PREP COMPLETE

P30 - EXTERNAL ΔV

1 V37E 30E

2 F 06 33 GETI (hr,min,.01sec)
(ACCEPT) PRO
(REJECT) LOAD DESIRED GETI

3 F 06 81 ΔVX,Y,Z (LV) (.1fps)
(ACCEPT) PRO
(REJECT) LOAD DESIRED GETI

4 F 06 42 HA,HP,ΔV (.1nm,.1fps)
Record ΔV _____
(ACCEPT) PRO
(REJECT) Reselect P30 or P27. Load new param.

5 F 16 45 M,TFI,MGA (marks,min-sec,.01°)
*MGA -00002 If *
* IMU not aligned*
SET DET
PRO

6 F 37 00E

7 SEPARATION CK LIST
PRIM GLY TO RAD - BYPASS (pull)
PLSS O2 vlv - FILL
O2 SM SUPPLY vlv - OFF
CAB PRESS REL vlv (2) - NORM
cb ELS (2) - close (verify)
cb SECS ARM (2) - close (verify)
cb SECS LOGIC (2) - close (verify)
AUTO RCS SEL CM (12) - MNA or MNB
(liftoff config)
ROT CONTR PWR NORM 1&2 - AC/DC
ABORT SYS PRPLNT - RCS CMD
SM RCS PRIM PRPLNT (4) - OPEN
VHF AM A&B - off (ctr)

18 06 18 AUTO MNVR TO FDAI RPY ANGLES (.01°)

19 F 50 18 REQUEST TRIM MNVR TO FDAI RPY ANGLES
ALIGN S/C ROLL (.01°)
GDC ALIGN

TVC CHECK & PREP
cb STAB CONT SYS (all) - close
cb SPS (12) - close
ATT DB - MIN
RATE - LOW
LIMIT CYCLE - ON
MAN ATT (3) - RATE CMD
BMAG MODE (3) - ATT1/RATE 2
ROT CONTR PWR DIRECT (2) - OFF
SCS TVC (2) - RATE CMD
If SCS, SCS TVC (2) - AUTO
* SC CONT - SCS *
TVC GMBL DRIVE P&Y - AUTO
+54·00m MN BUS TIE (2) - ON
(-06·00) TVC SERVO PWR 1 - AC1/MNA
2 - AC2/MNB
TRANS CONTR PWR - ON
ROT CONTR PWR NORMAL 2 - AC
RHC #2 - ARMED

TIG-5min HORIZ CHK - Horiz on 12° window
mark (Limit ±3° PNGCS GO/NO GO)
If NO GO set tw 180°,180°,0°
Track horiz with 24° window mark
At TIG-2 min Align GDC

55:00m PRIMARY TVC CHECK
(-05:00) GMBL MOT P1-Y1 -START/ON(LMP confirm)
If SCS, verify Thumbwheel Trim
THC - CW
Verify NO MTVC

SEC TVC CHECK
GMBL MOT P2-Y2 -START/ON(LMP confirm)
SET GPI TRIM
Verify MTVC
THC NEUTRAL
GPI returns to 0,0 (CMC) or trim (SCS)
ROT CONT PWR NORM 2 - AC/DC
(TRIM) Go to step 17
(BYPASS) BMAG MODE(3) - ATT1/RATE2 (verify)
ENTR

```
20    F 50 25    00204 GMBL TEST OPTION
           (ACCEPT)  SC CONT - CMC (verify)
                PRO
                     Monitor GPI Response:
                       00,20,-20,00,02,0-2,00,Trim
                          *TEST FAIL:        *
                          *SC CONT - SCS     *
                          *SCS TVC (2) - AUTO*
           (REJECT)  ENTR

21       06 40    TFI,VG,ΔVM                (min-sec,.1fps)
                          *PROG ALM - TIG slipped*
                          *V5N9E 01703           *
                          *KEY RLSE To 21        *
                     ROT CONTR PWR DIRECT (2) - MNA/B
                     SPS He vlvs (2) - AUTO (verify)
                     LIMIT CYCLE - OFF
                     FDAI SCALE - 50/15
                     cb SPS P2,Y2 - open (for crit. burn)
     58:00
   (-02:00)          ΔV THRUST A(B) - NORMAL
                     THC - ARMED
                     RHC (2) - ARMED
                     TAPE RCDR - CMD RESET/HBR

     59:25           DSKY BLANKS
   (-00:35)

     59·30           (AVE G ON)
   (-00:30)          EMS MODE - NORMAL

        06 40    TFI,VG,ΔVM                (min-sec,.1fps)
                     CHECK PIPA BIAS <2fps for 5 sec

     59:XX           ULLAGE AS REQ
   (-00:XX)
                          *IF NO ULLAGE:         *
                          *DIR ULLAGE PB - PUSH*
                          *CONTROL ATT W/RHC     *
                     MONITOR ΔVM (R3) COUNTING UP

     59:55
   (-00:05)
      F 99 40    ENG ON ENABLE REQUEST
           (AUTO IGN)    PRO AT TFI ≥0 sec
           (BYPASS IGN) ENTR to 24
```

```
22 00:00        IGN         *If SCS - THRUST ON PB - PUSH*

       06 40    TFC,VG,ΔVM          (mın-sec,.1fps,.1fps)
                          *F 97 40   SPS Thrust faıl   *
                          *(RESTART) PRO To IGN        *
                          *(RECYCLE) ENTR To TIG-05 sec*
                     SPS THRUST LITE - ON
                     MONITOR THRUSTING
                       Pc 95-105 psıa
                       EMS COUNTING DOWN
                       SPS INJ vlvs (4) - OPEN
                       SPS He vlvs tb (2) - gray
                       SPS FUEL/OXID PRESS - 175-195 psıa
                       PUGS - BALANCED
                          *PROG ALARM        *
                          *V5N9E 01407 VG INC*
                          *THC - CW, FLY MTVC*
                ECO
                          *EMER SPS CUTOFF:
                          *  ΔV THRUST (2) - OFF*

23   F 16 40    TFC(STATIC),VG,ΔVM      (mın-sec,.1fps)
                     ΔV THRUST A/B - OFF
                       SPS INJ vlvs (4) - CLOSED
                       SPS He tb (2) - bp
                     cb SPS P2,Y2 - closed (verıfy)
                     TVC SERVO PWR - AC1/MNA (verıfy)
                     TVC SERVO PWR 2 - OFF
                PRO

24   F 16 85    VG XYZ(CM)                        (.1fps)
                     NULL RESIDUALS
                     RECORD ΔV CTR & RESIDUALS ΔVC ____
                     EMS FUNC - OFF            VGX ____
                     EMS MODE - STBY           VGY ____
                     BMAG MODE (3) - RATE 2
                     ATT DB - MAX              VGZ ____
                     TRANS CONT PWR - OFF
                PRO

25   F 37       V82E

26   F 16 44    HA,HP,TFF                (.1nm,mın-sec)
                          *R3-59B59 HP >49.4 nm*
                PRO

27   F 37       OOE
```

5.5 EARTH ORBIT ENTRY

1 Verify CM/SM SEP ATT
- R _____ (180°)
- P _____
- Y _____ (0°)

2 EMS INITIALIZATION
- EMS FUNC - RNG SET
- SET RNG TO PAD DATA RNG
- EMS FUNC - Vo SET
- Slew scroll to pad data VIO
- EMS FUNC - ENTRY

3 RSI ALIGNMENT
- FDAI SOURCE - ATT SET
- ATT SET - GDC
- EMS ROLL - on(up)
- GDC ALIGN PB - PUSH & HOLD
- YAW tw - Position RSI thru 45° & back to LIFT UP
- GDC ALIGN PB - RELEASE
- EMS ROLL - OFF
- Align GDC to IMU

4 PWR REDUCT (Norm Deorb Only)
- HGA PWR - OFF
- FC PUMPS (3) - OFF
- Verify single suit compr oper, loads balanced
- FC 2 MN A&B - OFF
- 'S BD PWR AMP - Low
- cb ECS RAD CONT/HTR (2) - open
- cb WASTE H2O/URINE DUMP HTRS (2)-open
- cb HTRS OVLD (2) - open
- POT H2O HTR - OFF
- CAB FAN (2) - OFF
- GLY EVAP TEMP IN - MAN

P61 - ENTRY PREP

5 V37E 61E
05 09 01427 - ROLL REVERSED
*05 09 01426 - IMU UNSAT *

6 F 06 61 IMPACT LAT, LONG, HDS UP/DN (+/-)
(.01°,.01°,
±00001)

PAD VALUES
LAT_____
LONG_____
HDS UP/DN_____
PRO

7 F 06 60 GMAX,V400K,GAMMA EI (.01G,.fps,.01°)
Record
GMAX _____
V400K _____
GAMMA EI _____
PRO

8 F 06 63 RTOGO (.1nm) _____ PAD _____
VIO (fps) _____ PAD _____
TFE (min-sec)_____
Compare with MSFN for PGNS GO/NO GO
NO COMM, SET RTOGO & VIO IN EMS &
INITIALIZE

(ACCEPT) PRO
(RECALC) V32E to 8

P62 - CM/SM SEP & PRE-ENTRY MNVR

9 F 50 25 00041 REQUEST CM/SM SEP
SC CONT - SCS/FREE
YAW - 45° out-of-plane (left for RCS, right for SPS)
RATE - HIGH
ATT DB - MIN
MAN ATT (3) - RATE CMD
BMAG MODE (3) - ATT1/RATE2
PRIM GLY to RAD - BYPASS (verify)
SECS LOGIC (2) - on (up)
MSFN confirm GO for PYRO ARM
SECS PYRO ARM - ARM
MN BUS TIE (2) - ON (verify)
CM/SM SEP (2) - ON
CSM/LM FNL SEP (2) - on (up) (verify)
C&W MODE - CM
RCS TRNFR - CM
CM RCS MANF PRESS - 287-302 psia
CM RCS LOGIC - OFF
SECS PYRO ARM - SAFE
Monitor VMA/B:
If <25vdc go to EMERG POWERDOWN Pg E/6-1
AUTO RCS SEL A/C ROLL (4) - OFF
AUTO RCS SEL CM 2(6) - OFF
AUTO RCS SEL CM 1(6) - MNA or MNB
YAW back to 0°
PITCH TO ENTRY ATT
ROLL 0° (LIFT UP)
PITCH - HORIZ on 31.7° MARK (400K)
YAW 0°
ATT DB - MAX
MAN ATT (PITCH) - ACCEL CMD
EMS DATA - Verify
EMS FUNC - ENTRY (verify)
EMS MODE - NORMAL
MAINTAIN HORIZ TRK
PRO (Act ENTRY DAP)

10 F 06 61 IMPACT LAT, LONG, HDS/DN (.01°,.01°,-00001)
PRO

11 POSS 06 22 FINAL ATT DISP, RPY (.01°)
(Only if X-axis beyond 45° of Vel vector)

P63 - ENTRY INIT

12 06 64 G,VI,RTOGO (.01G,fps,.1nm)
FDAI SCALE - 50/15
ROT CONTR PWR DIR (both) - MNA/MNB
TAPE RCDR - CMD RESET/HBR
HORIZ CK
Pitch error needle goes toward
zero approaching .05G time
MAN ATT (PITCH) - RATE CMD
If CMC is GO:
BMAG MODE (3) - RATE 2
SC CONT - CMC/AUTO
*If DAP NO GO: *
* SC CONT - SCS*
* FLY BETA *
*If CMC NO GO: *
* SC CONT - SCS*
* FLY EMS *
RCS Deorb: Roll HDS UP
TRACK HORIZ with 29° window mk

