NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MSC INTERNAL NOTE NO. 69-FM-30

January 31, 1969

APOLLO MISSION F

MISSION PLANNING BRIEFING

FOR THE CREW

(NASA-TM-X-72237) APOLLO MISSION F: MISSION PLANNING BRIEFING FOR THE CREW (NASA) 178 p

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MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

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PROJECT APOLLO

APOLLO MISSION F
MISSION PLANNING BRIEFING FOR THE CREW

By Mission Planning and Analysis Division

January 31, 1969

MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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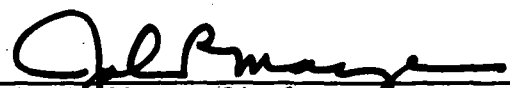
Approved: 

John P. Mayer, Chief
Mission Planning and Analysis Division

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FOREWORD

This document presents the slides used for the Apollo Mission F mission planning briefing held for the crew on January 24, 1969. The briefing was designed to give the crew a comprehensive view of the mission planning status. The slides are published for general information, and, therefore, no explanation is given. The scheduled Mission Planning and Analysis Division (MPAD) operational documents will explain and refine this information.

Questions should be directed to William J. Bennett, Mission Planning and Support Office, MPAD, at extension 4091.

CONTENTS

1.0 NOMINAL TRAJECTORY PROFILE

Gene W. Ricks

F MISSION DESIGN GROUND RULES AND GUIDELINES

- SIX POSSIBLE LAUNCH DAYS ACROSS NINE DAY PERIOD WITH 1, 2, 4, 7, 8, 9 TYPE SPACING
- LAUNCH WILL BE TARGETED TO ACHIEVE MOST FAVORABLE LIGHTING FOR PRIME G SITES IIP-2, IIP-6, IIP-8, IIIP-11, IIP-13 (HEREAFTER CALLED SITES 1, 2, 3, 4, AND 5 RESPECTIVELY)
- THE TWO ADDITIONAL LAUNCH DAYS PAST THE "NORMAL G" WINDOW ARE TARGETED TO THE LAST G SITE - ACCEPTING HIGH SUN ELEVATIONS AT SITES
- DAYLIGHT LAUNCH
- LAUNCH AZIMUTH RANGE 72° -108°
- EPO WILL BE 100 N. MI. CIRCULAR
- PACIFIC INJECTION ON SECOND AND THIRD REVOLUTIONS
- TLI TARGETED FOR FREE RETURN CIRCUMLUNAR: $h_{pc} \sim$ 60 N. MI. $h_{pg} \sim$ 20 N. MI.

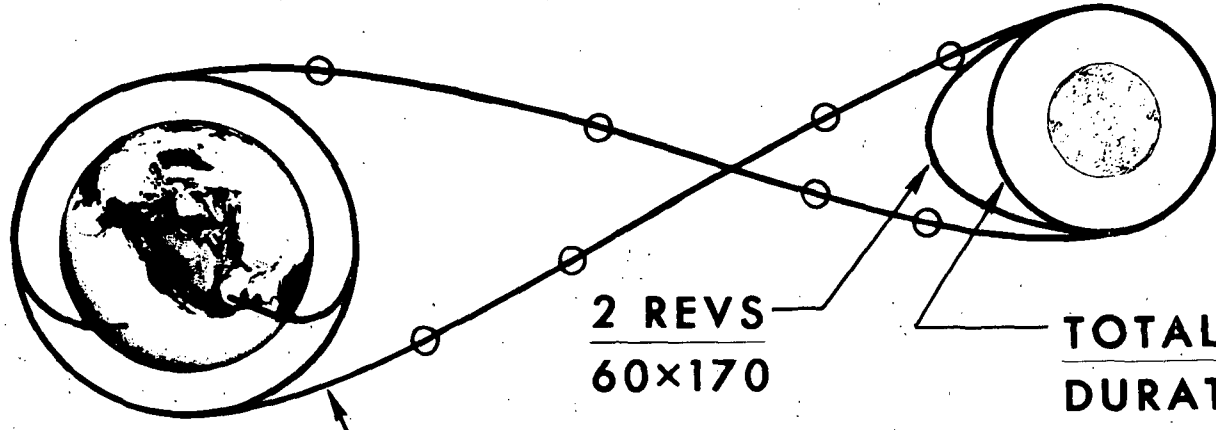
F MISSION DESIGN GROUND RULES AND GUIDELINES (CONTINUED)

- TWO STAGE LOI: TWO REVS IN 60 × 170; CIRCULARIZE TO 60 × 60
- LPO ORIENTATION SELECTED TO PASS OVER G SITE ON 13TH REV FOLLOWING LOI (1) WITH APPROACH AZIMUTH CORRESPONDING TO ACCEPTABLE SC PERFORMANCE AND FREE RETURN INCLINATION
- LUNAR OPERATIONS WILL CONSIST OF LM LANDING AND ASCENT SIMULATION (TWO DPS AND ONE APS BURN), LM ACTIVE RENDEZVOUS, AND UNMANNED APS BURN TO DEPLETION

F MISSION DESIGN GROUND RULES AND GUIDELINES (CONCLUDED)

- APS BURN TO DEPLETION TARGETED TO EARTH/MOON ESCAPE
- TOTAL LPO DURATION ~ 51^{h} INCLUDING OPTIONAL SLEEP PERIOD FOLLOWING APS BURN TO DEPLETION
- TEI WILL BE TARGETED TO RETURN ASAP TO 165° W LONGITUDE WITHIN AVAILABLE ΔV AND RETURN INCLINATION LIMIT OF 40°
- ENTRY GAMMA ~ -6.5° AND RELATIVE ENTRY RANGE ~ 1350 N. MI.

MISSION PROFILE

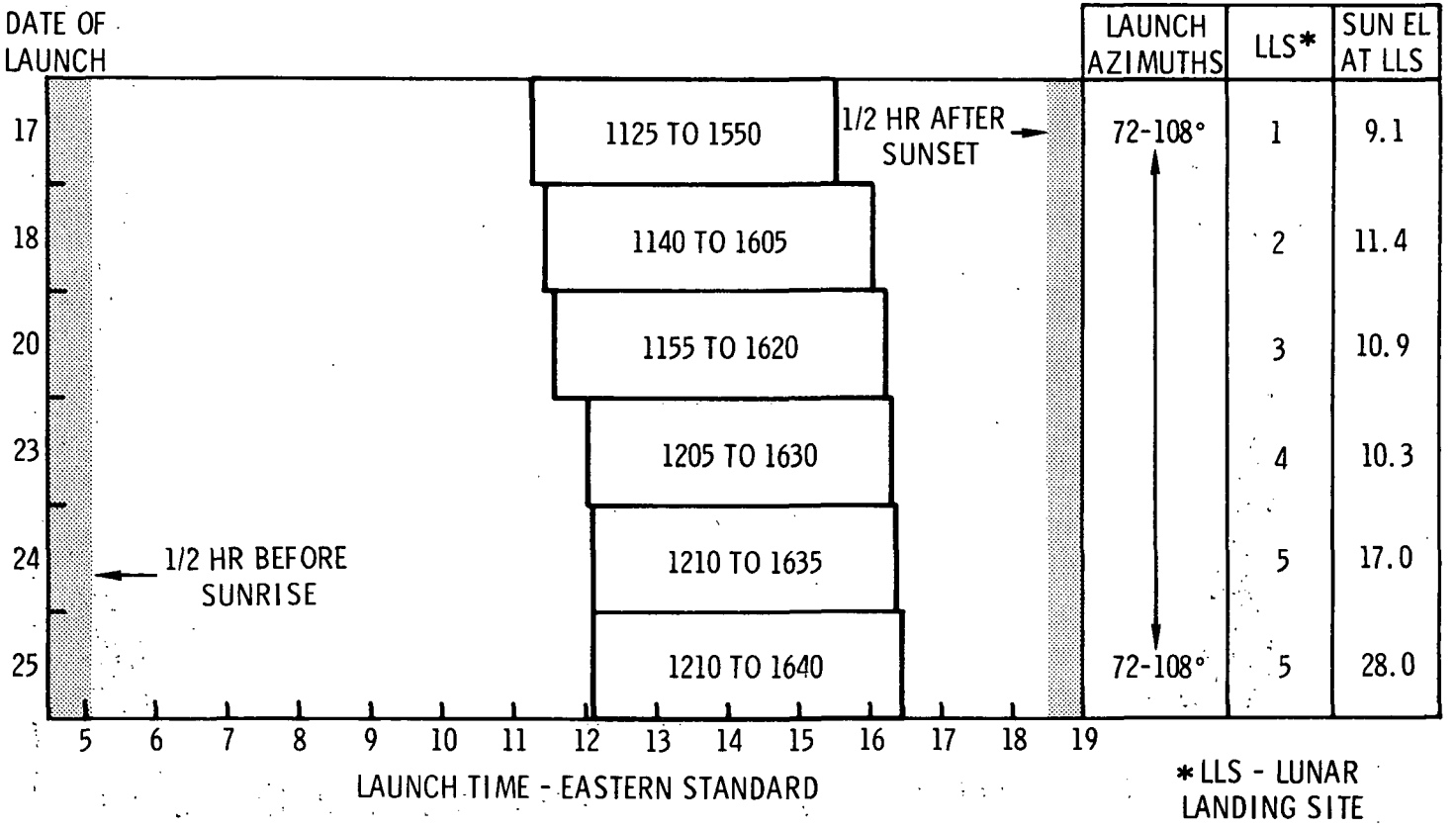


O = MIDCOURSE CORRECTION

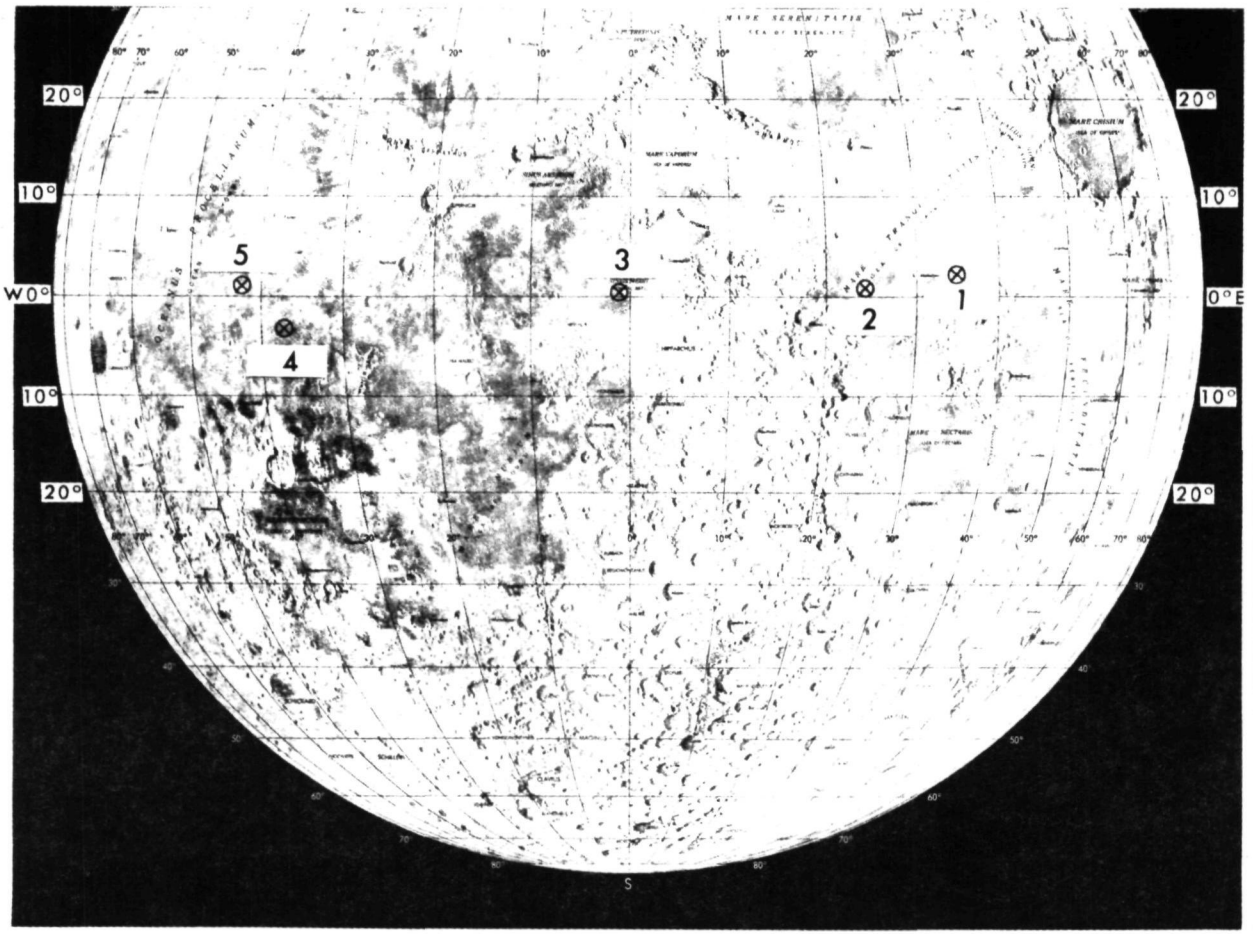
MISSION SUMMARY
MAY 17 72° - 1

LAUNCH TIME	11:34 E.S.T.
EARTH PARKING ORBIT COAST TIME	$2^{H}20^{M}$
TRANSLUNAR INJECTION BURN DURATION	$5^{M}07^{S}$
TRANSLUNAR FLIGHT TIME	$73^{H}40^{M}$
TOTAL FREE-RETURN CIRCUMLUNAR FLIGHT TIME	$150^{H}30^{M}$
LOI(1) BURN DURATION	$5^{M}53^{S}$
LOI(1) ΔV	2867 FPS
LOI(2) BURN DURATION	14.5^{S}
LOI(2) ΔV	137.5 FPS
DOI - Δt FROM LOI(1)	24^{H}
PHASING	DOI + $1^{H}10^{M}$
INSERTION	DOI + $3^{H}07^{M}$
RENDEZVOUS	DOI + $6^{H}15^{M}$
APS BURN TO DEPLETION	DOI + $\sim 9^{H}$
TRANSEARTH INJECTION BURN DURATION	$2^{M}40^{S}$
TRANSEARTH INJECTION BURN ΔV	3250 FPS
TRANSEARTH FLIGHT TIME	$63^{H}26^{M}$
TOTAL MISSION TIME	$7^{D}23^{H}32^{M}$

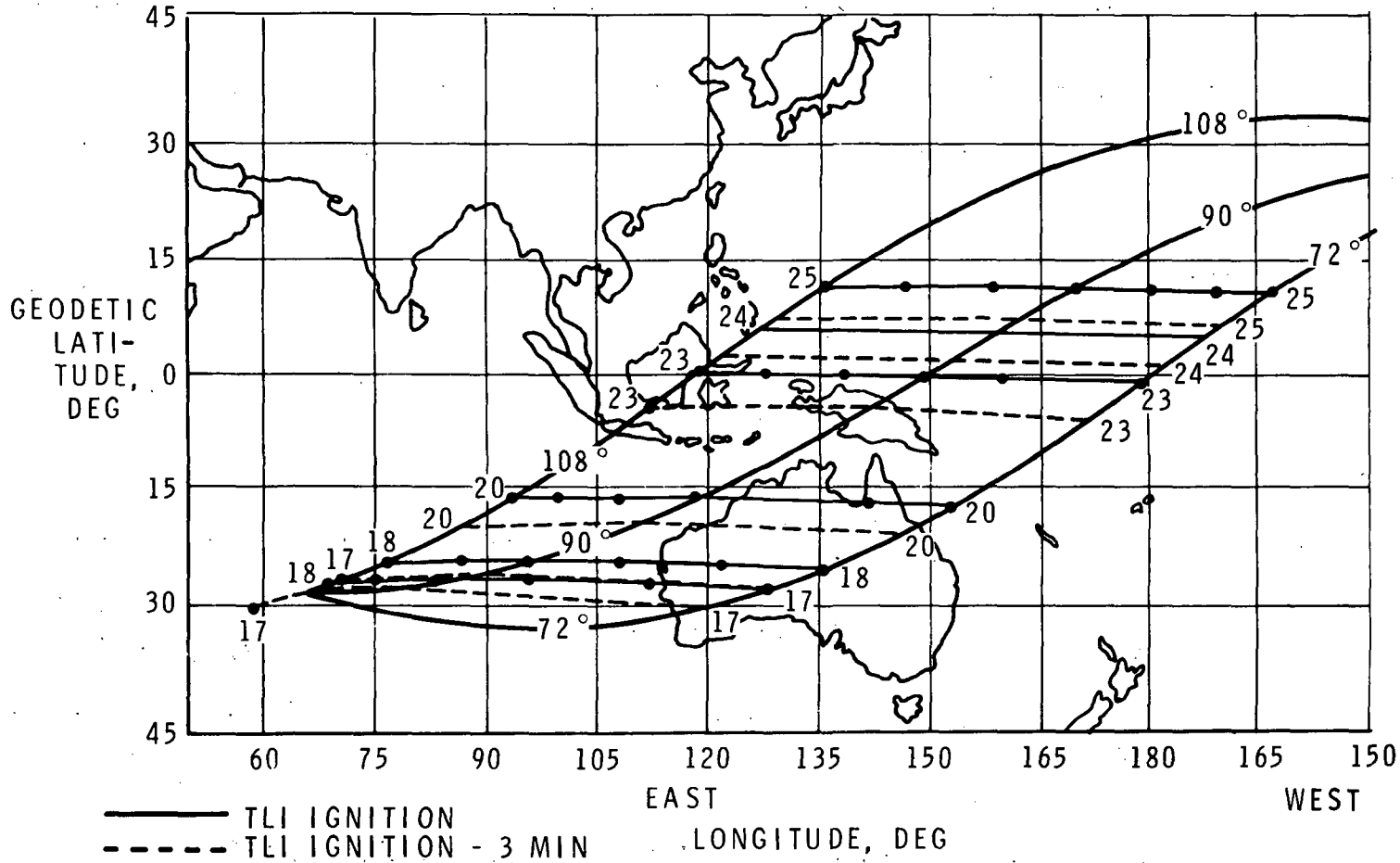
LAUNCH WINDOW SUMMARY
PACIFIC INJECTION



APOLLO CANDIDATE LUNAR LANDING SITES



TRANSLUNAR INJECTION POSITIONS FOR MAY WINDOW



EARTH PARKING ORBIT COAST TIMES*

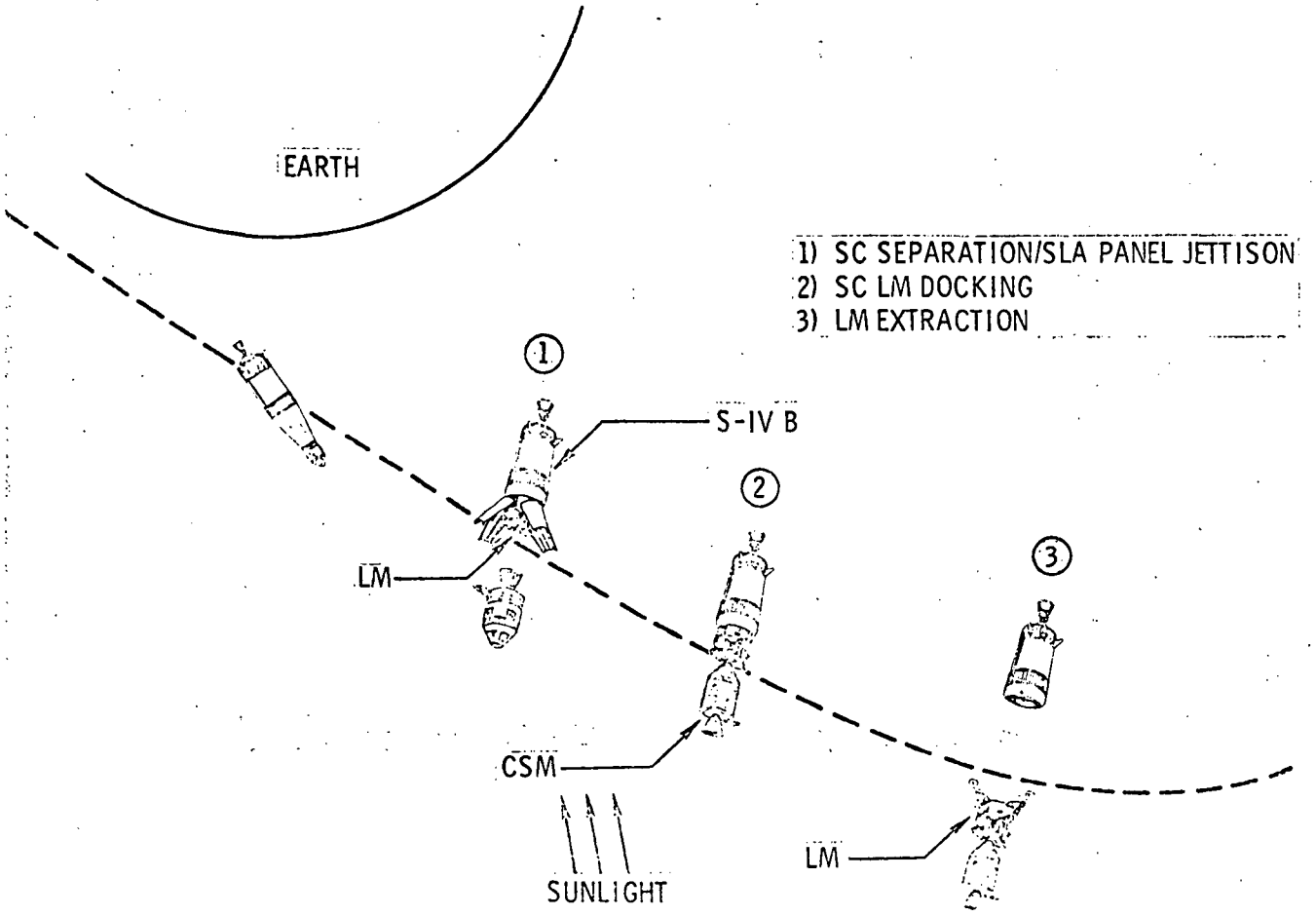
INJECTION OPPORTUNITY	MAY 17 → MAY 25
1	2 HR : 20 MIN → 2 HR : 40 MIN ↓ ↓ 2 HR : 06 MIN → 2 HR : 25 MIN
2	3 HR : 48 MIN → 4 HR : 09 MIN ↓ ↓ 3 HR : 35 MIN → 3 HR : 55 MIN

* Δt FROM EOI TO TLI IGNITION

OLD 3715S

MPAD 4062 S (IU)

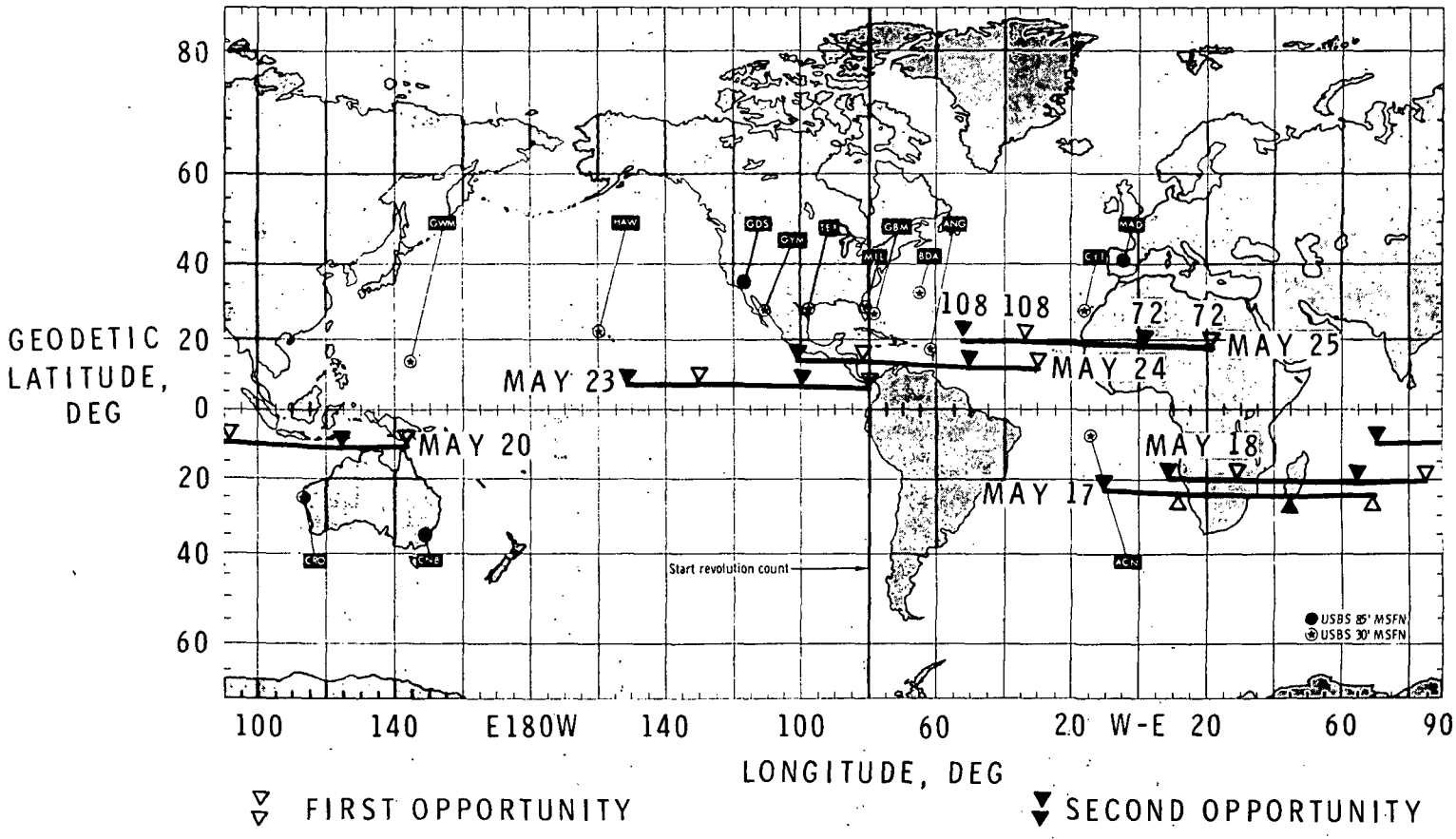
TRANSPOSITION, DOCKING, AND LM EXTRACTION



CIRCUMLUNAR FREE RETURN

MAY	17	18	20	23	24	25
TRANSLUNAR FLIGHT TIME, HR	74.2 ↓ 74.9	75.2 ↓ 75.5	74.9 ↓ 75.1	70.6 ↓ 71.3	70.0 ↓ 70.2	69.1 ↓ 69.3
FREE RETURN INCLINATION, DEG	30.5 ↓ 39.0	23.3 ↓ 24.9	16.4 ↓ 19.9	61.4 ↓ 69.7	17.2 ↓ 23.4	27.4 ↓ 33.7

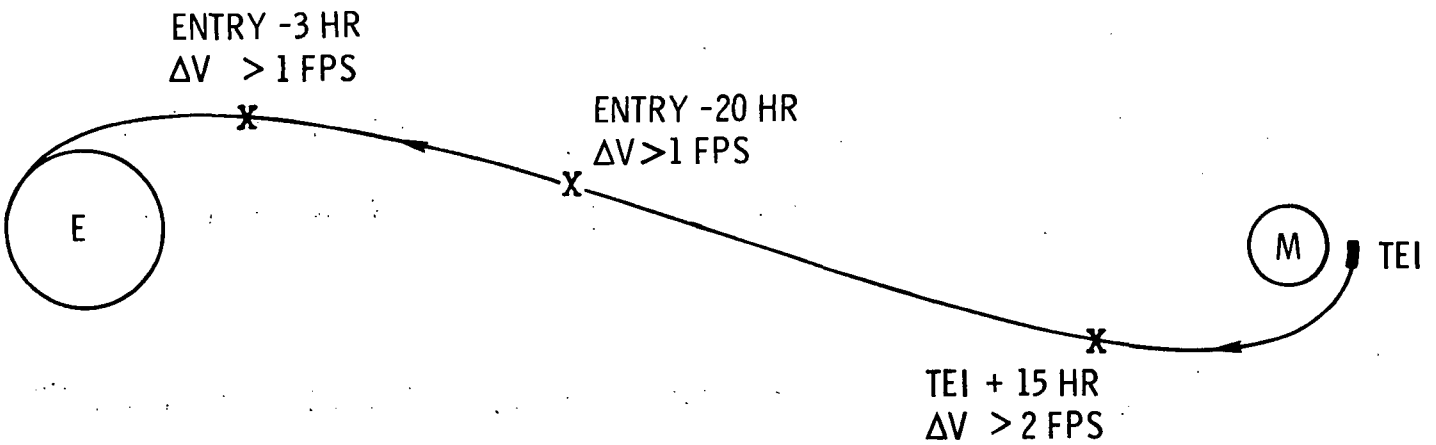
MAY WINDOW FREE RETURN LANDING LOCI



TRANSLUNAR MIDCOURSE CORRECTION PHILOSOPHY

- MAINTAIN SM/RCS FREE-RETURN CAPABILITY
- KEEP LUNAR APPROACH DISPERSIONS WITHIN LOI TARGETING CAPABILITY
- MCC TIMES COMPATIBLE WITH CREW WORK/REST CYCLE IF PRACTICAL

TRANSEARTH MIDCOURSE CORRECTION STRATEGY

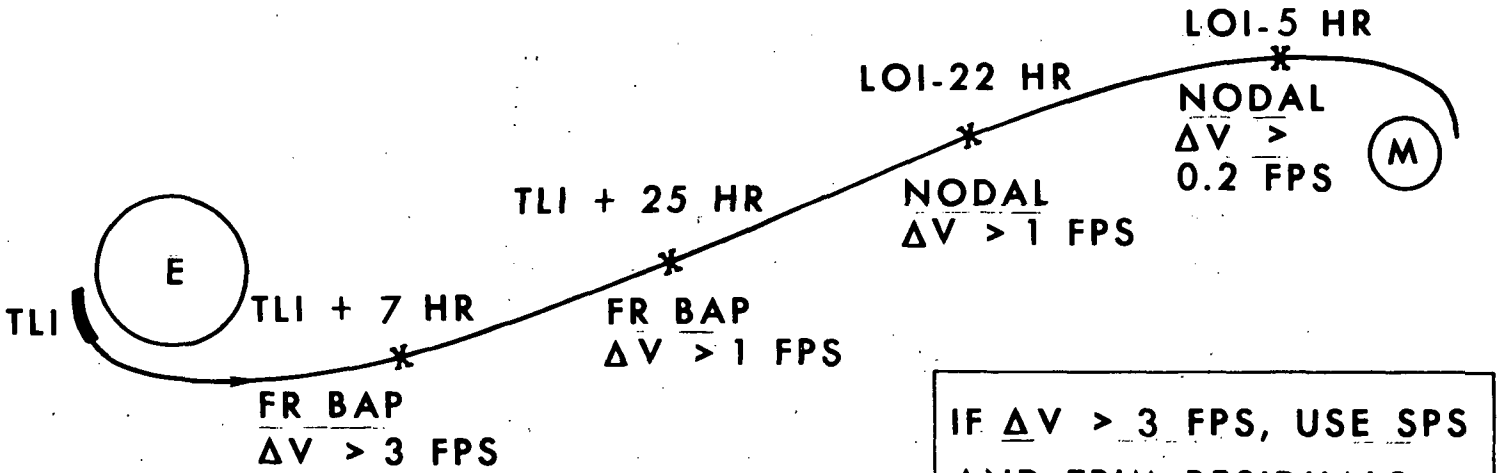


IF ΔV > 15 FPS, USE SPS
AND TRIM RESIDUALS

TRANSEARTH MIDCOURSE CORRECTION PHILOSOPHY

- CORRECTIONS FOR CORRIDOR CONTROL ONLY
- MAINTAIN SAFE ENTRY CONDITIONS WITHIN MSFN UNCERTAINTY
- MAKE CORRECTIONS AT CONVENIENT TIMES IF ΔV GREATER THAN LOCAL MSFN UNCERTAINTY

TRANSLUNAR MIDCOURSE CORRECTION STRATEGY



LUNAR ORBIT INSERTION

- TWO-STAGE:
  - LOI(1)—60 × 170 WITH PLANE CHANGE
  - LOI(2)—60 × 60 IN PLANE
- FIXED ATTITUDE BURNS

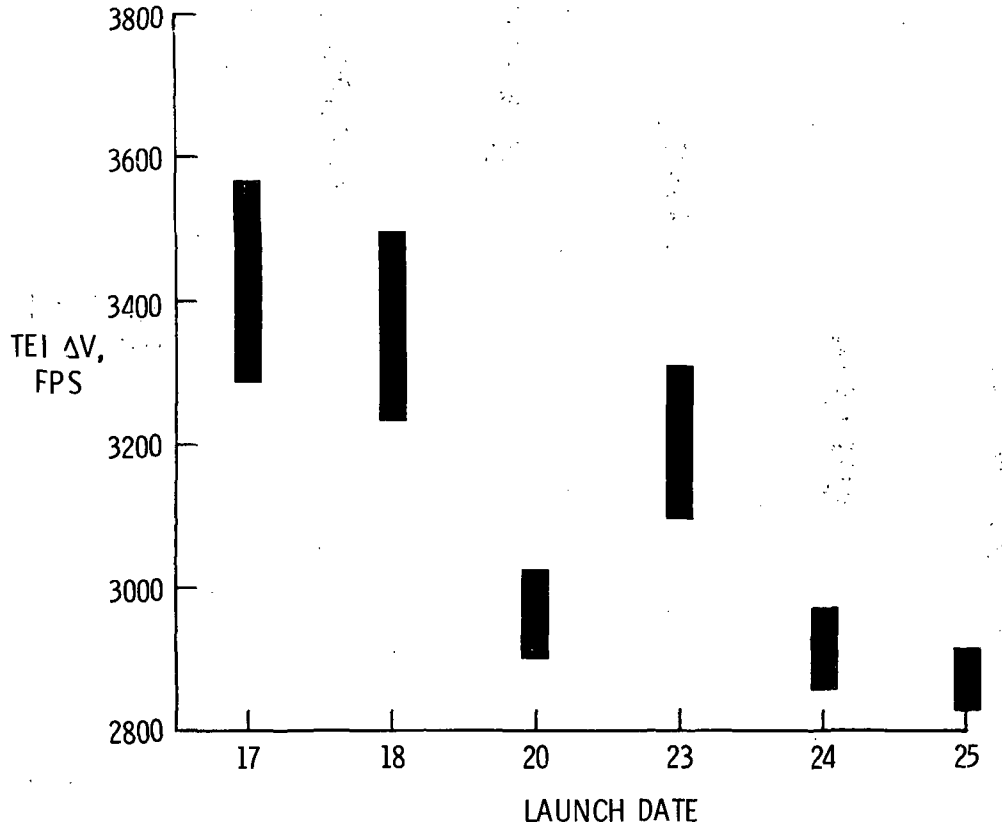
LUNAR ORBIT SUMMARY - MAY

	17	18	20	23	24	25
LUNAR ORBIT TARGET SITE	1	2	3	4	5	5
SUN ELEVATION AT SITE PASS (DEG)	9.1 ↓ 12.0	11.4 ↓ 14.3	10.9 ↓ 13.7	10.3 ↓ 12.9	17.0 ↓ 19.0	28.0 ↓ 30.0
APPROACH AZIMUTH AT SITE (DEG)	-95	-95.25	-95.75	-95	-95	-95
INCLINATION (DEG)	5.6	5.3	5.8	4.2	5.3	5.3

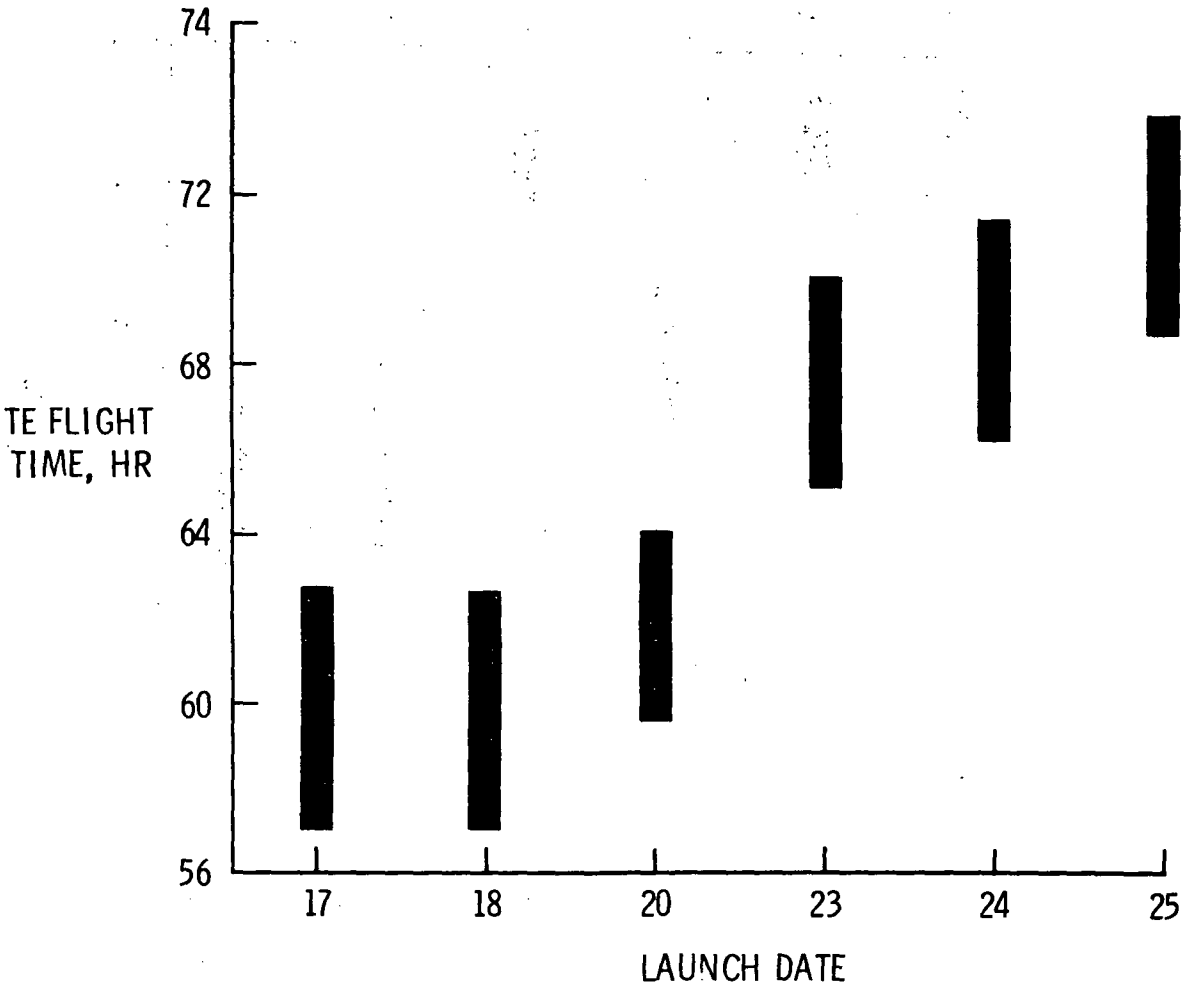
TRANSEARTH INJECTION

- NOMINALLY EXECUTED 51 HR AFTER LOI(1)
- TARGETED LANDING LONGITUDE = 165°W
- LANDING LATITUDE NOT DIRECTLY CONTROLLED
- TARGETED ENTRY PATH ANGLE ≈-6.5°
- RETURN TIME ASAP WHEN ΔV AVAILABLE
- RETURN INCLINATION <40°
- FIXED ATTITUDE BURN

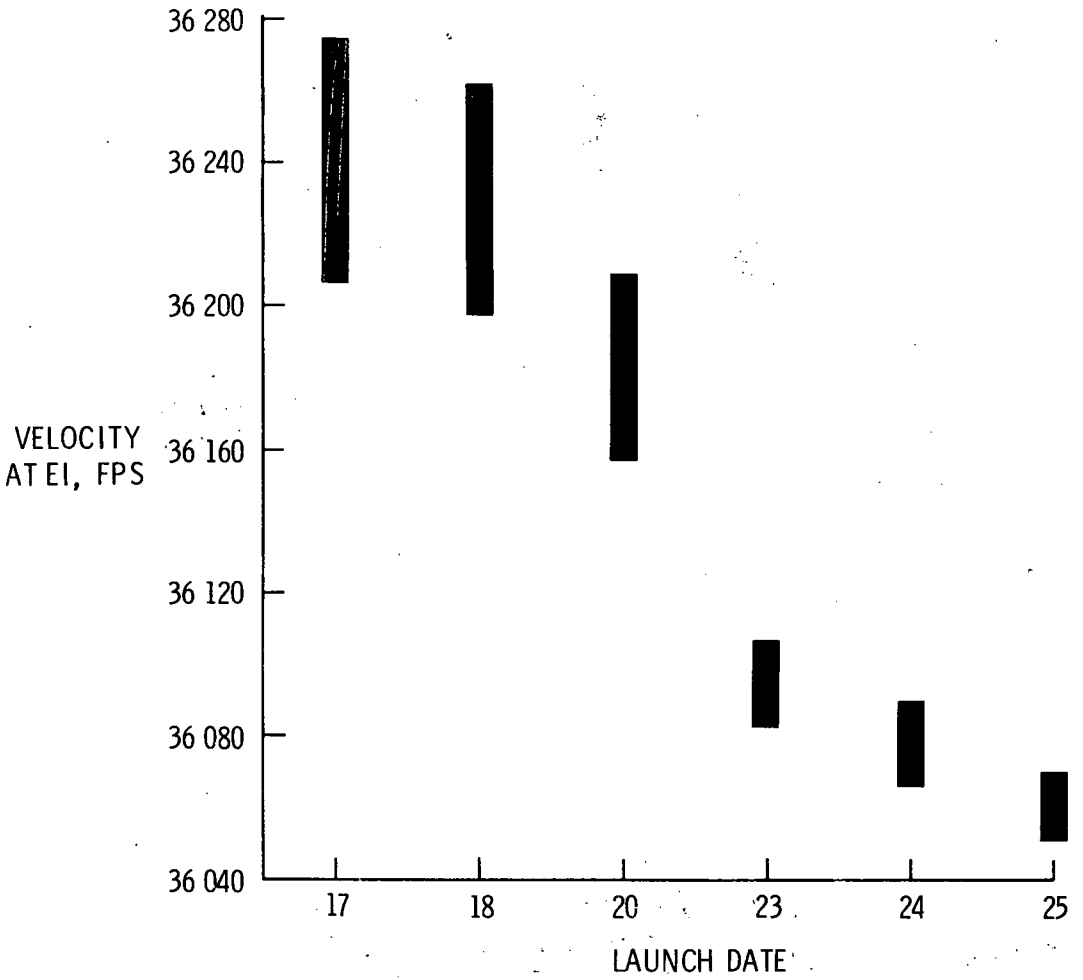
TRANSEARTH SUMMARY MAY 1969



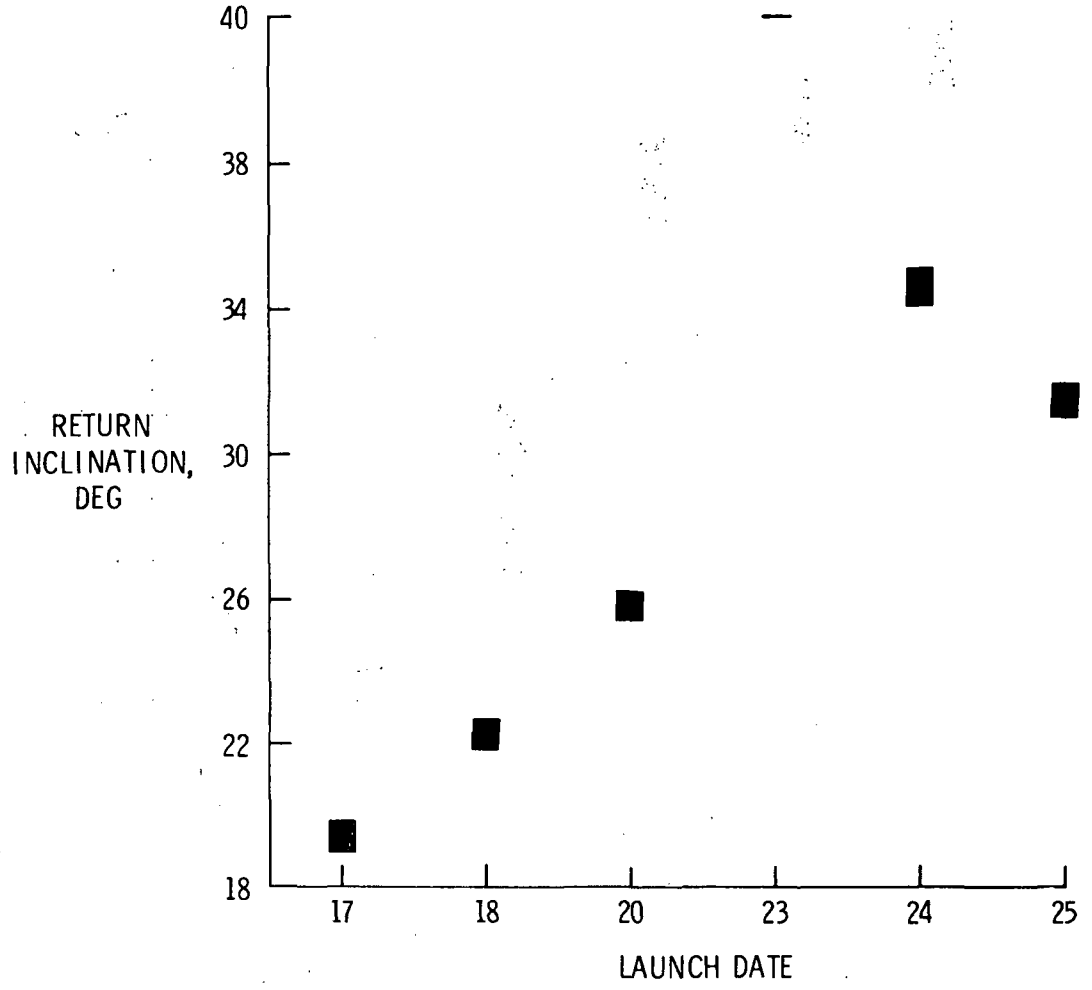
TRANSEARTH SUMMARY MAY 1969
(CONTINUED)



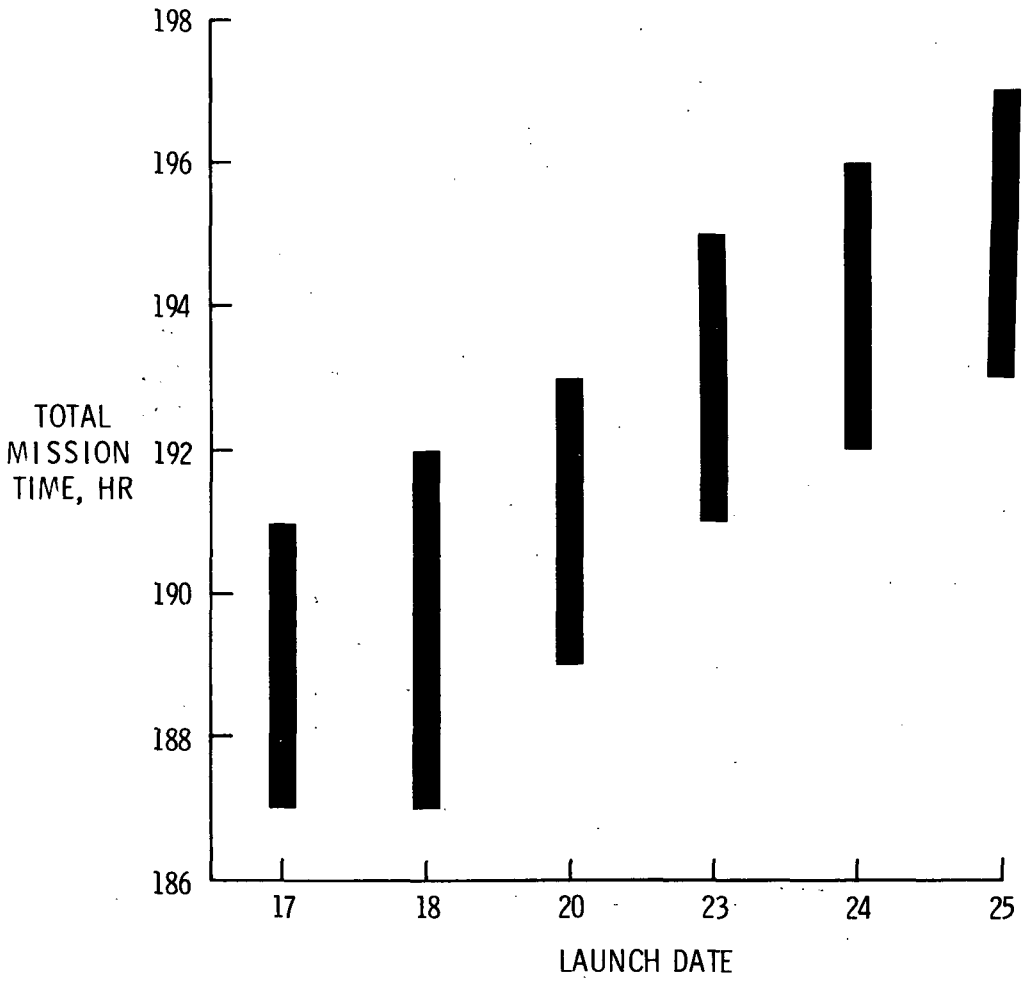
TRANSEARTH SUMMARY MAY 1969
(CONTINUED)



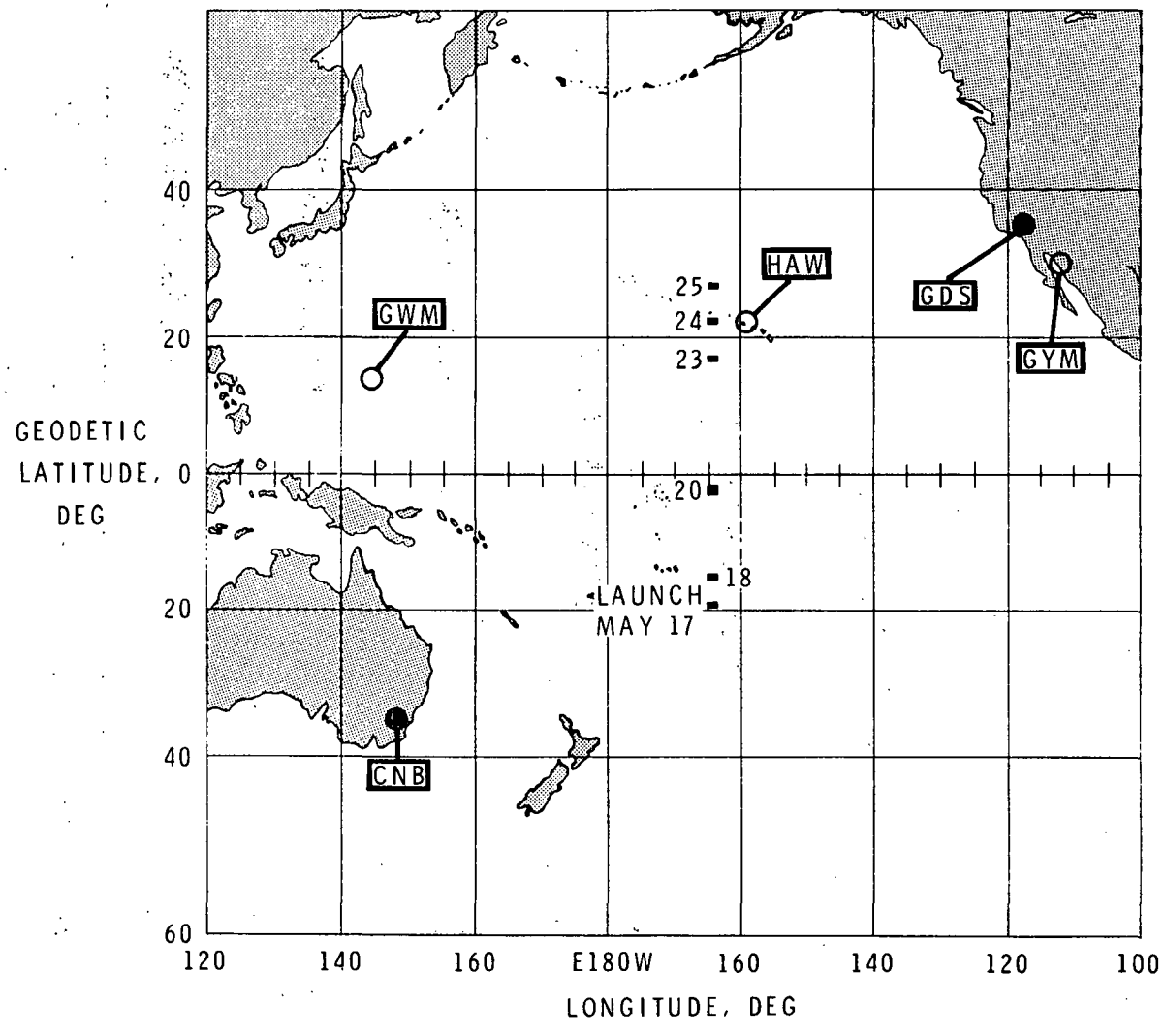
TRANSEARTH SUMMARY MAY 1969
(CONTINUED)



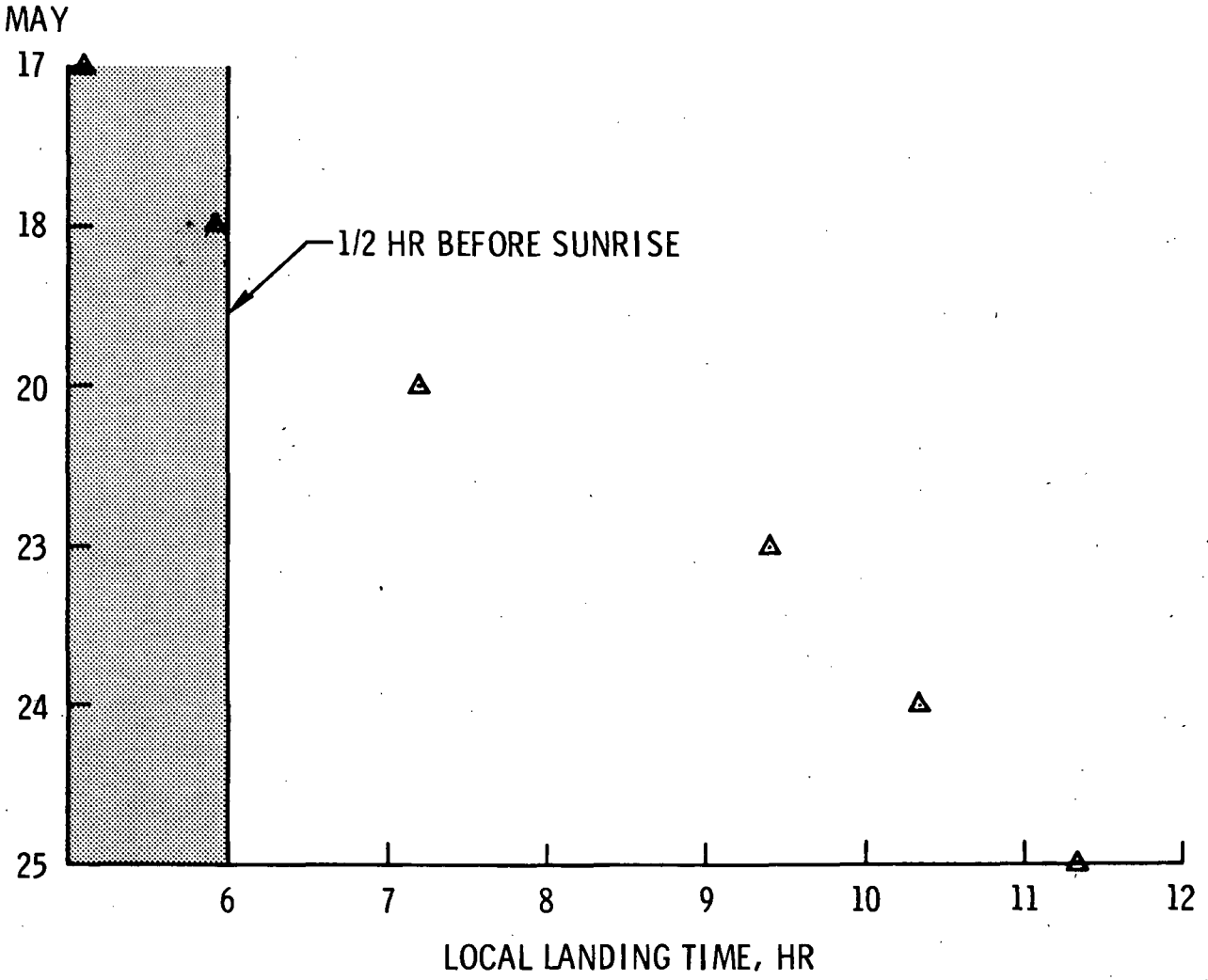
TRANSEARTH SUMMARY MAY 1969 (CONCLUDED)



MAY WINDOW NOMINAL RETURN LOCI



MAY WINDOW RETURN LANDING TIMES



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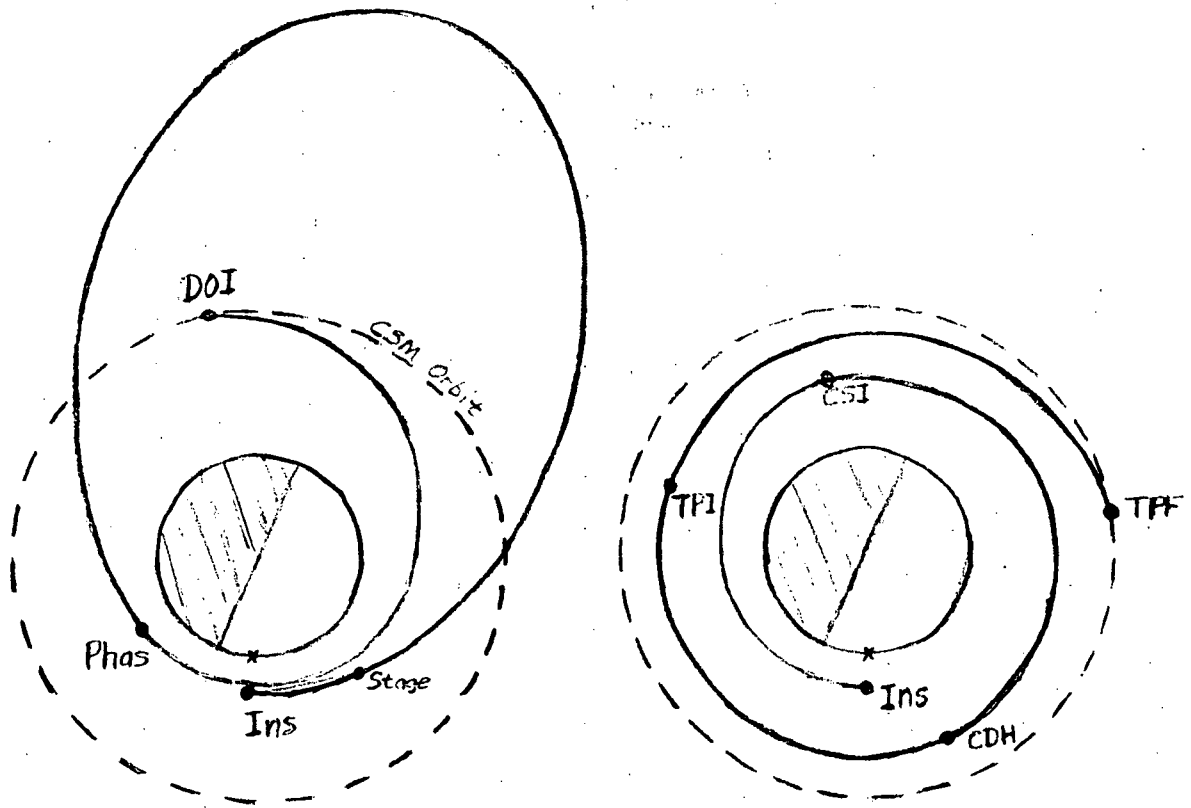
2.0 RENDEZVOUS

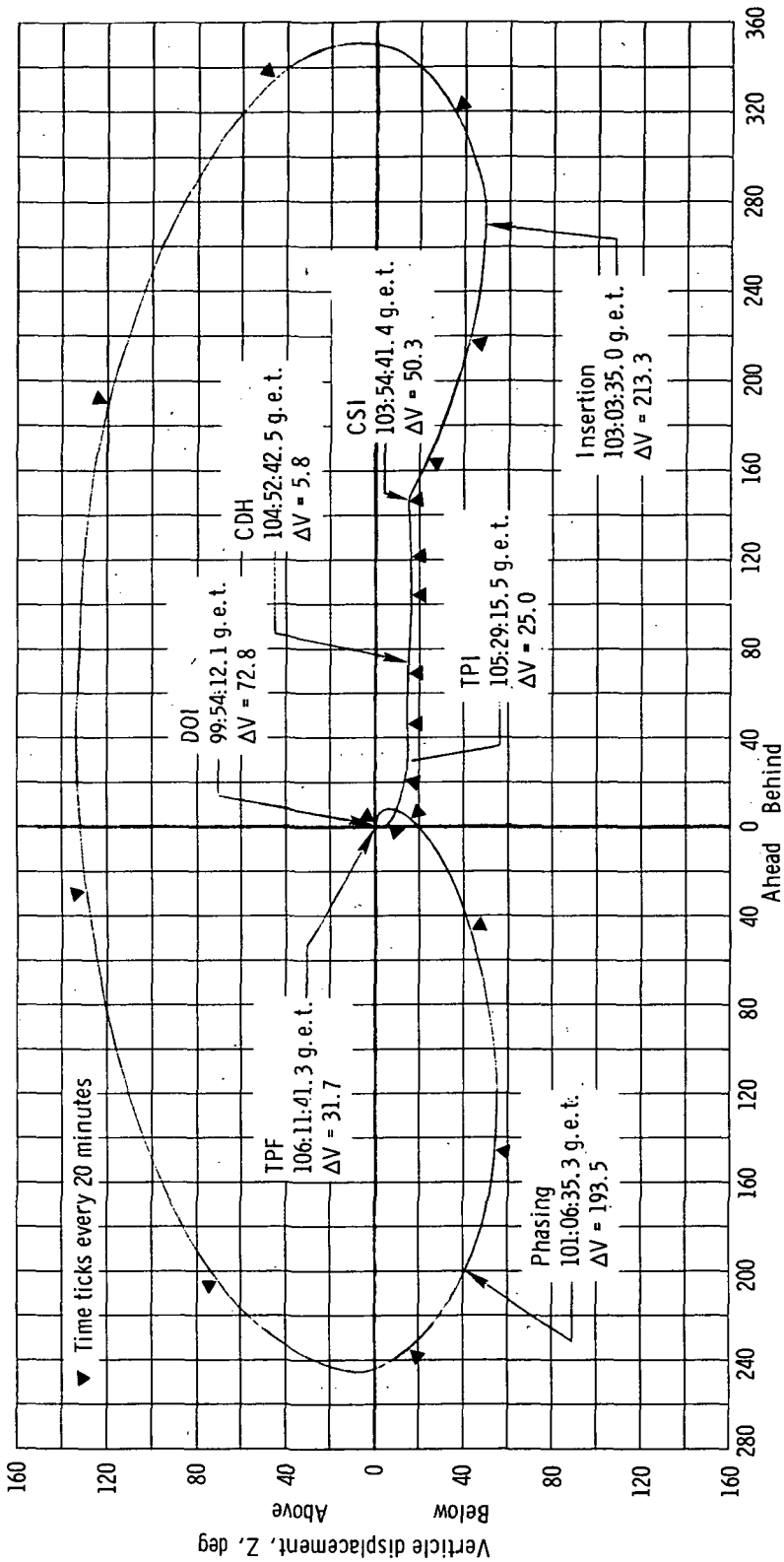
James D. Alexander and Kenneth A. Young

TABLE I. APOLLO 10 MANEUVER SUMMARY

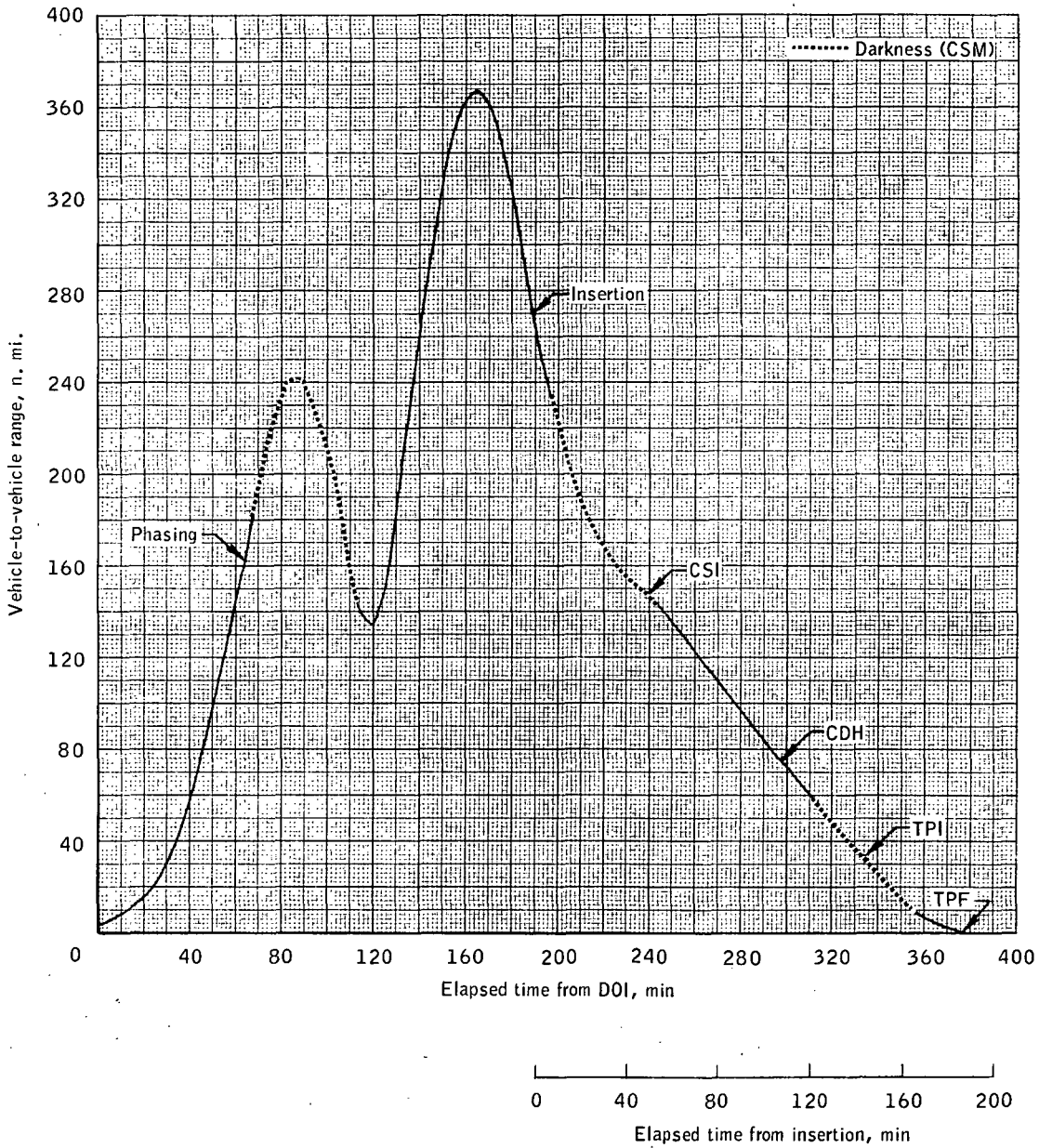
Maneuver	Δt from DOI, min	Δt from previous maneuver, min	Propulsion System	ΔV, fps	Burn duration, sec	Thrust direction, deg	Resulting orbit h_a/h_p n. mi.
DOI	-	-	DPS (40%)	72.8	27.5	180.0	58.2/ 8.2
Phasing	72.4	72.4	DPS (F.T.)	193.5	41.3	26.1	194.4/ 9.9
Insertion	189.3	116.9	APS	213.3	16.4	152.6	43.7/ 9.9
CSI	240.5	51.2	+X RCS	50.3	32.0	0.0	45.8/43.6
PC	269.5	29.0	+Y RCS	0.0	0.0	0.0	45.8/43.6
CDH	298.5	29.0	+Z RCS	5.8	7.4	277.3	46.1/42.8
TPI	335.1	36.6	+Z RCS	25.0	31.7	26.6	62.3/42.9
TPF	377.5	42.4	-Z RCS	31.7	40.0	305.3	61.2/51.8



F Nominal Rendezvous



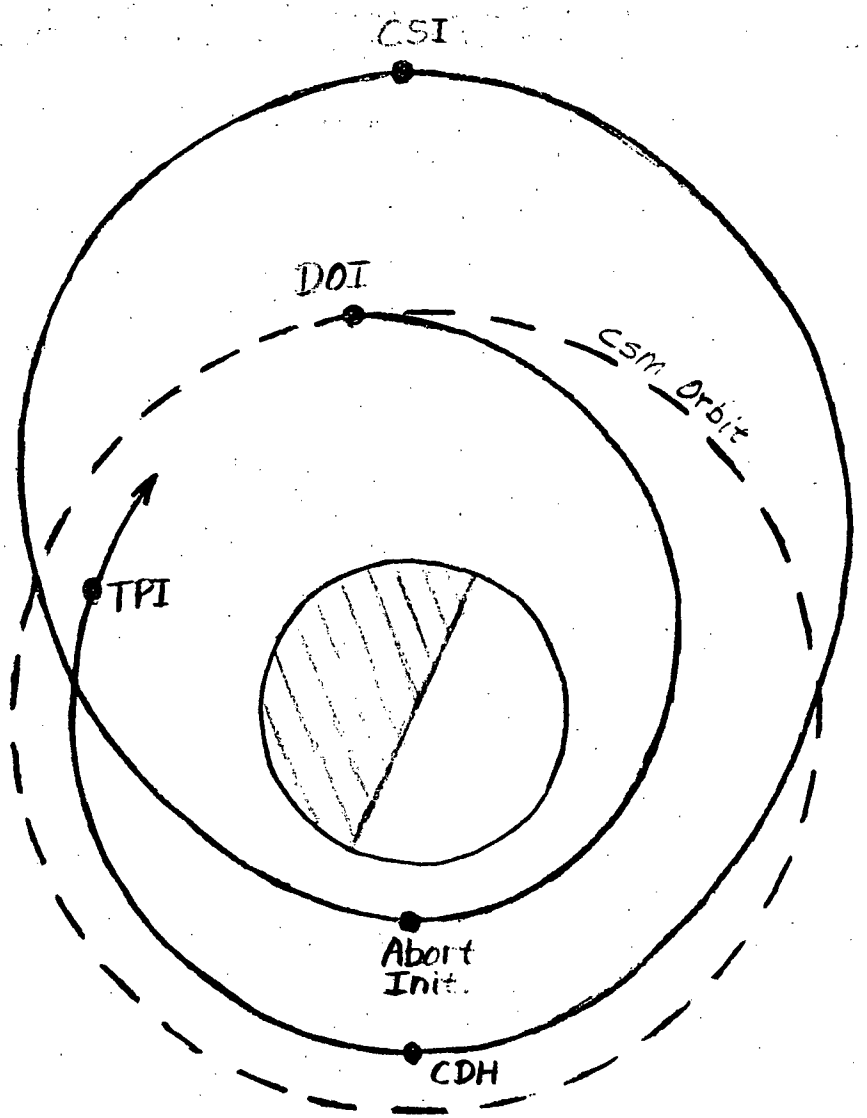
Apollo mission F rendezvous.



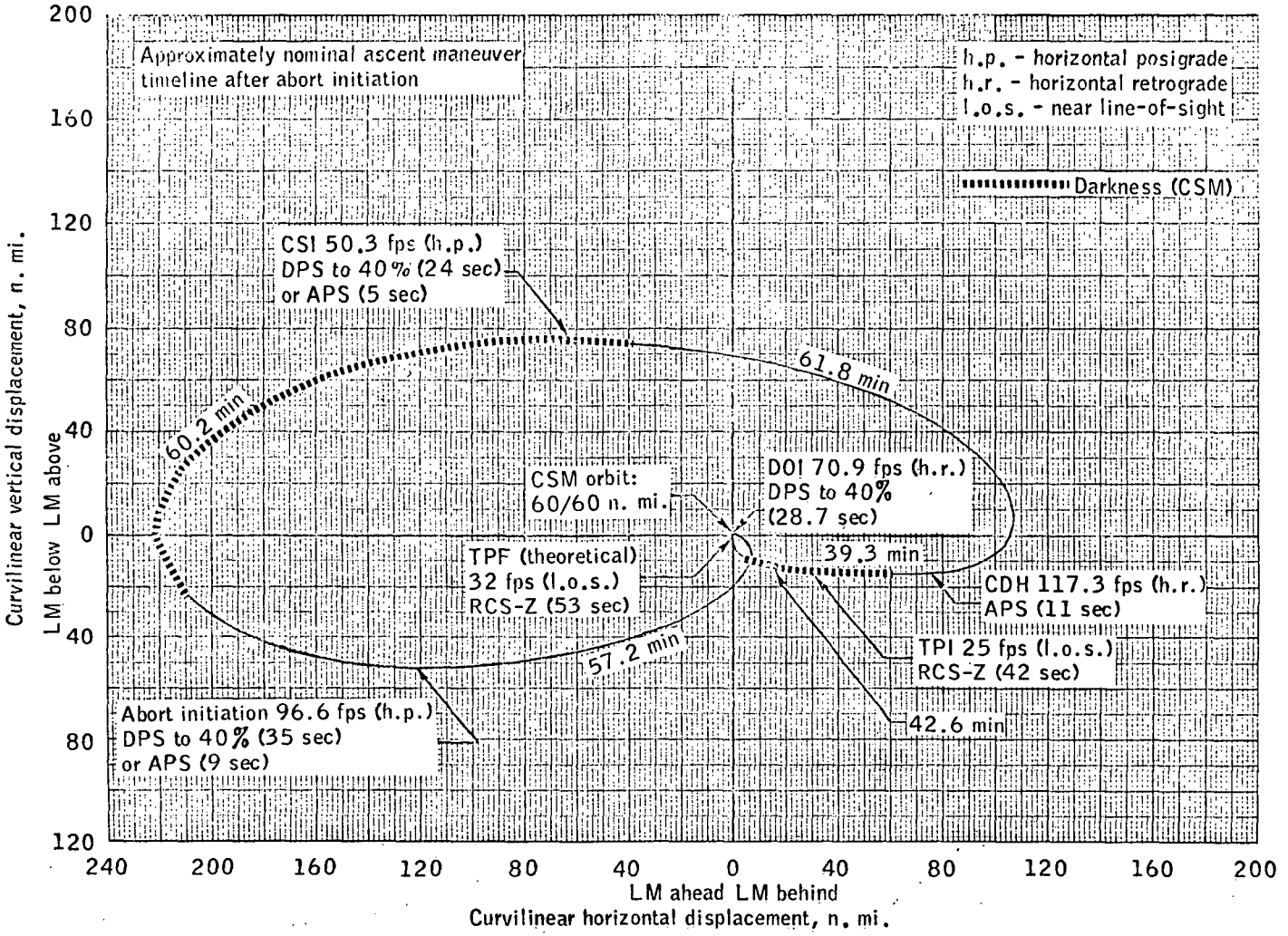
Time history of vehicle-to-vehicle range for LM-1.

F ABORT AND RESCUE PROCEDURES

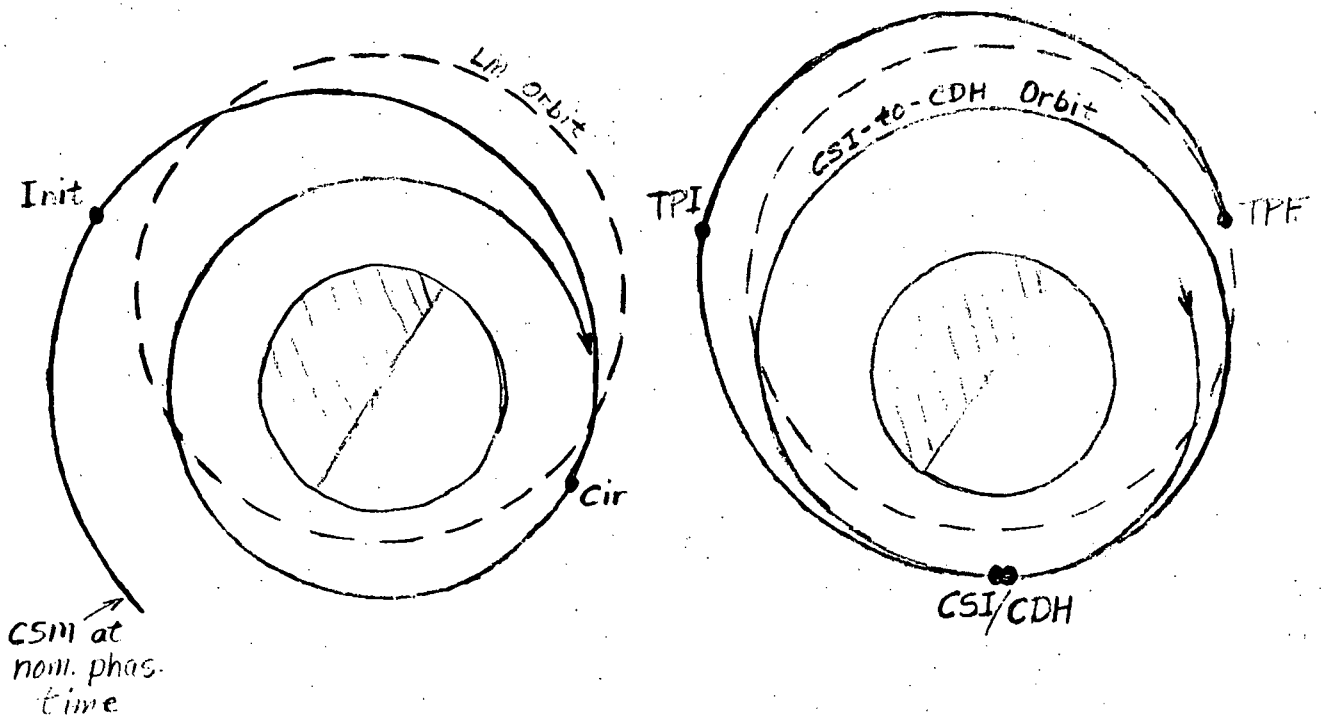
Contingency Realization	Magnitude of Failure	Immediate Action	Contingency Sequence	Rendezvous Time (rel to nom)
Within 5 min of DOI		Establish closing	Direct return	
Prior to Hoh peri		None	5-impulse (LM)	1 rev early
at Hoh peri	- DPS and APS	RCS to 97 fps	5-impulse (LM or comb)	1 rev early
	- RCS	Rescue init	6-impulse (CSM)	nominal
At phasing	- DPS	APS to nominal	Nominal (A/S + 2 hr)	nominal
	- APS, $\Delta V > 100$ fps	RCS to nominal	Nominal (CSM insert)	nominal
	- APS, $\Delta V < 100$ fps	RCS to 100 fps	5-impulse (LM or Comb)	1 rev early
	- RCS, $\Delta V < 50$ fps	Rescue init	6-impulse (CSM)	1 rev late
	- RCS, $\Delta V > 50$ fps	None	5-impulse (CSM)	1 rev late
At insertion	- APS	RCS to nominal	Nominal	nominal
		RCS to 130 fps	5-impulse (LM)	1 rev late
		RCS to 50 fps	5-impulse (LM)	2 rev late
	- RCS	None	5-impulse (CSM)	1 rev late
At CSI	- RCS	CSM CSI	Nominal (CSM)	nominal
At CDH	- RCS	CSM CDH	Nominal (CSM)	nominal



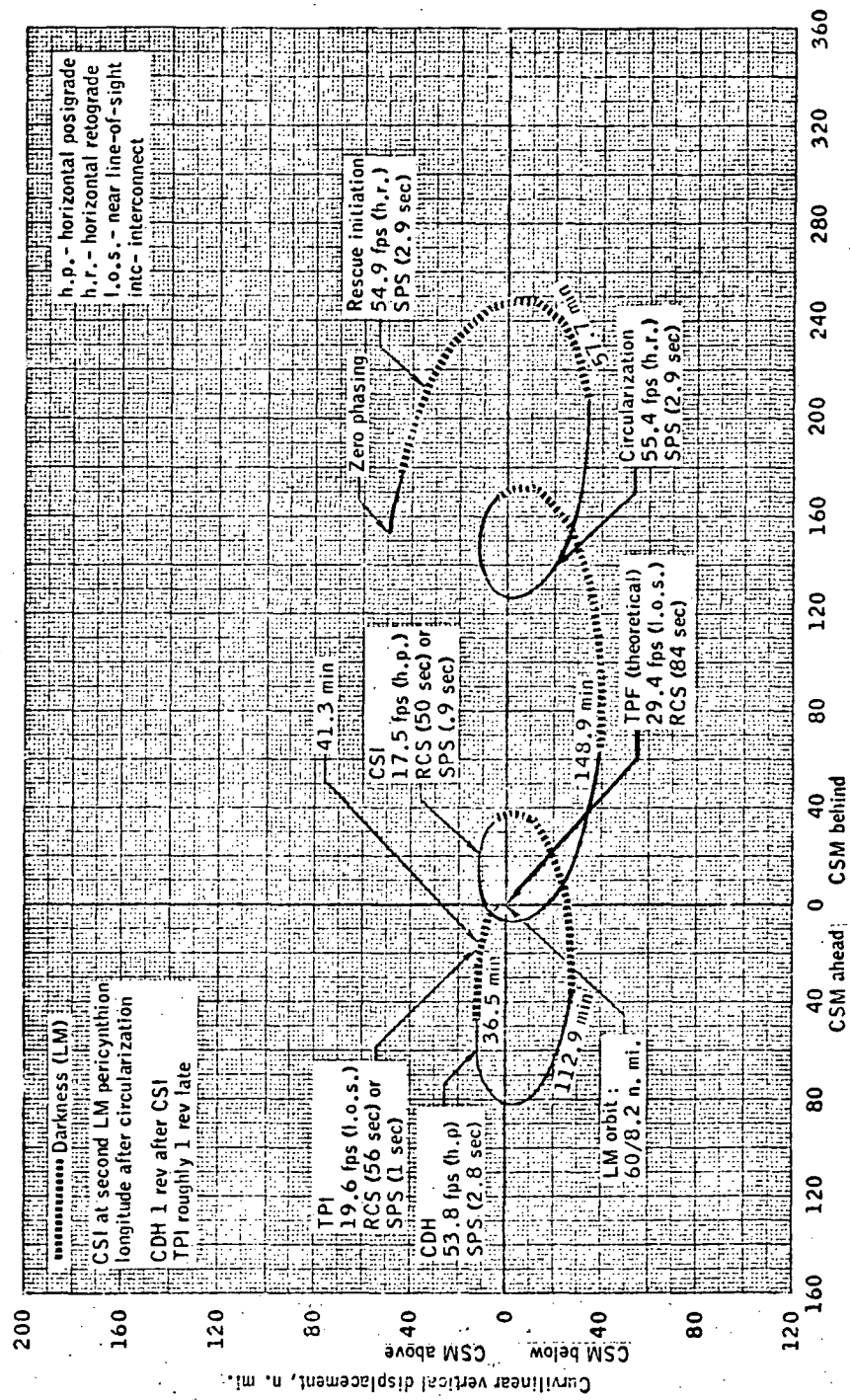
Early Rendezvous Abort Sequence



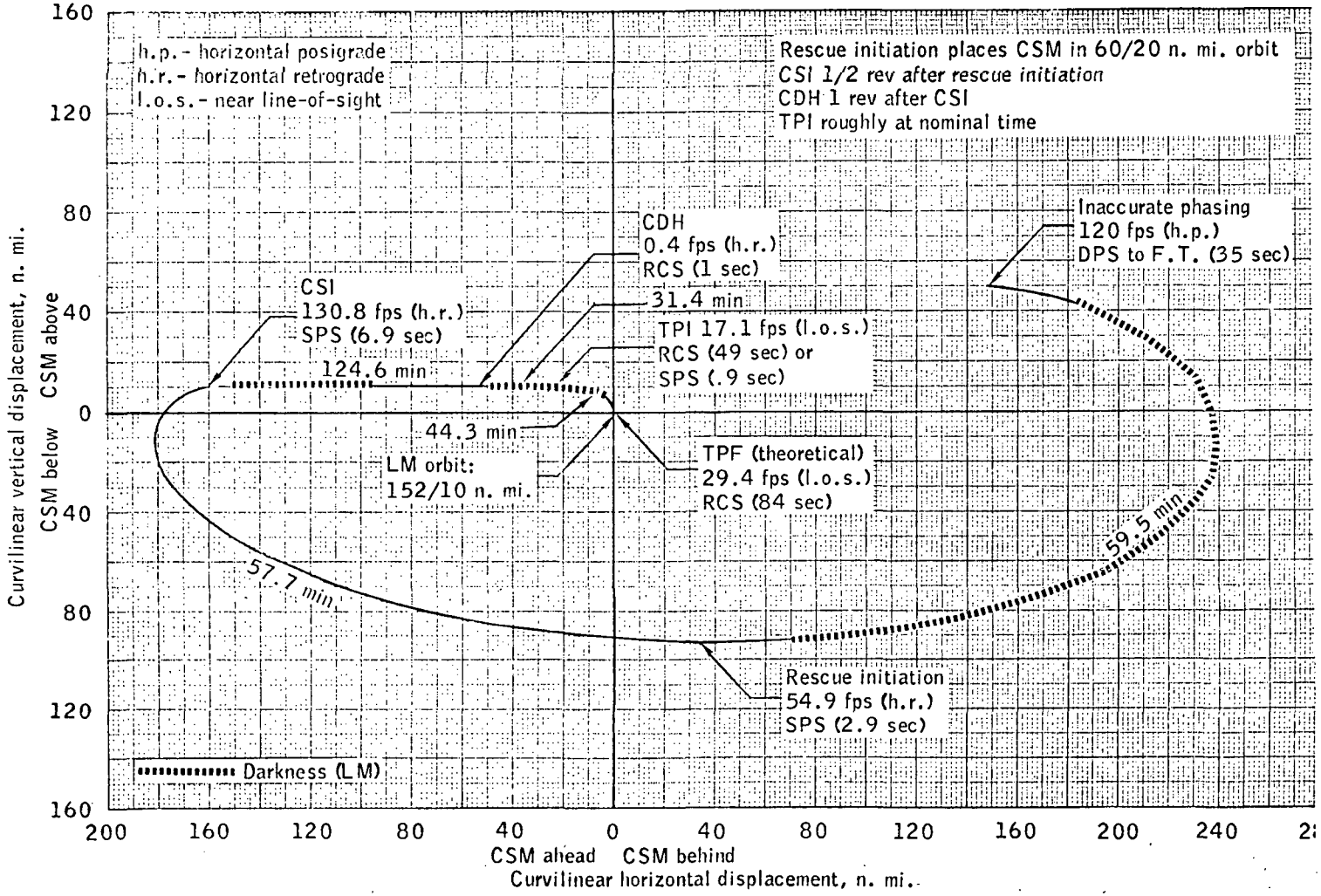
Relative motion (curvilinear, CSM-centered) for five-impulse abort initiated at pericynthion of Hohmann descent orbit after a nominal DOI (rendezvous one revolution earlier than nominal).