P64 - ENTRY POST .05G

13 RTOGO AT .05G AGREES WITH EMS - verify
HORIZ CK
.05E Lt - on (EMS start)
.05G time
(+0__:__:__) *No EMS start within 3 secs*
*EMS MODE - BACKUP/VHF RNG *
.05G sw - on (up)
EMS ROLL - on (up)
06 68 BETA, VI, HDOT (.01°,fps,fps)
Compare RSI & FDAI
If CMC or PAD cmds Lift DN,
MNVR Lift DN
EMS GO/NO GO
G-V Plot within limits
Rng ctr dwn 60 $\pm$ 7 during 10 sec period
Monitor G-meter for
convergence with pad data (Do)
(V<27K fps) Go To 17

P65 - ENTRY - UP CONT (V>27K fps)

14 F 16 69 BETA (.01°) _____
DL (.01G) _____ PAD _____
VL (fps) _____ PAD _____
IF NO AGREEMENT:
*SC CONT - SCS *
*FLY EMS *
PRO

15 06 68 BETA, VI, HDOT (.01°,fps,fps)
(V<VL +500 fps & RDOT Neg) Go To 17

P66 - ENTRY - BALLISTIC (D<DL)

16 06 22 DESIRED GMBL ANGLES RPY (.01°)
Monitor horiz ±12° of 31.7° mark

P67 - ENTRY - FINAL PHASE (0.2G)

17 06 66 BETA,CRSRNG ERR,DNRNG ERR (.01°,.1nm,.1nm)
KEY VERB
Record DNRNG ERR _____
KEY RLSE
Limit: ±100nm from PAD DRE
Monitor lift vector on RSI & FDAI
F 16 67 RTOGO,LAT,LONG (Vrel=1000fps)
(.1nm,.01°,.01°)
SC CONT - SCS
RTOGO NEG - LIFT UP
RTOGO POS - LIFT DOWN
Monitor altimeter

Go To EARTHLANDING pg 45

5.6 EARTHLANDING

90K' STEAM PRESS - PEGGED
50K' CABIN PRESS REL vlv (2) - BOOST/ENTRY
SECS PYRO ARM (2) - ARM

40K' * CM UNSTABLE *
(90K' + 63s) *RCS CMD - OFF *
* 40K' APEX COVER JETT PG-PUSH *
DROGUE DEPLOY PG - PUSH (2 sec
*after apex cover jett) *

30K' ELS LOGIC - ON (up)
ELS - AUTO

24K' RCS disable (auto)
(90K'+92s) *RCS CMD - OFF*

Apex cover jett (auto)
APEX COVER JETT PB - PUSH
(WAIT 2 SECS)
Drogue parachutes deployed (auto)
DROGUE DEPLOY PB - PUSH

If Drogues Fail:
*ELS - MAN *
*Stabilize CM *
5K' MAIN DPLY PB - PUSH
*ELS - AUTO *

23.5K' Cabin Pressure increasing (Drogues + 50s)
*If not increasing by 17K': *
CABIN PRESS REL vlv (RH) - DUMP

10K' Main parachutes deployed
MAIN DEPLOY PB - PUSH (within 1 sec)
VHF ANT - RECY
VHF AMA - SIMPLEX
VHF BCN - ON
CABIN PRESS REL vlv (2) - CLOSE
DIRECT O2 vlv - OPEN
CM RCS LOGIC - on (up)
CM PRPLNT - DUMP (burn audible)
Monitor CM RCS 1&2 for He press decrease
*NO BURN or PRESS DECREASE *
* USE BOTH RHC's *
*DO NOT FIRE PITCH JETS *
CM PRPLNT-PURGE (to zero He press)
*CM RCS He DUMP PB - PUSH *
*RHC (2) - 30 secs *
* NO PITCH *
STRUT LOCKS (2) - UNLOCK

cb FLT & PL BAT BUS A,B,&BAT C (3) - close
cb FLT & PLT MNA & B (2) - open
cb ECS RAD HTR OVLD (2) - open
cb SPS P&Y (4) - open

3K' CABIN PRESS REL vlv (RH) - DUMP (after purge completed)
FLOOD Lts - POST LDG
CM RCS PRPLNT (2) - OFF
ROT CONTR PWR DIRECT (2) - OFF

800' CAB PRESS RELF vlv - CLOSE (latch off)
MN BUS TIE (2) - OFF

AFTER LANDING:
cb MAIN REL PYRO (2) - close
MAIN RELEASE - on(up)

Go to POSTLANDING pg 47

5.7 POSTLANDING

STABILIZATION, VENTILATION, COMMUNICATIONS

1 DIRECT O2 vlv - CLOSE

2 Stabilization after landing
- ELS - AUTO (verify)
- cb MAIN REL PYRO (2) - close (verify)
- MAIN RELEASE - on (up) (verify)
- SECS PYRO ARM (2) - SAFE
- SECS LOGIC (2) - OFF
- cb BAT RLY BUS (2) - open
  - *No contact with recovery forces*
  - *VHF AM A&B - off (ctr) *
  - *VHF AM RCV ONLY - A *
- cb PL VENT - close
- cb FLOAT BAG (3) - close
- cb UPRIGHT SYS COMPRESS (2) - close
- If Stable II:
  - FLOAT BAG(3)-FILL till 2 min after upright, then - OFF
  - VHF AM A/B & BCN - OFF while inverted
- If Stable I:
  - After 10 Min Cooling Period,
    - FLOAT BAG (3) - FILL 7 min, then OFF

3 Post Stabilization And Ventilation
- PL BCN LT - BCN LT LOW
- PL VENT vlv - UNLOCK (Pull)
- Remove PL VENT Exh Cover
- PL VENT - HIGH or LOW
- PL DYE MARKER - ON (swimmer comm)
- Release footstraps and restraints
- cb MNA BAT BUS A & BAT C (2) - open
- cb MNB BAT BUS B & BAT C (2) - open
- cb FLT & PL BAT C - open
- cb PYRO A SEQ A - open
- cb PYRO B SEQ B - open
  - *EACH HR - CHECK DC VOLTS $\geq$ 27.5 V *
  - *If Not· *
  - * cb FLT & PL-BAT BUS A&B (2) -open*
  - * cb FLT & PL BAT C (1) - open *
  - * GO TO LOW POWER CHECKLIST *
- Unstow and install PLV DISTRIB DUCT
- Deploy grappling hook and line if req.

4 Post Landing Communications
VHF ANT-RECV (verify)
VHF BCN - ON (verify)
If no contact with recovery forces perform VHF BEACON Check
MONITOR VHF BEACON transmission with VHF AM B Rcvr and/or Survival Transceiver
*VHF Beacon not operating *
connect Survival Transceiver to ant
*cable behind VHF ant access pnl *
*and place radio in BCN mode *

LOW POWER CHECKLIST

VHF BCN - OFF
VHF AM (3) - RCV
FLOOD Lts - OFF
VHF AM A&B - off (ctr)
VHF AM RCV ONLY - A (verify)
COUCH LIGHTS - OFF
POSTLANDING VENT SYS: minimize use
SURV RADIO - plug into VHF BCN ANT cable conn behind VHF ant acess pnl & turn radio on in BCN mode

EGRESS PROCEDURES

STABLE I

Disconnect umbilicals
Neck dam on
CMP Center couch - 270° position
CDR,LMP Armrests stowed
CDR Connect raft to S/C, if desired, with green lanyard
Connect raft white lanyards to suits & inflate water wings when exiting
HATCH PISTON PRESS vlv - PRESS (Outbd)
CMP Side Hatch opened
CDR PL VENT - OFF
CMP cb Pnl 250 (all) - open
Egress with liferaft
LMP Put hardware kit out
LMP,CDR Egress

or C. STABLE II

LMP	cb CREW STA AUDIO (3) - open
ALL	Disconnect umbilicals
	Release footstraps
	Release restraint harness
	Couch seat pans (3) - 170° position
CMP	Arm rests stowed
	Survival kits removed from stowage
CDR	Connect life raft mainline to CDR or S/C
CMP	Connect first white lanyard from life raft to suit
CDR	Connect third white lanyard from life raft to suit
LMP	Connect rucksacks together to yellow lanyard on raft bag
CMP	PRESSURE EQUALIZATION vlv - OPEN
CMP,LMP	Remove and stow fwd hatch
CMP	Exit feet first with rucksacks; when clear of S/C inflate water wings and raft
LMP	Exit feet first; when clear of S/C inflate water wings
CDR	Exit feet first; when clear of S/C inflate water wings

6.0 TLI ABORTS

TLI Aborts are contained in the ESD since the bulk of the functions concern entry preparations and performance. This allows a single source of procedures for procedure review, validation, checkout, and training These procedures incorporate TLI preparations as found in reference 6 with the TLI Abort Procedures and these tie into normal lunar return Entry Procedures found in section 5. The guidelines for this contingency are specified in reference 7.

Initial preparations for TLI position the necessary system switches in addition to performing an EMS ΔV test and a GDC alignment. After the DET is set for monitoring TB6 the CMP increases the light level of the LEB DSKY to maximum and returns to the his couch. This is done so that the LEB DSKY can be observed in the event sunlight or reflections wash out the main display panel DSKY during critical maneuvers. The crew then straps in and prepares for monitoring TB6 as indicated by the SII SEP Lite. The times sequence of procedures is keyed on this display and includes the DET START function and SIVB IGNITION. During the burn the crew monitors the FDAI's for attitude excursions and abnormal rates, reporting status checks to Mission Control at discreet times during the maneuver. Upon SIVB SHUTDOWN the CMP records the DSKY displayed performance parameters and awaits ground confirmation.

The rational for TLI aborts is described in reference 7. A summarization is extracted to provide background and guidelines in this document. The abort procedures cover aborts 10 minutes after contingent SIVB shutdown and aborts 90 minutes after normal SIVB shutdown time.

The 10 minute TLI abort is designed to be used during TLI in the event a spacecraft problem develops which can result in catastrophe if immediate action is not taken. If the situation permits, the crew should always allow the SIVB to complete TLI, at which time the ground and crew can perform a malfunction analysis to determine if an abort is advisable. If a failure occurs that necessitates the shutdown of the SIVB and the quick return of the crew to earth, this abort is designed to be as insensitive to execution errors as possible and still be targeted to midcorridor. The burn attitude with the fixed horizon reference is a constant value for any shutdown time. The burn duration is a function of shutdown time and is available from crew charts. Since the primary purpose of this abort is to return to earth as quickly as possible there are no restrictions as to landing location. However, if the time to EI is greater than about two hours a midcourse correction should be anticipated.