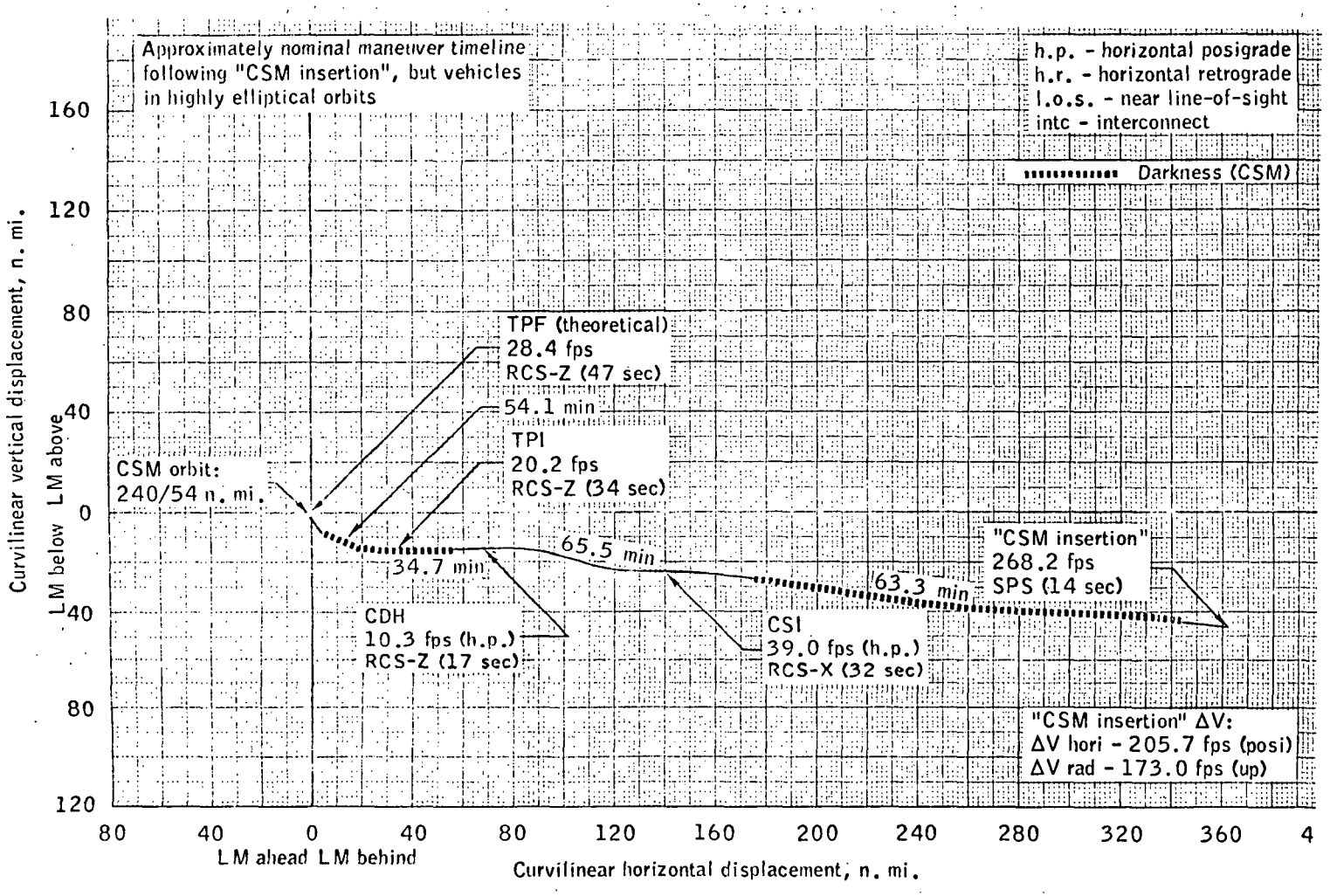
Six-Impulse Rescue
after Small Phasing



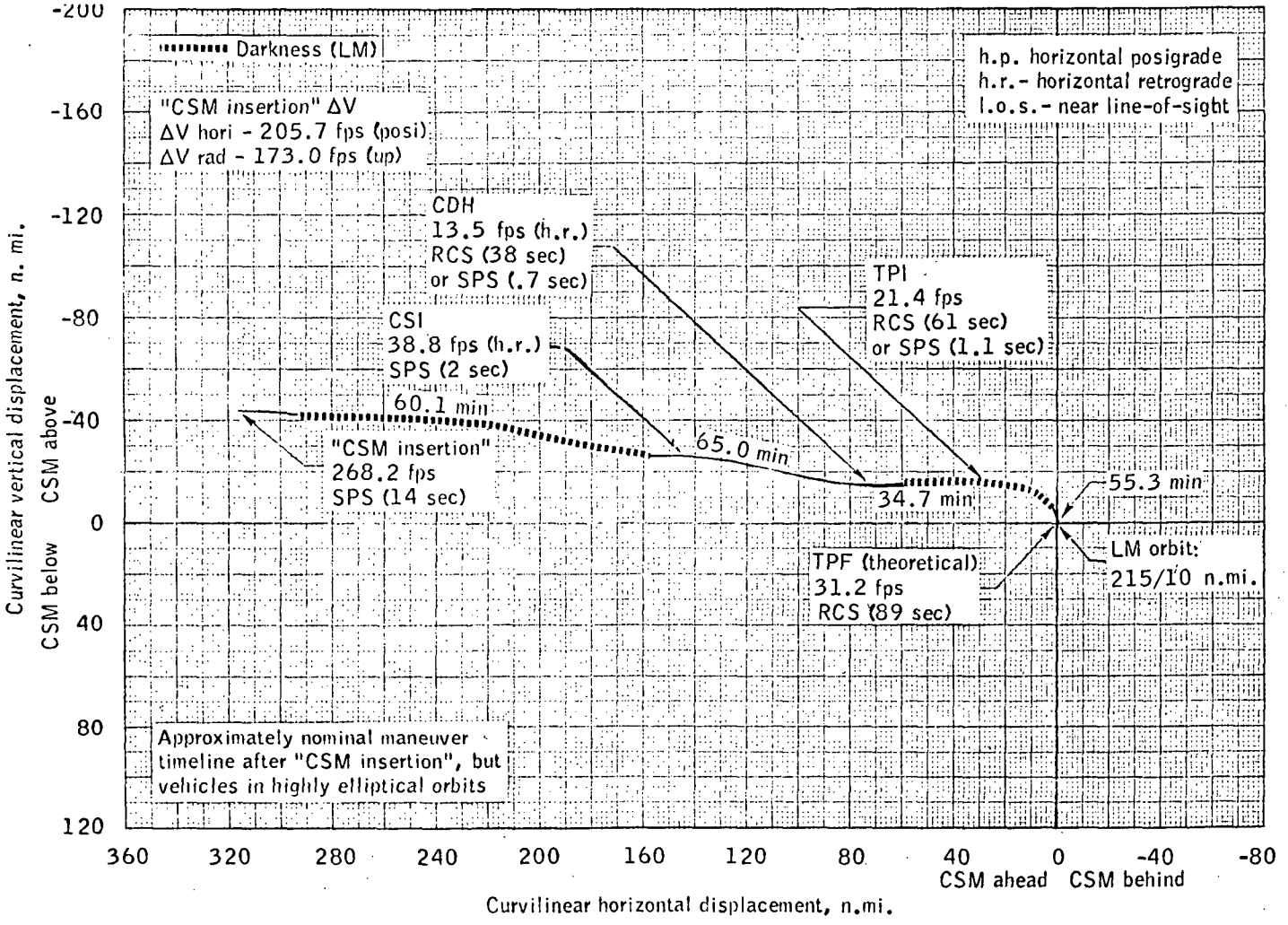
Relative motion (curvilinear, LM-centered) for six-impulse rescue initiated at 15 minutes after a zero phasing (with LM in Hohmann descent orbit).



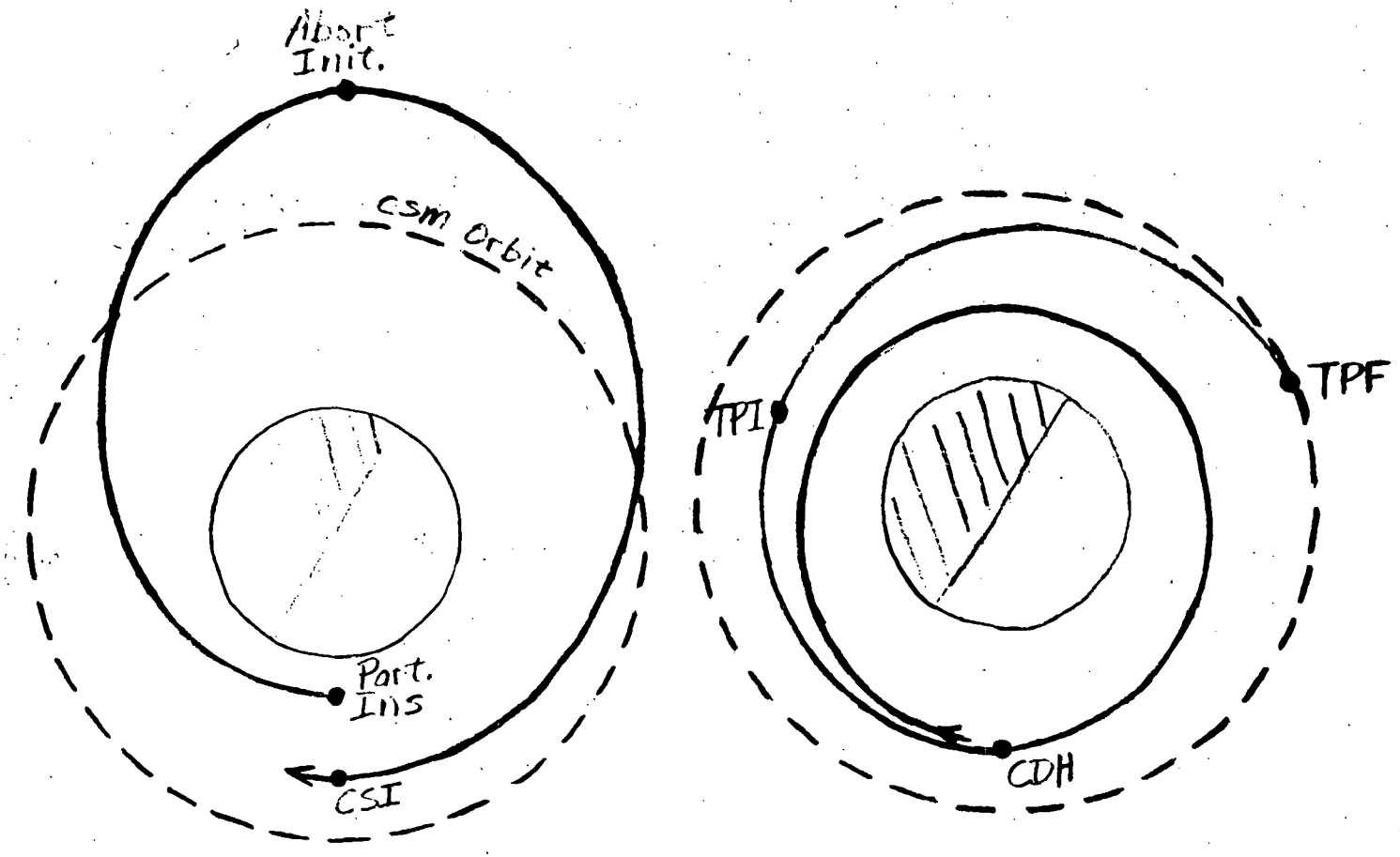
Representative relative motion (curvilinear, LM-centered) for five-impulse rescue initiated at longitude of LM anocynthion after an inaccurate phasing maneuver (120 fps).



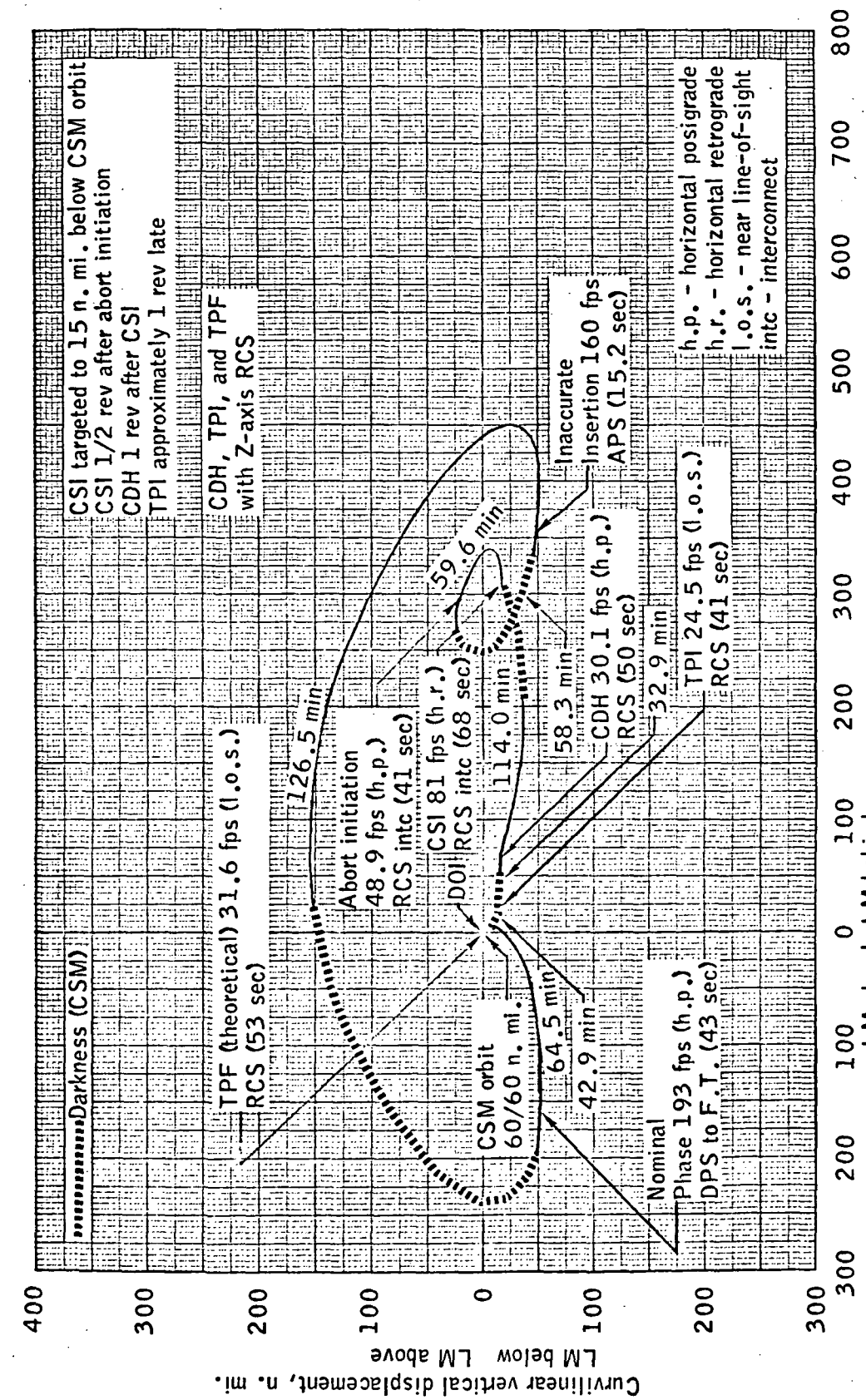
Relative motion (curvilinear, CSM-centered) for abort following a "CSM insertion maneuver" applied one minute after nominal insertion time.



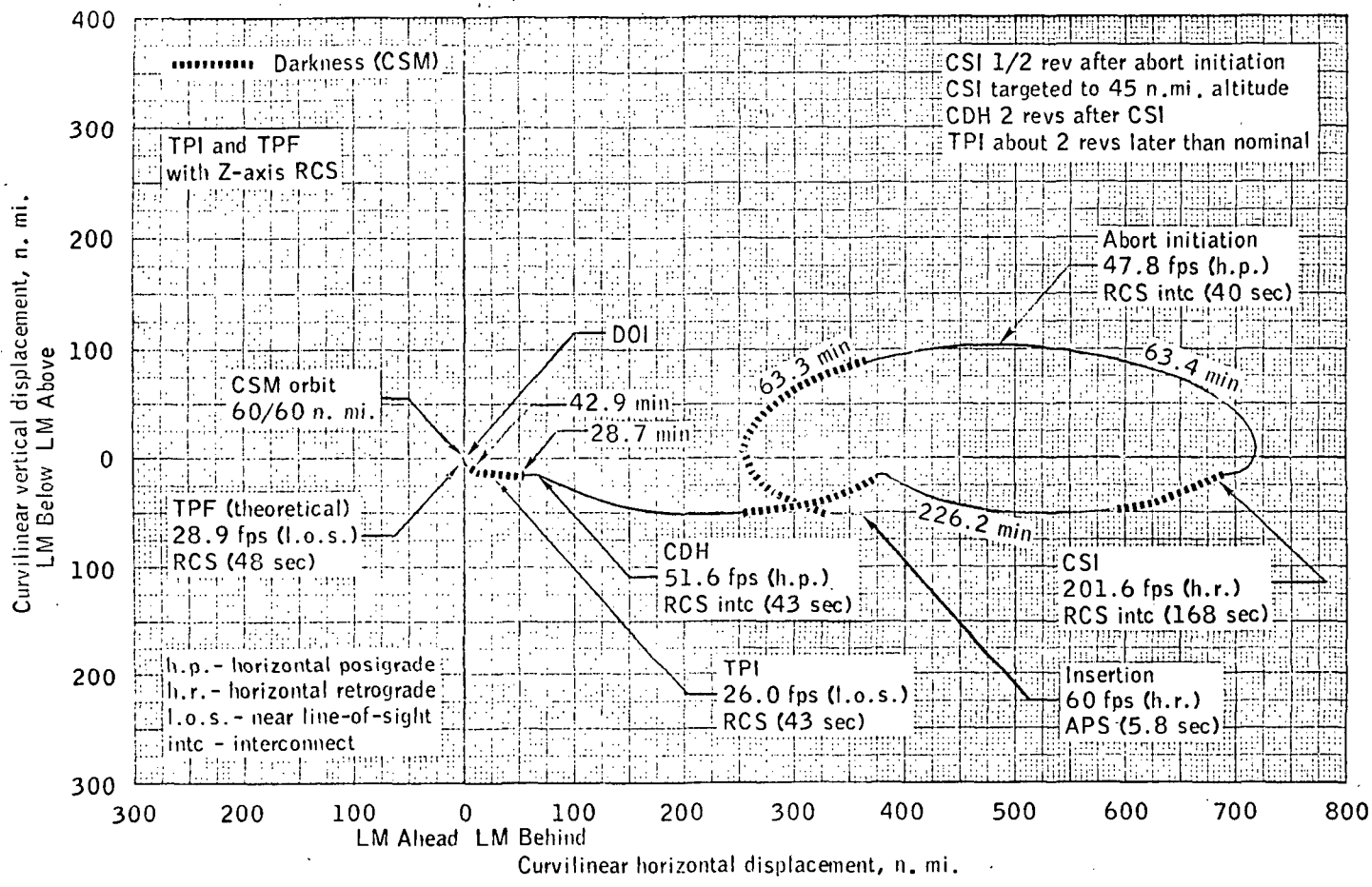
Relative motion (curvilinear, LM- centered) for rescue initiated one minute after a zero insertion.



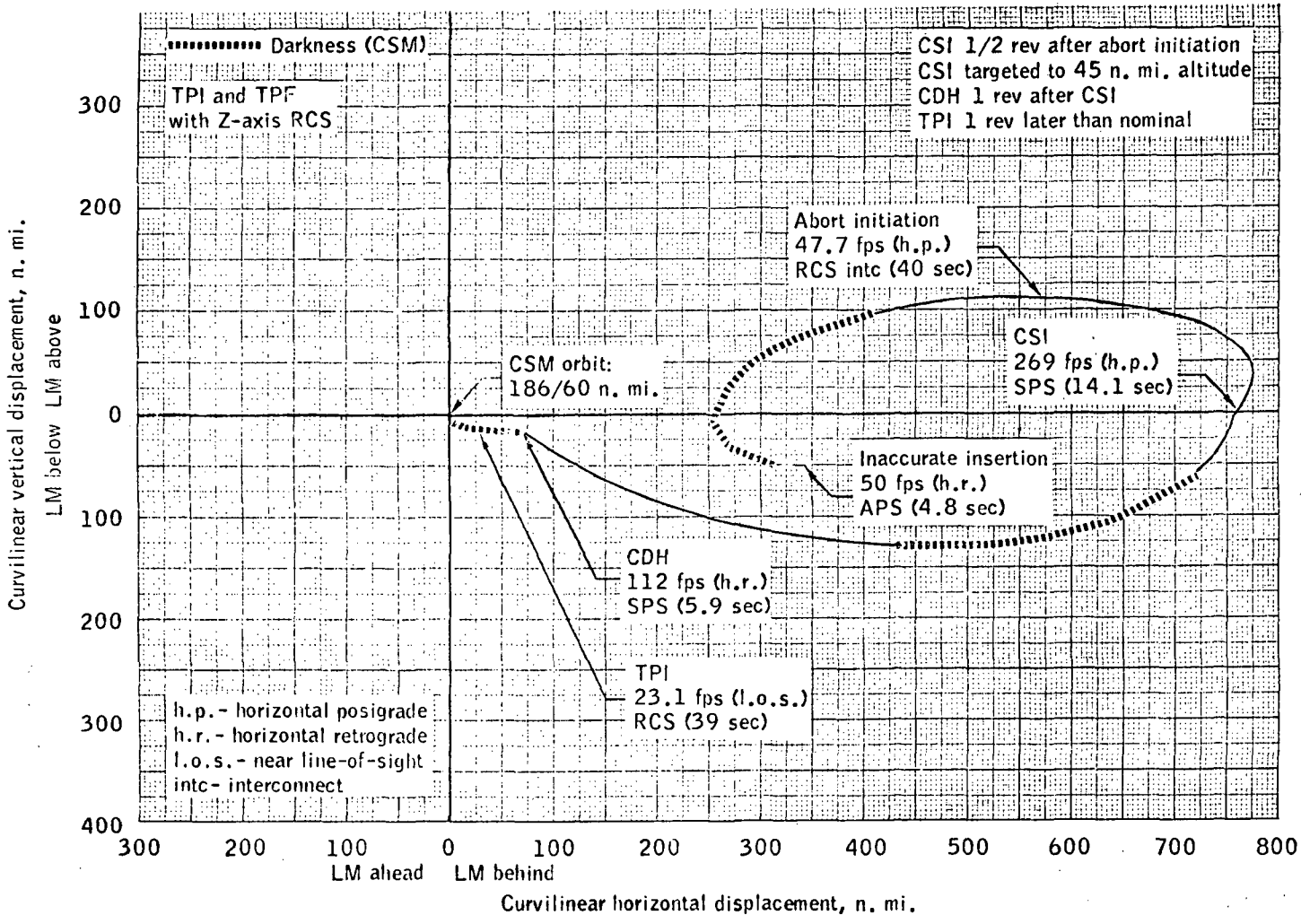
Five-Impulse Abort Sequence
after partial Insertion



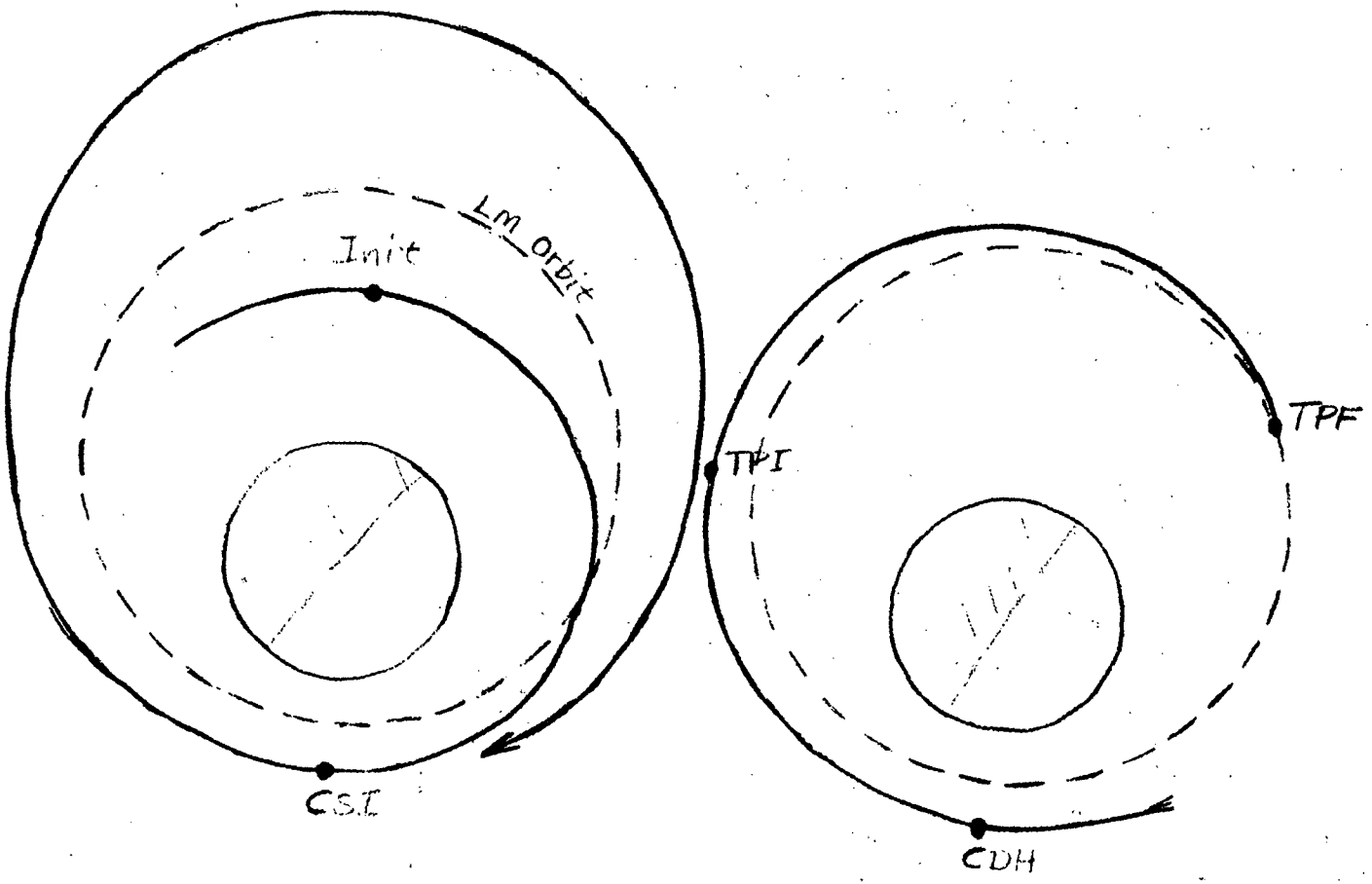
Representative relative motion (curvilinear, CSM-centered) for five-impulse abort initiated at resulting apocynthion after an inaccurate insertion maneuver (160 fps), assuming a nominal phasing maneuver.



Representative relative motion (curvilinear, CSM-centered) for a five-impulse abort initiated at LM apocynthion after an inaccurate insertion maneuver (60 fps). Two revolutions required between CSI and CDH.



Representative relative motion (curvilinear, CSM-centered) for five-impulse "combined" abort technique initiated at resulting LM apocynthion after an inaccurate insertion (50 fps); CSM performs CSI and CDH.



Five-Impulse Rescue Sequence
after partial Insertion

TIME CRITICAL ABORT

Time assumption - Must be docked in 80-90 minutes

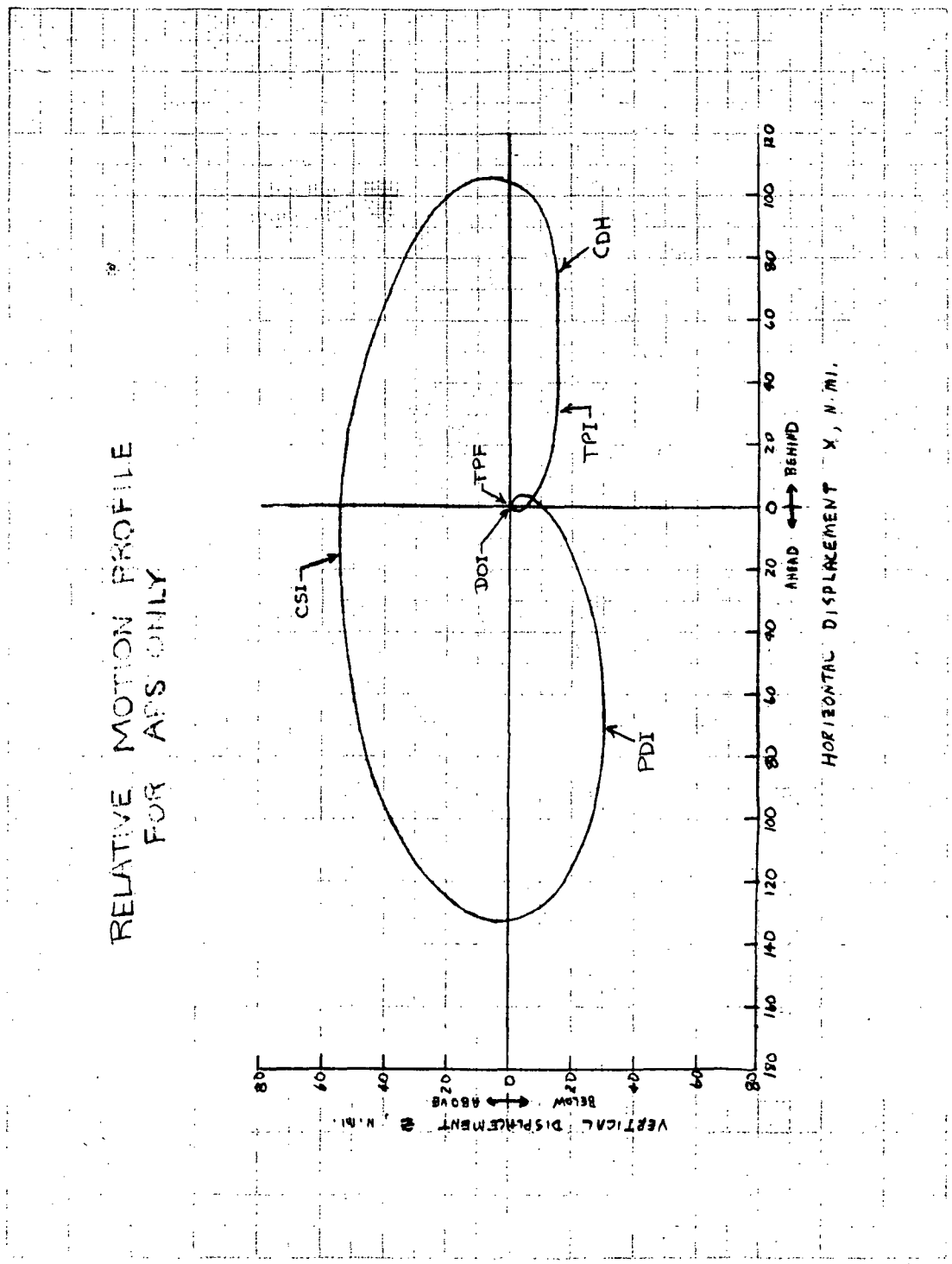
Basic procedure - 2-impulse to 1-2 n. mi. offset, using approximately 90° transfer. Then manually drive to CSM.

DOI + 30 min	-	150 + 100 = 250 fps
DOI + 60 min	-	500 + 600 = 1100 fps
Phasing +	-	750 + 750 = 1500 fps

Pre-Thrust	-	10 min
Transfer	-	30
Man, braking	-	30
Docking	-	10
		80 min

TABLE II. APS ONLY RENDEZVOUS MANEUVER SUMMARY

Maneuver	Δt from DOI, min.	Δt from previous maneuver, min.	Propulsion System	ΔV, fps	Burn Duration, sec.		Thrust Direction deg.	Resulting orbit h_a/h_p n. mi.
					APS	RCS		
DOI	-	-	APS	42.1	3.1	-	180.0	58.2/30.0
Phasing	57.9	57.9	APS	71.6	5.2	46.2	0.0	113.0/30.0
CSI	118.4	60.5	RCS	21.5	1.6	13.8 (4-jet)	0.0	113.0/45.8
CDH	179.5	61.1	RCS	91.8	6.7	58.7 (4-jet)	180.0	45.9/43.1
TPI	218.7	39.2	RCS	25.0	1.8	31.7 (2-jet)	26.6	61.9/43.2
TPF	261.1	42.4	RCS	31.6	-	40.0 (2-jet)	305.3	60.9/58.1


RELATIVE MOTION PROFILE
FOR APS ONLY
CDH
TPI
TPF
DOI
CSI
PDI
VERTICAL DISPLACEMENT Z, N. MI.
BELOW
ABOVE
HORIZONTAL DISPLACEMENT X, N. MI.
AHEAD
BEHIND

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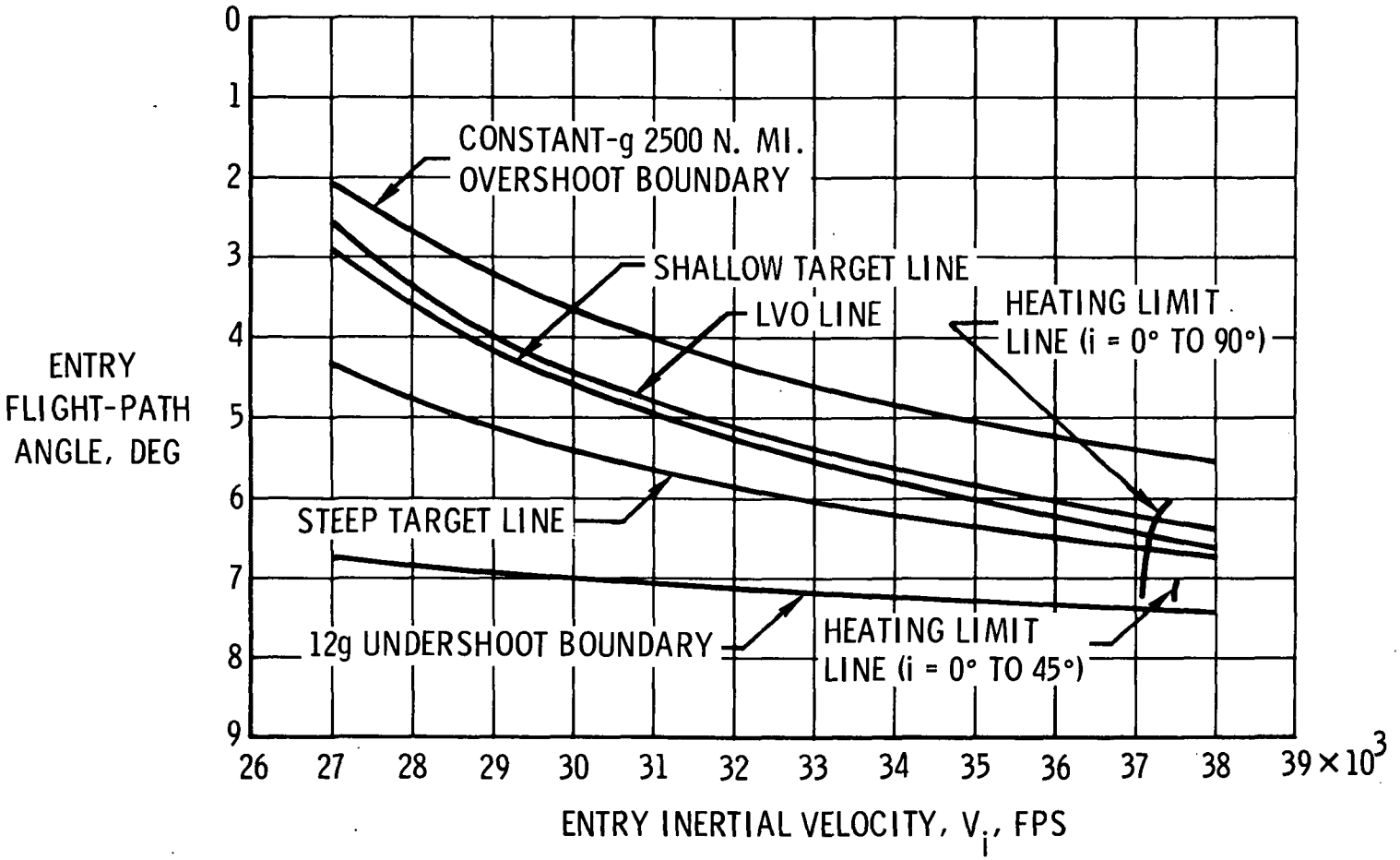
3.0 REENTRY