The 90 minute TLI abort is to be used if a critical subsystem malfunction is determined and the decision to abort is made after the

TLI cutoff and before TLI cutoff plus approximately 80 minutes This allows sufficient separation and procedural time to set up for the SPS deorbit burn performed at about TLI + 90. Note that generally the deorbit burns will be performed a few minutes before TLI + 90 according to crew charts shown in reference 8. The no-comm exception requires that 90 minutes be the input time of ignition for P-37 (onboard return-to-earth abort program) so that onboard calculations can correspond with ground calculations to compute the CM landing point This TLI abort is designed so that return flight time does not exceed 18 hours and abort ΔV does not exceed 7000 fps. This abort can be performed using chart ΔV's and attitudes and the earth's horizon serves as a sufficient reference. The maneuver is targeted to achieve the midcorridor entry target line and timed to result in a designated recovery area

It is obvious for abort decisions early in the TLI + 90 minute timeframe that a G&N SPS burn should be performed. In order to keep the TLI abort procedures consistent and with emphasis on simplicity, the procedures here reflect a SCS SPS abort burn to cover the full abort decision timeframe.

A midcourse correction for corridor control after a TLI abort may be desired if the SPS burn did not meet expectations. The TLI abort procedures in this section adapt to the normal lunar return timeline and procedures prior to the final MCC.

6.1 TLI PREPARATION PROCEDURES

GET = 1:50	Don Helmets & Gloves
	XLUNAR - INJECT (verify)
	EDS PWR - on (verify)
	EMS FUNC - OFF (verify)
	EMS MODE - STBY
	EMS FUNC - ΔV SET/VHF RNG
	EMS MODE - NORMAL
	Set ΔV ind. to +1586.8 fps
	EMS FUNC - ΔV Test
	SPS THRUST Lt - on/off (10 sec)
	ΔV ind. stops at -0.1 to -41.5
	EMS MODE - STBY
	EMS FUNC - ΔV SET/VHF RNG
	Set ΔVC _____
	EMS FUNC - ΔV
	GDC ALIGN
	FDAI Select - 1/2
CRO AOS	cb SECS LOGIC (2) - close (verify)
(__:__:__)	cb SECS ARM (2) - close
	SECS LOGIC (2) - on (up)
	MSFN Confirm GO for PYRO ARM (if poss)
	SECS PYRO ARM (2) - on (up)
	TRANS CONTROL PWR - ON
	ROT CONTR PWR NORMAL (2) - AC/DC(verify)
	ROT CONTR PWR DIRECT (2) - MNA/MNB
	LV IND/GPI - SII/SIVB (verify)
	LV GUID - IU (verify)
	cb DIRECT ULLAGE (2) - closed
	Set EVENT TIMER to 51:00
	Begin MONITOR For TB6
CRO LOS	CMP to Couch
(__:__:__)	
(2:21:42)	TB 6 - SII SEP Lt on (TIG-9 min, 38 sec)
	KEY V83E
	SET ORDEAL
	FDAI #2 ORB RATE at 180, 0, 0
	SII SEP Lt out (38 sec later)
51:00	Start DET COUNTING UP
	SC CONT - SCS (verify)
	MONITOR LV TANK PRESS
	ΔP < 36 psid (OXID > FUEL)
	ΔP < 26 psid (FUEL > OXID)
	*EMERGENCY CSM/LV SEP *
	UP TLM CM - BLOCK (verify)
	UP TLM IU - BLOCK (verify)

57:00 V37E 47E (check bias) Record _____
(Limit: 9.8 fps/min)
F 16 83 ΔVX,Y,Z (.1fps)
58:00 N62E
F 16 62 VI,HDOT,HPAD (fps,fps,.1nm)
MONITOR VI (_____) at ECO
SCS TVC SERVO PWR 1 - AC1/MNA
2 - OFF
TAPE RCDR - CMD RESET/HBR
58:20 EMS MODE - NORMAL
58:36 SII SEP Lt - ON
TLI Inhibit Signals will not
* be honored after 59:42 *
58:38 SIVB ULLAGE Begins
59:42 SII SEP Lt - off (TIG - 18 sec)
59:52 SIVB FUEL LEAD
59:55 SIVB ULLAGE discontinues
59·59 LV ENG 1 Lt - on
00:00 SIVB IGNITION (__:__:__GETI)
00:02 LV ENG 1 Lt - off
SUNRISE MONITOR THRUST & ATTITUDE ±45°/P,Y
(__:__:__) MONITOR LV TANK PRESS ±10°/sec P,Y
SIVB ECO (Lt on) (BEGIN TB7)
*EMER SIVB CUTOFF AT 6 SEC *
* PAST BURN TIME IF VI ATTAINED *
*THC CCW & NEUTRAL IN 1 SEC *
* or SII/SIVB sw - LV STAGE *
*Premature Shutdown: *
* HA<4K nm CSM & LM - Two phasing mnvrs, two SPS *
* mnvrs to circularize at 150 nm*
* earth orbit *
* CSM only - SPS phasing mnvr, MCC's, low *
* earth orbit mission *
* 4K nm<HA<10K nm CSM & LM - Two phasing mnvrs, two SPS *
* mnvrs to circularize at 150 nm*
* earth orbit *
* CSM only - SPS phasing mnvr, MCC's, low *
* earth orbit mission *
10K nm<HA<25K nm CSM & LM - Two phasing mnvrs, APS burn to
* depletion, third phasing mnvr,*
* SPS burn to semisync orbit *
* CSM only - Two phasing mnvrs, SPS burn to*
* semisync orbit *
*25K nm<HA<40K nm CSM & LM - Two phasing mnvrs, APS burn to *
* depletion, third phasing mnvr, *
* SPS burn to semisync orbit *
* CSM only - Two phasing mnvrs, SPS burn to *
* semisync orbit *
* HA>40K nm DPS avail - DPS LOI_1, circularize with SPS *
* DPS not avail - Lunar flyby or CSM only to *
* lunar orbit (if req'd ΔV *
* <4,000 fps) *

HAW AOS
(__:__:__) KEY VERB (freeze display)

SIVB ATT HOLD 20 sec & BEGIN VENTING
SIVB MNVR TO ORB RT. (HDS DN) (.3°/sec)
Record VI _____
HDOT _____
HPAD _____
KEY RLSE

F 16 62

KEY RLSE
F 16 83 ΔVX,Y,Z (.1fps)
Record ΔVX _____
ΔVY _____
HAW LOS ΔVZ _____
(__:__:__) ΔVC _____

TAPE RCDR - off (ctr)
EMS MODE - STBY
EMS FUNC - OFF
SECS PYRO ARM (2) - SAFE
PRO

BURN STATUS REPORT

_____ΔTIG	_____VI
_____BT	_____HDOT
_____VGX	_____H
_____R	_____ΔVC
_____P	_____FUEL
_____Y	_____OXID
	_____UNBAL

REMARKS

F 37
08:00 00E
GDS AOS CMP TO LEB
(__:__:__)

6.2 TLI 10 MIN ABORT

SECS LOGIC (2) - on (up)
SECS PYRO ARM (2) - ARM

00:00 TRANS CONTR - CCW (4 sec) & +X
DET RESET (verify)
00:03 SIVB/CSM SEP
LV ENG 1 Lt - out
* CSM/LV SEP PB - PUSH *
* RCS CMD-ON *
00:05 TRANS CONTR - neutral then +X for 10 sec
SIVB/GPI sw - GPI
*Excessive rates: *
* ΔV THRUST A - NORMAL *
* SPS THRUST - DIRECT *
*When rates damped: *
* ΔV THRUST (2) - OFF *
* SPS THRUST - NORMAL *
cb MNA BAT C - close
cb MNB BAT C - close

00:14 TRANS CONTR +X - OFF
V37E 00E
PITCH UP to LOCAL VERT (+X axis toward the earth)
RATE - LOW
BMAG MODE (3) - ATT1/RATE 2
EDS PWR - OFF
SECS PYRO ARM (2) - SAFE
SECS LOGIC (2) - OFF
cb SECS ARM (2) - open
cb EDS (3) - open

01:00 TRANS CONTR -X (8 to 10 sec)

RATE - HIGH

MNVR TO RETRO ATT
R_____(180°)
P_____(199°)
Y_____(0°)

RETRO UPDATE
GETI _____ .05G _____
GET DROGUE _____
ΔV _____ ENTRY P _____
VC _____ R _____
Δtb _____ Y _____
GET 400K _____

ALIGN HORIZ ON RET +1° MK
GMBL CHECK (Time Permitting)
MN BUS TIE (2) - ON
GMBL MTRS (4) - ON (LMP Confirm)
cb SPS P2,Y2 - open
RATE - LOW
EMS MODE - STBY
EMS FUNC - ΔV SET/VHF RNG
SET ΔV from chart
EMS FUNC - ΔV
EMS MODE - NORMAL

09:45 ΔV THRUST A - NORMAL
V37E 47E (THRUST MONITOR)

F 16 83 ΔVX,Y,Z (.1 fps)

NOTE: For aborts during 1st min of TLI,
KEY V82E F 16 44 (Ha,Hp,Tff)
Burn until Hp < 19NM.

09:50 TRANS CONTR +X

10:00 THRUST ON PB - PUSH
TRANS CONTR +X - OFF
BURN ΔV req'd
ΔV THRUST (2) - OFF
Report cutoff
cb SPS P2, Y2- close
GMBL MTRS (4) - OFF (LMP Confirm)
TRANS CONT PWR - OFF
TVC SERVO PWR (2) - OFF
MN BUS TIE (2) - OFF
cb SPS P1&2, Y1&2 - open

F 37 00E

Go to ENTRY PREP & SUPERCIRC ENTRY PROCEDURE
If est. time to EI<01:55:00 omit MCC and enter the SUPERCIRC CKLIST as early as possible. Pg 23
If est. time to EI>01:55:00 anticipate a MCC. Enter the ENTRY PREP CKLIST at step 9 pg 18

6.3 TLI 90 MIN ABORT PROCEDURES

TLI+25 — Normal CSM/LV Separation- If decision to abort made before TLI+25 min, abort at this time. If abort decision occurs after separation start with V37E 00E at 00:14

SECS LOGIC (2) - on (up)
MSFN Confirm GO for PYRO ARM
SECS PYRO ARM (2) - ARM

00:00 — TRANS CONTR - CCW (4 sec) & +X
DET RESET (verify)

00:03 — SIVB/CSM SEP
LV ENG 1 Lt - out
* CSM/LV SEP PB - PUSH *
* RCS CMD-ON *

00:05 — TRANS CONTR - neutral then +X for 10 sec

SIVB/GPI sw - GPI
*Excessive rates: *
* ΔV THRUST A - NORMAL *
* SPS THRUST - DIRECT *
*When rates damped: *
* ΔV THRUST (2) - OFF *
* SPS THRUST - NORMAL *
cb MNA BAT C - close
cb MNB BAT C - close

00:14 — TRANS CONTR +X - OFF

V37E 00E
PITCH UP to LOCAL VERT (+X axis toward the earth)
RATE - LOW
BMAG MODE (3) - ATT1/RATE 2
EDS PWR - OFF
SECS PYRO ARM (2) - SAFE
SECS LOGIC (2) - OFF
cb SECS ARM (2) - open
cb EDS (3) - open

01:00 — TRANS CONTR +X (8 to 10 sec)

RATE - HIGH

MNVR TO RETRO ATT
R_____(Block Data)
P_____(Block Data)
Y_____(Block Data)

RETRO UPDATE (NO COMM - use Block Data)

GETI _____ .05G _____

	ΔV _____	GET DROGUE	_____
	VC _____	ENTRY P	_____
	Δtb _____	R	_____
GET	400K _____	Y	_____

XX:XX
- Set DET counting up to GETI
- ALIGN HORIZ ON RET +1° MK
- GMBL CHECK (Time Permitting)
- MN BUS TIE (2) - ON
- GMBL MTRS (4) - ON (LMP Confirm)
- cb SPS P2,Y2 - open
- RATE - LOW
- EMS MODE - STBY
- EMS FUNC - ΔV SET/VHF RNG
- SET ΔV from chart
- EMS FUNC - ΔV
- EMS MODE - NORMAL
- TAPE RCDR - CMD RESET/HBR/RCD/FWD

59:45
- ΔV THRUST A - NORMAL

V37E 47E (THRUST MONITOR)

F 16 83 ΔVX,Y,Z (.1 fps)

59:59
- THRUST ON PB - PUSH
  - TRANS CONTR +X - OFF
  - BURN ΔV req'd
  - ΔV THRUST (2) - OFF
  - Report cutoff
- cb SPS P2,Y2 - close
- GMBL MTRS (4) - OFF (LMP Confirm)
- TRANS CONT PWR - OFF
- TVC SERVO PWR (2) - OFF
- MN BUS TIE (2) - OFF
- cb SPS P1&2, Y1&2 - open

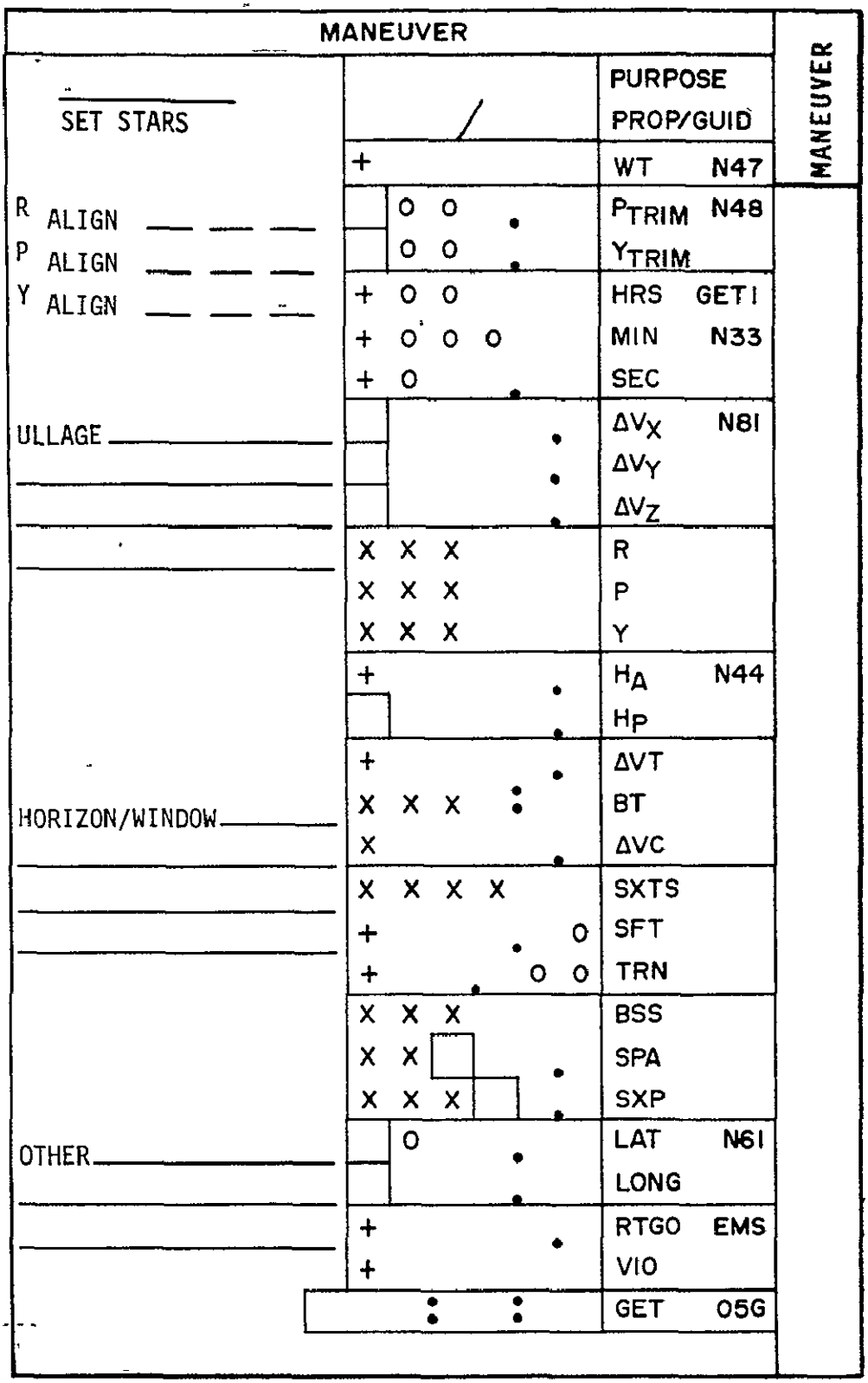
F 37 00E

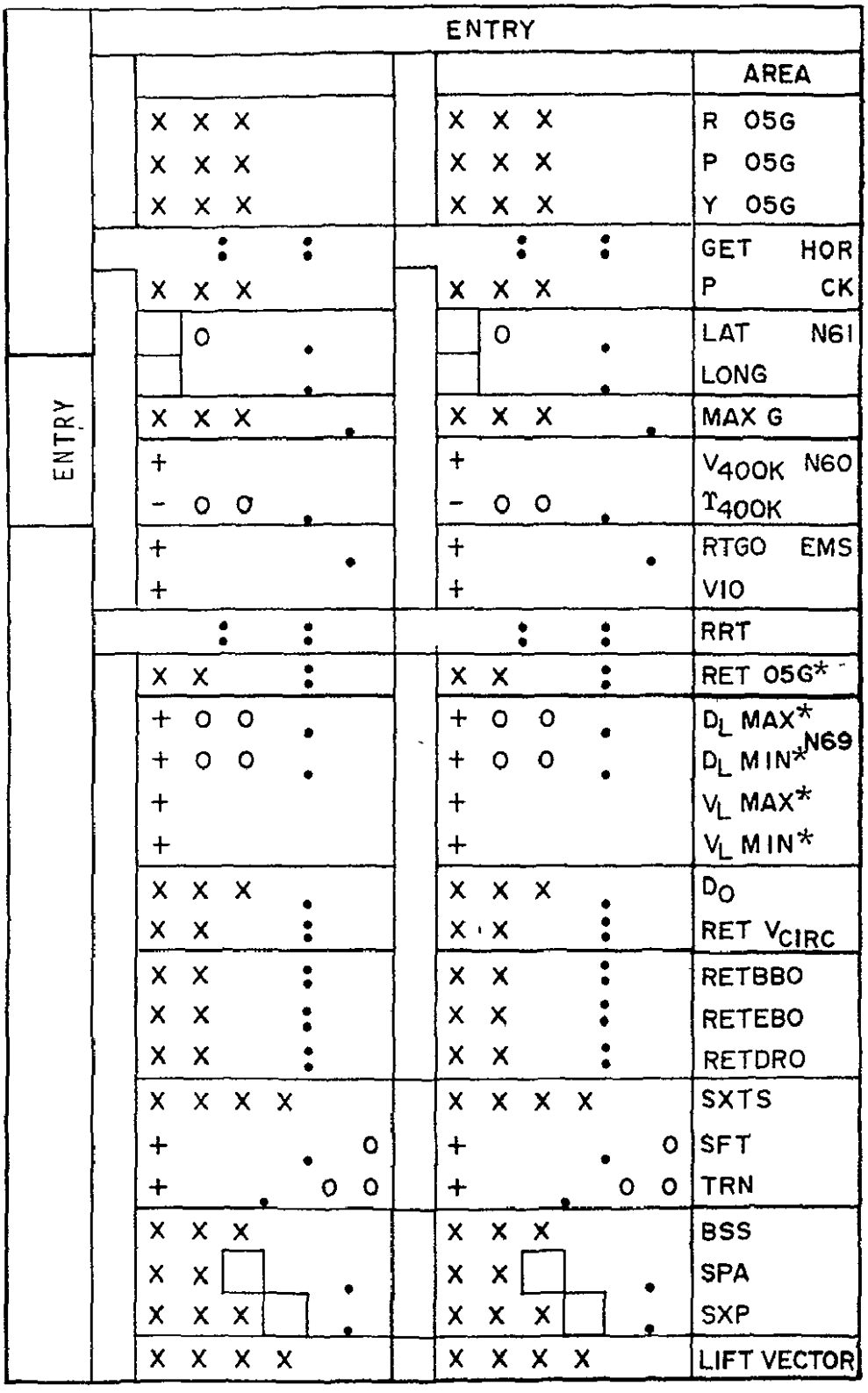
Go to ENTRY PREP & SUPERCIRC ENTRY PROCEDURE
Step 9 pg 11

7.0 ENTRY PADS

Data PADS are used by the crew to record voice callups from the mission control center. The PAD formats are a function of the data transmitted and the form the flight crew finds to be efficient in performing their tasks after extensive training. The PADS presented in this section are included as examples and training aids.

P27 UPDATE																
PURP			V				V				V					
GET			:	:			:	:			:	:				
304	01	INDEX					INDEX				INDEX					
	02															
	03															
	04															
	05															
	06															
	07															
	10															
	11															
	12															
	13															
	14															
	15															
	16															
	17															
	20															
	21															
	22															
	23															
	24															
	N34	HRS	X	X	X						X	X	X			
		MIN	X	X	X	X					X	X	X	X		
NAV CHECK		SEC	X	X							X	X				
	N43	LAT		0								0				
		LONG														
		ALT	+	0							+	0				


MANEUVER
MANEUVER
SET STARS
PURPOSE
PROP/GUID
WT N47
R ALIGN
P ALIGN
Y ALIGN
PTRIM N48
YTRIM
HRS GETI
MIN N33
SEC
ULLAGE
ΔVX N81
ΔVY
ΔVZ
R
P
Y
HA N44
HP
HORIZON/WINDOW
ΔVT
BT
ΔVC
SXTS
SFT
TRN
BSS
SPA
SXP
OTHER
LAT N61
LONG
RTGO EMS
VIO
GET 05G


ENTRY
AREA
R 05G
P 05G
Y 05G
GET HOR
P CK
LAT N61
LONG
MAX G
V_{400K} N60
γ_{400K}
RTGO EMS
VIO
RRT
RET 05G*
D_L MAX*
D_L MIN* N69
V_L MAX*
V_L MIN*
D_O
RET V_{CIRC}
RETBBO
RETEBO
RETDRO
SXTS
SFT
TRN
BSS
SPA
SXP
LIFT VECTOR
ENTRY

EARTH ORBIT ENTRY UPDATE		
X -	X -	AREA
X X - .	X X - .	Δ V TO
X X X X X X X X X	X X X X X X X X X	R 05G P 05G Y 05G
+ +	+ +	RTGO EMS VIO
X X :	X X :	RET 05G
□ 0 . □ :	□ 0 . □ :	LAT N61 LONG
X X : □ .	X X : □ .	RET 02G DRE (55°) N66
R R / X X :	R R / X X :	BANK AN RET RB
X X : X X : X X :	X X : X X : X X :	RETBBO RETEBO RETDROG
X X X X X □	X X X — X X □	(90°/fps) CHART DRE (90°) UPDATE
POST BURN		
X X X	X X X	R 05G
+ +	+ +	RTGO EMS VIO
X X :	X X :	RET 05G
X X : □ .	X X : □ .	RET 02G DRE ±100nm N66
R R / X X :	R R / X X :	BANK AN RETRB
X X : X X : X X :	X X : X X : X X :	RETBBO RETEBO RETDROG +53sec to main

3.0 ENTRY CHARTS AND TLI CHARTS

Crew charts provide additional onboard capability for monitoring mission events and supply information to perform specific functions if communication with MSFN have failed. Presented in this section are six onboard crew charts applicable to the reentry phase of the Apollo 8 mission as presented in reference 9 and two TLI abort charts as presented in reference 7.