John K. Burton

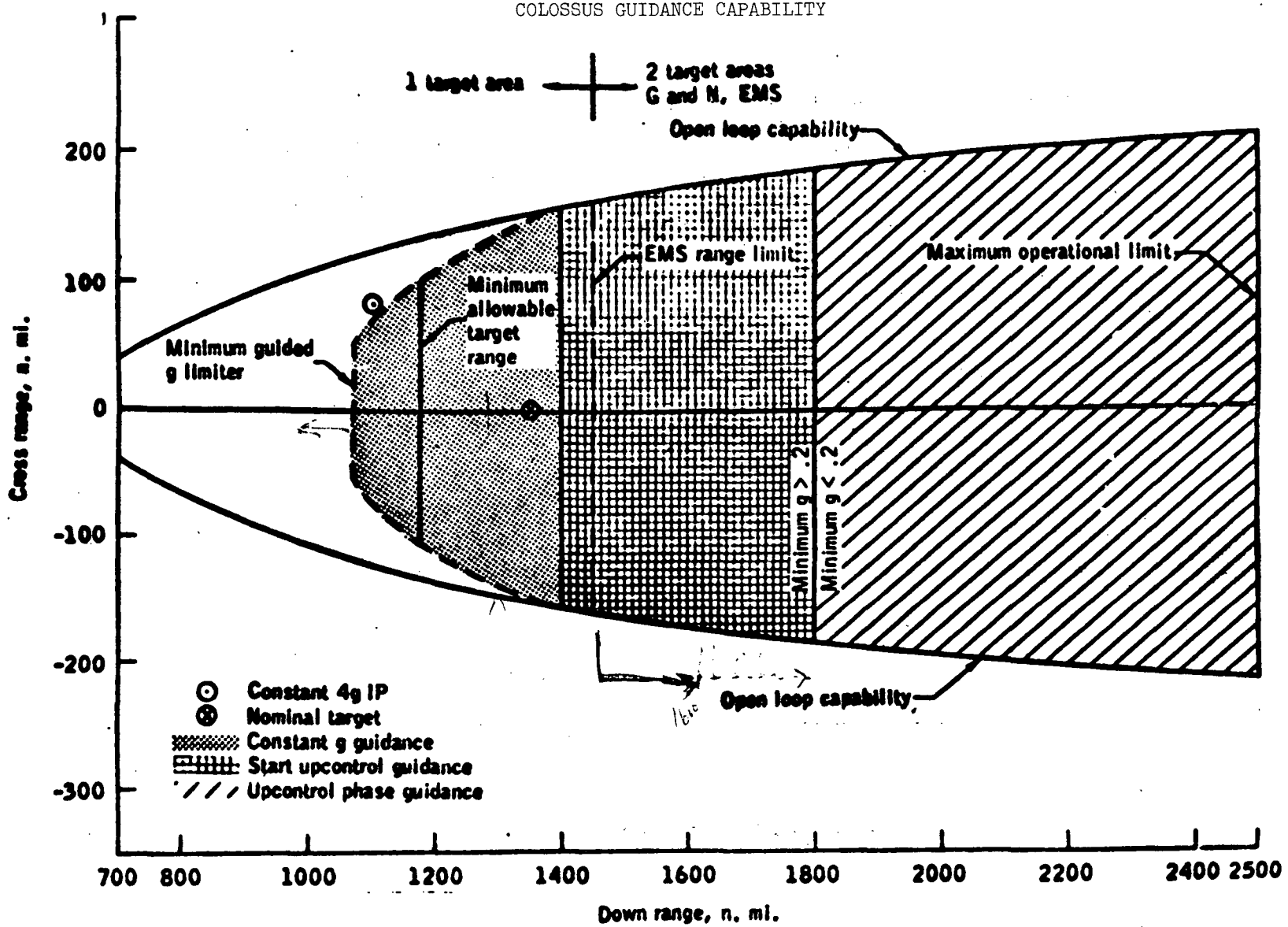
ENTRY PHASE

- ENTRY CORRIDOR
- ENTRY TARGETING
- NOMINAL ENTRY
- MONITORING PROCEDURES
- BACKUP MODES

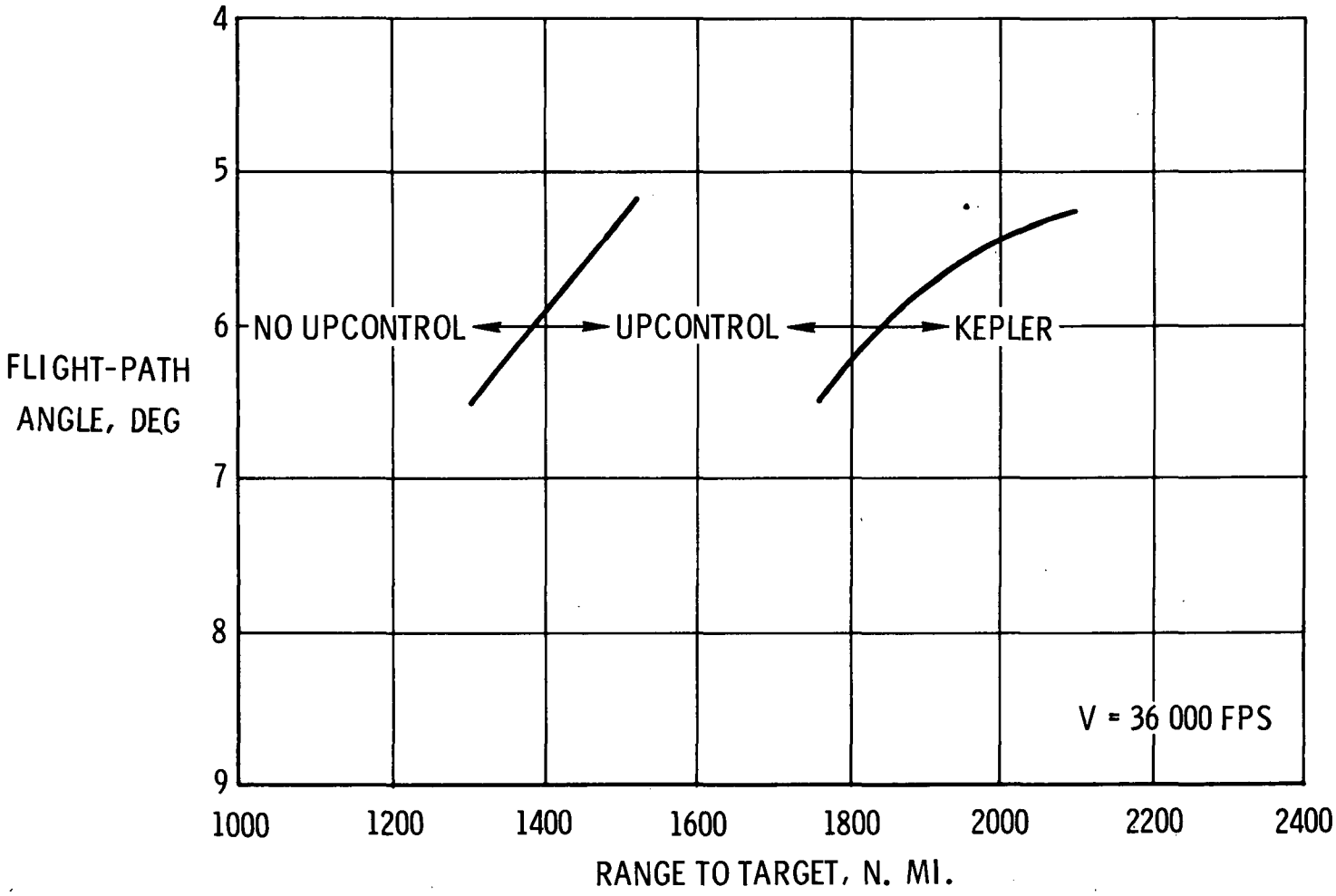
ENTRY CORRIDOR



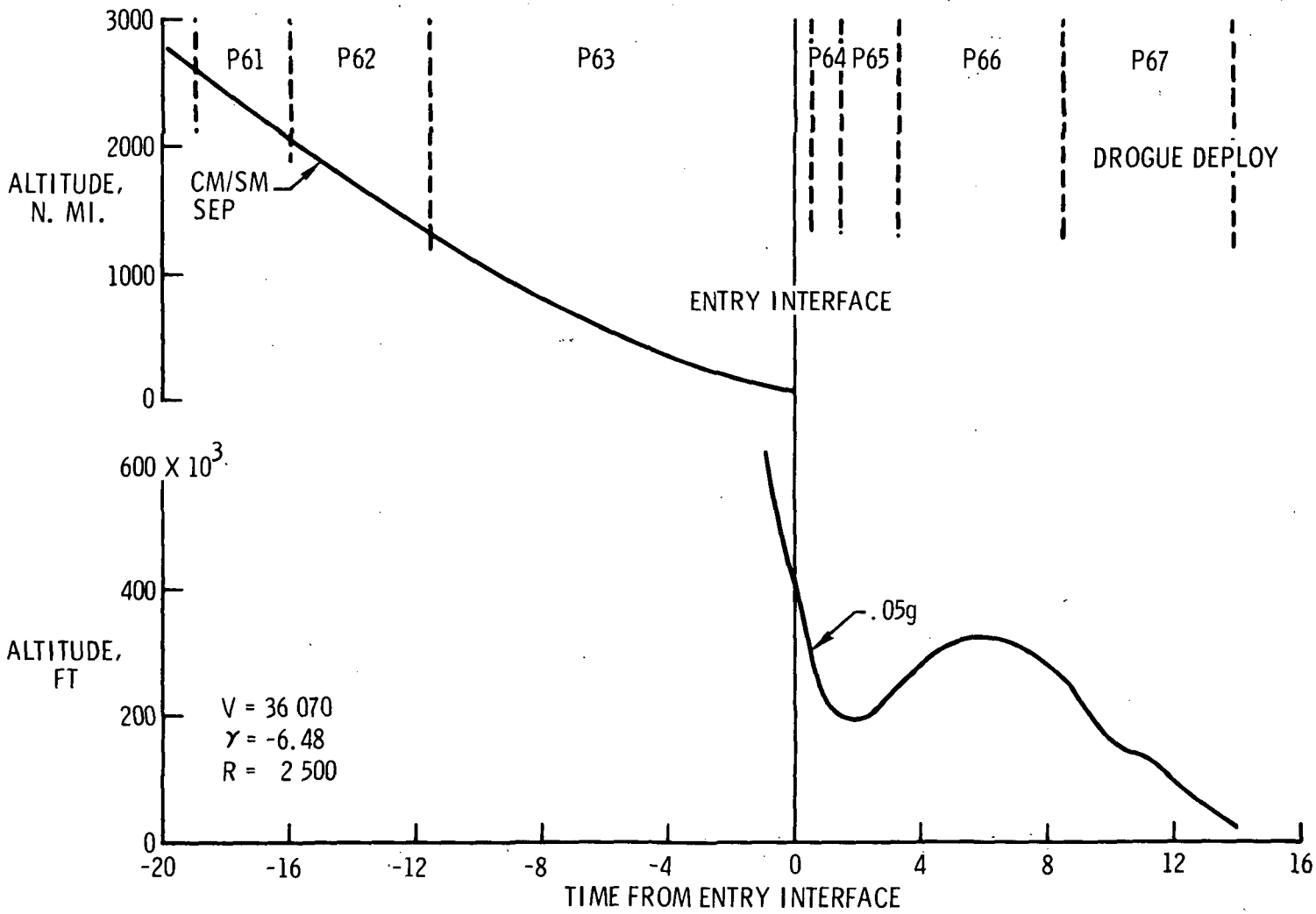
COLOSSUS GUIDANCE CAPABILITY



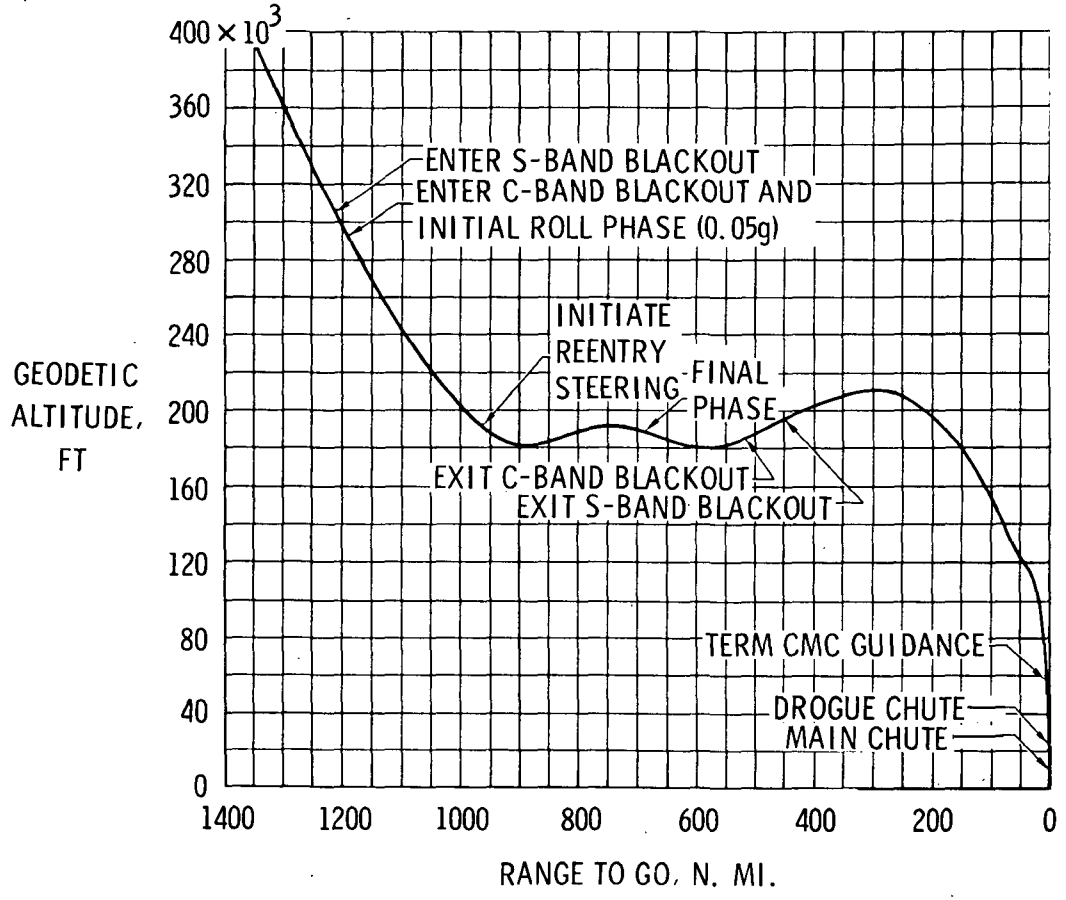
PROGRAM PHASING (γ VS RANGE)



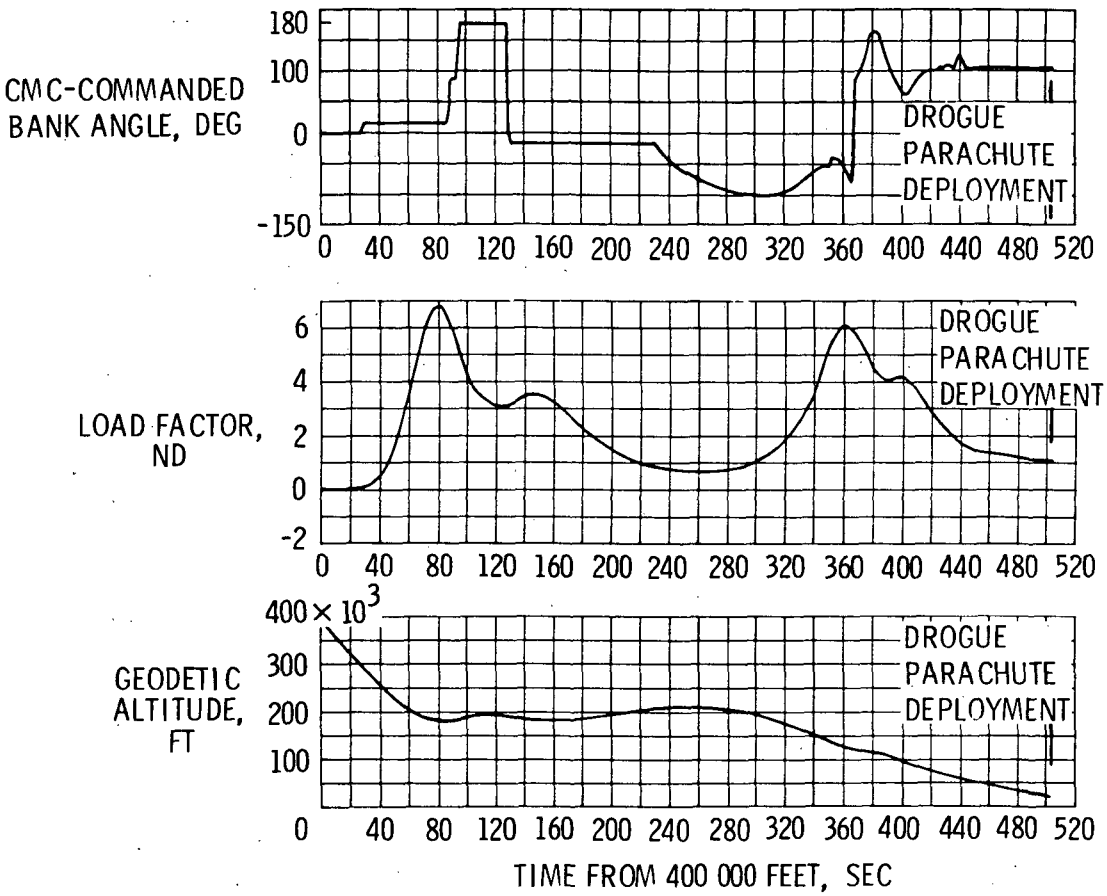
PROGRAM PHASING (ALTITUDE VS TIME)

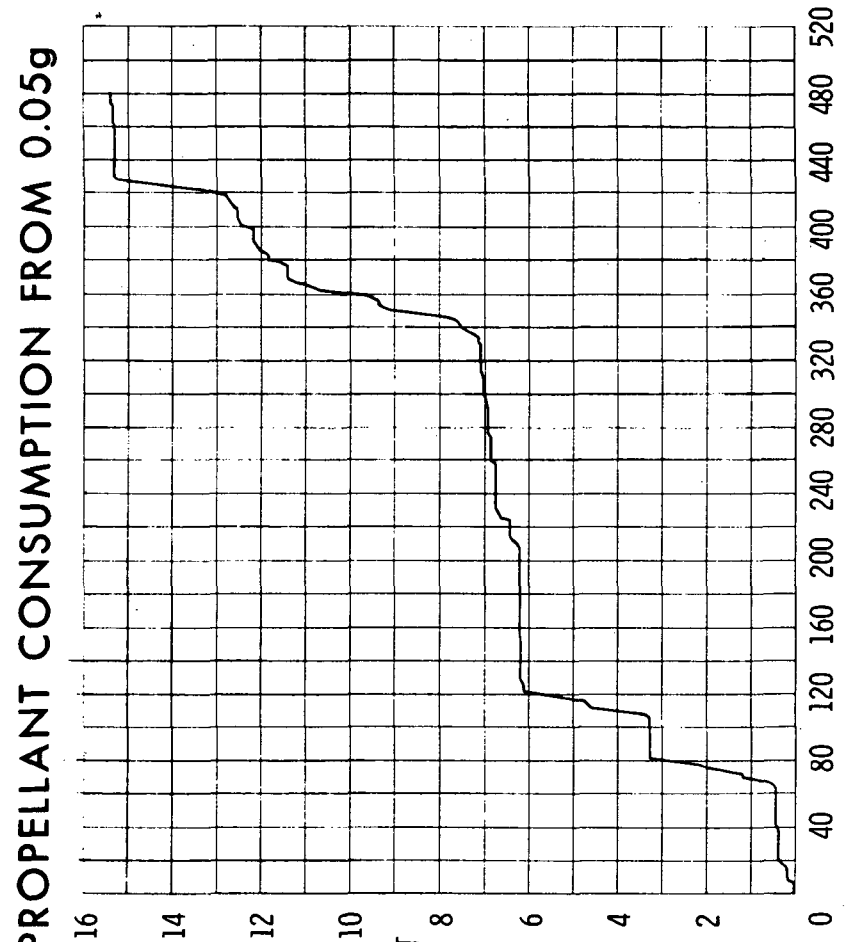


GEODETIC ALTITUDE VERSUS RANGE-TO-GO

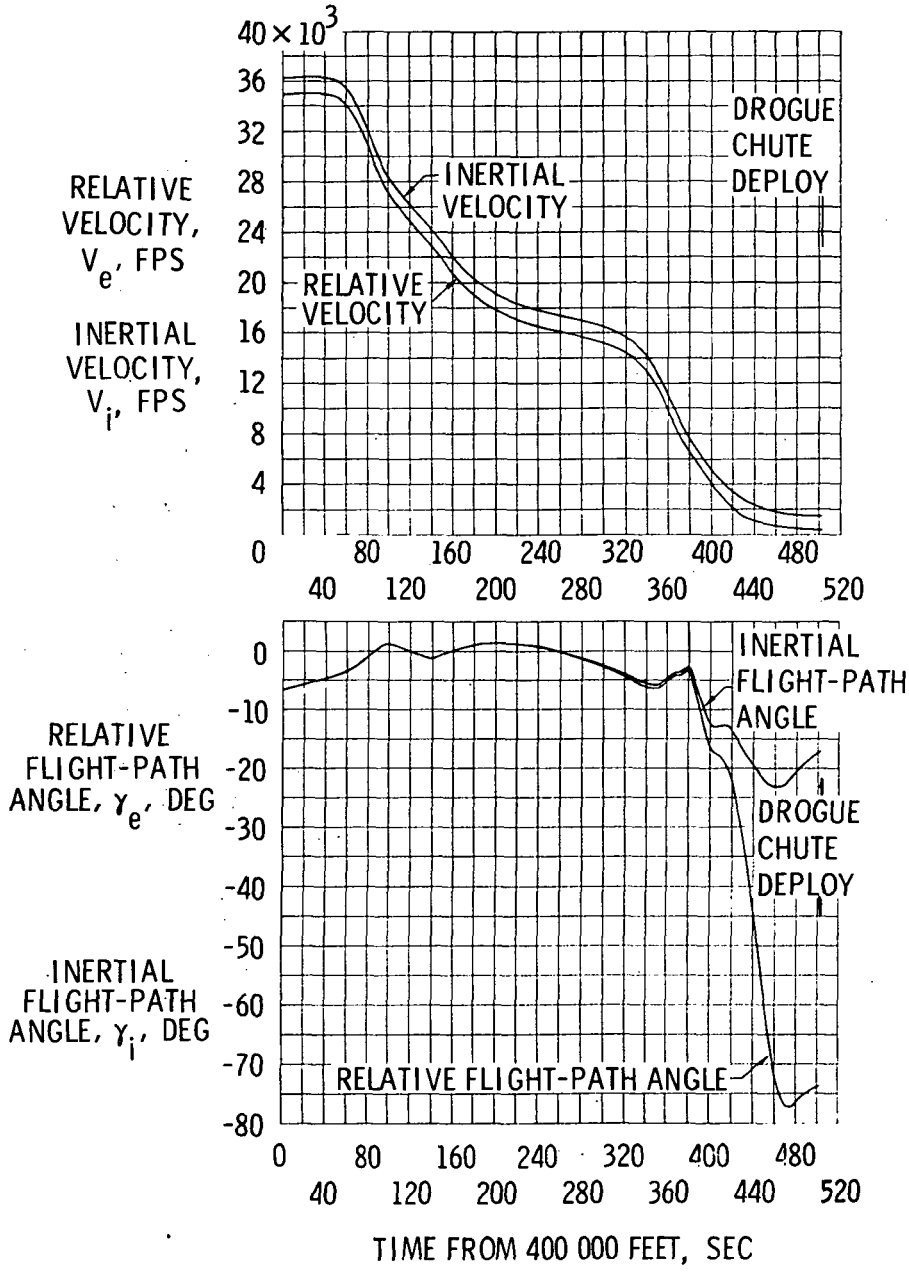


CMC-COMMANDED BANK ANGLE, LOAD FACTOR, AND ALTITUDE TIME HISTORIES

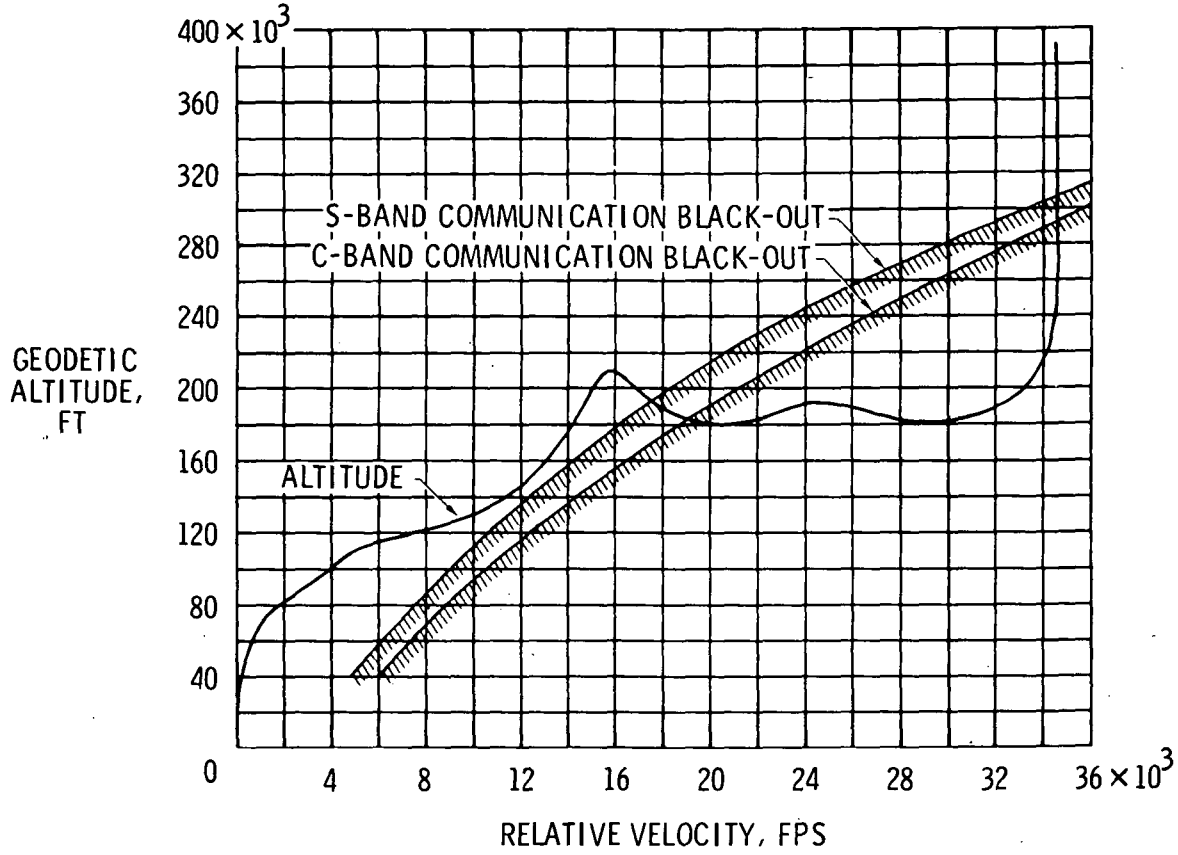



RCS PROPELLANT CONSUMPTION FROM 0.05g
RCS PROPELLANT CONSUMPTION FROM 0.05g, LB
0
2
4
6
8
10
12
14
16
40
80
120
160
200
240
280
320
360
400
440
480
520
TIME FROM 0.05g TO DROGUE DEPLOY, SEC

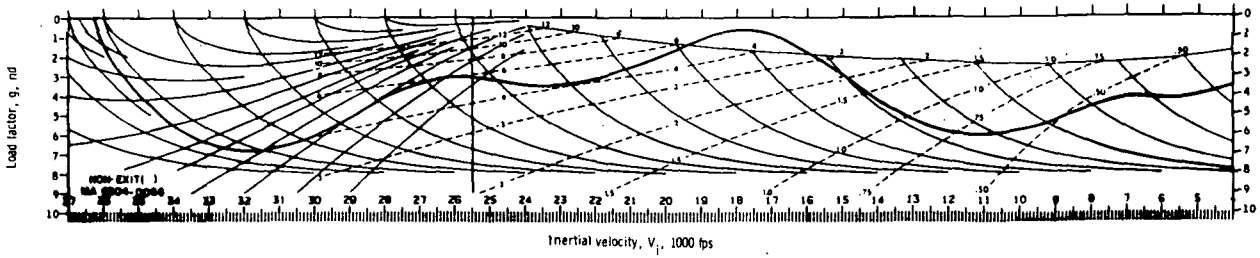
REENTRY VELOCITY AND FLIGHT-PATH ANGLE TIME HISTORIES



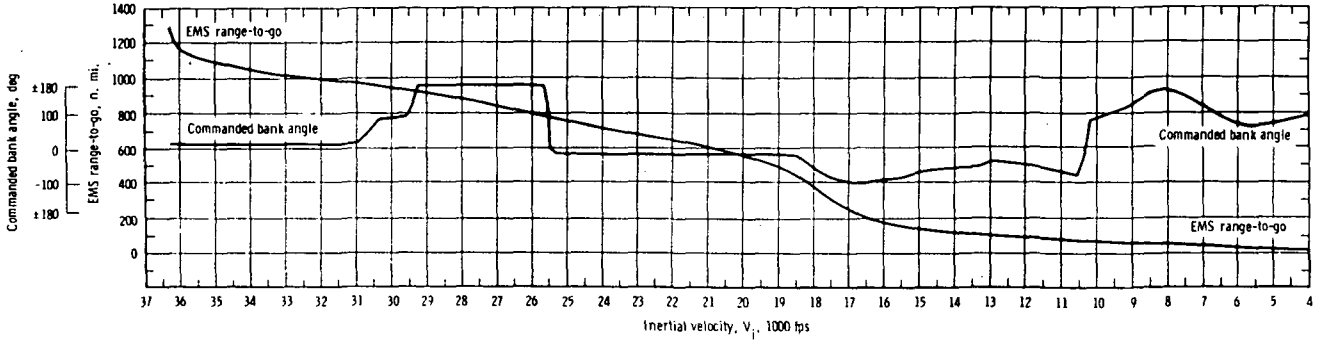
COMMUNICATIONS BLACKOUT



EMS PARAMETERS



LOAD FACTOR VERSUS INERTIAL VELOCITY



CMC-COMMANDED BANK ANGLE AND EMS RANGE-TO-GO VERSUS INERTIAL VELOCITY

APOLLO 8 MISSION MONITORING PLAN

TIME	MONITORING TEST	PURPOSE OF TEST	EFFECT OF FAILURE
EI-1 HOUR	EMS SELF TEST	DETERMINE IF EMS IS SATISFACTORY FOR MONITORING ENTRY	CONSTANT g BECOMES PRIME BACKUP MODE AND BACKUP MODE RANGING WILL BE LIMITED TO 1250 N. MI.
EI-17 MINUTES	IMU - HORIZON CHECK WITH HORIZON ON 31.7 DEGREE WINDOW MARK, FDAI BALL SHOULD READ WITHIN ±5 DEGREES OF ATTITUDE PASSED FROM GROUND	CHECK OF IMU ALIGNMENT	IMU HAS FAILED - G AND N NO GO FOR ENTRY

APOLLO 8 MISSION MONITORING PLAN (CONTINUED)

TEST	MONITORING TEST	PURPOSE OF TEST	EFFECT OF FAILURE
EI-5 MINUTES TO .05g	CMC HORIZON CHECK* MANUALLY TRACK HORIZON AND MONITOR: 1. PITCH ERROR NEEDLE SHOULD GO TO ZERO ±5 DEGREES AT .05g 2. FDAI BALL SHOULD AGREE WITHIN ±5 DEGREES OF GROUND GIMBAL ANGLES AT .05g *AT .05g TRIM, HORIZON SHOULD BE AT 34° MARK	CHECK OF IMU ALIGNMENT AND GUIDANCE CALCULATION OF TRIM ATTITUDE	CMC IS NO GO FOR ENTRY

APOLLO 8 MISSION MONITORING PLAN (CONTINUED)

TIME	MONITORING TEST	PURPOSE OF TEST	EFFECT OF FAILURE
P64	MONITOR THAT CMC IS COMMANDING PROPER ATTITUDE TO CONVERGE EMS g LEVEL TO DO	VERIFY PROPER ENTRY TRAJECTORY	CMC NO GO - COMPLETE ENTRY WITH EMS
P65	VL, DL CHECK VERIFY THAT CMC VALUE FOR VL IS WITHIN ± 800 FPS AND DL IS WITHIN ± 0.6g OF GROUND VALUES	VERIFY CMC PLANNED REFERENCE TRAJECTORY	CMC NO GO - COMPLETE ENTRY WITH EMS

APOLLO 8 MISSION MONITORING PLAN (CONTINUED)

TEST	MONITORING TEST	PURPOSE OF TEST	EFFECT OF FAILURE
EI +30 SECONDS .05g	CMC PROGRAM SHOULD SEQUENCE FROM P63 TO P64 AT RET .05g ±5 SECONDS	VERIFY PIPA SENSING OF g LEVEL	CMC IS NO GO FOR ENTRY
EI +40 SECONDS (.05g +10 SECONDS)	EMS RANGE CHECK RANGE COUNTER SHOULD COUNT DOWN 60 ± 10 N. MI. 10 SECONDS AFTER EMS START	VERIFY OPERATION OF RANGE COUNTER	EMS NO GO FOR RANGING SUSPECT EMS SCROLL, VERIFY EMS g LEVEL
EI +60 SECONDS 1g	CORRIDOR VERIFICATION CHECK IF VERIFIED EMS INDICATES VIOLATION OF OFFSET LINES DETERMINE IF CMC IS AT PROPER ATTITUDE	VERIFY INITIAL LIFT VECTOR ORIENTATION	REVERSE INITIAL ATTITUDE - RETURN CONTROL TO CMC AT ~2.0g IF COMMANDING PROPER ATTITUDE

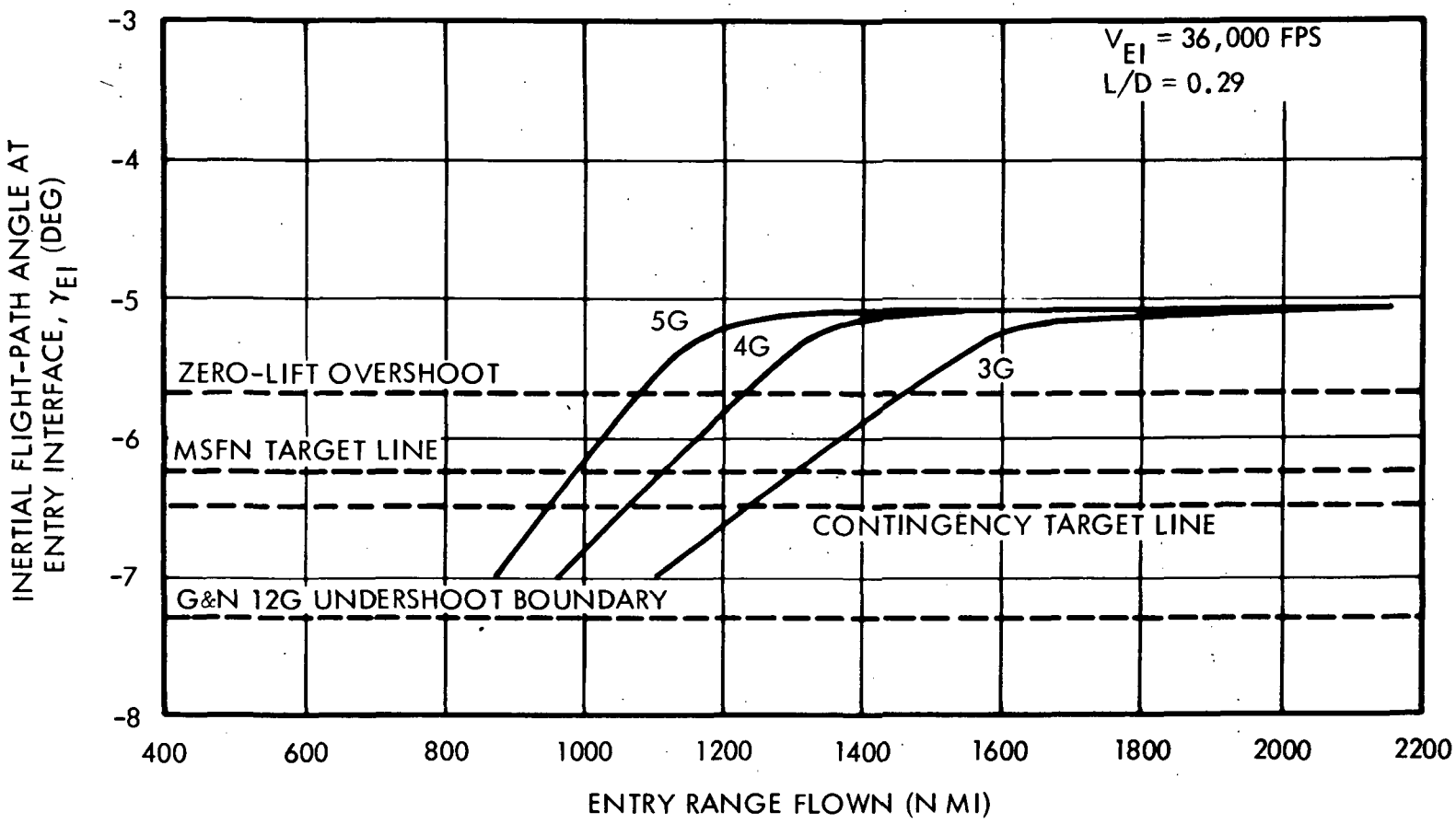
APOLLO 8 MISSION MONITORING PLAN (CONTINUED)

TIME	MONITORING TEST	PURPOSE OF TEST	EFFECT OF FAILURE
CONTINUOUS EMS CHECK	VERIFY THAT EMS g LEVEL IS WITHIN ± 1.0g OF g METER	VERIFY EMS OPERATION	IF POSSIBLE CALL UP CMC DISPLAY OF g-LEVEL (N64) AND COMPARE TO EMS g-LEVEL. IF CMC AND EMS g-LEVEL AGREE WITHIN ± 1.0g, THE g- METER IS NO GO FOR MONITORING, OTHERWISE, THE EMS IS NO GO FOR MONITORING AND RANGING
P64-P65	CONTINUOUS EMS -CMC CHECK VERIFY THAT THE EMS V, g TRACE DOES NOT VIOLATE OFFSET AND ONSET LINES WITH THE CMC NOT COMMANDING 180 ± 15° (OFFSET) OR 0 ± 15° (ONSET)	VERIFY PROPER ENTRY TRAJECTORY	CMC NO GO - COMPLETE ENTRY WITH EMS

APOLLO 8 MISSION MONITORING PLAN (CONCLUDED)

TIME	MONITORING TEST	PURPOSE OF TEST	EFFECT OF FAILURE
P65	VERIFY THAT EMS V, g TRACE APPROACHES P65 VALUES OF VL, DL WITHOUT VIOLATING OFFSET LINES	VERIFY ENTRY TRAJECTORY	CMC NO GO FOR ENTRY
P66	VERIFY WITH HORIZON THAT CM IS IN PROPER TRIM ATTITUDE FOR SECOND ENTRY	VERIFY TRIM ATTITUDE	CMC NO GO FOR SECOND ENTRY - USE EMS RANGING
P67	VERIFY EMS V, g TRACE DOES NOT VIOLATE g ONSET LINES WITHOUT CMC COMMANDING $0 \pm 15°$	VERIFY ENTRY TRAJECTORY	CMC NO GO - COMPLETE ENTRY WITH EMS

RANGING CAPABILITY FOR CONSTANT g FLIGHT



RECOMMENDED BACK UP CONTROL PROCEDURES

ENTRY TECHNIQUE	ENTRY MODE	METHOD UTILIZED TO FLY
• PRIMARY	GNCS	AUTOMATIC
• BACKUP	EMS	• UTILIZE IF GNCS FAILED PRIOR TO OR DURING ENTRY
		• MAINTAIN CONSTANT 4G TO V = 25,500 FPS - AT 25,500 FPS UTILIZE EMS RANGE LINES TO RANGE TO PLANNED LANDING AREA
• SECONDARY	CONSTANT G	• UTILIZE IF GNCS AND EMS FAILED
		• FLY CONSTANT G BY MANUAL LIFT VECTOR CONTROL AND MONITORING G-METER

4.0 NAVIGATION

MSFN . . . . . Howard G. deVezin

Onboard. . . . . Robert T. Savely

RTCC NAVIGATION PROGRAM MODIFICATIONS AND VERIFICATION

- 2 SMALL PROGRAM ERRORS
  - CORRECTED
  - VERIFYING WITH APOLLO 8 DATA RUNS
- CONSTANTS
  - DATA WEIGHTS
    - IMPROVED VALUES FROM APOLLO 8 DATA PROCESSING
  - LUNAR EPHEMERIS
    - DE19
    - MORE ACCURATE
    - WILL ELIMINATE PREDICTED ERRORS IN RANGE NEAR MOON WHICH WERE OBSERVED IN APOLLO 8
    - WILL VERIFY CORE LOADED VALUES POINT BY POINT
    - WILL PERFORM CONSISTENCY CHECK WITH ONBOARD VALUES

MSFN SENSITIVITY

- WATER BOILER VENTING
  - CISLUNAR PHASES
    - SERIOUSLY EFFECTS NAVIGATION ACCURACIES (UP TO 10 HR RECOVERY PERIOD)
  - LUNAR ORBIT
    - SMALL EFFECT ON NAVIGATION
- WATER DUMPS
  - CISLUNAR
    - DETECTED BY MSFN
    - CAN DEGRADE NAVIGATION ACCURACY
    - DEGRADATION IS MINIMUM IF PERFORMED NEAR MANEUVERS
  - LUNAR ORBIT
    - NO EFFECT ON NAVIGATION ACCURACY

MSFN SENSITIVITY (CONCLUDED)

- ANTENNA MOTION
  - CISLUNAR
    - PTC RATES, ANTENNA SWITCHING, AND RE-ORIENTATION FOR MANEUVER OR FOR OBSERVATION DETECTED BY MSFN BUT NO EFFECT ON NAVIGATION ACCURACY
  - NOT DETECTED IN LUNAR ORBIT

SUMMARY

- RTCC NAVIGATION PROGRAM AND MSFN SITES BOTH OPERATED NOMINALLY FOR APOLLO 8 MISSION
- ONLY MINOR CHANGES TO BOTH FOR F MISSION RESULTING IN IMPROVED ACCURACY
- MAJOR CONCERN IN CISLUNAR NAVIGATION
  - WATER BOILER VENTING
- WATER DUMPS CAN CAUSE PROBLEMS IN CISLUNAR NAVIGATION IF NOT PERFORMED NEAR MANEUVERS

APOLLO 8 MSFN PERFORMANCE

- OVERALL PERFORMANCE NOMINAL
- MINOR CALIBRATION ERRORS
  - FREQUENCY, STATION LOCATION
  - WILL BE IMPROVED FOR F MISSION

APOLLO 8 PERFORMANCE SUMMARY

MANEUVER	QUANTITY	TARGET VALUE	ACHIEVED VALUE	Δ
MCC 1	H_{PCA}	61.923 N. MI.	~64 N. MI.	~2 N. MI.
MCC 4	H_{PCA}	61.67	64.19	2.52
LOI 1	H_A, H_P	169.2, 59.9	168.8, 60.8	.4, .9
LOI 2	H_A, H_P	60.1, 60.1	62.1, 60.4	2.0, 0.3 *
MCC 5	γ	-6.51°	-6.33°	.18°

APOLLO 8 PERILUNE ALTITUDE DISPERSIONS (TL)

	DISPERSION	PREDICTED ACCURACY (3σ)
2 HR PRIOR TO MCC 1	4 N. MI.	15 N. MI.
MCC 1 TO MCC 4	2 - 5 N. MI.	6 N. MI.
2 HR PRIOR TO MCC 4	1 N. MI.	6 N. MI.
4 HR PRIOR TO LOI	0.25 N. MI.	1.5 N. MI.