The first chart presents the reentry corridor dynamic limit lines and reference lines as a function of reentry velocity (V_{EI}) and flight-path angle (γ_{EI}) at 400,000 ft altitude. The purpose of this chart is to insure, for the no communication case, that a proper V_{EI} - γ_{EI} combination will be attained at reentry interface.

The dynamic limit lines, the constant g overshoot and 12 g undershoot boundaries, are based on aerodynamic and reentry conditions which result in the most restrictive corridor Three reference lines are also included on the chart and they are the lift vector orientation (LVO) line, the shallow target line, and the steep target line. The lift vector orientation line and the steep target line are both stored in the onboard computer and are utilized in programs 63 and 37, respectively. For a reentry velocity and flight-path angle located above the LVO line the onboard computer will command a lift vector down roll attitude at 0.05 g and will maintain that attitude to about 1 3 g Below the LVO line the computer will command a lift vector up attitude to approximately 1.3 g.

If program 37 is used in conjunction with return-to-earth targeting or midcourse corrections, the program will target automatically to the steep target line unless the flight-path angle override option is desired If the flight-path angle override option is used, the desired flight-path angle at 400,000 ft altitude (reentry interface) is input into the CMC with the CMC determining the resulting reentry velocity. It is recommended that the steep target line be used for all onboard return-to-earth targeting and midcourse corrections. This steep target line will also be used for Mission Control Center (MCC) targeting for reentry velocities greater than 31,000 ft/sec For reentry velocities below 31,000 fps the MCC will utilize the shallow target line in order to increase the maneuver capability of the spacecraft

The second chart depicts the CMC commanded constant drag value, DO, as a function of reentry velocity at 400,000 ft altitude. During the reentry program 64 the guidance logic is generating roll commands which will attempt to drive the spacecraft to the commanded constant aerodynamic drag value, DO During this program (P64) the EMS V-g trace and the independent G meter will be monitored to insure that the spacecraft's actual drag level is converging to DO. If the

computer is not generating the right roll commands during this period, a manual takeover is executed and the backup mode flown. For the lunar reentry return velocity DO is about 4 g's.

The third chart presents the pitch gimbal angle necessary to acquire the horizon at the 31 7 degree mark in the commander's rendezvous and docking windown This chart was generated assuming that the 0.05 g predicted trim pitch gimbal angle was 152.2 degrees; consequently, it is dependent on the given trajectory and vehicle parameters from which it was obtained. However, the chart is relatively insensitive to both the trajectory and vehicle parameters and could be used with a one to two degree accuracy throughout the reentry corridor for the lunar return velocities. Should the pitch trim gimbal angle at 0.05 g change during the mission, real time update of this chart can be accomplished by biasing the chart by the difference between the nominal and updated .05 g trim angle. Also, the pitch angle necessary to get the horizon at the 31 7 degree mark at 17 minutes prior to EI will be voiced to the crew and can be used as a second data point to update this chart.

The fourth chart can be used to determine the required magnitude of pitch from some given reference to locate the horizon at a prescribed elevation on the commander's rendezvous and docking window; i.e , at the 31 7 degree mark. Included are data for two different modes of approaching entry interface (400,000 feet altitude), each mode being illustrated for a lift vector up and a lift vector down CM attitude. The two modes are briefly defined as follows: (1) maintain the inertial attitude necessary to achieve aerodynamic trim conditions at the predicted time the spacecraft will experience a load factor of 0.05 g or, (2) continually maneuver the CM to cause it to be trimmed to its present position vector at all times assuming that the atmosphere existed beyond entry interface (this is what is done by the CMC) With either mode being chosen, the required pitch to obtain the horizon at some location in the window is shown for any time up to twenty minutes prior to entry interface. This can be done by subtracting the desired horizon position in the window from the pitch angle from chart 4. For example, if the CM is in a lift up 0.05 g trim attitude (top solid line) and the horizon is desired to be at the 31.7 degree mark in the window 12 minutes before entry interface, subtract 31.7 degrees from the value of ϕ from the chart approximately 94.3 degrees The range of usable angles is shown on the chart by the cross hatched area representing the field of view for an 80th percentile pilot

The two sets of dashed lines indicate the attitude region within which the angle of attack will be not greater than 45 degrees for either lift up (top set) or lift down (bottom set). This is significant since the crew could likely see a sharp jump of the roll and

yaw error needles on the FDAI if the entry DAP were active and the angle of attack increased to a value greater than 45 degrees. As this occurs the DAP converts from a 0.1 second sampling DAP to a two second predictive DAP and interchanges the yaw and roll error signals on the FDAI.

If onboard return-to-earth targeting is required, the target longitude and latitude obtained from program 37 will need to be corrected to obtain the nominal 1350 n. mi. reentry range. The fifth chart shows the longitude correction (the solid line) which is to be added or subtracted, depending on whether the target longitude from the DSKY is west (minus sign) or east (plus sign), as a function of inertial velocity at 400,000 ft altitude. The dashed lines on the chart depict the longitude corrections to be used for the fast and slow lunar return trajectories.

Corresponding to the longitude correction, a latitude correction must also be made. The latitude correction is determined by calling up program 21 and inputing various mission elapsed times. The output from this program is then used to plot a ground track. A latitude correction can then be determined for the corresponding change in longitude. This latitude correction may then be used to modify the target latitude obtained from P37.

The sixth chart is to be used as a backup chart in the case of an earth orbit alternate mission The chart shows two curves which are: (1) backup bank angle (BBA) versus burn error in the X-direction ($\Delta\Delta V_X$); (2) downrange error at .2 g (P67) versus backup bank angle. An equation is shown on the chart to correct the backup bank angle for burn errors in the Z-direction. In order to obtain the correct burn residuals (errors) from the DSKY the S/C must be in the retro-fire attitude. The nominal retro elapsed time to reverse the bank angle (RETRB) is noted on the chart and is to be corrected by Δ RETRB shown on the right scale if burn errors are incurred. The use of this chart can be best shown by an example. Suppose a deorbit maneuver was performed and burn errors resulted in:

$$\Delta\Delta V_X = + 10.0 \text{ fps}$$

$$\Delta\Delta V_Z = - 7.0 \text{ fps}$$

From the BBA curve the backup bank angle for a $\Delta\Delta V_X$ of + 10.0 fps is about 66°. The backup bank angle correction (ΔBBA) for the Z-axis error is $(-0.40) \cdot (-7.0)^\circ$ or $+2.8^\circ$. The total backup bank angle (BBA_T) is then BBA + ΔBBA or 68.8°. For a BBA_T of 68.8° the expected downrange error display on the DSKY at 0 2 g is about -150 n. mi. Using this BBA_T a ΔRETRB of about +14 sec is obtained. This value is then added to the nominal RETRB of 22 min which

results in a corrected RETRB of 22 min 14 sec. This crew chart will be updated via voice 1 to 3 hours prior to all earth orbit reentries to compensate for deviations from the nominal end of mission orbital elements. The data points to update these two curves will be voiced up and recorded on the earth orbit entry pad message shown in section 7.0.

Charts 7 and 8 are onboard crew charts necessary to perform a 10 minute abort from TLI. These charts provide the SPS burn attitude, SPS ΔV requirement, and time to entry interface as functions of the inertial velocity at S-IVB cutoff. Charts for aborts after nominal TLI during the translunar coast phase are unnecessary since block data will be relayed to the crew for these cases while the crew is still in earth parking orbit.

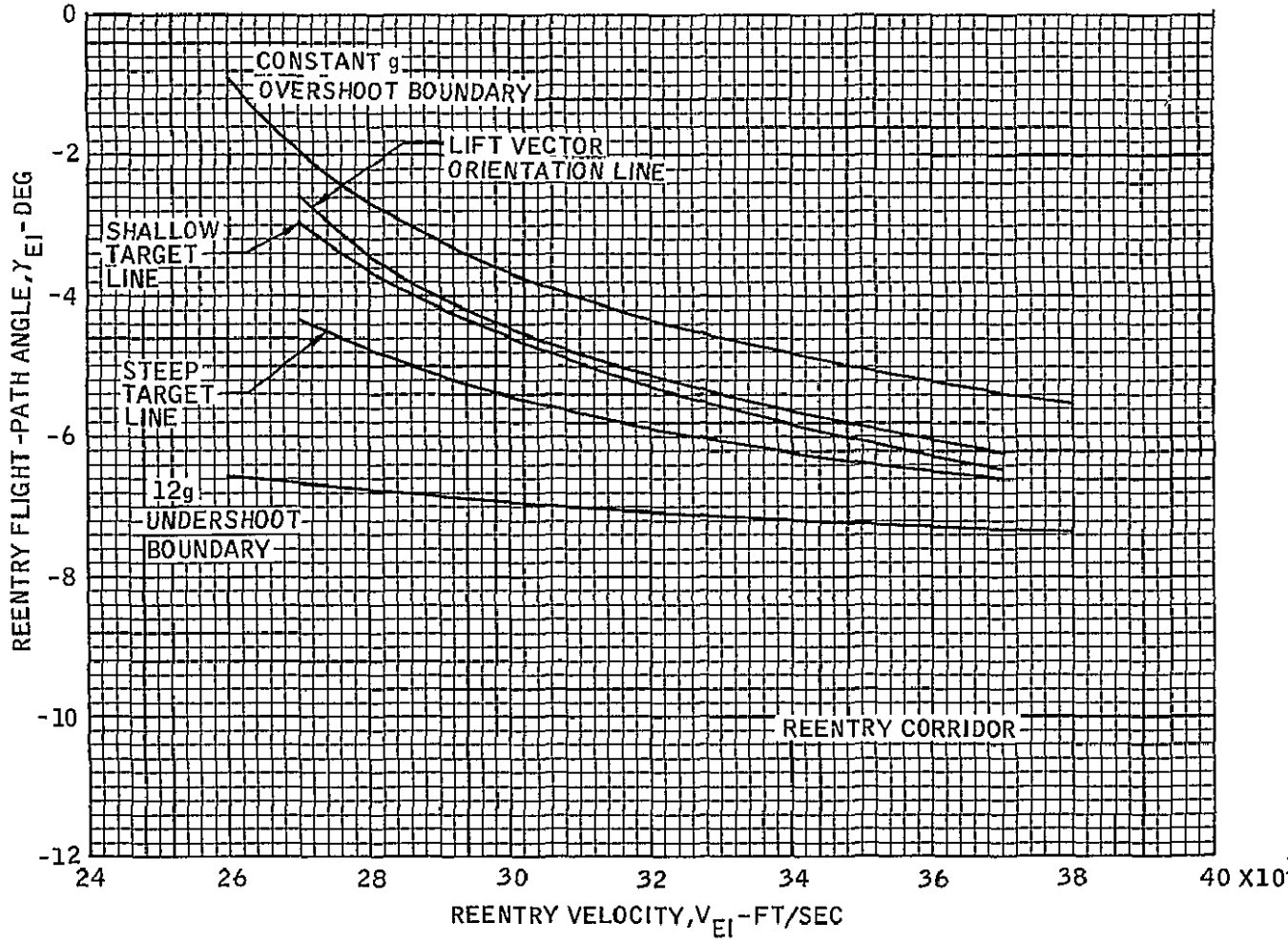

CONSTANT g
OVERSHOOT BOUNDARY
LIFT VECTOR
ORIENTATION LINE
SHALLOW
TARGET
LINE
STEEP
TARGET
LINE
12g
UNDERSHOOT
BOUNDARY
REENTRY CORRIDOR
REENTRY FLIGHT-PATH ANGLE, γ_{EI}-DEG
REENTRY VELOCITY, V_{EI}-FT/SEC
0
-2
-4
-6
-8
-10
-12
24
26
28
30
32
34
36
38
40 X10^3

Chart 1

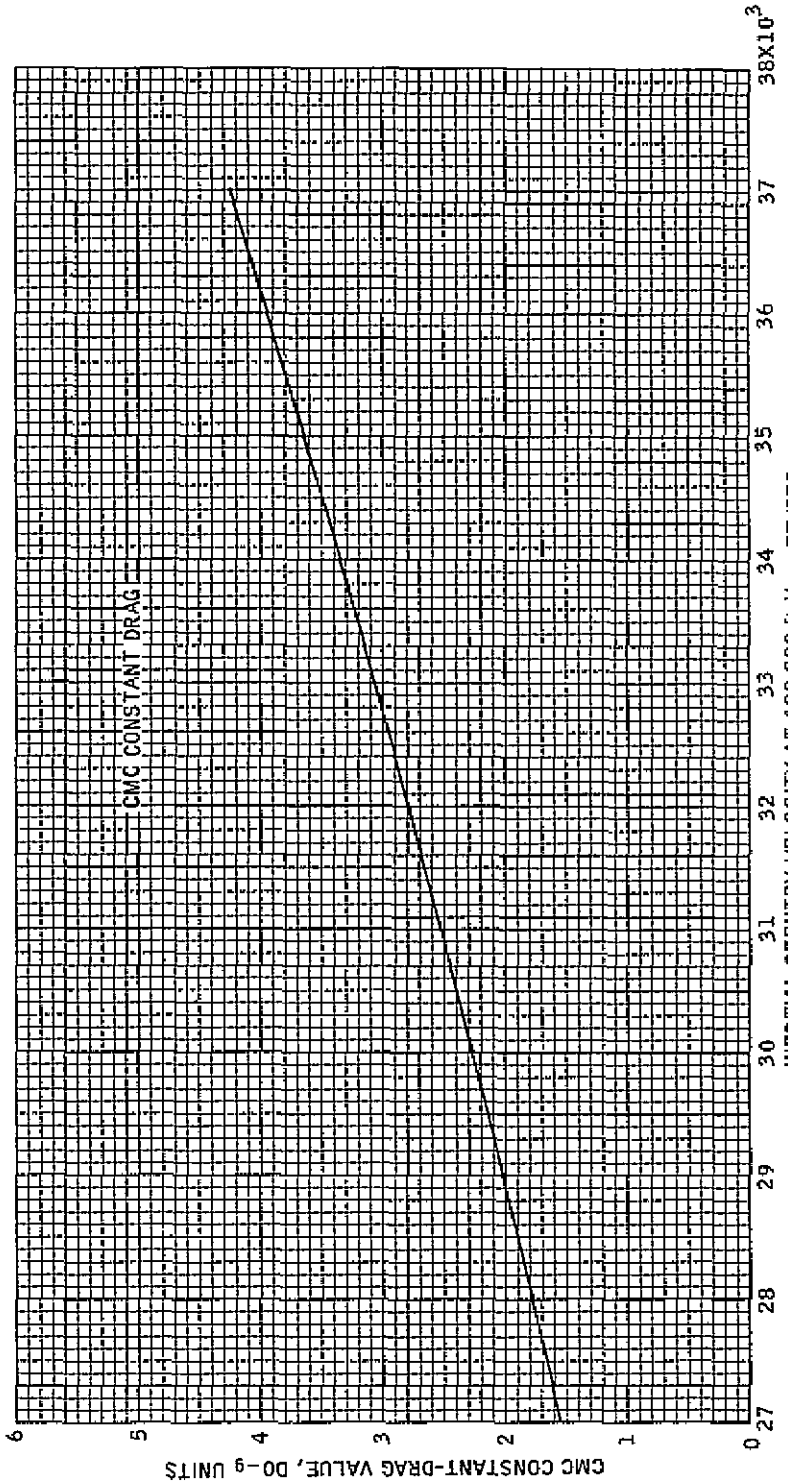
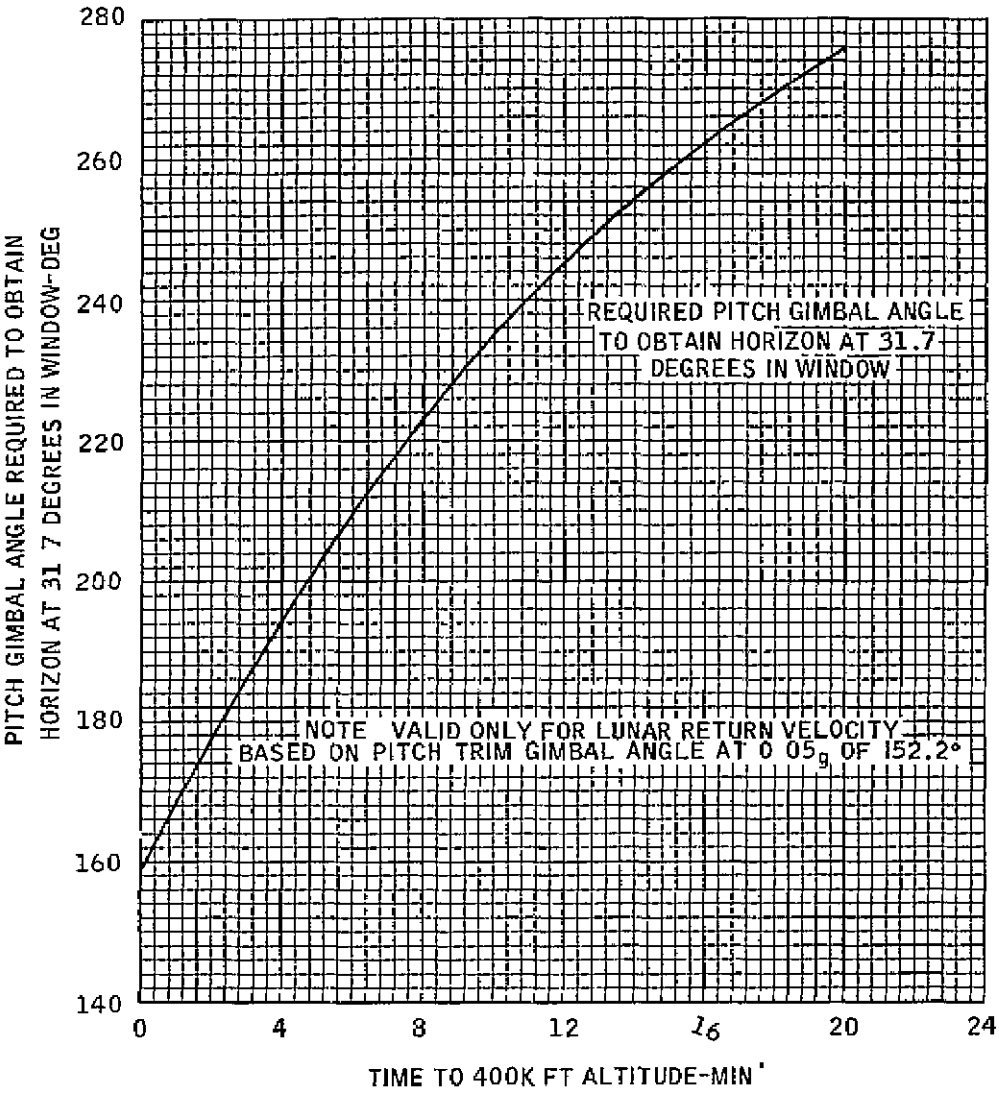

CMC CONSTANT DRAG
CMC CONSTANT-DRAG VALUE, D0-g UNITS
0
1
2
3
4
5
6
27
28
29
30
31
32
33
34
35
36
37
38X10^3
INERTIAL REENTRY VELOCITY AT 400 000 ft, V_{EI} - FT/SEC

Chart 2


280
260
240
220
200
180
160
140
0
4
8
12
16
20
24
PITCH GIMBAL ANGLE REQUIRED TO OBTAIN HORIZON AT 31 7 DEGREES IN WINDOW-DEG
TIME TO 400K FT ALTITUDE-MIN
REQUIRED PITCH GIMBAL ANGLE TO OBTAIN HORIZON AT 31.7 DEGREES IN WINDOW
NOTE VALID ONLY FOR LUNAR RETURN VELOCITY BASED ON PITCH TRIM GIMBAL ANGLE AT 0 05g OF 152.2°