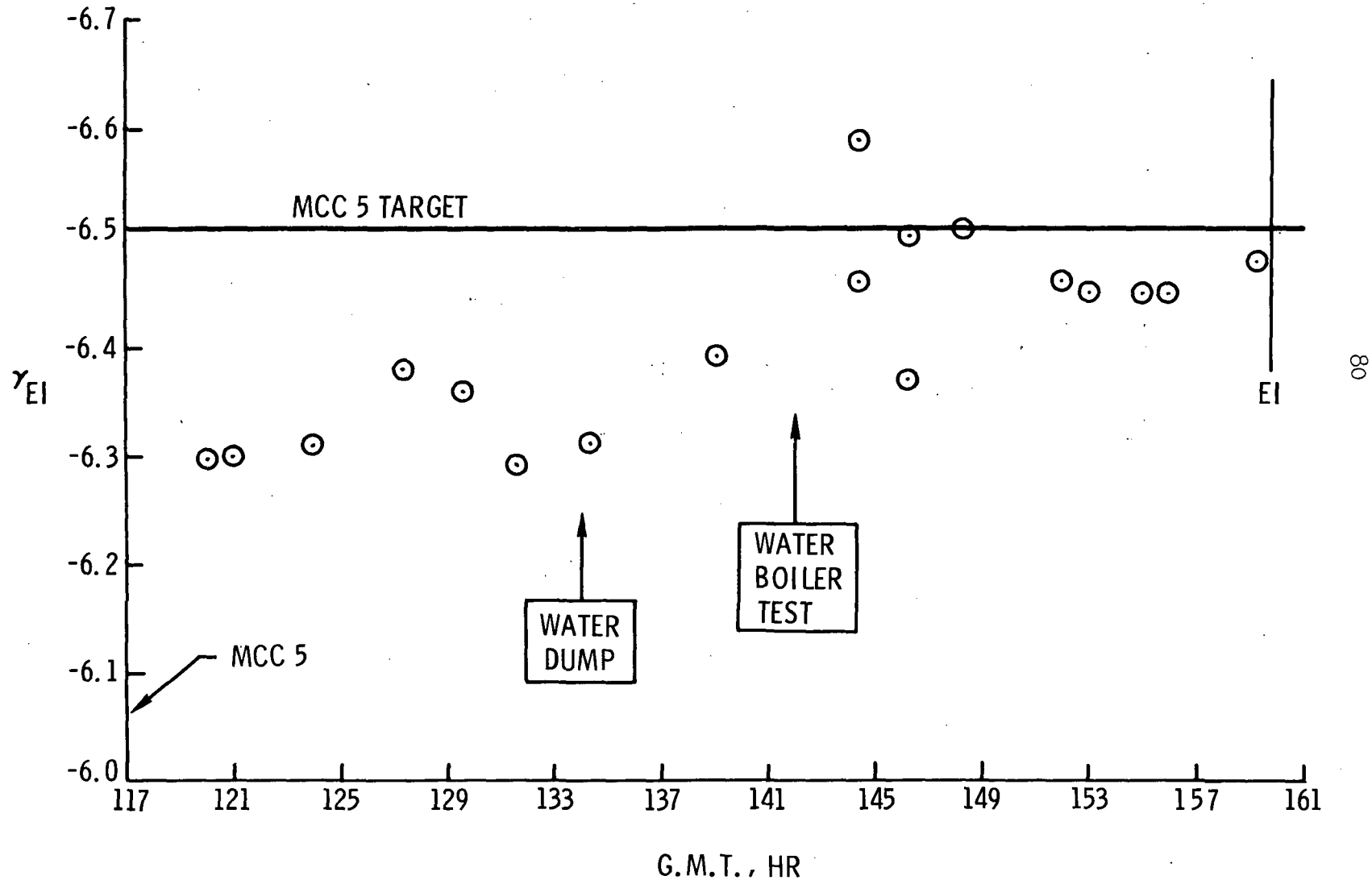
APOLLO 8 FLIGHT-PATH ANGLE DISPERSIONS

AT EI (TE)

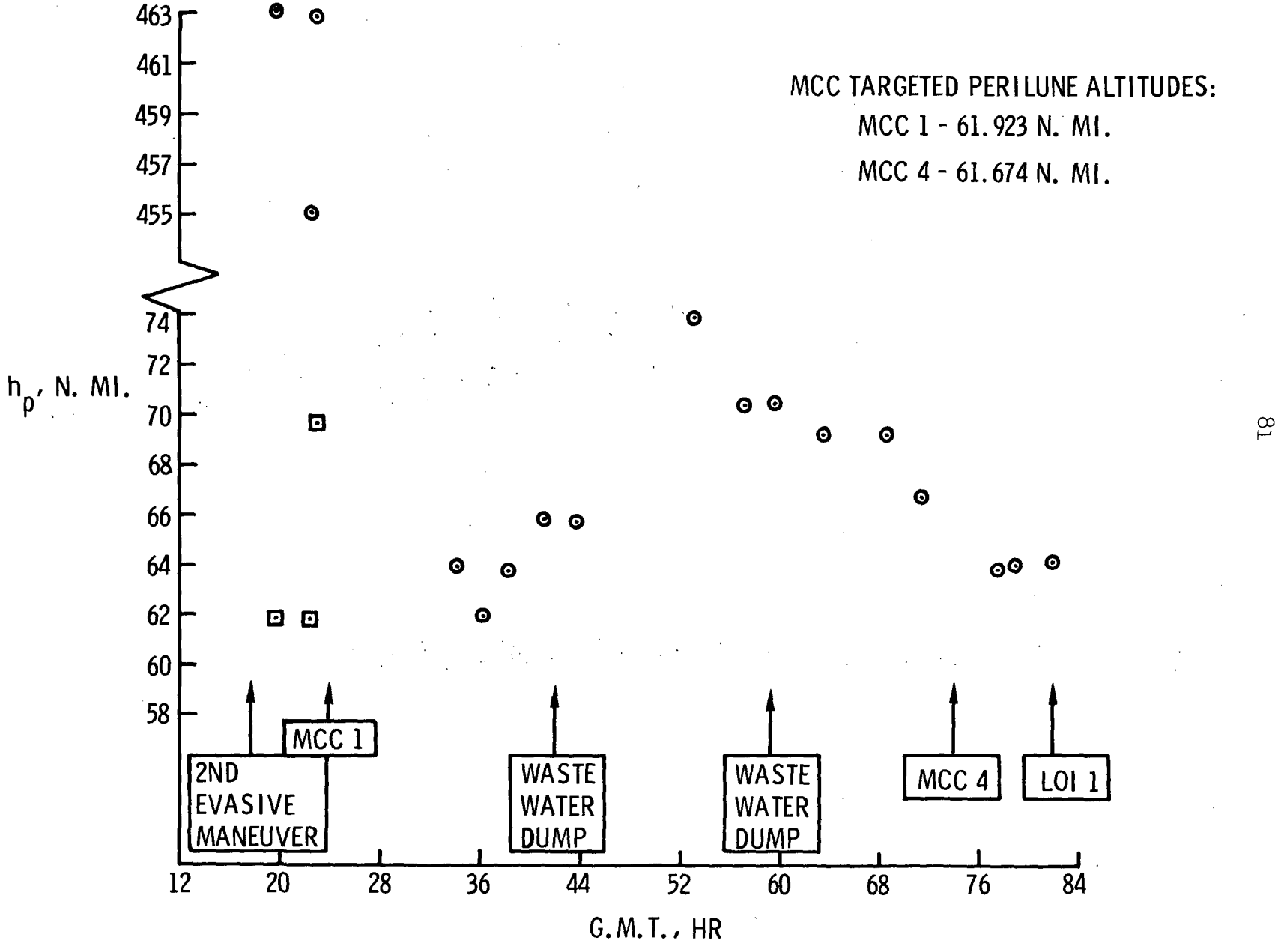
	γ DISPERSION	PREDICTED ACCURACY (3σ)
MCC 5 TO MCC 5 + 16 HR	.05°	.5°
IMMEDIATELY FOLLOWING WATER-BOILER TEST	0.1°	0.1°*
8 HR AFTER WATER-BOILER TEST ($\approx$ 8 HR PRIOR TO EI)	0.025°	0.06°

CORRIDOR WIDTH ±1.0°

APOLLO 8 ENTRY INTERFACE FLIGHT-PATH ANGLE PREDICTIONS



APOLLO 8 PERILUNE ALTITUDE ESTIMATES



TRANSLUNAR ONBOARD NAVIGATION

A. 2 BATCHES OF 5 SETS (~TLI + 5, TLI + 14)

B. Δh

PRE - APOLLO 8 — 32 KM
APOLLO 8 — 24 KM
APOLLO 9 — ? KM

TRANSEARTH ONBOARD NAVIGATION

A. SCHEDULE IN FLIGHT PLAN

B. EI-30 CROSSOVER FOR COMM LOSS

C. ACCURACY (APOLLO 8 PREMISSION)

	$3\sigma_\gamma$	$3\sigma_{\dot{r}}$
EI- 15	.50	2300
EI- 9	.54	1900
EI- 4	.21	390
EI- 2	.18	180

TRANSEARTH STATE VECTOR CORRECTIONS (3σ)

P-23 LOSS OF COMM V06N49 DISPLAY

OBSERVATION TIME, MIN FROM TEI	ΔR, N. MI.	ΔV, FPS	OBSERVATION TIME, MIN FROM TEI	ΔR, N. MI.	ΔV, FPS
75.0	14.2	0	675.0	16.6	2.9
76.5	14.5	3.1	676.5	5.5	.9
78.0	2.4	12.9	678.0	4.8	.8
85.0	0	.4	685.0	80.2	13.9
86.5	1.4	11.8	686.5	23.0	3.9
88.0	.6	4.9	688.0	9.6	1.6
95.0	1.2	3.5	695.0	11.5	1.9
96.5	1.3	4.3	696.5	5.9	1.0
98.0	1.1	4.3	698.0	.8	.1

LOSS OF COMMUNICATION NAVIGATION PROCEDURES

- TL ABORTS

  A. REINITIALIZE W MATRIX AND INITATE TRACKING AS SOON AS POSSIBLE AFTER ABORT (3 SETS)

  B. SCAN STARS ON FB CHART FOR POSSIBLE TARGETS (PRELIMINARY DATA INDICATES STARS AVAILABLE FOR LAST HALF OF ABORTS NEARLY IDENTICAL TO FB)

  C. THREE SETS EVERY 2.5 HOURS FOR 20 TO 40 HOUR RETURN TIMES

  D. LAST INTERVAL BEFORE FINAL MCC STARTS AT MCC-1.5 HOUR AND CONSISTS OF 5 SETS

LOSS OF COMMUNICATION NAVIGATION PROCEDURES (CONTINUED)

- FB ABORTS (SCHEDULE PROVIDED)

  A. FB TRACKING FOR COMMUNICATION LOSS ON TL LEG ASSUMES TL TRACKING

  B. DATA PROVIDED IS FOR PERICYNTHION OF 60 N. MI. (DATA FOR HIGHER PERICYNTHION WILL BE SIMILAR BUT AOS AND LOS TIMES MAY VARY)

  C. PERICYNTHION GREATER THAN 60 N. MI. CHECK LO ABORT CHART FOR ADDITIONAL TARGETS

LOSS OF COMMUNICATION NAVIGATION PROCEDURES (CONTINUED)

- LO ABORTS (DETAILED SCHEDULES PROVIDED)
  - A. THE FIRST AND LAST 17 HOURS OF THE SCHEDULE SHOULD NOT BE CHANGED
  - B. THE DATA IN THE MIDDLE OF THE TE LEG MAY BE MOVED AROUND FOR REST PERIODS AND MCC'S
  - C. CHANGE TO EI CHART AT EI-40

LOSS OF COMMUNICATION NAVIGATION PROCEDURES (CONTINUED)

- GENERAL TE OPTICAL NAVIGATION RULES

  A. A SIGHTING IS TO CONSIST OF THREE MARKS

  B. A SIGHTING INTERVAL IS TO CONSIST OF AT LEAST 3 STAR/HORIZON SIGHTINGS - TWO STARS AS CLOSE TO THE ORBIT PLANE AS POSSIBLE AND ONE STAR AS FAR OUT OF THE ORBIT PLANE AS POSSIBLE

  C. 15 SIGHTINGS WITHIN THE LSOI

     (1) AT LEAST 8 LUNAR SIGHTINGS, AS SOON AFTER TEI AS POSSIBLE AND BEFORE TEI + 3 HOURS

     (2) THREE SIGHTING INTERVALS WITHIN THE LSOI

  D. AT LEAST 4 SIGHTINGS PRIOR TO A MCC AND AT LEAST 3 SIGHTINGS AFTER EACH MCC EXCEPT THE LAST MCC

LOSS OF COMMUNICATION NAVIGATION PROCEDURES (CONCLUDED)

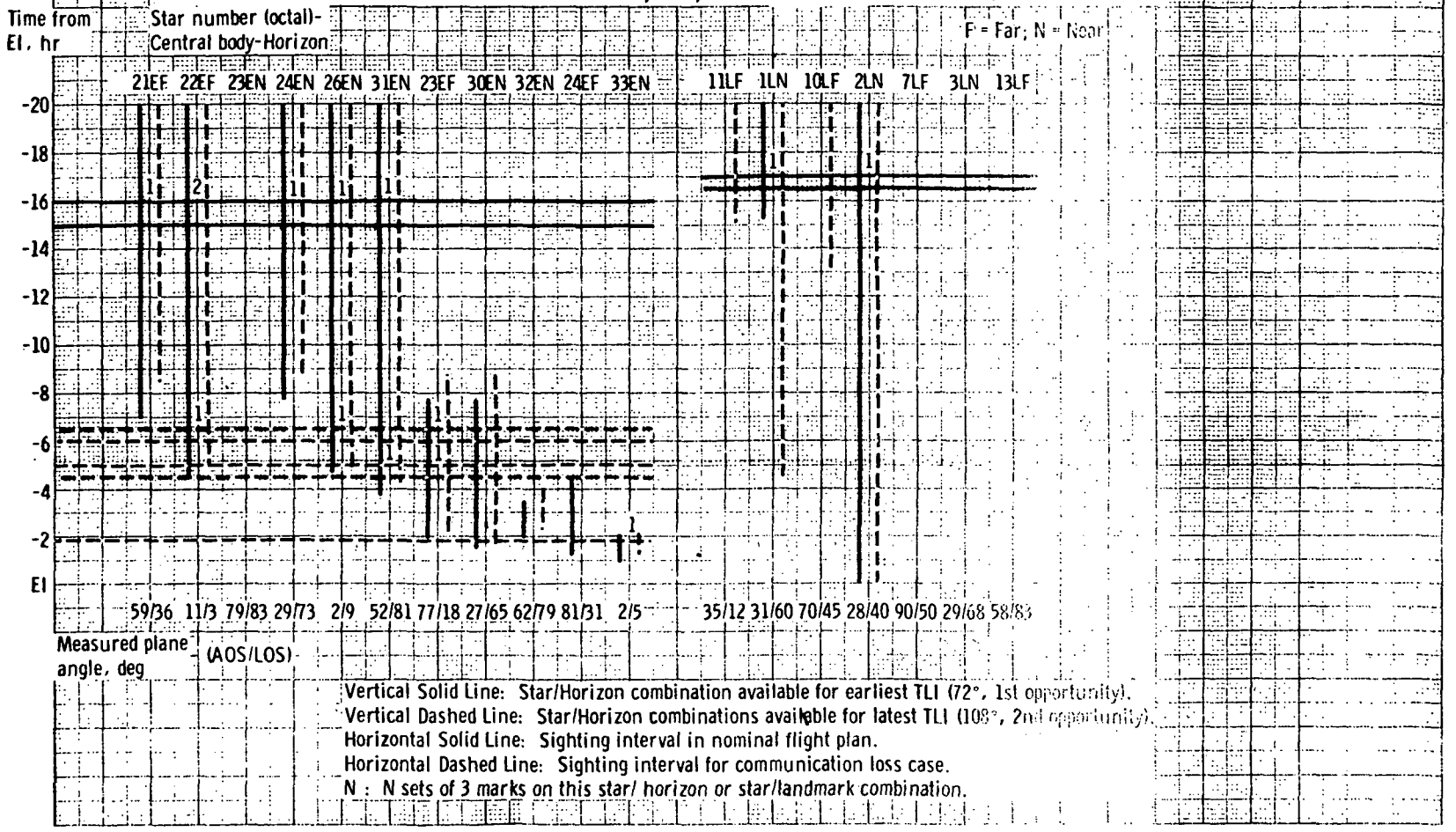
E. IN THE INTERVAL 35 000 N. MI. FROM THE MOON TO 100 000 N. MI. FROM THE EARTH USE AT LEAST 5 SIGHTING INTERVALS SPACED EVENLY

F. 25 SIGHTINGS WITHIN 100 000 N. MI. RADIUS OF THE EARTH

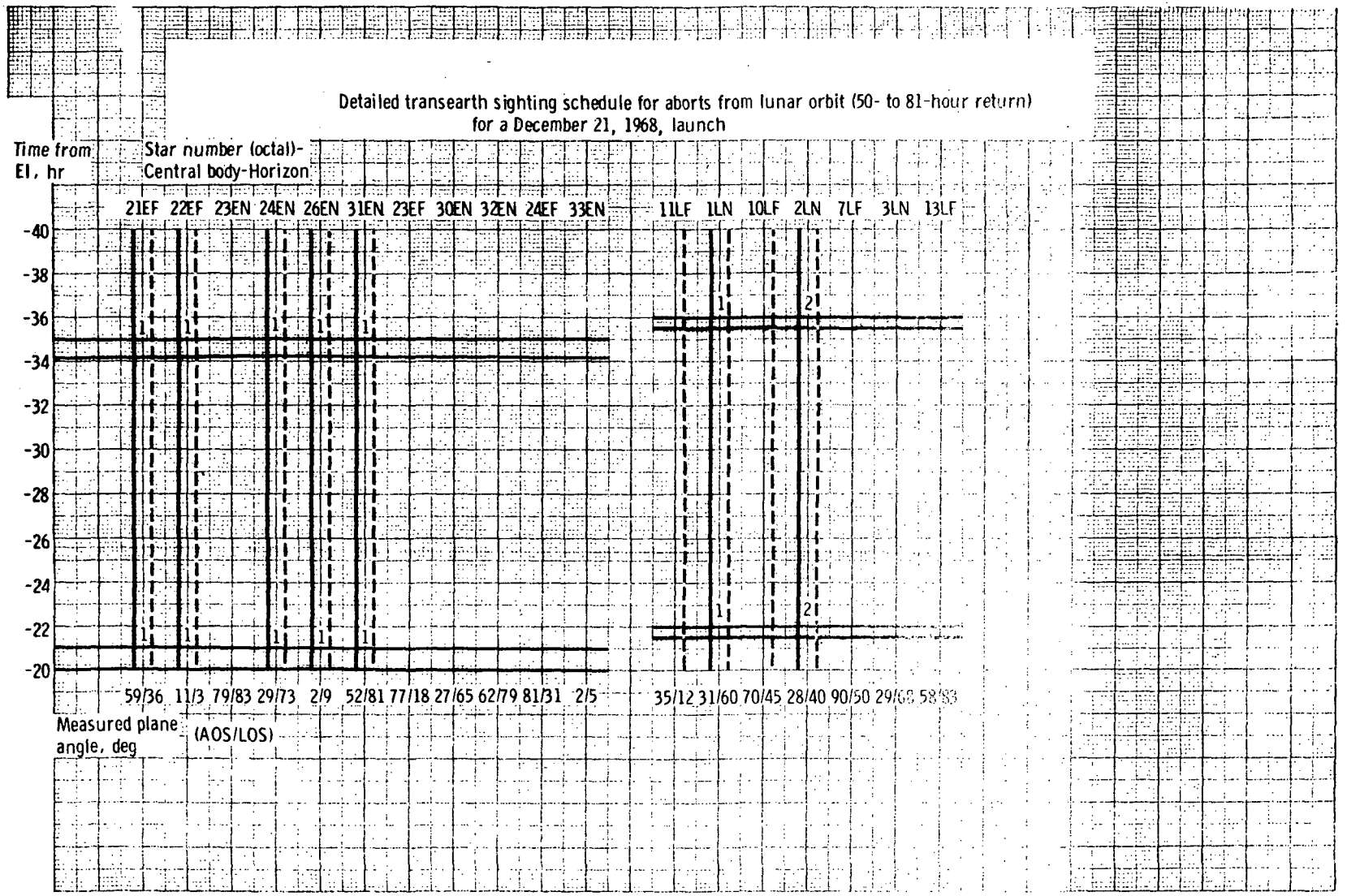
(1) ONE HOUR OF OPTICAL SIGHTINGS PRECEDING THE LAST MCC AT ENTRY - 2 HOURS

(2) ONE SIGHTING INTERVAL MUST USE THE MOON AS REFERENCE BODY AND MUST PRECEDE THE LAST SIGHTING INTERVAL PRIOR TO MCC AT ENTRY - 2

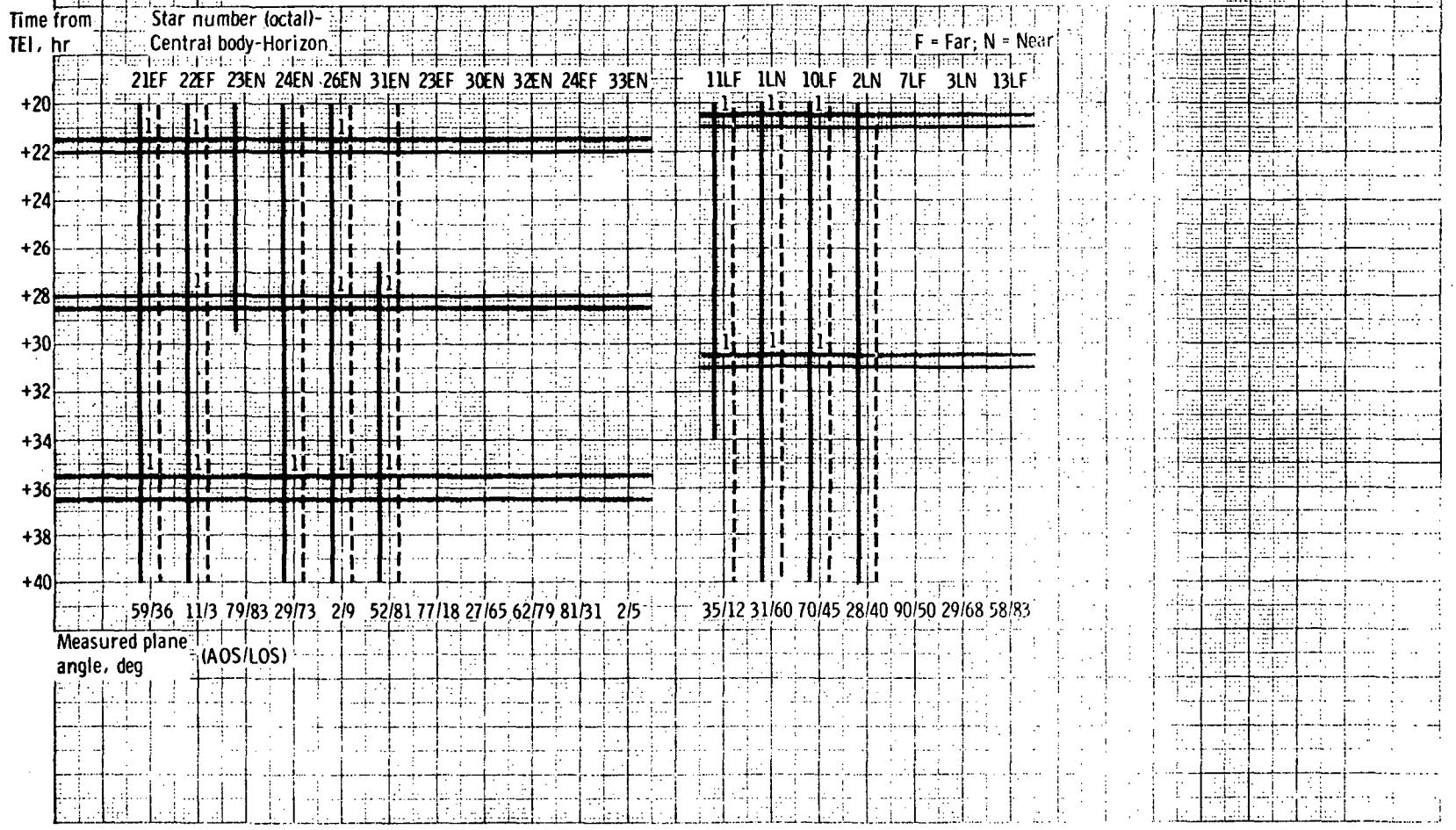
Detailed transearth sighting schedule for aborts from lunar orbit (50- to 81-hour return) for a December 21, 1968, launch

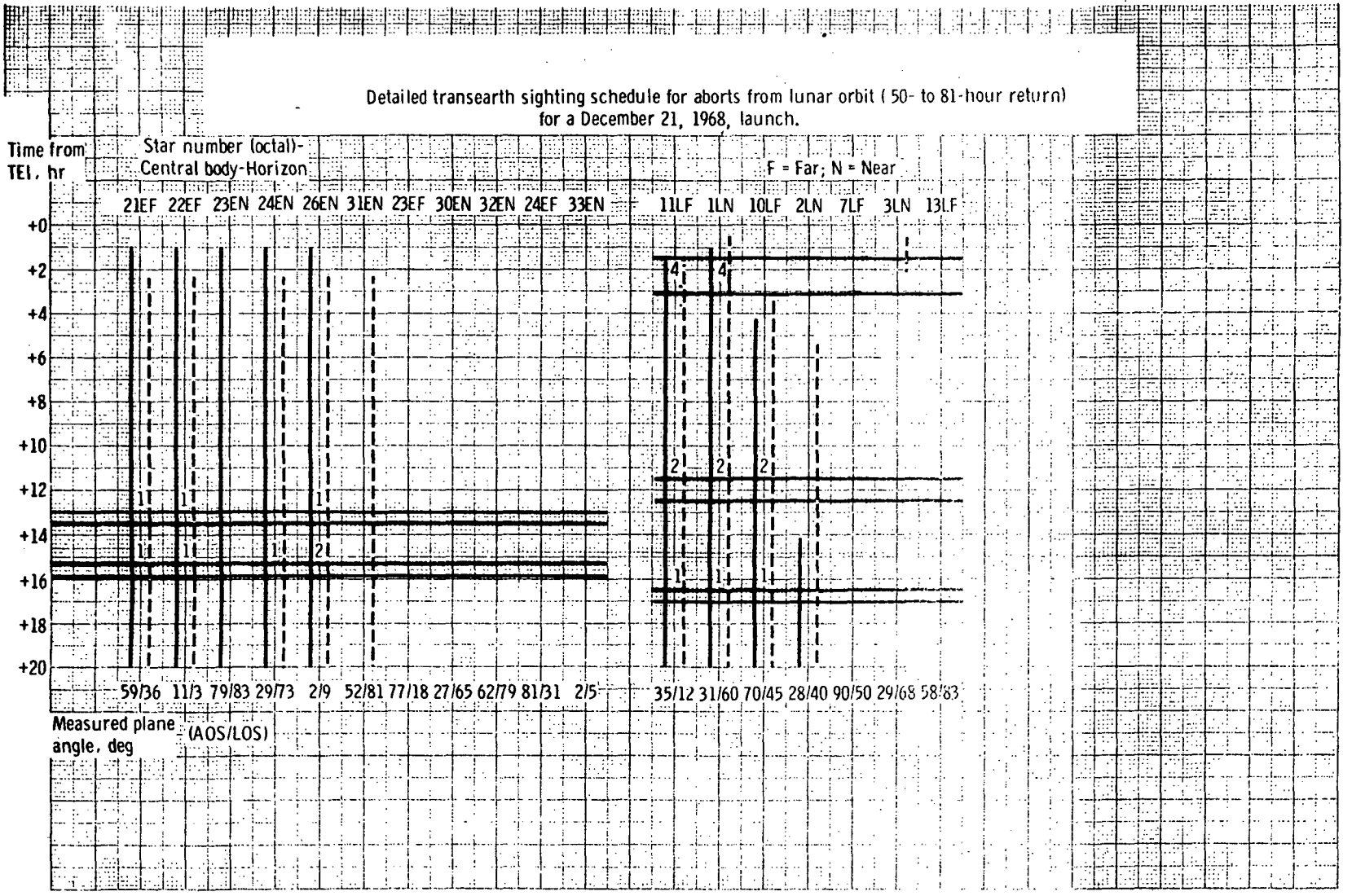


Detailed transearth sighting schedule for aborts from lunar orbit (50- to 81-hour return) for a December 21, 1968, launch



Detailed transearth sighting schedule for aborts from lunar orbit (50- to 81-hour return) for a December 21, 1968, launch




Detailed transearth sighting schedule for aborts from lunar orbit (50- to 81-hour return) for a December 21, 1968, launch.
Time from TEI, hr
Star number (octal)-Central body-Horizon
F = Far; N = Near
21EF 22EF 23EN 24EN 26EN 31EN 23EF 30EN 32EN 24EF 33EN
11LF 1LN 10LF 2LN 7LF 3LN 13LF
+0
+2
+4
+6
+8
+10
+12
+14
+16
+18
+20
59/36 11/3 79/83 29/73 2/9 52/81 77/18 27/65 62/79 81/31 2/5
35/12 31/60 70/45 28/40 90/50 29/68 58/83
Measured plane angle, deg (AOS/LOS)

F RENDEZVOUS

- W MATRIX
  - VALUES
  - REINITIALIZATION
- TRACKING SCHEDULE

F TRACKING SCHEDULE

LM			CSM		
DOI	-189		DOI	-189	
IT	-184		IT	-178	
CT	-155		CT	-155	
Phasing	-125		Phasing	-125	
IT	-117	($W = W_o$)	IT	-115	($W = W_o$)
CT	-89		CT	-95	
IT	-35	($W = W_o$)	IT	-55	($W = W_o$)
CT	-14		CT	-35	
Insertion	0		Insertion	0	
IT	18	($W = W_o$)	IT	23	($W = W_o$)
CT	41		CT	35	
CSI	51		CSI	51	
IT	57	($W = W_o$)	IT	57	($W = W_o$)
CT	74		CT	78	
PC	80		PC	80	
IT	83		IT	83	
CT	97		CT	97	

F TRACKING SCHEDULE (CONT'D)

LM		CSM	
CDH	109	CDH	109
IT	113 ($W = W_o$)	IT	114 ($W = W_o$)
CT	132	CT	131
TPI	146	TPI	146
IT	150	IT	150
CT	157 ($W = W_o$?)	CT	157 ($W = W_o$?)
MC1	161	MC1	161
IT	165	IT	165
CT	173	CT	173
MC2	176	MC2	176

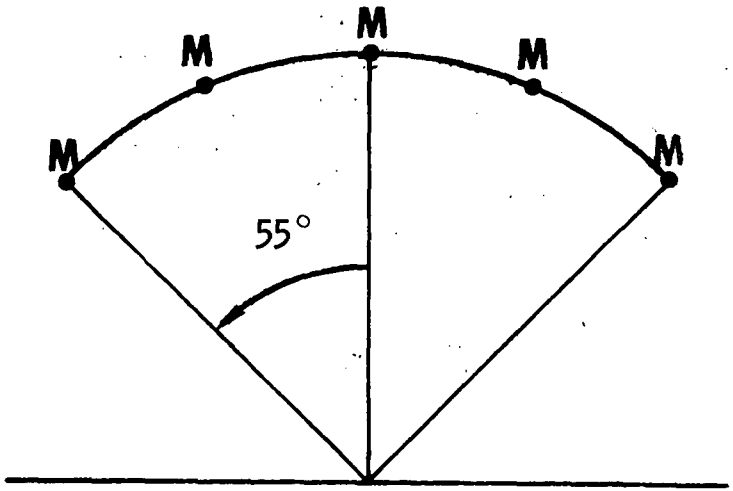
P-22 RESULTS

3σ REL ERRORS AT PDI

	MSFN	OPTICS	
U (FT)	13 200	9 300	✓
V	93 000	90 000	
W	32 000	3 600	★

	μ	σ
SXT	---	---
SCT	---	---

P-22 PROCEDURE



ALTITUDE UNCERTAINTY AS A FUNCTION OF TRACKING TIME

APPROX. ARC	TIME BETWEEN MARKS (SEC)	$3\sigma_h$
30°	10	7200
60°	20	2400
85°	30	1500
110°	40	1350

F ALTERNATE LANDMARK TRACKING

- 2 REVOLUTIONS BEGINNING AT $\simeq$ 80:45
- 2 REVOLUTIONS BEGINNING AT $\simeq$ 95:00
- 4 REVOLUTIONS IN 60 x 8
- 3 REVOLUTIONS BEGINNING AT $\simeq$ 120:30
  - EVALUATE TARGETING
  - IMPROVE LANDING SITE LOCATIONS

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5.0 CONSUMABLES

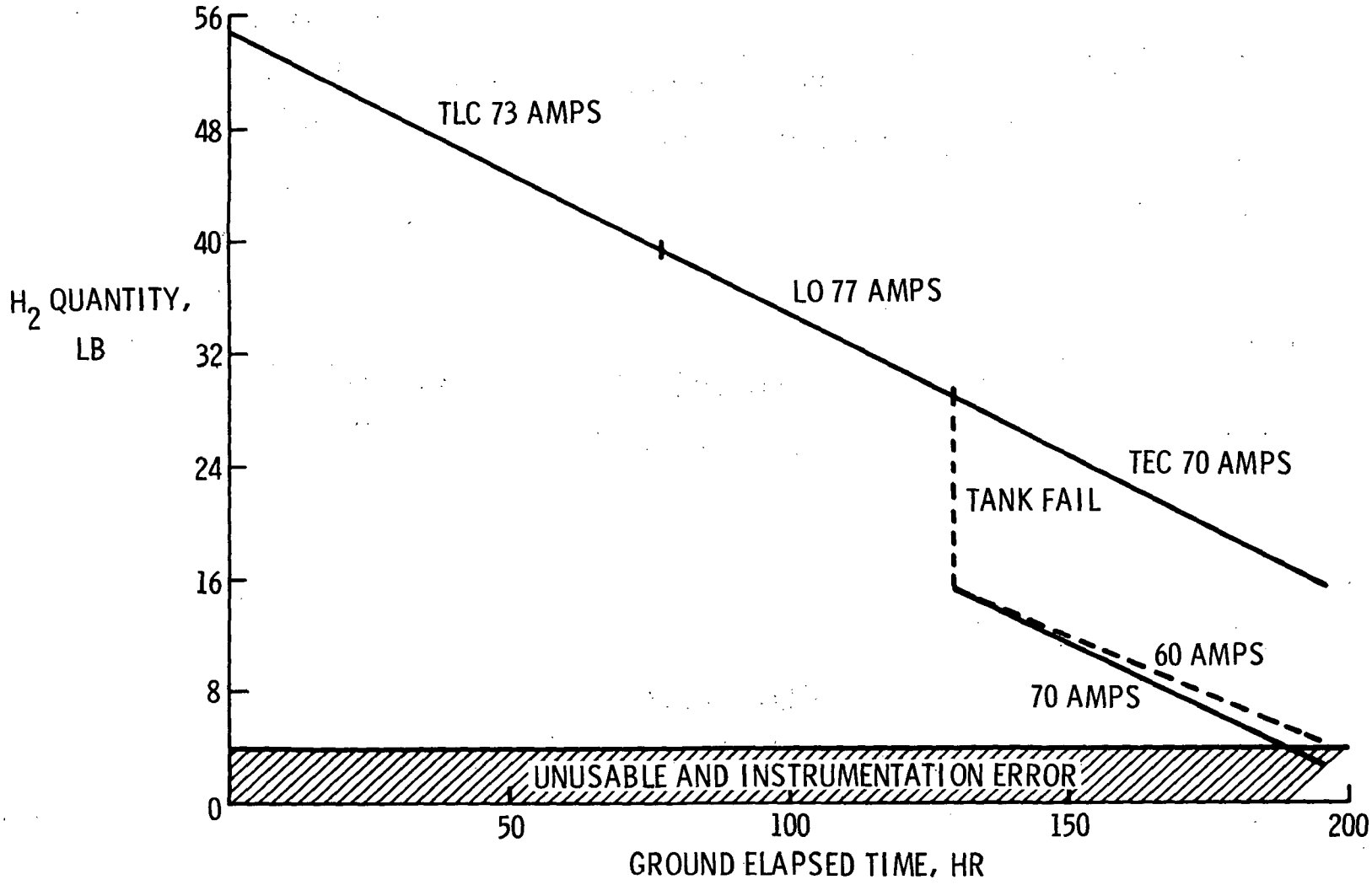
CRYOGENIC SUMMARY

CSM-106

ASSUMPTIONS:

- 100% FILL FOR H_2 AND O_2
- FIRST OPPORTUNITY LIFT-OFF
- AVERAGE CURRENTS FOR EACH PHASE WERE USED
- TANK FAILURE ASSUMED AT TEI
- NO ECS UNCERTAINTY IS INCLUDED
- NO CRYOGENIC VENTING
- A 5% UNCERTAINTY IN THE EPS PROFILE IS INCLUDED

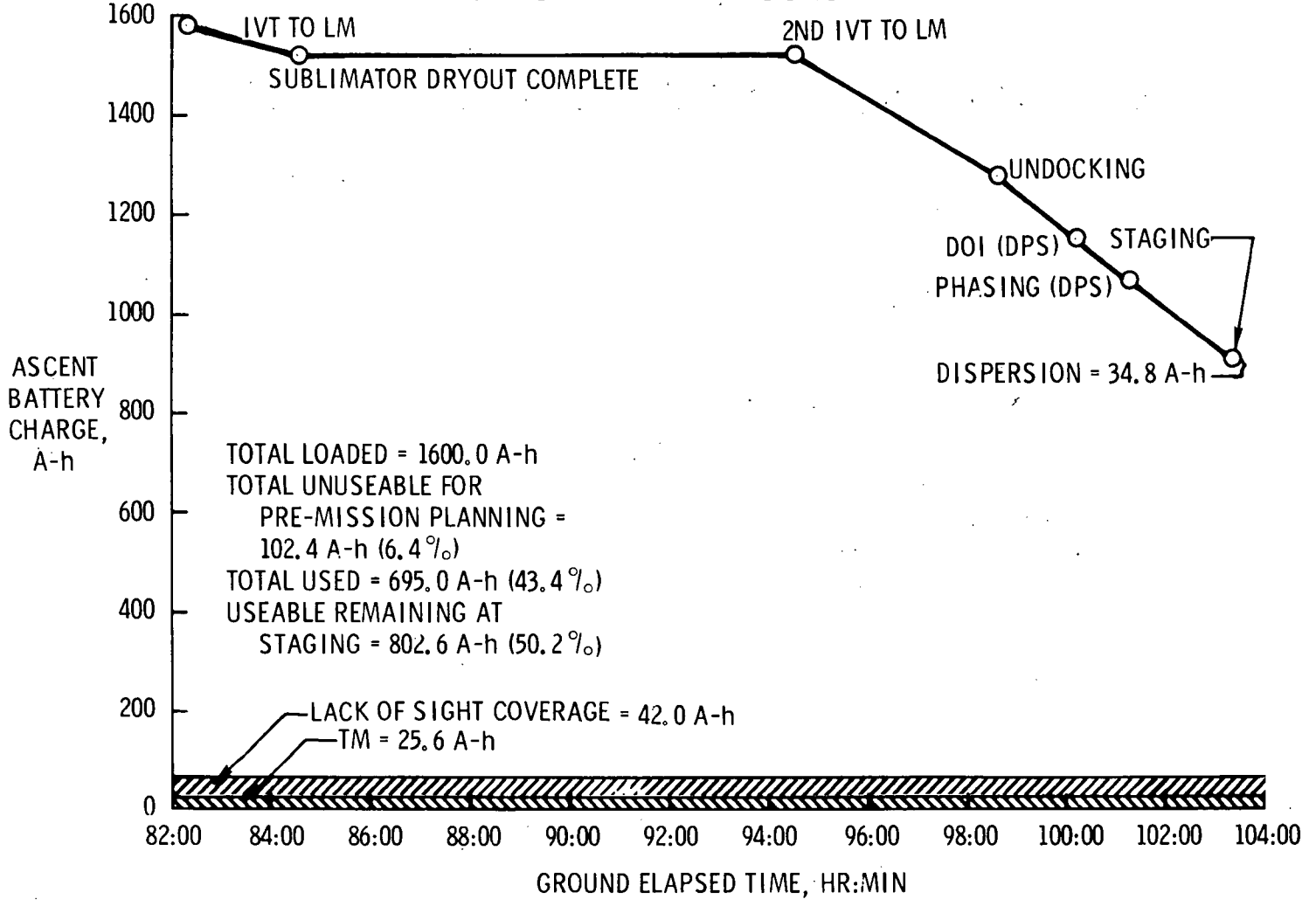
HYDROGEN REQUIREMENTS FOR CSM-106



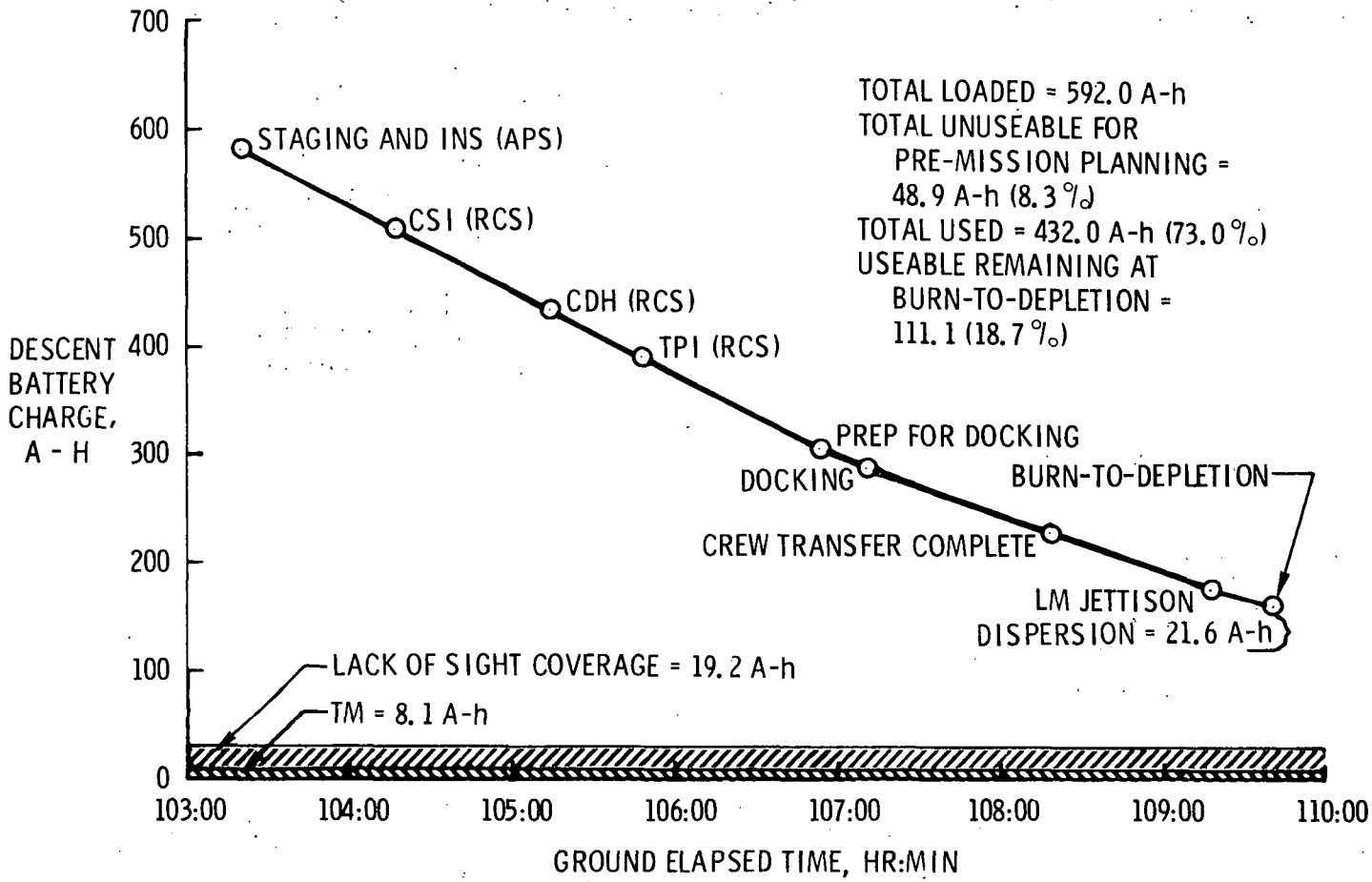
CRYOGENIC SUMMARY
CSM-106

EVENT	H_2, LB	O_2, LB
LOADED (2 TANKS)	58.6	660.2
UNUSABLE	2.4	13.0
INSTRUMENTATION ERROR (2.65%)	1.5	17.5
AVAILABLE FOR MISSION PLANNING	54.7	629.7
PRELAUNCH	3.7	29.9
MISSION		
EPS	37.6	307.5
ECS (.4 LB/HR + 2 LM AND TUNNEL PRESS)	-	97.3
5% UNCERTAINTY IN EPS PROFILE	1.9	15.4
TOTAL REQUIRED	43.2	450.1
MARGIN	11.5	179.6