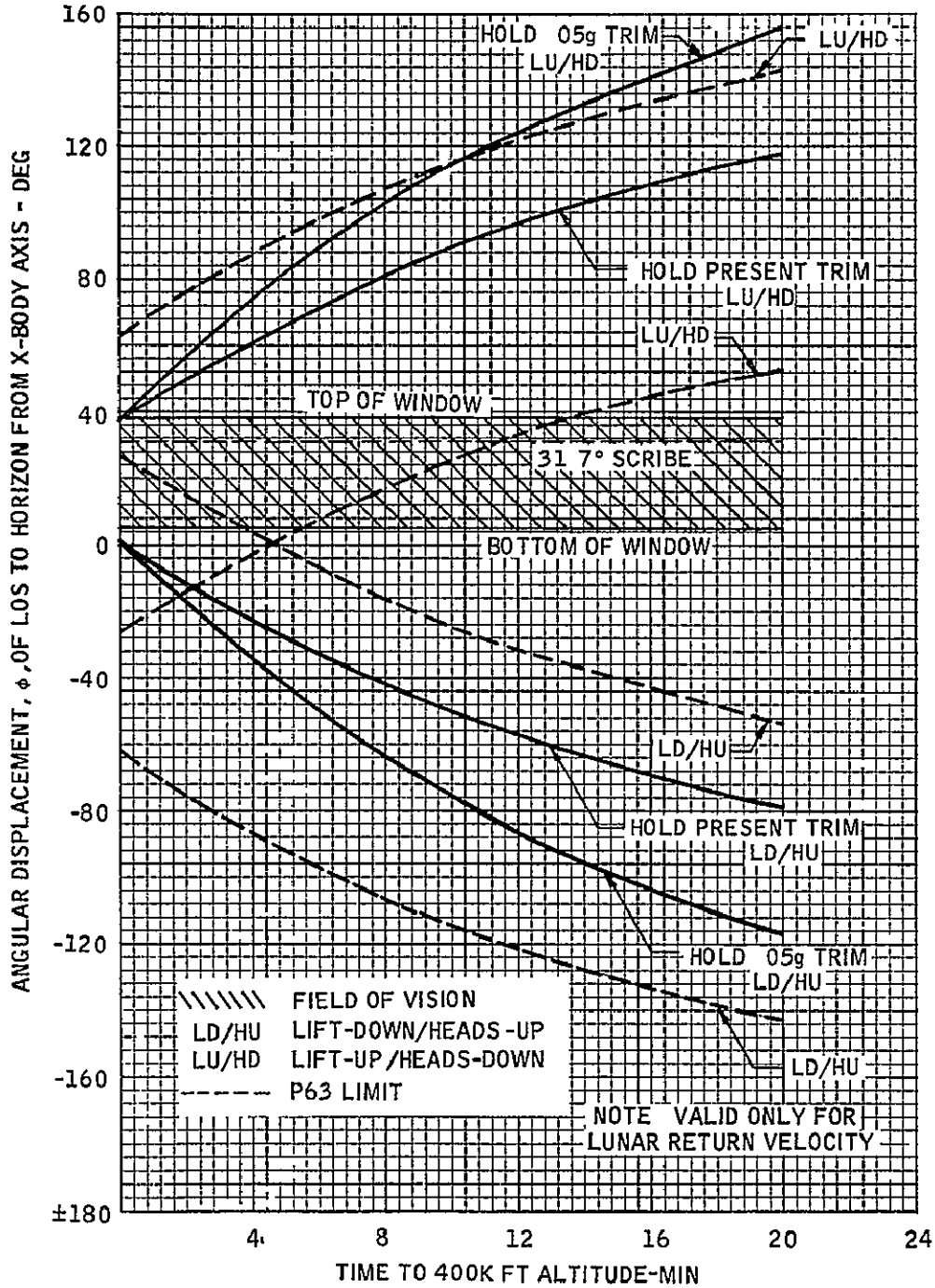

160
120
80
40
0
-40
-80
-120
-160
±180
ANGULAR DISPLACEMENT, ϕ, OF LOS TO HORIZON FROM X-BODY AXIS - DEG
HOLD 05g TRIM
LU/HD
LU/HD
HOLD PRESENT TRIM
LU/HD
LU/HD
TOP OF WINDOW
31.7° SCRIBE
BOTTOM OF WINDOW
LD/HU
HOLD PRESENT TRIM
LD/HU
HOLD 05g TRIM
LD/HU
LD/HU
FIELD OF VISION
LD/HU LIFT-DOWN/HEADS-UP
LU/HD LIFT-UP/HEADS-DOWN
P63 LIMIT
NOTE VALID ONLY FOR
LUNAR RETURN VELOCITY
4
8
12
16
20
24
TIME TO 400K FT ALTITUDE-MIN

Chart 4

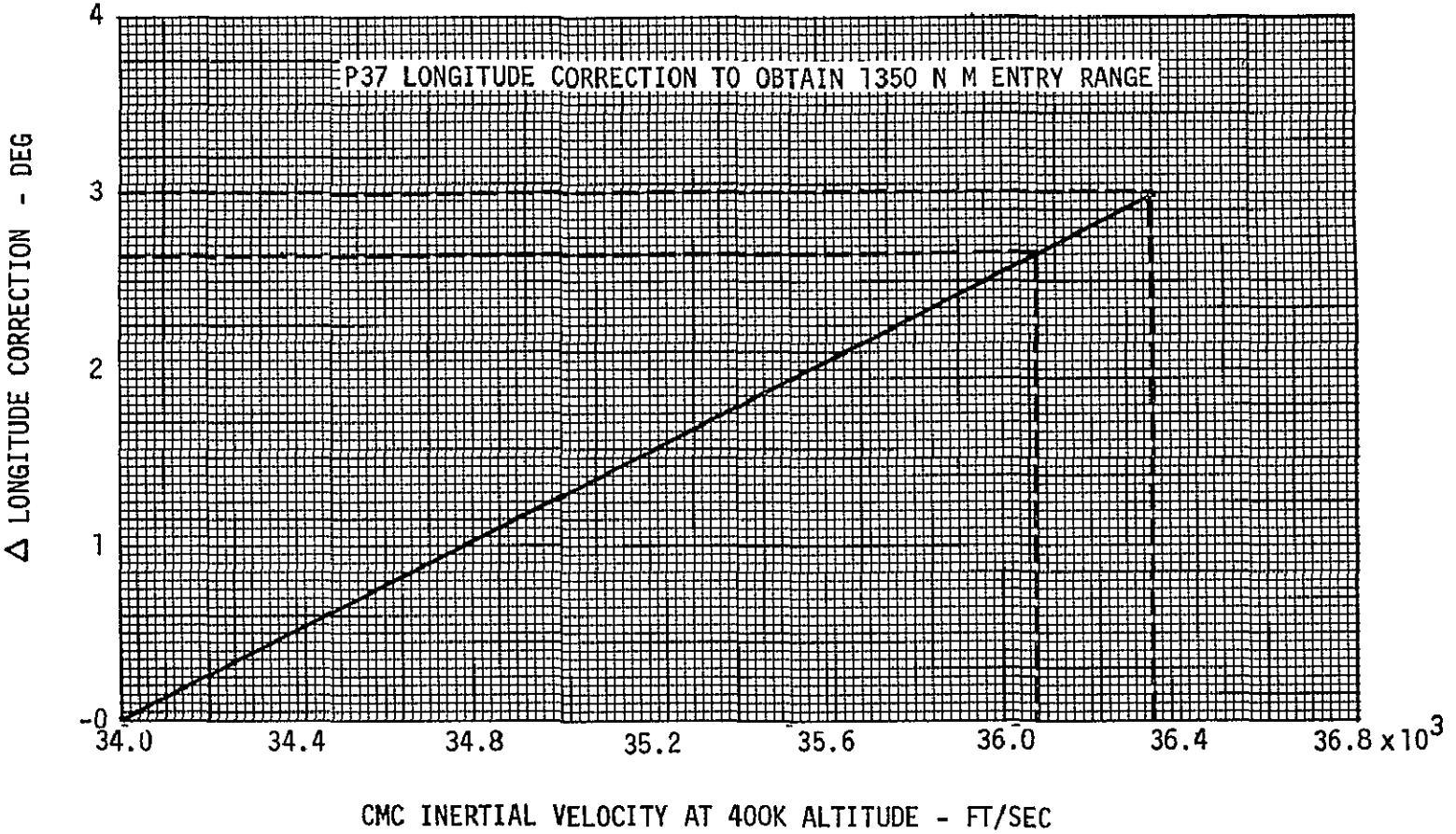

P37 LONGITUDE CORRECTION TO OBTAIN 1350 N M ENTRY RANGE
Δ LONGITUDE CORRECTION - DEG
4
3
2
1
-0
34.0
34.4
34.8
35.2
35.6
36.0
36.4
36.8 x 10^3
CMC INERTIAL VELOCITY AT 400K ALTITUDE - FT/SEC

Chart 5

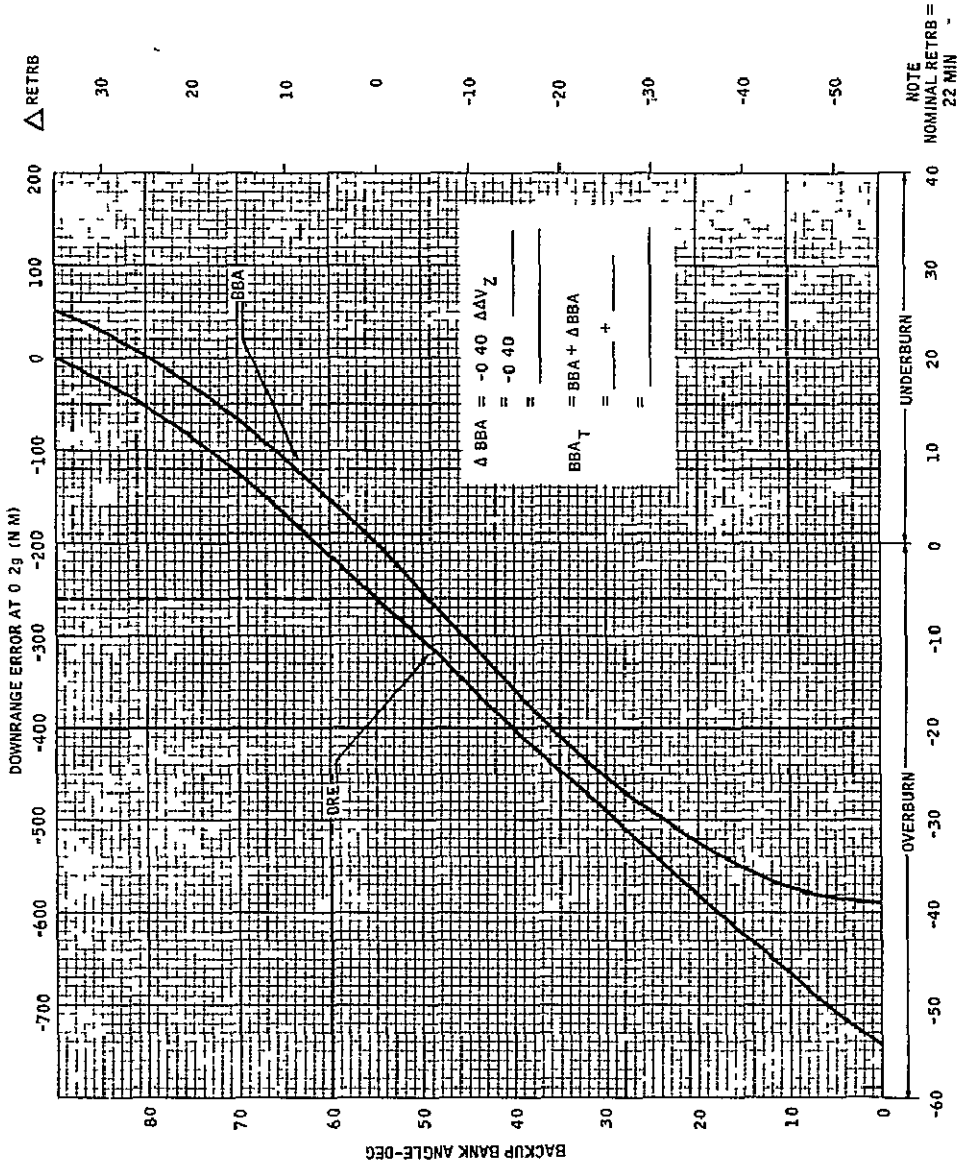

DOWNRANGE ERROR AT 0 2g (N MI)
-700
-600
-500
-400
-300
-200
-100
0
100
200
Δ RETRB
30
20
10
0
-10
-20
-30
-40
-50
BACKUP BANK ANGLE-DEG
80
70
60
50
40
30
20
10
0
BBA
ORE
Δ BBA = -0 40 ΔΔV_Z
= -0 40 ____
= ____
= ____
BBA_T = BBA + Δ BBA
= ____ + ____
= ____
OVERBURN
UNDERBURN
-60
-50
-40
-30
-20
-10
0
10
20
30
40
ΔΔV_X FT/SEC
NOTE
NOMINAL RETRB =
22 MIN