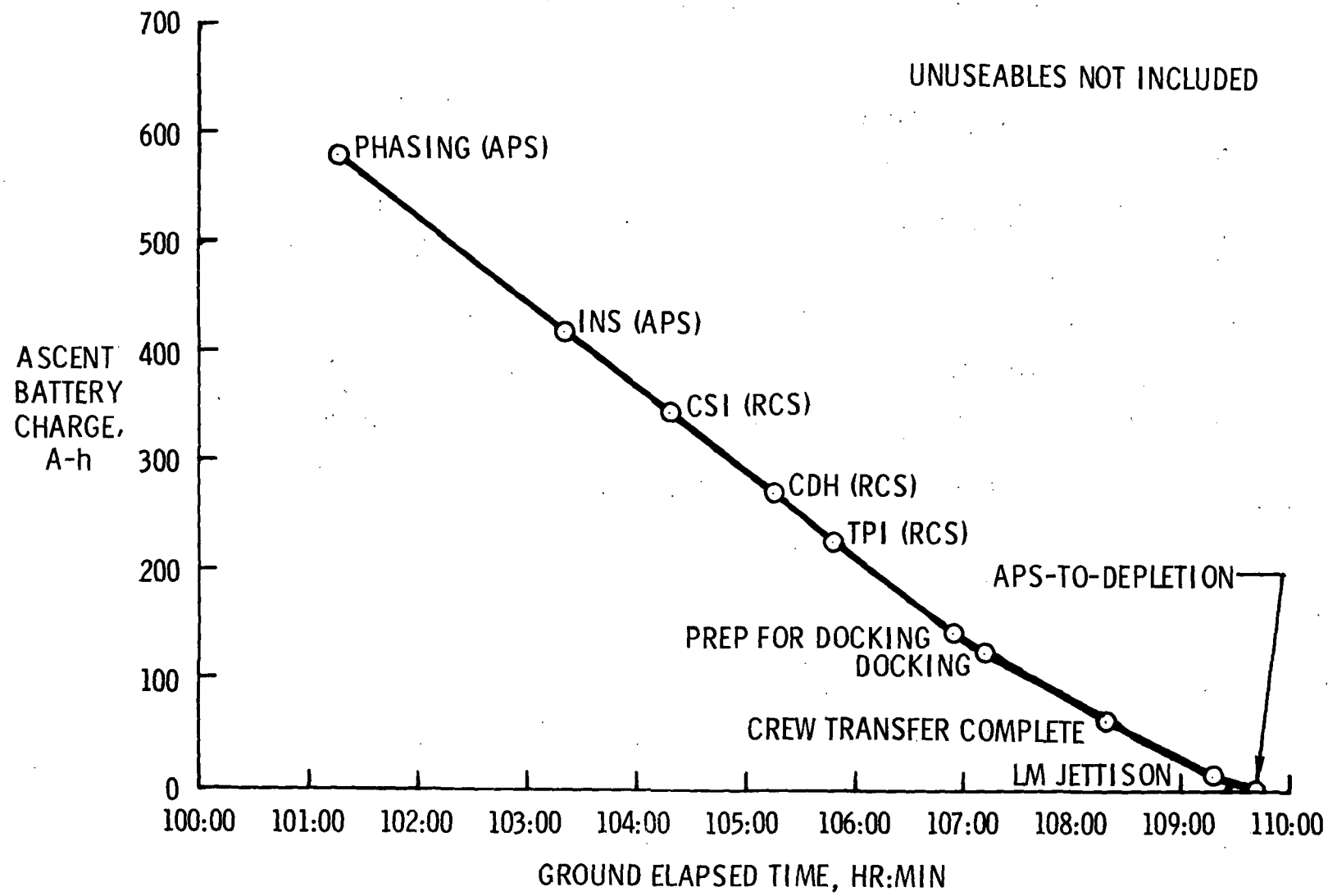
DESCENT ELECTRICAL LOAD ANALYSIS FOR AN F MISSION FLIGHT PLAN



ASCENT ELECTRICAL LOAD ANALYSIS FOR AN F MISSION FLIGHT PLAN



ASCENT ELECTRICAL LOAD ANALYSIS FOR A DESCENT ENGINE FAILURE AT THE PHASING BURN



LM ECS ANALYSIS FOR AN F MISSION FLIGHT PLAN

- DESCENT

H_2O USABLE	317.00	O_2 USABLE	44.61
H_2O USED	77.6	USED	4.03
REMAINING	239.4	REMAINING	40.58

- ASCENT

H_2O USABLE	80.80	O_2 USABLE	4.12
USED	47.00	USED	2.30
REMAINING	33.80	REMAINING	1.82

FOR STAGING JUST PRIOR TO PHASING AN ADDITIONAL 16.7 LB OF H_2O IS REQUIRED

AND .73 LB OF O_2 IS REQUIRED

MISSION F LM PROPELLANT BUDGET
(POUNDS OF PROPELLANT)

SYSTEM	DPS	APS	LM RCS
LOADED	18 230	2 632	632
AVAILABLE	17 648	2 579	507
REQUIRED	830	BTD	336
REMAINING	16 818	-	171

MISSION F CSM PROPELLANT BUDGET
(POUNDS OF PROPELLANT)

SYSTEM	SPS	SM RCS	CM RCS
LOADED	40 836	1342	270
AVAILABLE	40 216	1216	231
REQUIRED	36 030	600~ 800	32
REMAINING	4 186	616~ 416	199
LM RESCUE	2 009	506~ 542	
MARGIN	2 177	110~ (-) 126	

SM-RCS PROPELLANT
LUNAR MODULE RESCUE REQUIREMENTS
(POUNDS OF PROPELLANT)

	PRIMARY GUIDANCE	BACKUP MODE (PGNCS FAILED)
PRE TPI	61	49*
TPI - TPF	400	443
DOCKING	45	50
TOTAL LM RESCUE	506	542

*CSI AND CDH BURNS NOT TRIMMED

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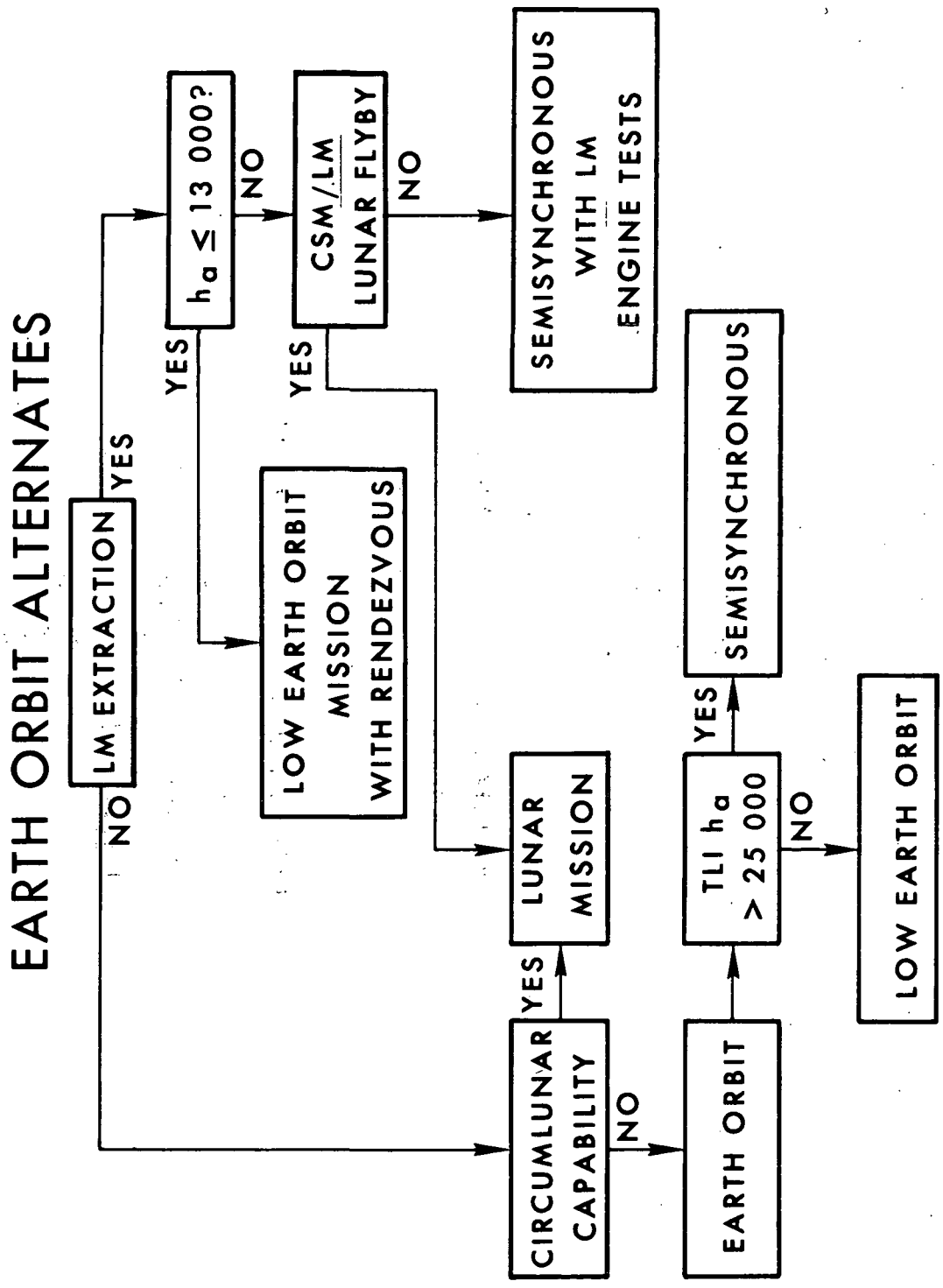
6.0 ALTERNATE MISSIONS


EARTH ORBIT ALTERNATES
LM EXTRACTION
YES
NO
$h_a \leq 13\,000$?
YES
NO
CSM/LM LUNAR FLYBY
YES
NO
SEMISYNCHRONOUS WITH LM ENGINE TESTS
LOW EARTH ORBIT MISSION WITH RENDEZVOUS
LUNAR MISSION
CIRCUMLUNAR CAPABILITY
YES
NO
EARTH ORBIT
TLI h_a > 25 000
YES
NO
SEMISYNCHRONOUS
LOW EARTH ORBIT

ALTERNATE MISSION #1

(LOW EARTH ORBIT CSM ONLY)

- SIMULATED LOI (100-400)
- FURTHER MCC'S TO APPROXIMATE LUNAR MISSION TIMELINE
- APPROXIMATELY A 10 DAY MISSION

ALTERNATE MISSION #2

(SEMISYNCHRONOUS WITH CSM ONLY)

- PHASING MANEUVER TO ADJUST ORBIT PERIOD TO G.E.T. SIMULATED LOI TRACK
- SIMULATED LOI (NEAR SEMISYNCHRONOUS)
- PHASING MANEUVER TO PLACE PERIGEE OVER RECOVERY ZONE AT A LATER TIME
- SPS TO SEMISYNCHRONOUS ORBIT
- FURTHER MCC'S TO APPROXIMATE LUNAR TIMELINE
- APPROXIMATELY A 10 DAY MISSION

ALTERNATE MISSIONS #3 & 4

(LOW EARTH ORBIT WITH RENDEZVOUS)

- PHASING MANEUVER TO INSURE TRACKING FOR SECOND SIMULATED PDI MANEUVER
- SIMULATED DOI (1 HOUR PRIOR TO SIMULATED PDI)
- SIMULATED PDI
- PHASING MANEUVER TO INSURE TRACKING FOR SIMULATED LOI
- SIMULATED LOI (100-400 N. MI. ORBIT)
- TWO SPS MANEUVERS TO CIRCULARIZE AT 150 N. MI.
- LM ACTIVE RENDEZVOUS
- APS BURN TO DEPLETION (AGS CONTROLLED)
- FURTHER MCC'S TO COMPLETE LUNAR MISSION TIMELINE
- APPROXIMATELY 10 DAY MISSION

*IF TLI $h_a \leq 4000$ N. MI. MANEUVERS 4 AND 5 COULD PRECEDE 1, 2, 3

ALTERNATE MISSION #5

- PHASING MANEUVER TO INSURE TRACK FOR SIMULATED LOI
- SIMULATED LOI (APPROXIMATELY SEMISYNCHRONOUS)
- PHASING MANEUVER TO INSURE TRACKING FOR PDI
- SIMULATED DOI (1 HOUR PRIOR TO SIMULATED PDI)
- SIMULATED PDI (APPROXIMATELY SEMISYNCHRONOUS)
- APS TO DEPLETION (AGS CONTROLLED)
- PHASING MANEUVER TO PUT PERIGEE OVER RECOVERY ZONE LATER (40 SECOND MANEUVER)
- SPS-(SEMISYNCHRONOUS)
- MCC'S TO COMPLETE LUNAR MISSION TIMELINE
- APPROXIMATELY A 10 DAY MISSION

TABLE I

Sequence of Events for Alternate 3 Based on July 15, 1969, 75° Launch Azimuth

Event	g.e.t. d:hr:min:sec	Duration sec	ΔV fps	h_a/h_p n. mi.	Propulsion System	Nodal Shift deg	Latitude deg	Longitude deg	SPS Prop. Remaining lbs
LOI	1:01:01:19.0	766.1	3664.0	393.9/101.9	SPS	15.1 E	29.7	-98.4	9370
1st DPS	1:23:00:00	7	70	400.0/100.0	DPS				
2nd DPS	2:00:28:19.7	364.0	1628.0	427.1/101.8	DPS	6.8 E	31.1	-80.7	9370
Deboost	3:01:40:15.7	40.9	475.1	150.0/101.8	SPS	0.3 W	33.1	-83.1	6735
Circularization	3:05:23:17.7	6.8	85.8	150.4/150.2	SPS	-	-33.1	43.1	6269
First Phasing	4:01:38:07.2	15.0 (10%) 15.6 (40%)	133.0	226.1/149.9	DPS	-	32.7	-78.3	6269
Second Phasing	4:02:23:56.3	15.0 (10%) 3.2 (F.T.)	67.0	226.1/112.0	DPS	-	-32.7	90.8	6269
Insertion	4:03:09:09.1	12.6	170.9	128.5/111.9	APS	-	32.7	-106.1	6269
CSI	4:03:52:05.4	31.8	49.6	139.8/111.9	RCS (4-jet)	-	-33.1	61.1	6269
CDH	4:04:36:56.7	14.2	21.9	139.9/139.6	RCS (4-jet)	-	33.1	-129.4	6269
TPI	4:05:20:08.2	26.4	21.8	151.0/139.5	RCS (2-jet)	-	-33.1	32.2	6269
TPF *	4:05:52:47.1	36.2	30.0	149.9/149.8	RCS (2-jet)	-	20.1	150.7	6269

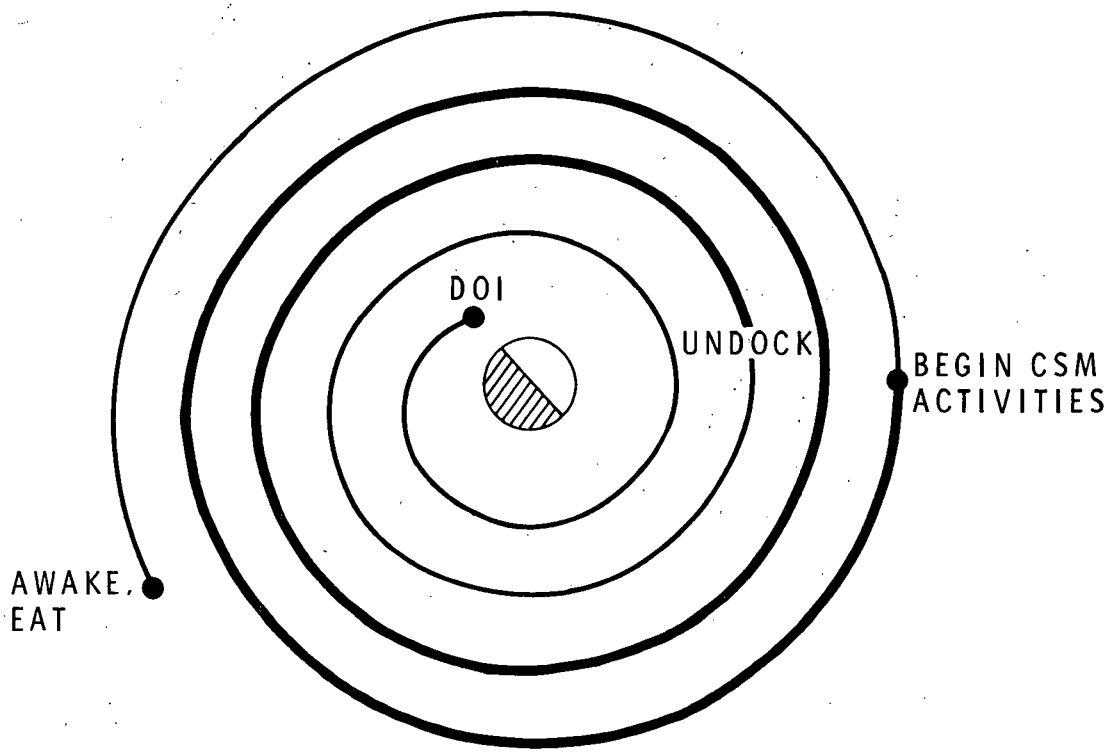
* The maneuvers that follow the rendezvous consist of an APS burn to depletion, SPS orbit shaping maneuvers (at least one a day for duration of mission), and the deorbit burn.

The APS burn to depletion is scheduled as soon as possible after the rendezvous. This burn must have MSFN coverage. End-of-mission SPS burns will place the spacecraft in a base ellipse for deorbit (240 x 90).

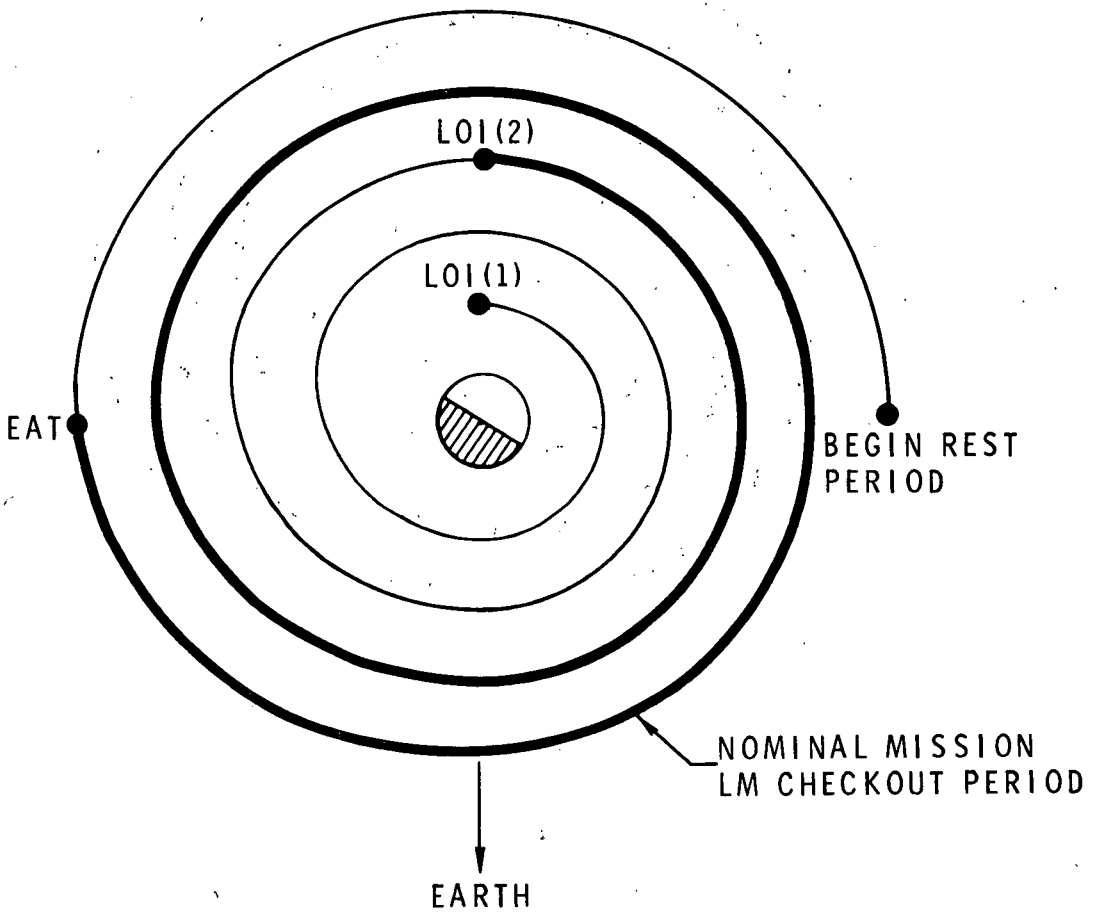
ALTERNATE MISSION EARTH ORBIT GUIDELINES

- LM TESTING TAKES PRIORITY OVER CSM TESTING
- A LUNAR MISSION TIMELINE IS DESIRABLE
- NO ADDITIONAL CREW TRAINING WILL BE NECESSARY
- RCS DEORBIT CAPABILITY WILL BE MAINTAINED
- COVERAGE FOR ALL SPS AND DPS MANEUVERS IS DESIRABLE.
  COVERAGE FOR ALL LARGE LM MANEUVERS IS MANDATORY
- ALTERNATE MISSIONS WILL BE OPEN ENDED UP TO 10 DAYS

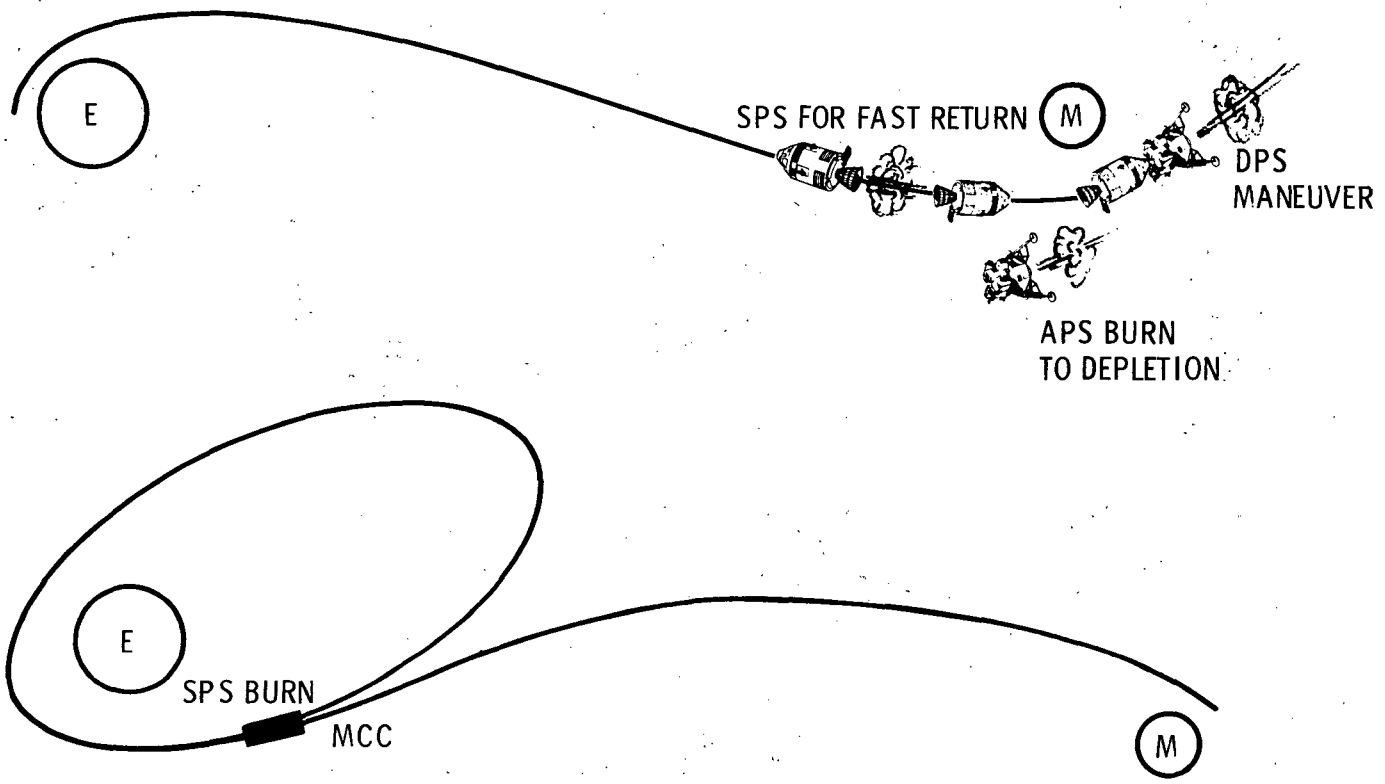
DOI DAY



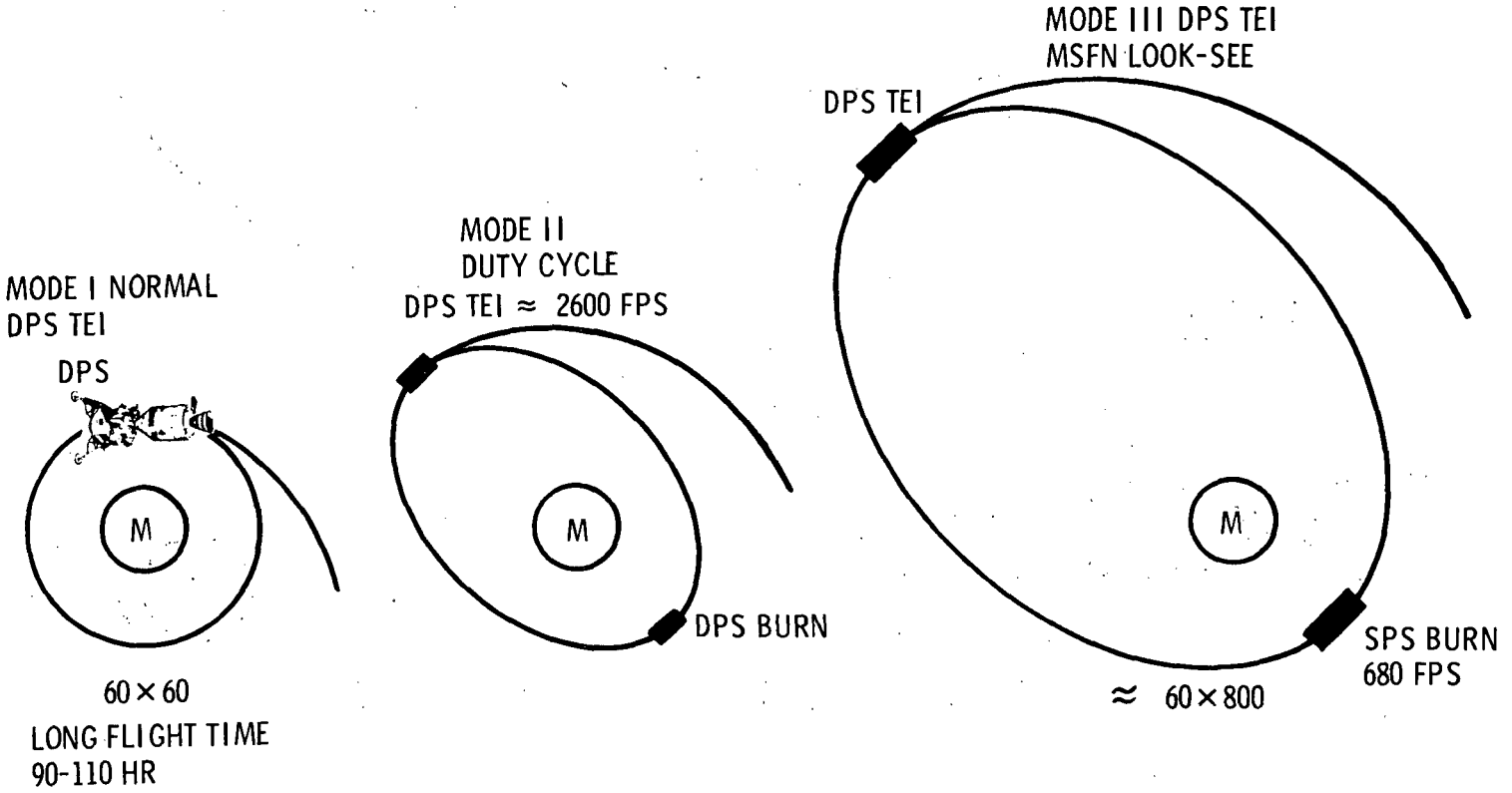
LOI DAY


LOI(2)
LOI(1)
EAT
BEGIN REST PERIOD
NOMINAL MISSION
LM CHECKOUT PERIOD
EARTH

CSM/LM FLYBY


E
SPS FOR FAST RETURN
M
DPS
MANEUVER
APS BURN
TO DEPLETION
E
SPS BURN
MCC
M

VARIOUS DPS TEI'S



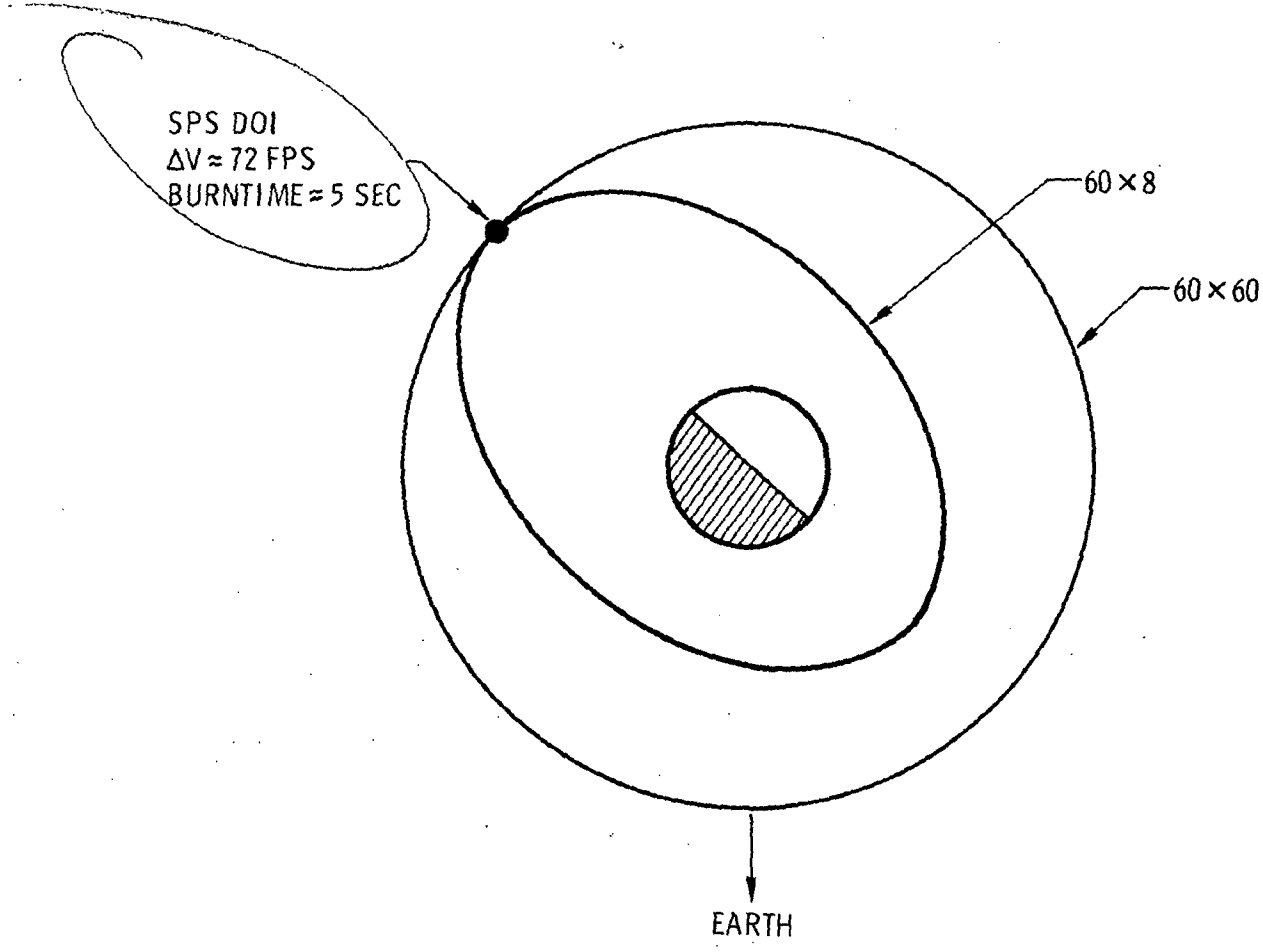
LUNAR ORBIT ALTERNATES

- ALTERNATE 3: CONTINGENCY:LM NO GO FOR UNDOCK
  - DPS-GO FOR BURN
    - DPS TEI
    - APS BURN TO DEPLETION
    - SPS FOR FAST RETURN
  - DPS-NO GO
    - APS BURN TO DEPLETION
    - RETURN TO NOMINAL MISSION
  - DPS, APS NO GO
    - CULL THE LM

LUNAR ORBIT ALTERNATES (CONCLUDED)

- ALTERNATE 4: CONTINGENCY:LM NO GO FOR RENDEZVOUS
  - STATION KEEP
  - POSSIBLY MINI FOOTBALL
  - GO TO APPROPRIATE ALTERNATE 3

SPS DOI ORBIT



LUNAR ALTERNATE RENDEZVOUS

- ALTERNATE 5
  - DPS ONLY RENDEZVOUS
- ALTERNATE 6
  - APS ONLY RENDEZVOUS

TLI AND TLC CONTINGENCY

- ALTERNATE 1
  - FAILURE OF T, D, AND E
  - APOLLO 8 TYPE MISSION
- ALTERNATE 2
  - NON-NOMINAL TLI
  - T, D, AND E
  - SPS FREE-RETURN CSM/LM
  - IF NO-GO FOR CSM/LM LPO, CONSIDER CSM ONLY-LM TEST DURING TLC
  - OTHERWISE CSM/LM FLYBY

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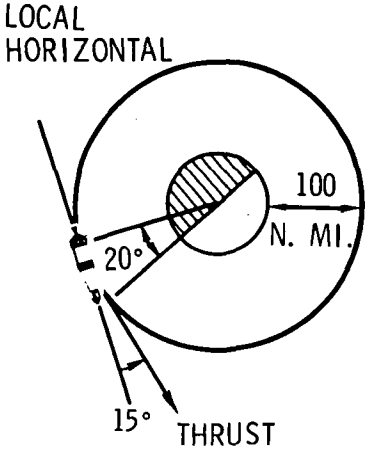
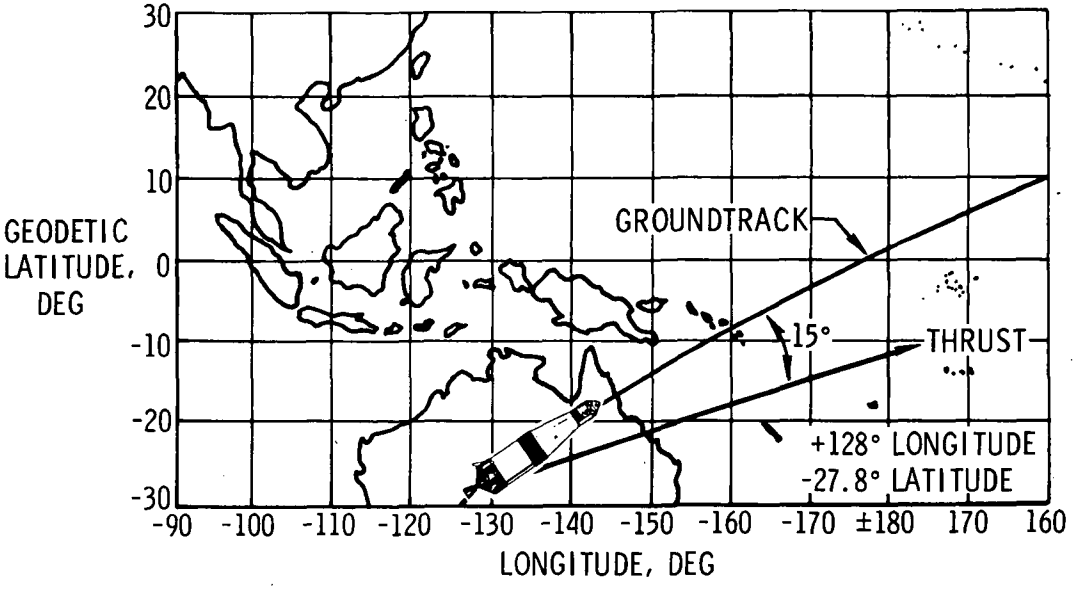
7.0 ABORTS

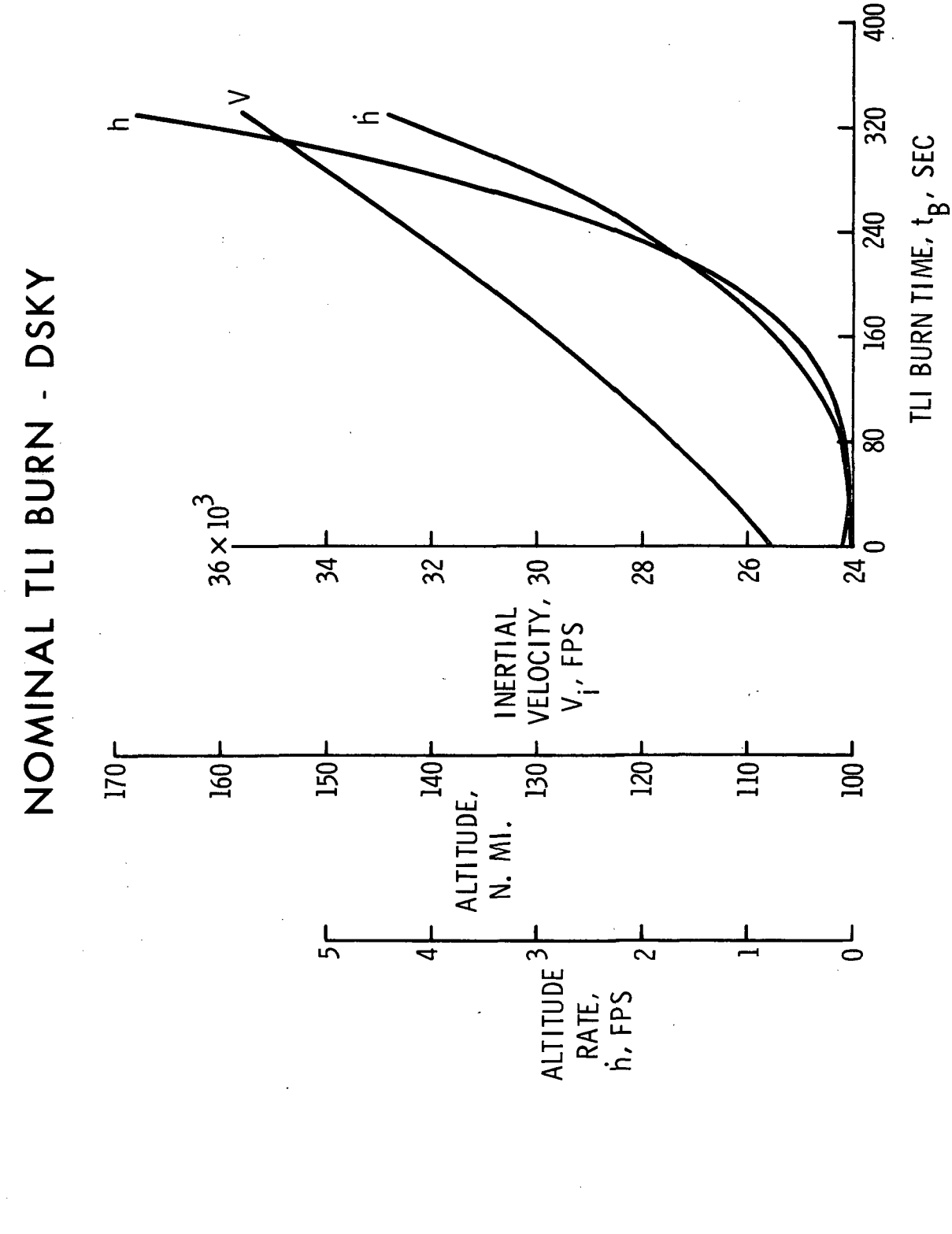
LAUNCH VEHICLE ATTITUDE AT TLI IGNITION



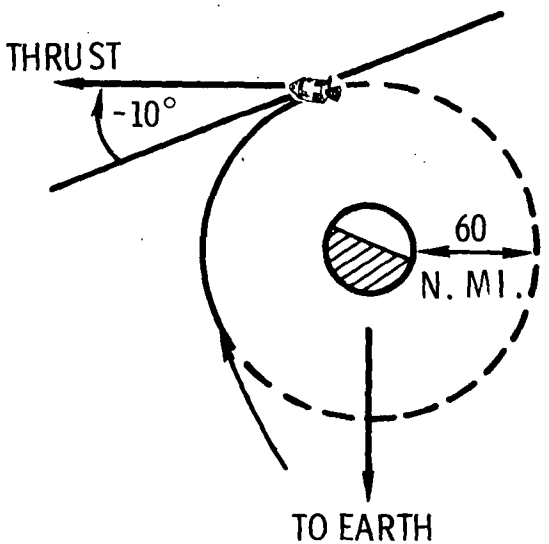
PITCH WITH RESPECT
TO LOCAL HORIZONTAL



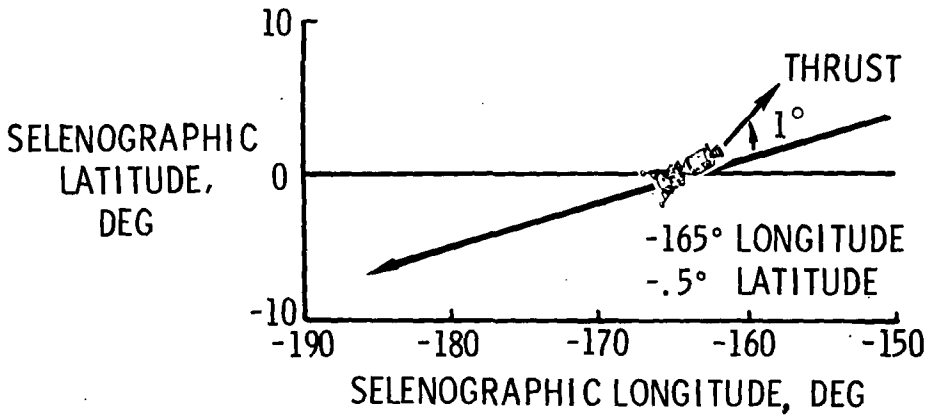
YAW, LOCAL HORIZONTAL SYSTEM


NOMINAL TLI BURN - DSKY
h
V
ḣ
36 × 10^3
34
32
30
28
26
24
INERTIAL VELOCITY, V_i, FPS
170
160
150
140
130
120
110
100
ALTITUDE, N. MI.
5
4
3
2
1
0
ALTITUDE RATE, ḣ, FPS
0
80
160
240
320
400
TLI BURN TIME, t_B, SEC