Chart 6

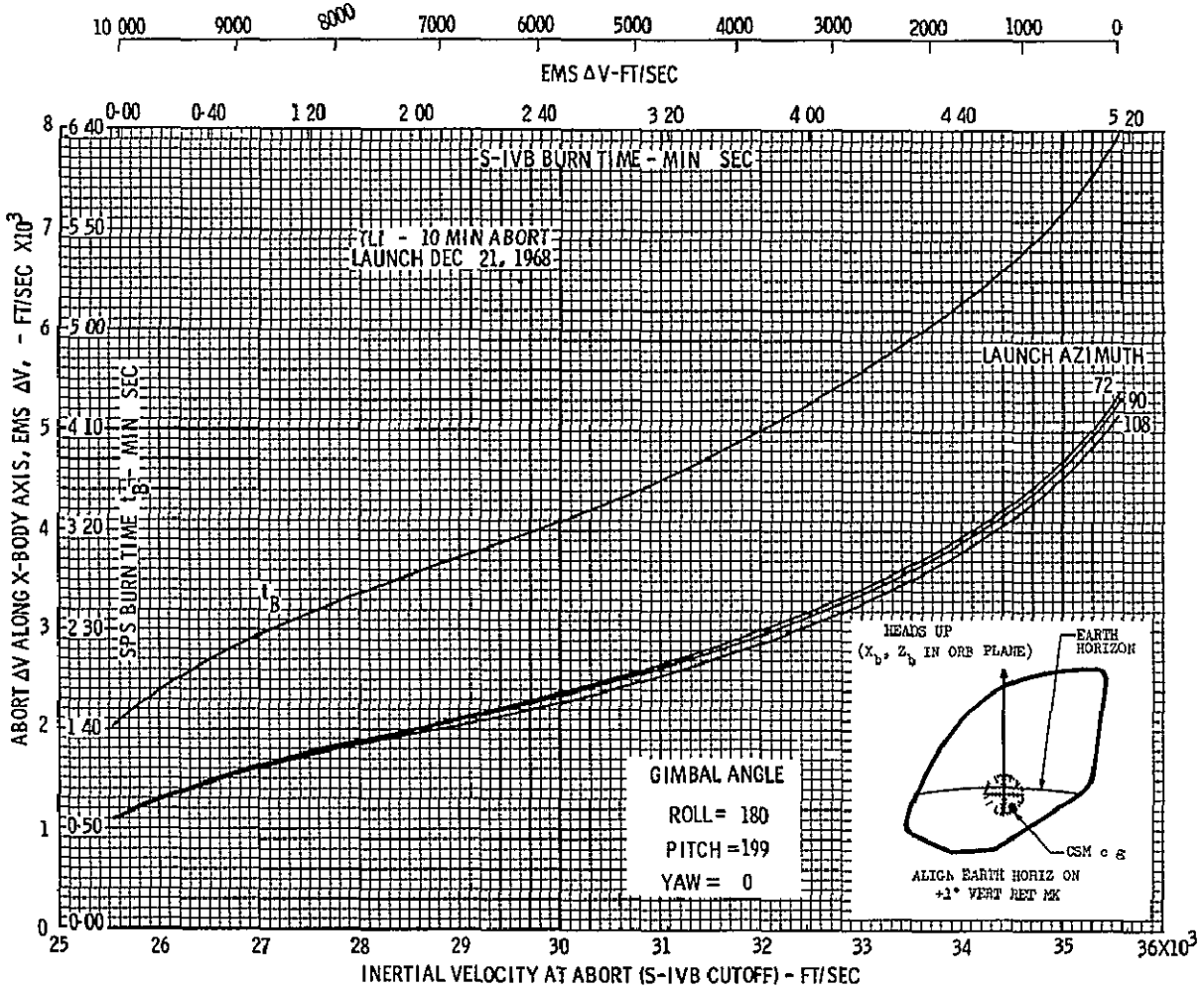

10 000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
EMS ΔV-FT/SEC
0-00
0-40
1 20
2 00
2 40
3 20
4 00
4 40
5 20
S-IVB BURN TIME - MIN SEC
TLI - 10 MIN ABORT
LAUNCH DEC 21, 1968
LAUNCH AZIMUTH
72
90
108
6 40
5 50
5 00
4 10
3 20
2 30
1 40
0-50
0-00
SPS BURN TIME t_B - MIN SEC
t_B
ABORT ΔV ALONG X-BODY AXIS, EMS ΔV, - FT/SEC X10^3
0
1
2
3
4
5
6
7
8
25
26
27
28
29
30
31
32
33
34
35
36X10^3
INERTIAL VELOCITY AT ABORT (S-IVB CUTOFF) - FT/SEC
GIMBAL ANGLE
ROLL = 180
PITCH = 199
YAW = 0
HEADS UP
(X_b, Z_b IN ORB PLANE)
EARTH HORIZON
CSM ⊂ ε
ALIGN EARTH HORIZ ON
+1° VERT RET MK

Chart 7

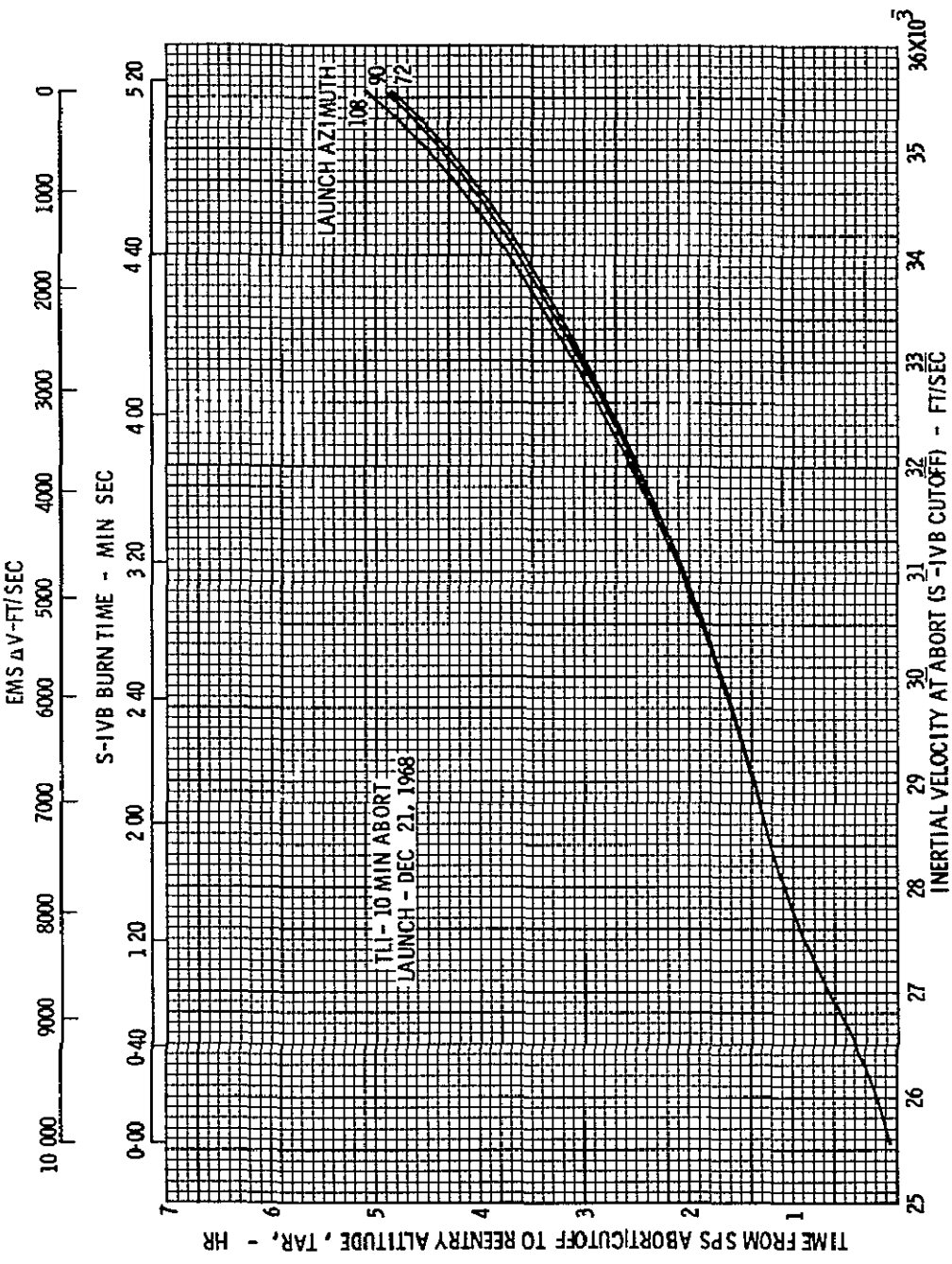

EMS ΔV-FT/SEC
10 000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
S-IVB BURN TIME - MIN SEC
0-00
0-40
1 20
2 00
2 40
3 20
4 00
4 40
5 20
TLI - 10 MIN ABORT
LAUNCH - DEC 21, 1968
LAUNCH AZIMUTH
108
90
72
TIME FROM SPS ABORT/CUTOFF TO REENTRY ALTITUDE, TAR, - HR
7
6
5
4
3
2
1
INERTIAL VELOCITY AT ABORT (S-IVB CUTOFF) - FT/SEC
25
26
27
28
29
30
31
32
33
34
35
36X10³

Chart 8

9.0 REFERENCES

1. Apollo Mission Techniques, Missions F & G Transearth Injection, Midcourse Corrections, and Entry, MSC Internal Note S-PA-9T-040 dated February 24, 1969.

2. Apollo Entry Summary Document, Mission F Preliminary Copy, MSC Internal Note MSC-CF-P-69-1 dated January 20, 1969.

3. Mission F Flight Plan, Preliminary Copy, dated March 12, 1969.

4. Apollo Operations Handbook, Command and Service Modules, Volume II Operational Procedures, Block II, dated February 20, 1969.

5. Apollo Mission Techniques Earth Parking Orbit Retrofire and Entry Procedures (Missions C Prime, D, F, and G) MSC Internal Note S-PA-8M-035 dated December 16, 1968.

6. Apollo Abort Summary Document, Mission F, MSC Internal Note MSC-P-69-4 dated February 3, 1969.

7. Apollo Mission Techniques, Missions F & G Contingency Procedures, Draft copy, MSC Internal Note S-PA-9T-043 dated March 3, 1969.

8 Operational Abort Plan for the Apollo 8 Mission, MSC Internal Note 68-FM-209 dated November 26, 1968.

9. United States Government Memorandum "Apollo 8 Reentry Crew Charts," 68-FM23-216 dated December 12, 1968.

10. Reentry Crew Briefing Handout, F Mission Lunar Return, held February 24, 1969.