SPACECRAFT ATTITUDE AT LOI

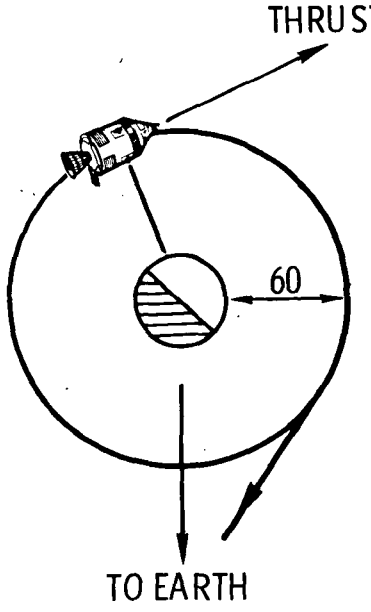


PITCH WITH RESPECT TO LOCAL HORIZONTAL

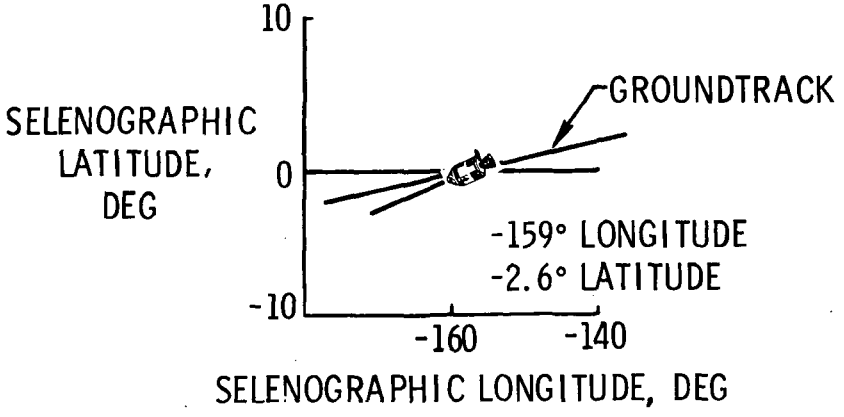


YAW, LOCAL HORIZONTAL SYSTEM

SPACECRAFT ATTITUDE AT TRANSEARTH INJECTION



PITCH WITH RESPECT TO LOCAL HORIZONTAL



YAW, LOCAL HORIZONTAL SYSTEM

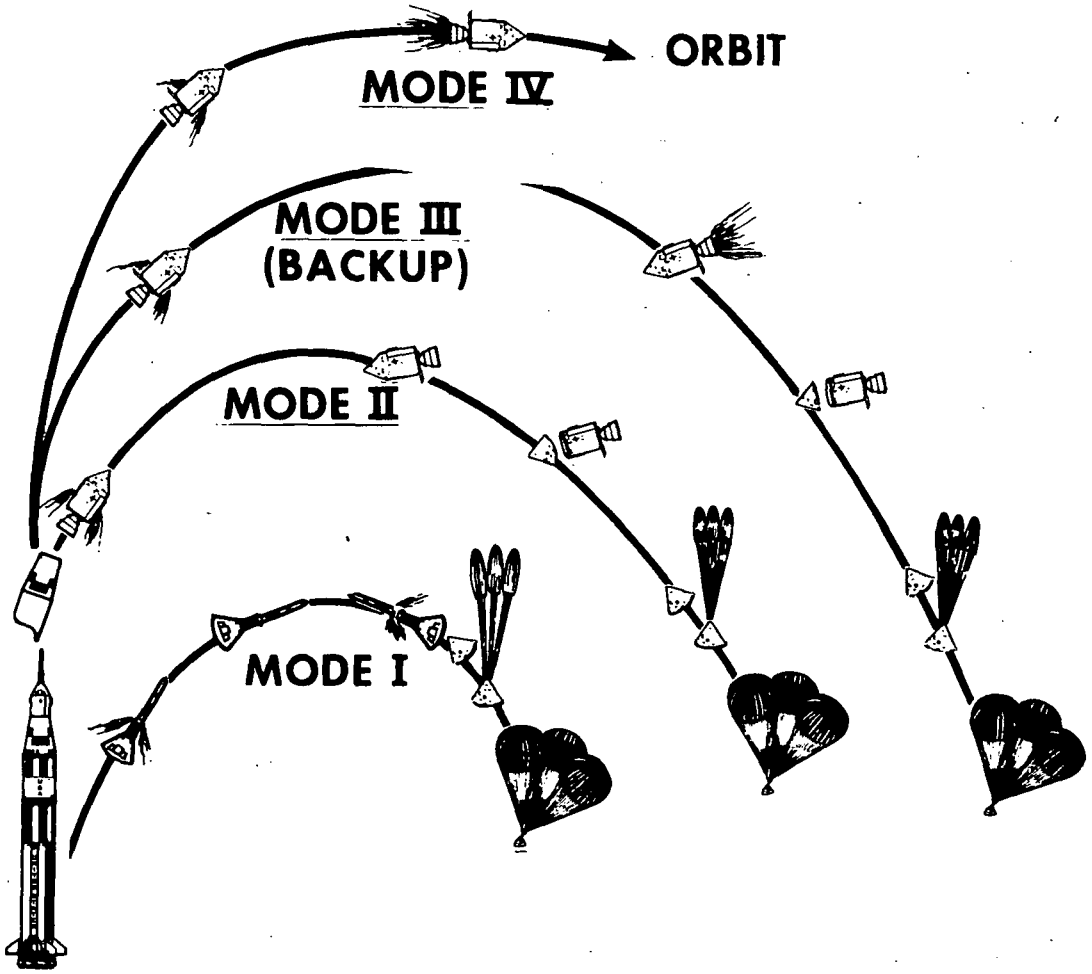
RECOMMENDED ACTION FOR PROBLEMS DURING LOI

GUIDANCE AND CONTROL (IMU DRIFTS, ETC)	MANUAL TAKEOVER AT 10°/SEC OR 10° ATTITUDE DEVIATION AND COMPLETE LOI AT IGNITION ATTITUDE
NON-SPS (ECS ETC)	COMPLETE LOI
SPS (PRESS ETC)	CREW CHART ABORT SPS AT 15 MINUTES OR DPS AT PERILUNE
INADVERTANT SHUTDOWNS (CMC ETC)	DPS ABORT AFTER 2 HOURS

ALLOWABLE ATTITUDE DEVIATIONS FOR LUNAR ALTERNATE MISSIONS

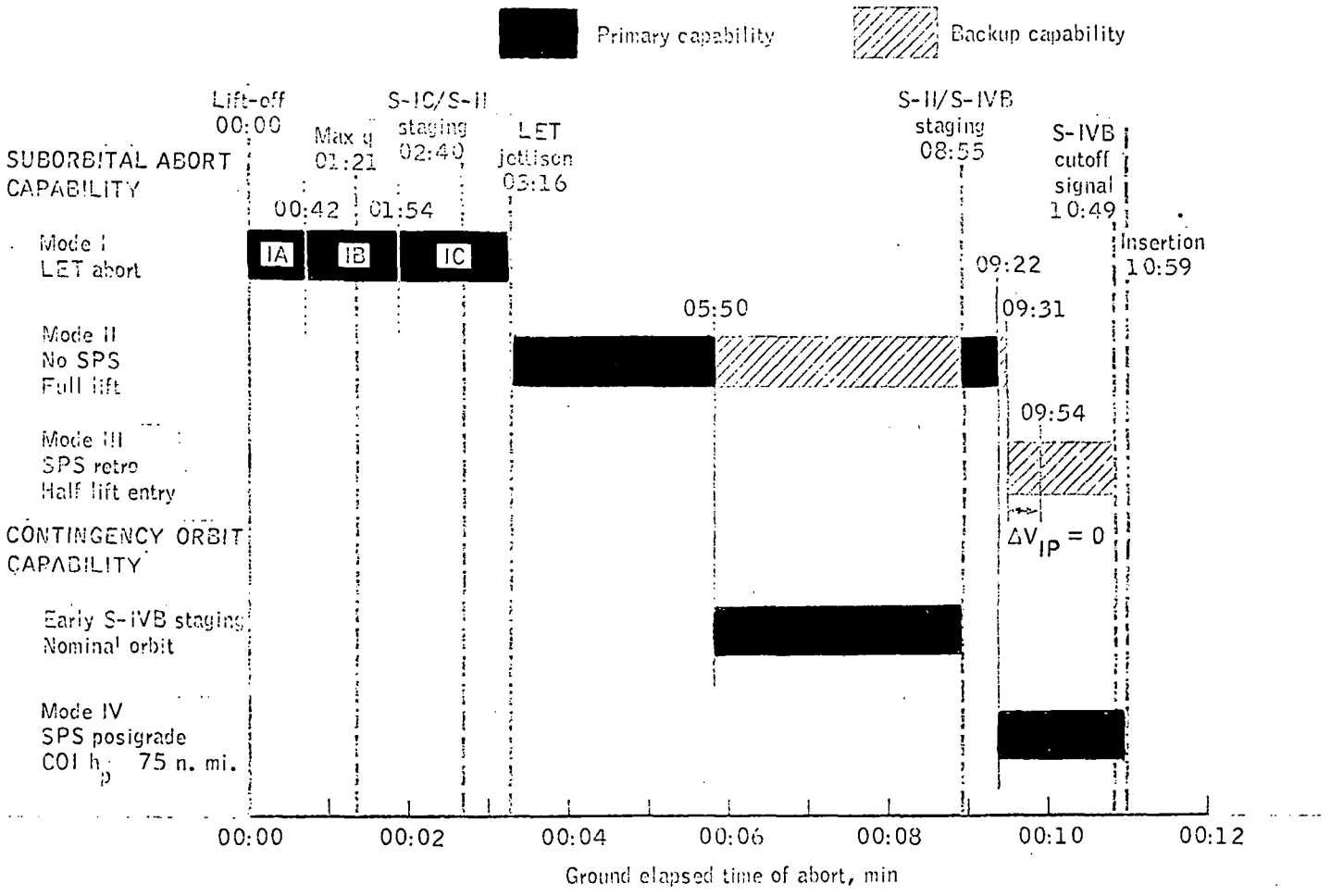
ALTERNATE MISSION DESIGNATION	ΔV_{MCC}, FPS	NEGATIVE PITCH, DEG	POSITIVE PITCH, DEG	NEGATIVE YAW, DEG	POSITIVE YAW, DEG
CSM FLYBY	7000	-54.0	60.9	-65.8	52.5
CSM/LM FLYBY	3000	-32.8	41.3	-51.8	26.4
CSM LUNAR ORBIT	4000	-39.2	46.9	-56.7	34.4
CSM/LM LUNAR ORBIT	~ 1000	-15.6	22.9	-39.4	9.8
RETURN TO NOMINAL	~ 150	-1.6	3.2	-29.5	.3

APOLLO LAUNCH ABORT MODES



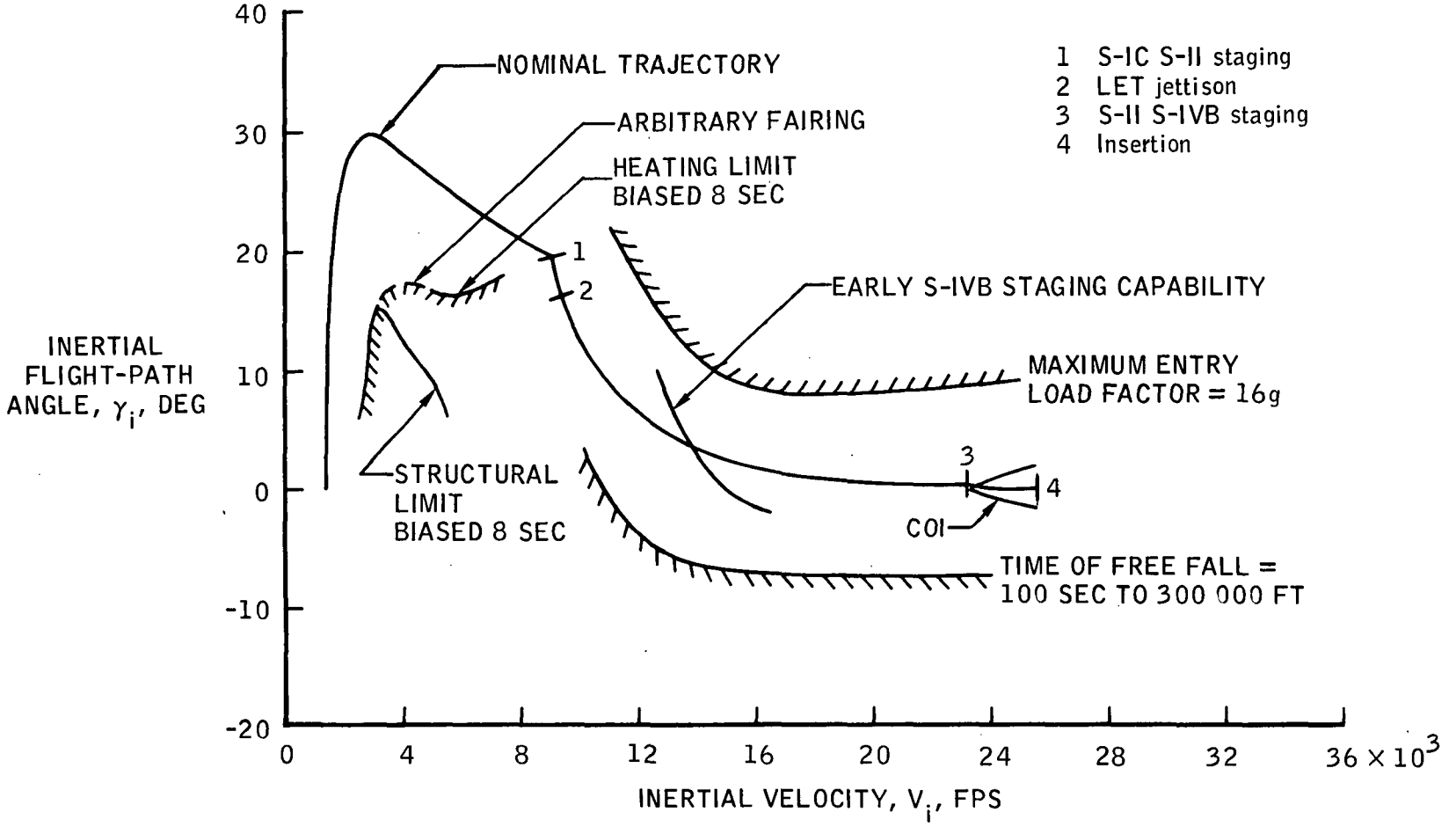
NASA/MSC/DFO
MISSION PLANNING AND ANALYSIS DIVISION
BRANCH FAB DATE 3-7-68
BY Henderson PLOT NO. MPAD 3201V

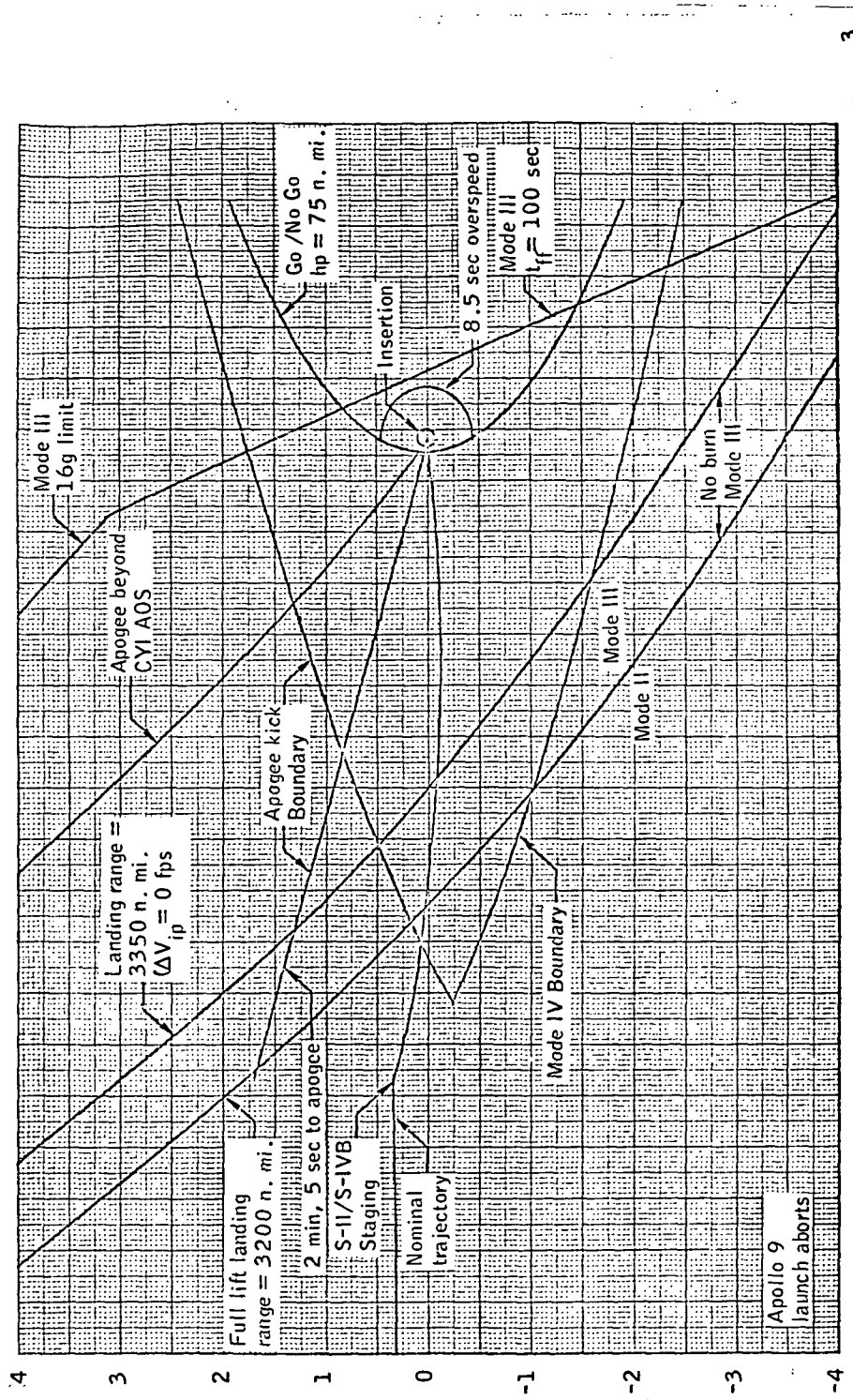
APOLLO 9 LAUNCH TIMELINE AND CONTINGENCY CAPABILITY



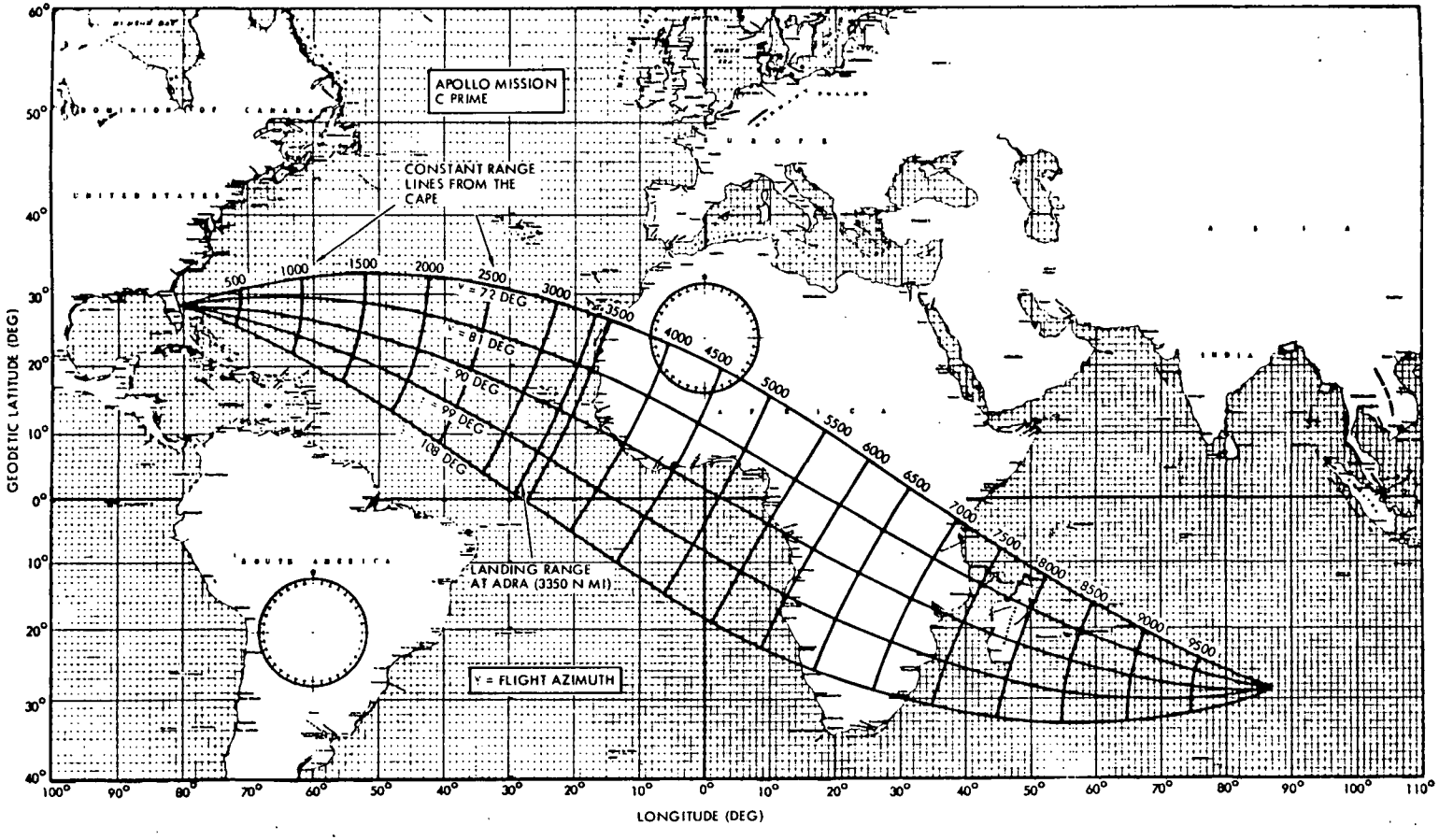
Apollo 9 launch timeline and contingency capability.

LAUNCH ABORT AND CAPABILITY LIMITS

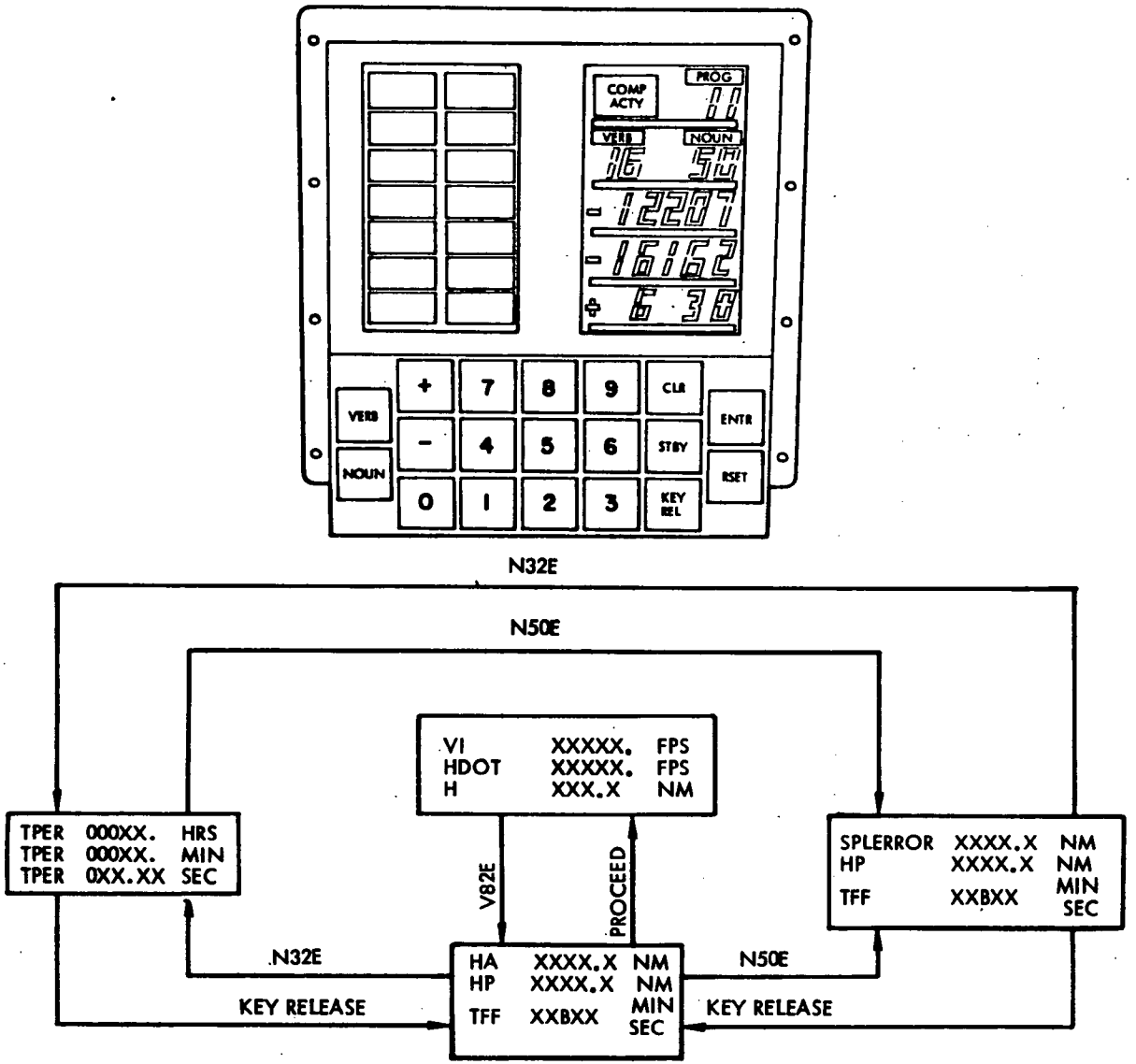




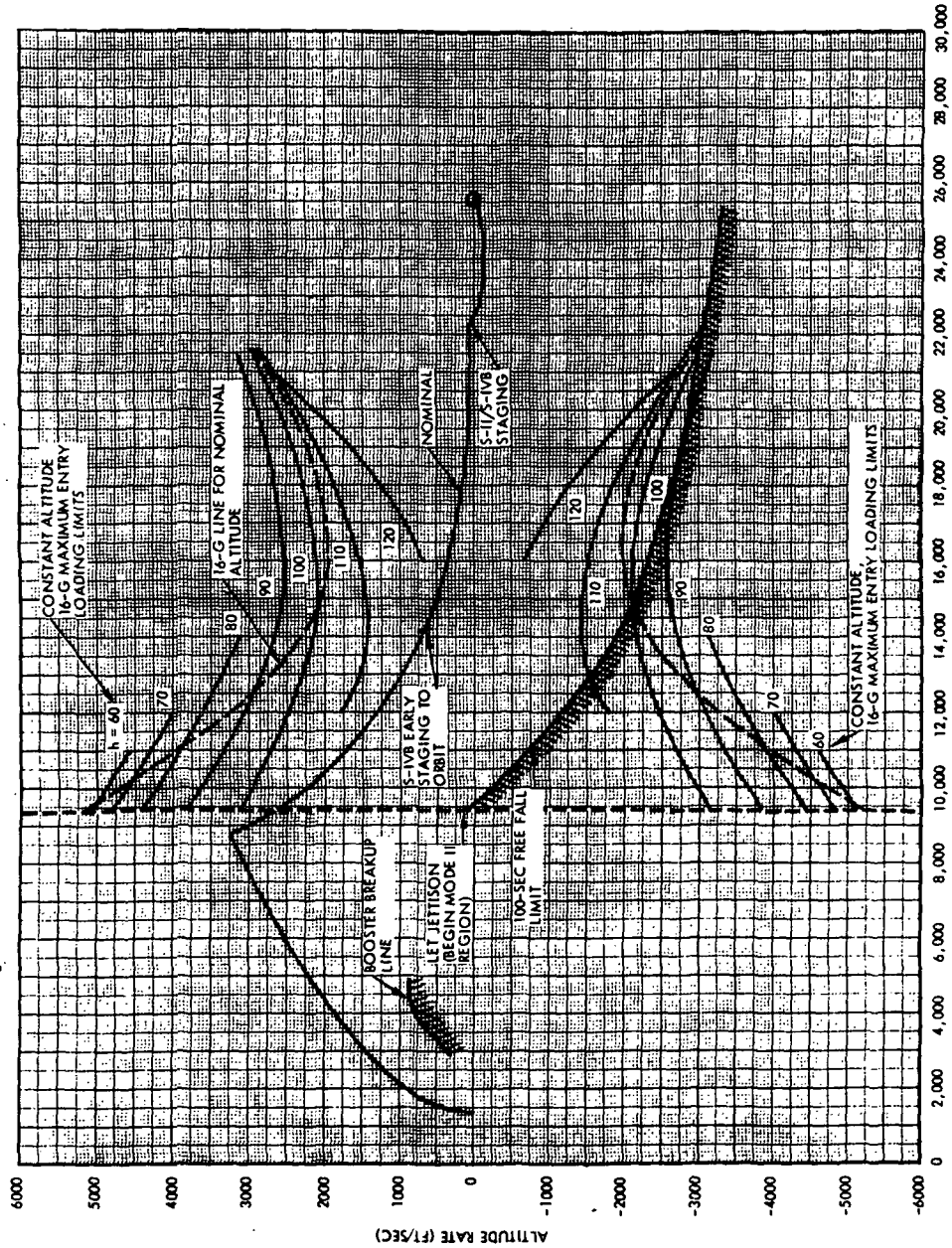
Near-insertion abort mode overlap.



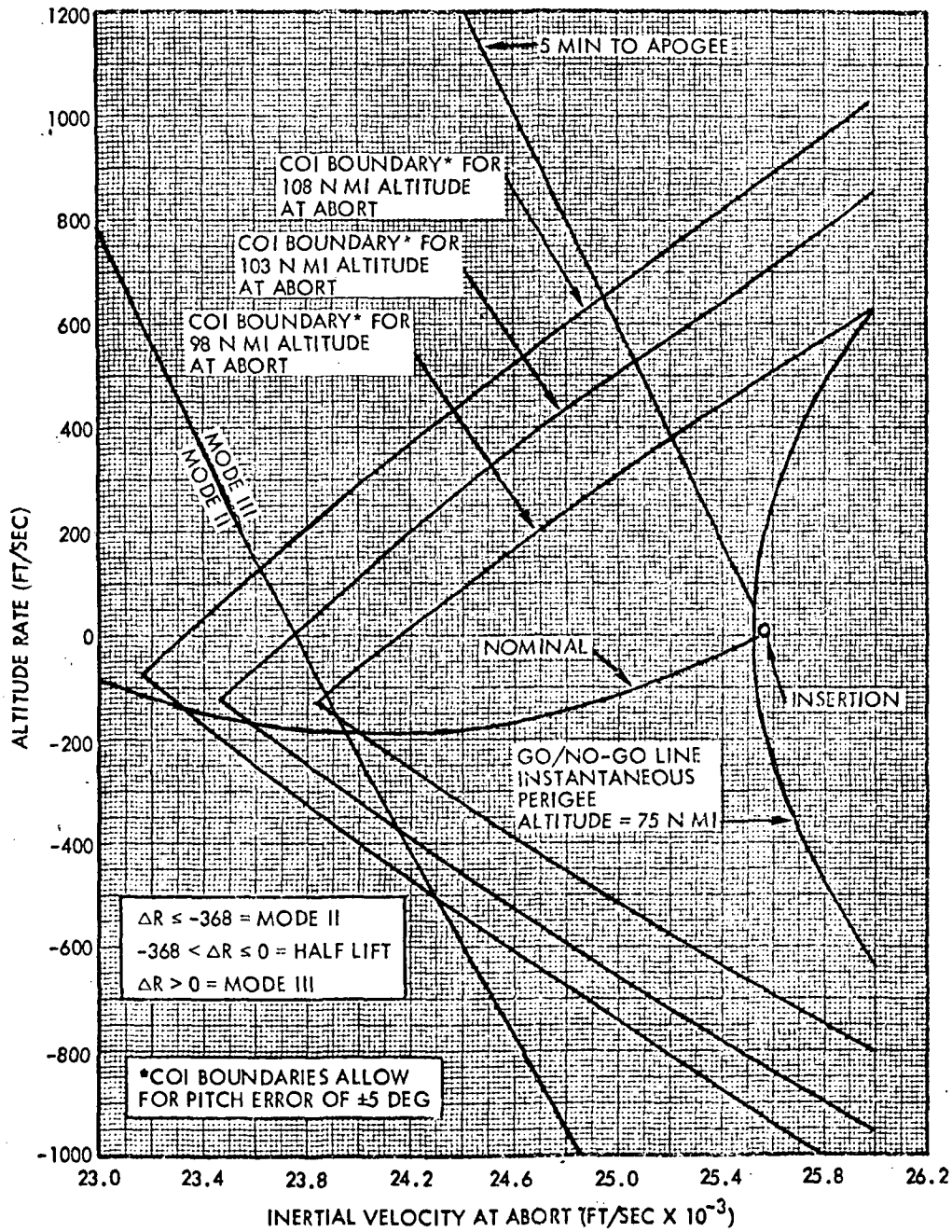
Ground Track Traces Along Flight Azimuths of 72, 81, 90, 99, and 108 Degrees for the Apollo C Prime Mission



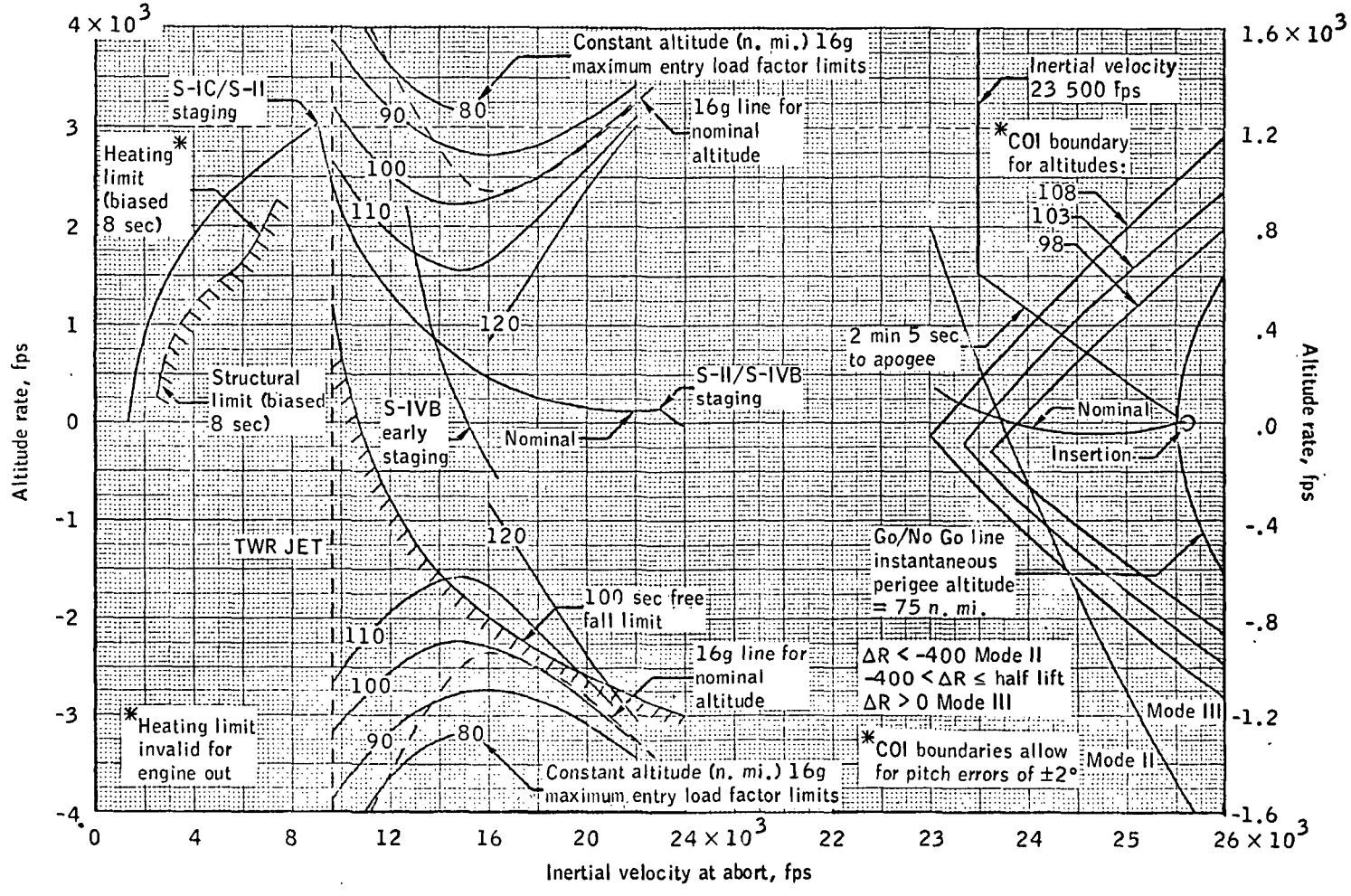
AGC display keyboard panel and display parameters.



No-voice crew chart 1 for the launch phase.



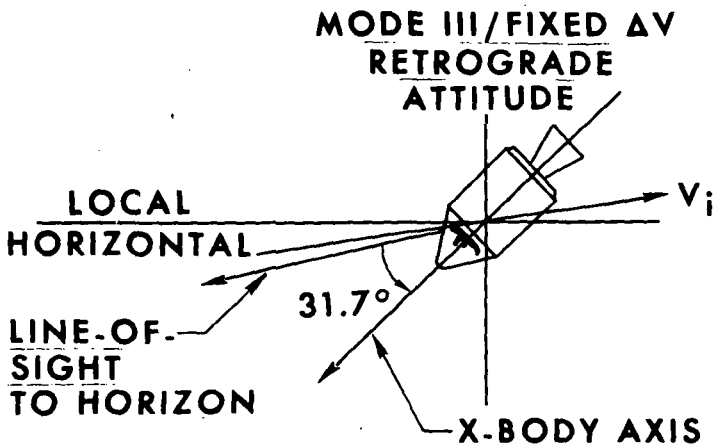
No-voice crew chart 2 for the launch phase.

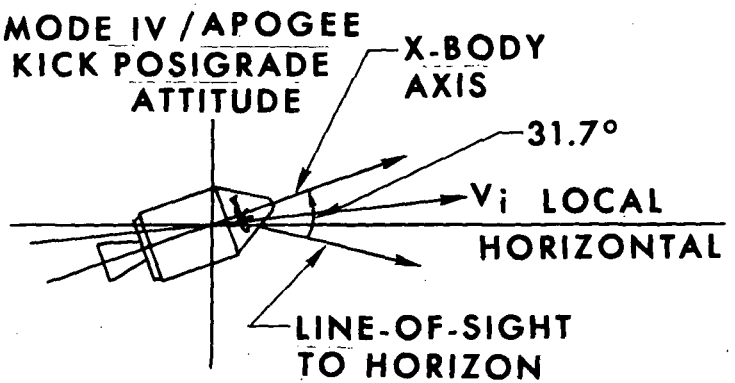


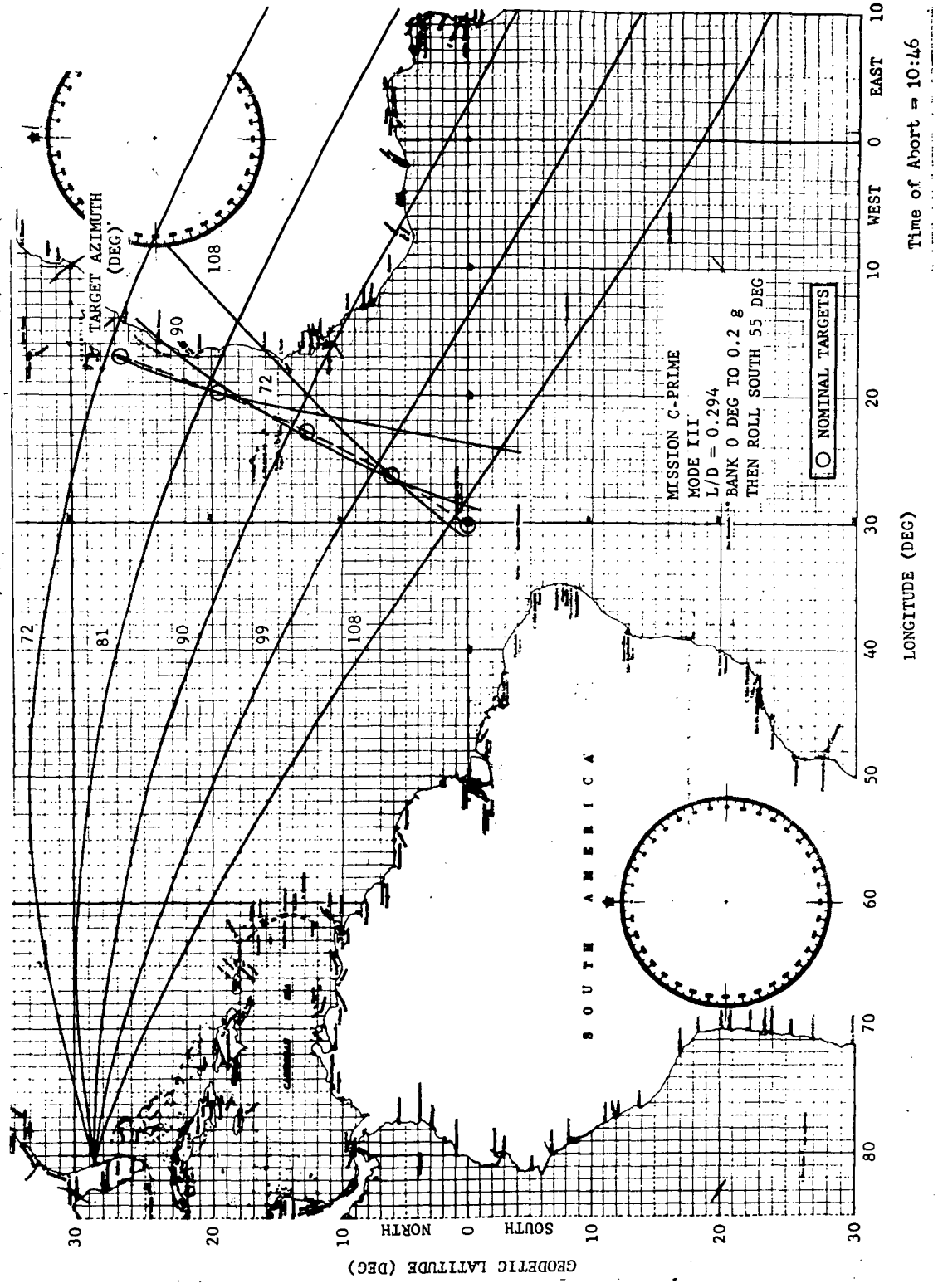
No-voice crew chart for launch phase.

MPAD 3725 S

SPACECRAFT ATTITUDE REQUIRED AT SPS IGNITION FOR LAUNCH ABORT MANEUVERS



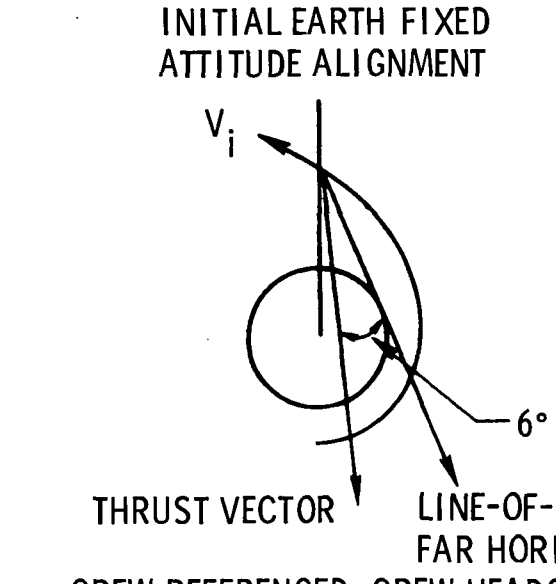




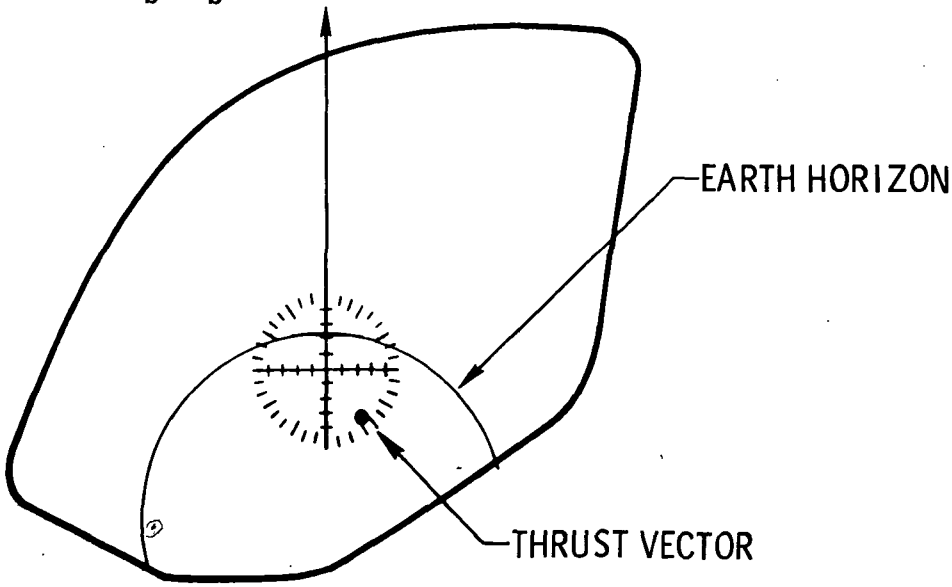
CM landing range trace for various CMC targets (7_a = 10:46).

Flight azimuth, deg

DEFINITION OF ATTITUDE FOR TLI-PLUS-90-MINUTE ABORTS



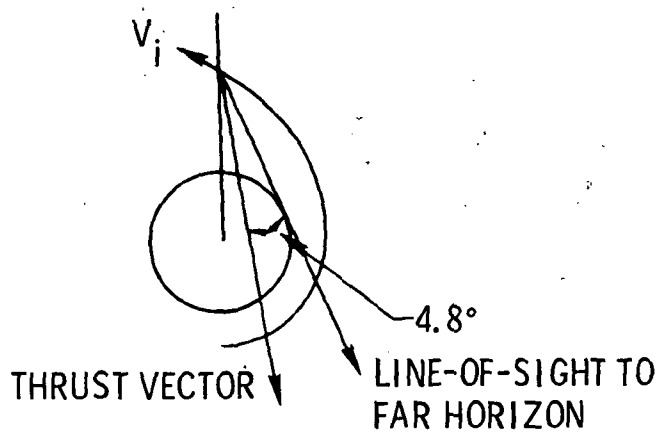
CREW REFERENCED: CREW HEADS UP
(X_b, Z_b IN-ORBITAL PLANE)



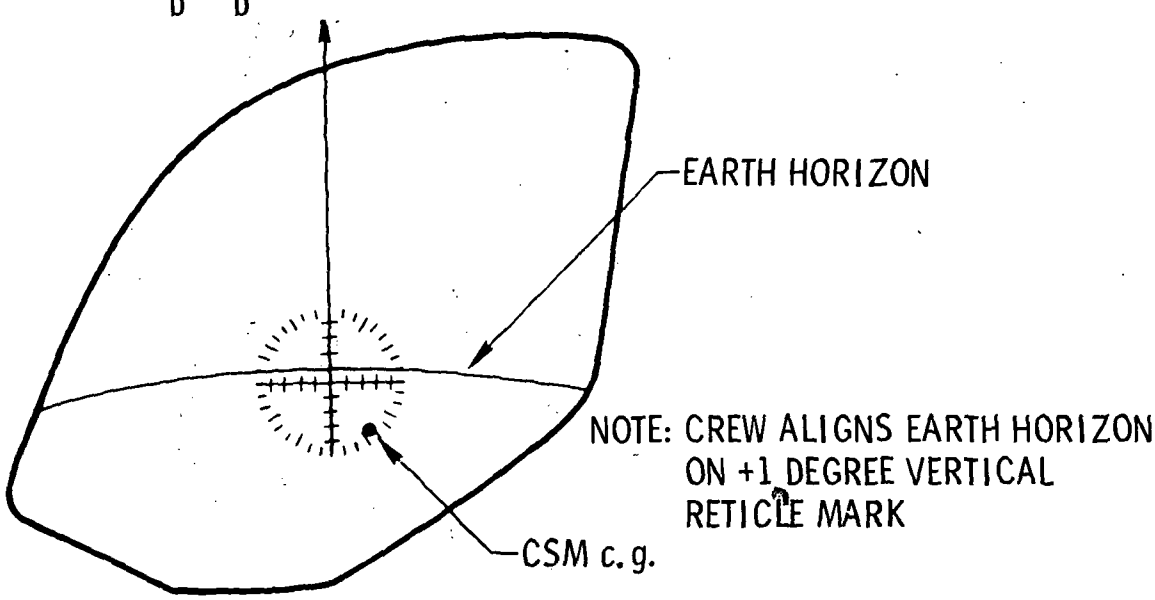
NOTE: EARTH HORIZON SHOULD APPEAR SLIGHTLY ABOVE THE +2 DEGREE VERTICAL RETICLE MARK

DEFINITION OF ATTITUDE FOR FIXED ABORTS FROM TLI

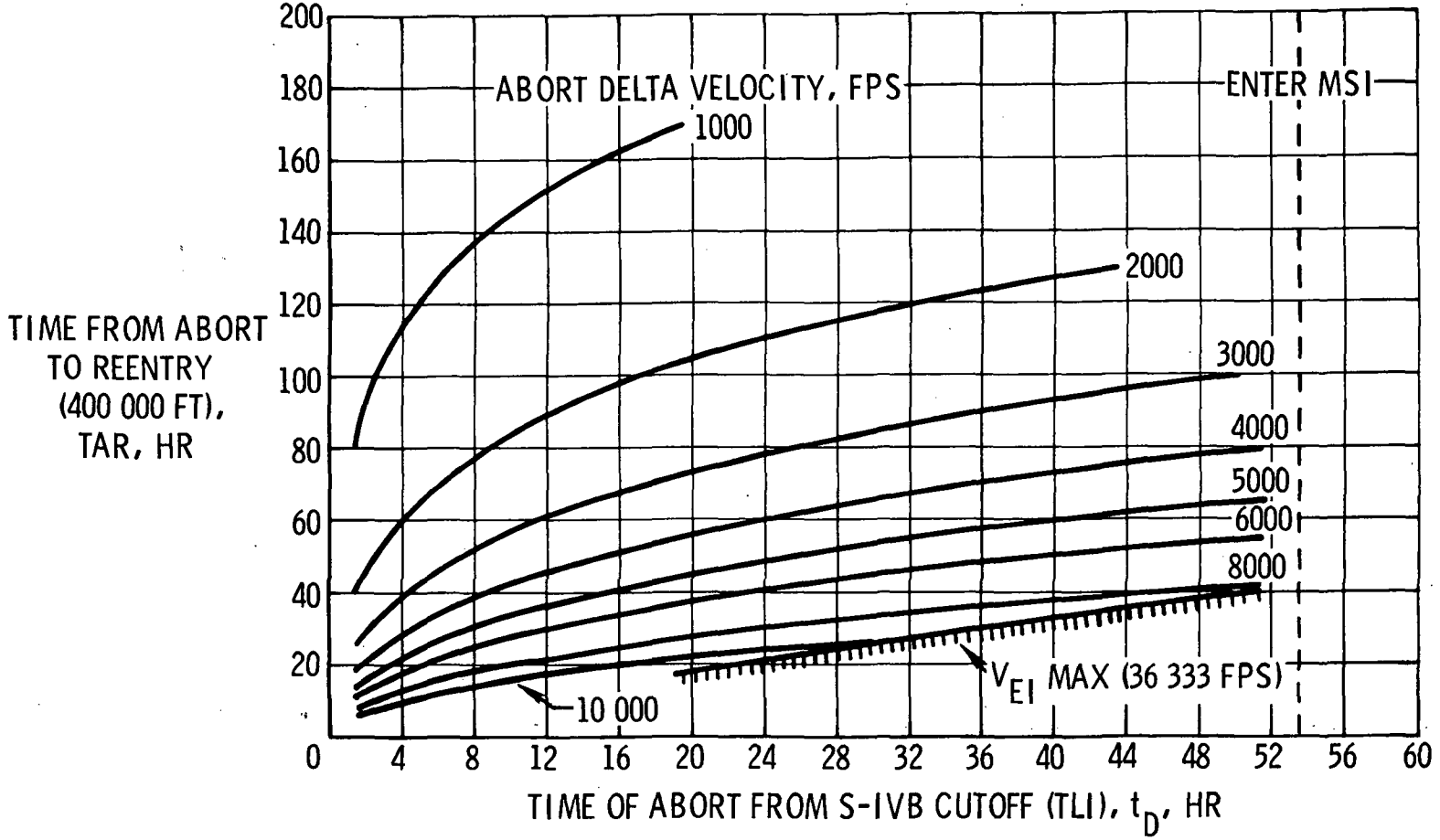
INITIAL EARTH FIXED ATTITUDE ALIGNMENT



CREW REFERENCED: CREW HEADS UP (X_b, Z_b IN ORBITAL PLANE)

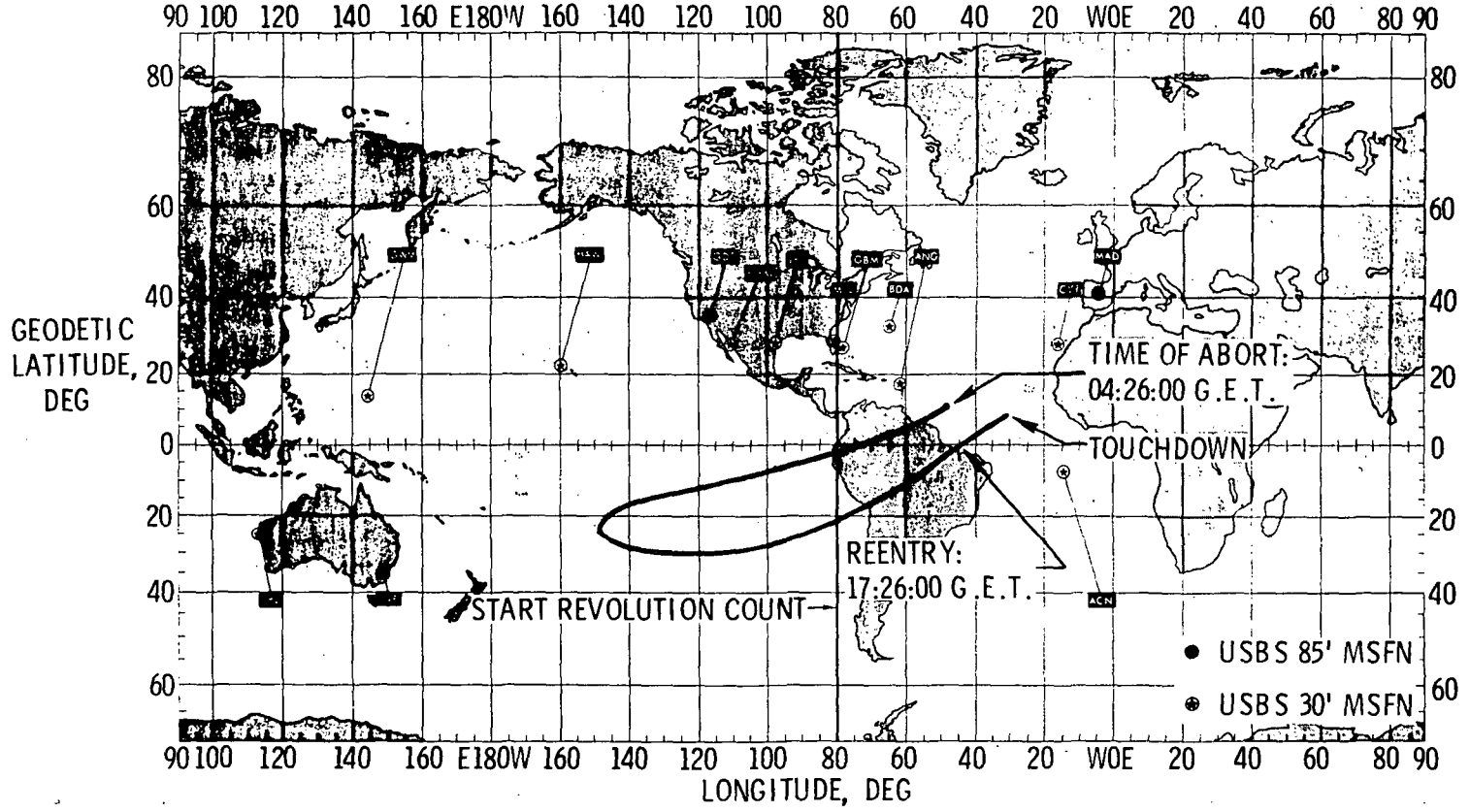


UNSPECIFIED AREA ABORTS FROM THE NOMINAL TRANSLUNAR COAST (DECEMBER 21, 1968 LAUNCH ψ_L = 72°, FIRST OPPORTUNITY)



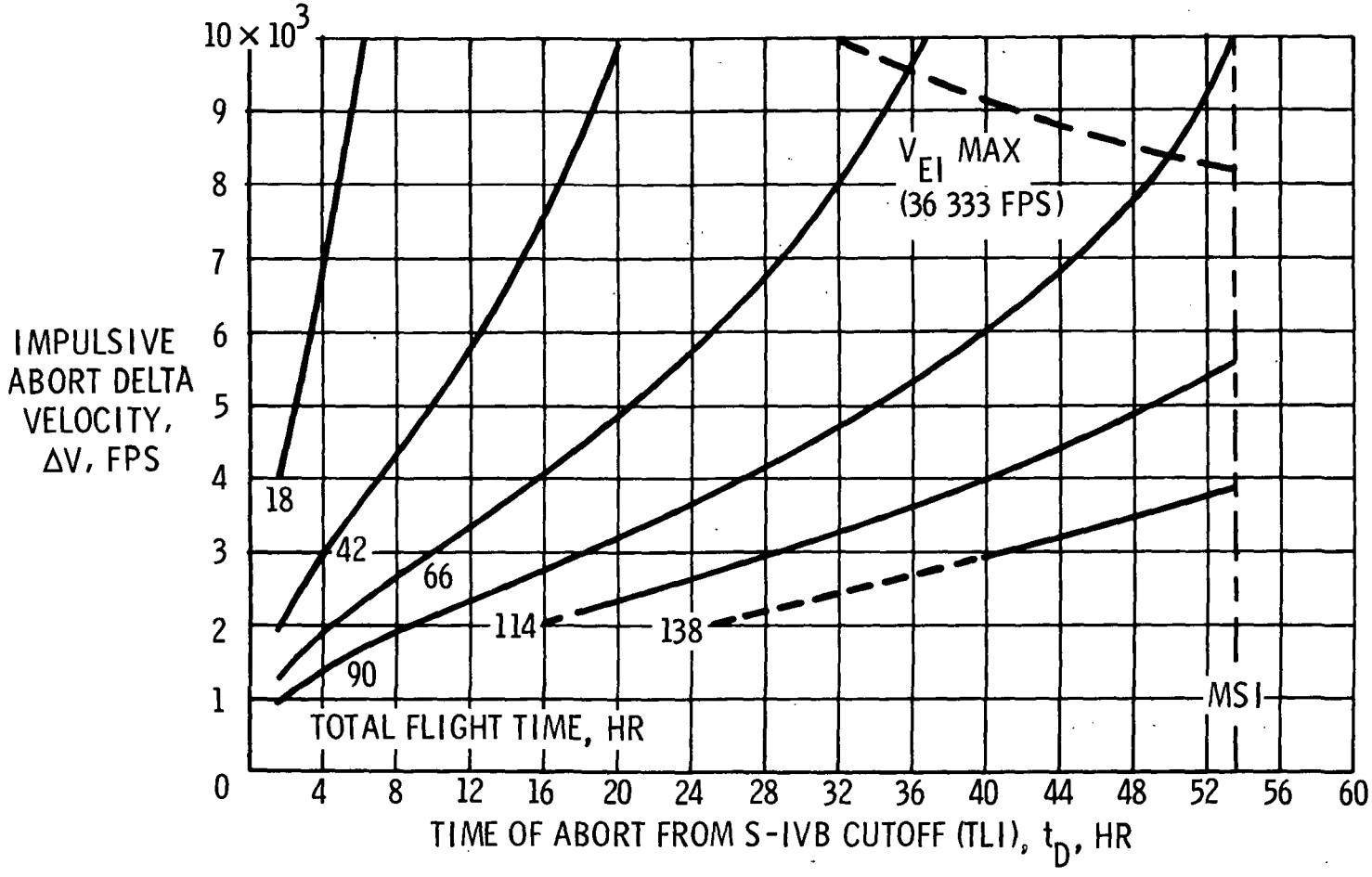
POSTABORT GROUNDTRACKS FOR VARIOUS ABORT TIMES DURING TLC

90 MINUTE ABORT (04:26:00 G.E.T.)



ABORT ΔV REQUIRED TO ACHIEVE TOTAL FLIGHT TIMES TO THE MPL. JANUARY 24, 1969, LAUNCH

FIRST INJECTION OPPORTUNITY, ψ_L = 72°



TRANSLUNAR CONTINGENCY TECHNIQUES

MISSION PHASE	FAILURE	ABORT TECHNIQUE	TRAJECTORY DATA SOURCE
TLI	TIME CRITICAL (CATASTROPHIC CSM SYSTEMS FAILURE)	FIXED INERTIAL ATTITUDE MANEUVER 10 MINUTES FOLLOWING MANUAL S-IVB SHUTDOWN TARGETED TO ENTRY CORRIDOR CENTERLINE	PREFLIGHT CHARTS. INERTIAL ATTITUDE (PITCH AND GIMBAL ANGLE) PROVIDED IN EPO

TRANSLUNAR CONTINGENCY TECHNIQUES (CONTINUED)

MISSION PHASE	FAILURE	ABORT TECHNIQUE	TRAJECTORY DATA SOURCE
IMMEDIATELY FOLLOWING TLI UNTIL TIME OF NOMINAL T AND D	A. TIME CRITICAL PLUS COMM LOSS	A. ABORT AT TLI + 90 MIN (IMPLUSIVE POINT) VIA P-37 TO A CLA	MANEUVER PADS PROVIDED IN EPO
	B. NON-TIME CRITICAL PLUS COMM LOSS PLUS T AND D NOT PERFORMED	B. ABORT AT TLI + 5 HR (IMPULSIVE POINT) VIA P-37 TO PRIME CLA (MPL)	

TRANSLUNAR CONTINGENCY TECHNIQUES (CONTINUED)

MISSION PHASE	FAILURE	ABORT TECHNIQUE	TRAJECTORY DATA SOURCE
T AND D UNTIL ~ LOI - 20 HR (ACTUAL TIME TBD)	A. TIME CRITICAL CSM SYSTEMS	A. SPS DIRECT RETURN (W/O LM) TO A CLA $\Delta V \leq$ 8000 FPS (PRETHRUST TARGETING VIA P-37 FOR NO COMM)	A. GROUND PERIODICALLY SUPPLIES DATA (TIG., ΔV, AND CLA) FOR P-37 INPUT

TRANSLUNAR CONTINGENCY TECHNIQUES (CONTINUED)

MISSION PHASE	FAILURE	ABORT TECHNIQUE	TRAJECTORY DATA SOURCE
T AND D UNTIL ~ LOI - 20 HR (ACTUAL TIME TBD)	B. TIME CRITICAL CSM SYSTEM PLUS SPS FAILURE	B. DPS XΔV MANEUVER AT H_{PC} + 2 HR TO A CLA FOLLOWING TLC MCC MANEUVERS FOR H_{PC} = 60 N. MI. (1500 FPS ΔV MAX)	B. GROUND VOICE AND UPLINK
	C. NON-TIME CRITICAL	C. SPS OR RCS MANEUVER BEFORE LOI - 5 HR TO THE PRIME CLA FLYBY AT 60 N. MI. < H_{PC} < 1500 N. MI.	C. GROUND UPLINK AND/OR VOICE
	D. NON-TIME CRITICAL NO SPS	D. DPS OR RCS MANEUVER BEFORE LOI - 5 HR TO THE PRIME CLA FLYBY AT 60 N. MI.< H_{PC} < 1500 N. MI.	D. GROUND VOICE AND UPLINK

TRANSLUNAR CONTINGENCY TECHNIQUES (CONTINUED)

MISSION PHASE	FAILURE	ABORT TECHNIQUE	TRAJECTORY DATA SOURCE
~ LOI - 20 HR TO MCC 4 (LOI - 5 HR)	A. TIME CRITICAL CSM SYSTEMS	A. SPS MANEUVER AT H_{PC} + 2 HR TO A CLA FOLLOWING FLYBY AT H_{PC} = 60 N. MI.	A. GROUND UPLINK AND/ OR VOICE
	B. TIME CRITICAL CSM SYSTEMS PLUS SPS FAILURE	B. DPS XΔV MANEUVER AT H_{PC} + 2 HR TO A CLA FOLLOWING TLC MCC MANEUVERS FOR H_{PC} = 60 N. MI. (1500 FPS ΔV MAX)	B. GROUND VOICE AND UPLINK

TRANSLUNAR CONTINGENCY TECHNIQUES (CONTINUED)

MISSION PHASE	FAILURE	ABORT TECHNIQUE	TRAJECTORY DATA SOURCE
~ LOI - 20 HR TO MCC 4 (LOI - 5 HR)	C. NON-TIME CRITICAL	C. SPS OR RCS MANEUVER BEFORE LOI - 5 HR TO THE PRIME CLA FLYBY AT 60 N. MI. $< H_{PC} <$ 1500 N. MI.	C. GROUND UPLINK AND/ OR VOICE
	D. NON-TIME CRITICAL NO SPS	D. DPS OR RCS MANEUVER BEFORE LOI - 5 HR TO THE PRIME CLA FLYBY AT 60 N. MI. $< H_{PC} <$ 1500 N. MI.	D. GROUND VOICE AND UPLINK

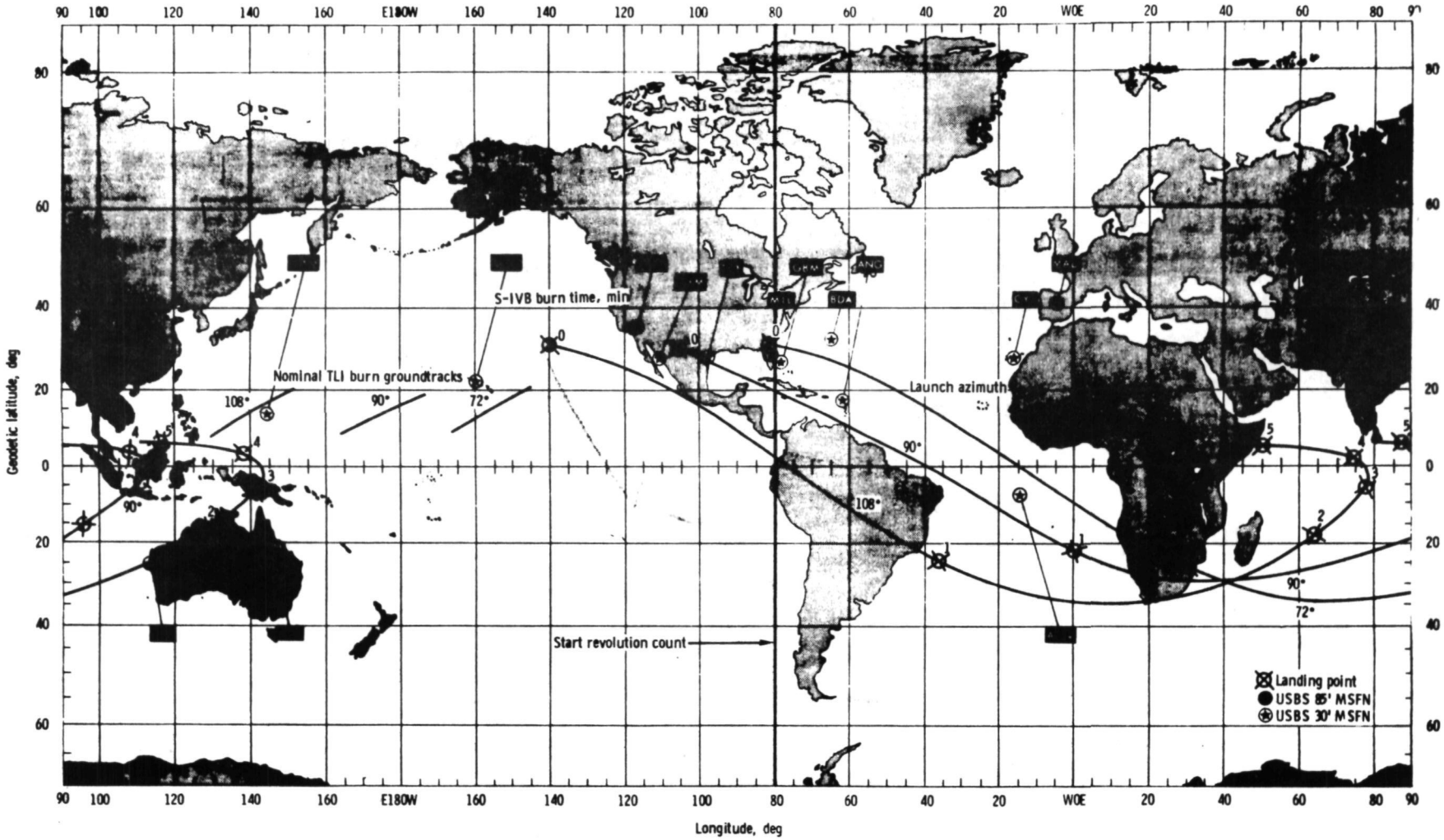
TRANSLUNAR CONTINGENCY TECHNIQUES (CONTINUED)

MISSION PHASE	FAILURE	ABORT TECHNIQUE	TRAJECTORY DATA SOURCE
AFTER LOI - 5 HR	A. TIME CRITICAL CSM SYSTEMS	A. SPS MANEUVER AT H_{PC} + 2 HR TO A CLA FOLLOWING FLYBY AT H_{PC} = 60 N. MI.	A. GROUND UPLINK AND/OR VOICE
	B. TIME CRITICAL CSM SYSTEMS PLUS SPS FAILURE	B. DPS XΔV MANEUVER AT H_{PC} + 2 HR TO A CLA FOLLOWING TLC MCC MANEUVERS FOR H_{PC} = 60 N. MI. (1500 FPS ΔV MAX)	B. GROUND VOICE AND UPLINK

TRANSLUNAR CONTINGENCY TECHNIQUES (CONCLUDED)

MISSION PHASE	FAILURE	ABORT TECHNIQUE	TRAJECTORY DATA SOURCE
AFTER LOI - 5 HR	C. NON-TIME CRITICAL	C. SPS OR RCS BEFORE H_{PC} + 15 HRS TO THE PRIME CLA AS FAST AS PRACTICAL $V_{EI} < 36\,323$ FPS	C. GROUND UPLINK AND/OR VOICE
	D. NON-TIME CRITICAL NO SPS	D. DPS OR RCS BEFORE H_{PC} + 15 HRS TO THE PRIME CLA AS FAST AS PRACTICAL $V_{EI} < 36\,323$ FPS	D. GROUND VOICE AND UPLINK

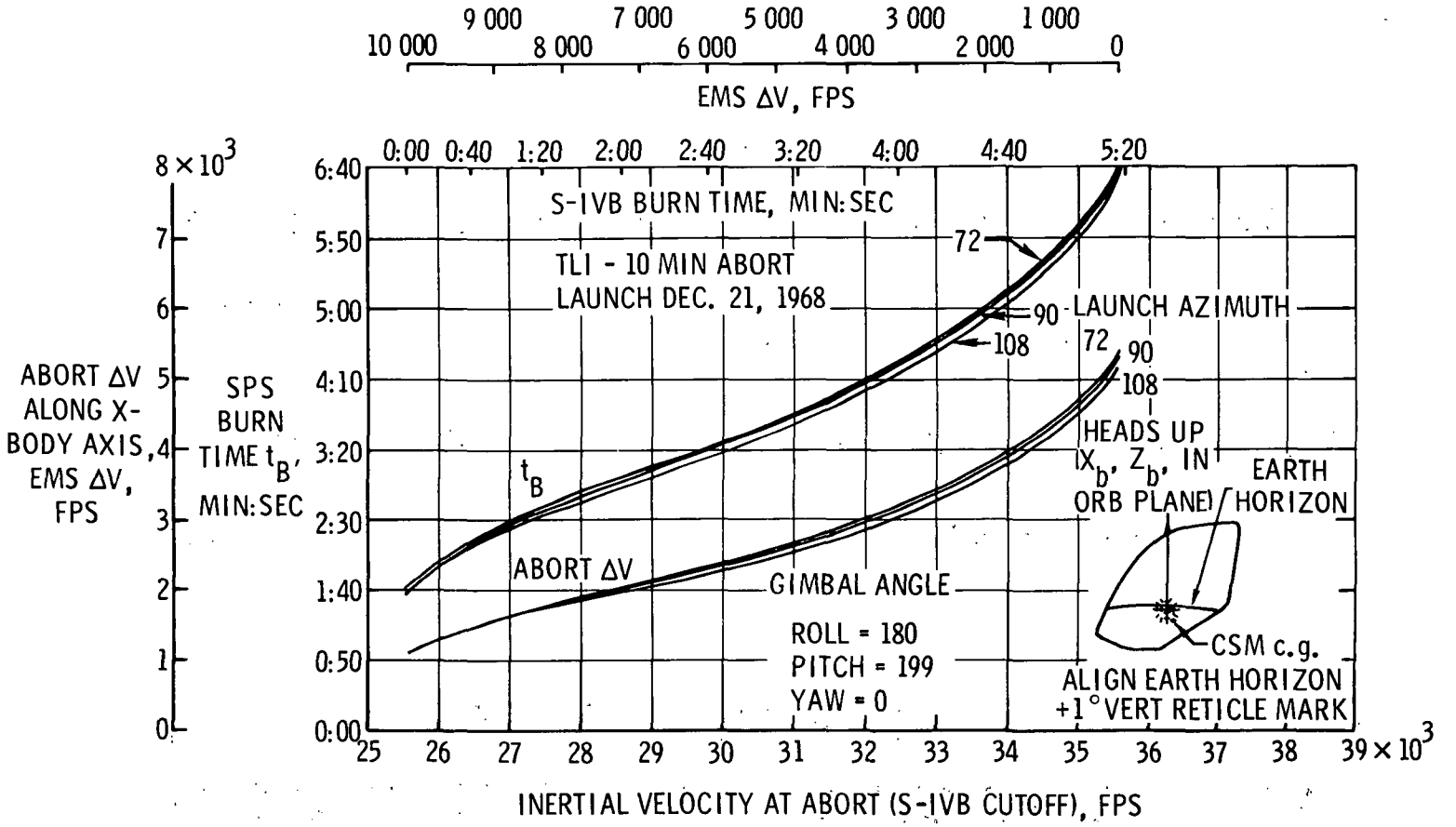
Do This



First injection opportunity, December 21, 1968.

TLI burn groundtracks and fixed-attitude abort landing point loci.

TLI ABORT CREW CHART



LOI ABORT CRITERIA FOLLOWING INADVERTENT SPS SHUTDOWN

- LM/DPS PRIMARY FOR ABORT DURING ENTIRE LOI BURN
  - PROVIDES ABORT CAPABILITY THROUGHOUT LOI BURN
  - RETAINS SPS ABORT CAPABILITY IN EVENT OF DPS PROBLEMS
  - LM REMAINS AVAILABLE FOR CSM SYSTEMS BACKUP

LOI ABORT CRITERIA FOLLOWING INADVERTENT SPS SHUTDOWN (CONCLUDED)

LOI BURN DURATION MIN:SEC	PRIMARY ABORT PROCEDURE
0:00 - 2:00	MODE I AT 2 HR (DPS)
2:00 - 3:00	MODE II AT 2 HR (DPS)
3:00 - END LOI (1)	MODE III AT PERILUNE (DPS)
	BACKUP ABORT PROCEDURE*
0:00 - 3:00	MODE I ASAP (SPS)
3:00 - END LOI (1)	MODE III AT PERILUNE (SPS)

*LM JETTISON MAY BE REQUIRED

LOI ABORT CRITERIA FOLLOWING MANUAL SPS SHUTDOWN

- SPS PRIMARY FOR SHUTDOWNS PRIOR TO 3:00 INTO LOI
  - SINGLE IMPULSE ABORT USING CREW CHART
  - LM/DPS BACKUP AVAILABLE
- LM/DPS PRIMARY FOR SHUTDOWNS AFTER 3:00 INTO LOI
  - STANDARD PROCEDURE FOR MODE III REGION
  - RETAINS SPS ABORT CAPABILITY IN EVENT OF DPS PROBLEMS

LOI ABORT CRITERIA FOLLOWING MANUAL SPS SHUTDOWN (CONCLUDED)

LOI BURN DURATION, MIN:SEC	PRIMARY ABORT PROCEDURE
0:00 - 3:00	MODE I AT 15 MIN (SPS)
3:00 - END LOI (1)	MODE III AT PERILUNE (DPS)
	BACKUP ABORT PROCEDURE
0:00 - 2:00	MODE I AT 2 HR (DPS)
2:00 - 3:00	MODE II AT 2 HR (DPS)
3:00 - END LOI (1)	MODE III AT PERILUNE* (SPS)

*LM JETTISON MAY BE REQUIRED

CSM PROBLEMS CONSIDERED

- INADVERTENT SPS SHUTDOWN
- SPS PROBLEMS
- NON-SPS RELATED PROBLEMS
- ATTITUDE/ATTITUDE RATE LIMITS EXCEEDED

LOI ABORT CRITERIA FOR NON-SPS SYSTEM PROBLEMS

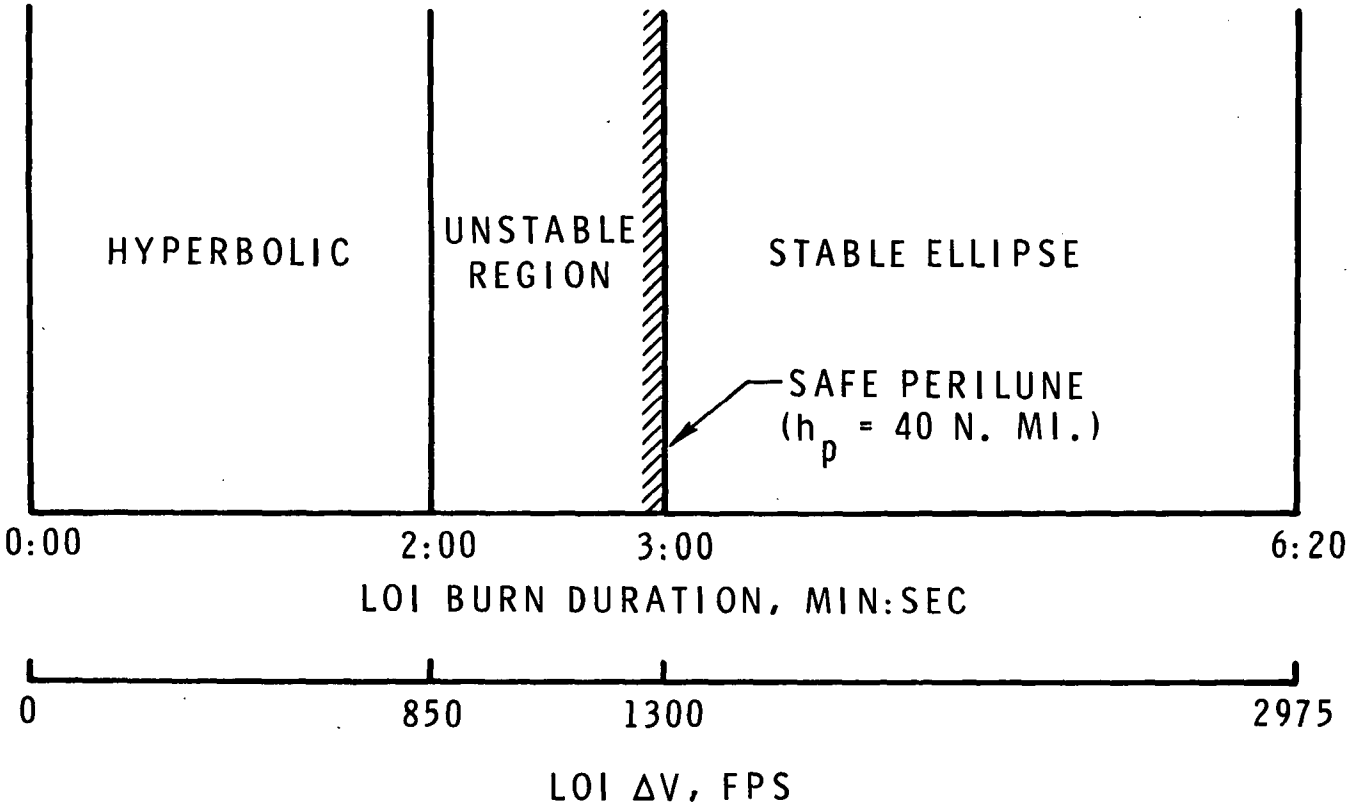
- CONTINUE NOMINAL LOI BURN
  - ABORT MODE EARLY TEI (SINGLE IMPULSE)
  - MISSION TIME NOT INCREASED
  - UNDESIRABLE PREABORT ORBITS AVOIDED
  - MULTIPLE ABORT OPPORTUNITIES PROVIDED
  - MORE COMPLETE CSM SYSTEMS CHECK ALLOWED
- PRIMARY ABORT PROCEDURE
  - MODE III AT PERILUNE (DPS)
- BACKUP ABORT PROCEDURE
  - MODE III AT PERILUNE* (SPS)

*REQUIRES LM JETTISON

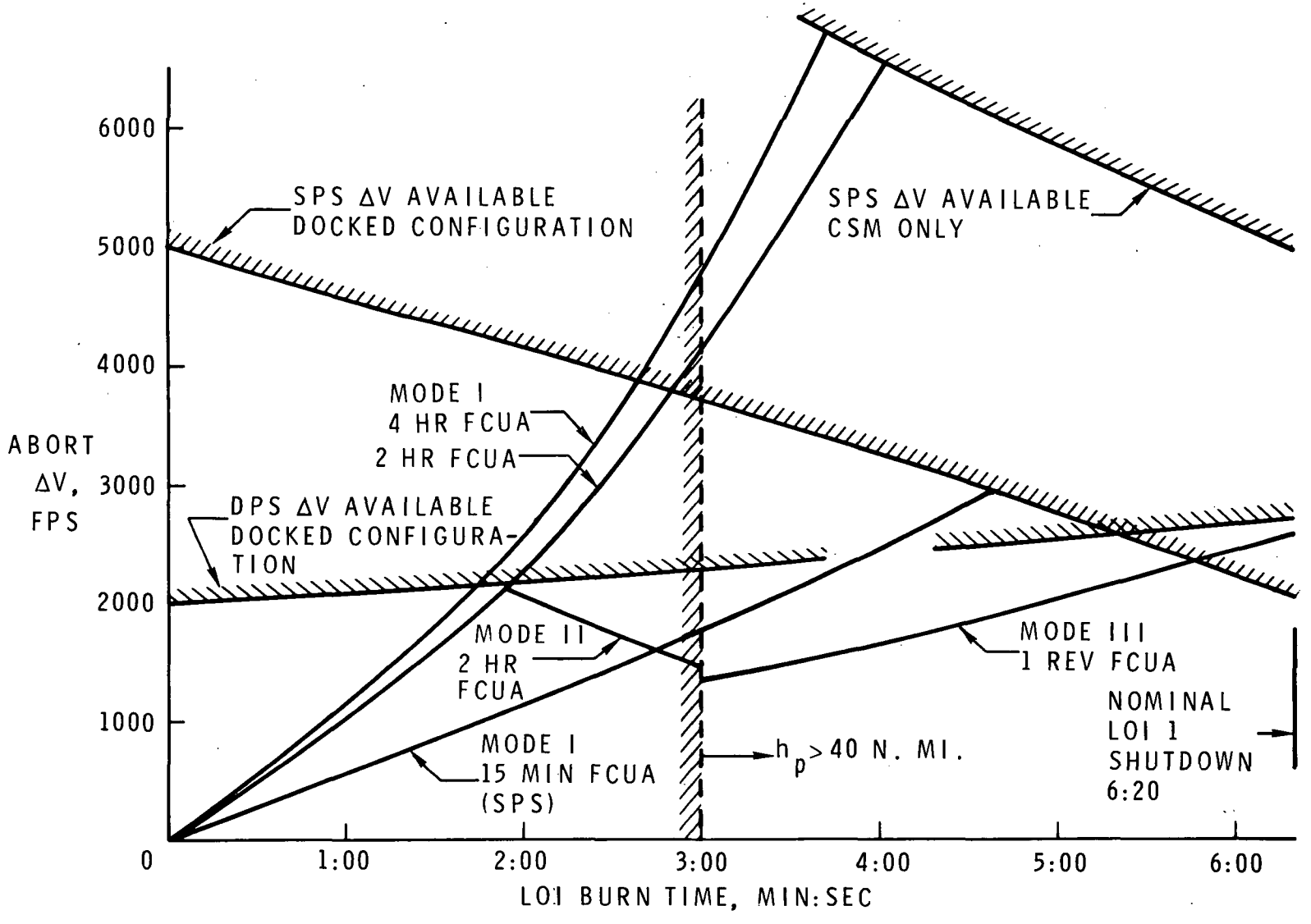
LOI ABORT PROCEDURE SUMMARY

CSM PROBLEMS	CREW ACTION	ABORT PROCEDURE
SPS PROBLEMS	MANUAL SPS SHUTDOWN	LOI BURN < 3:00 MODE I-15 MIN (SPS) LOI BURN > 3:00 MODE III ABORT (DPS)
NON-SPS SYSTEM PROBLEMS	CONTINUE G AND N LOI BURN	EARLY TEI AS REQUIRED
ATTITUDE OR ATTITUDE RATE LIMITS EXCEEDED	INITIATE SCS TAKEOVER COMPLETE LOI	EARLY TEI AS REQUIRED
INADVERTENT SPS SHUTDOWN	LOI BURN < 3:00 IMMEDIATE LM ACTIVATION LOI BURN > 3:00 COAST TO AOS DELAYED LM ACTIVATION	LOI BURN 0:00 - 2:00 MODE I-2 HR (DPS) LOI BURN 2:00 - 3:00 MODE II-2 HR (DPS) LOI BURN 3:00 - 6:20 MODE III (DPS)

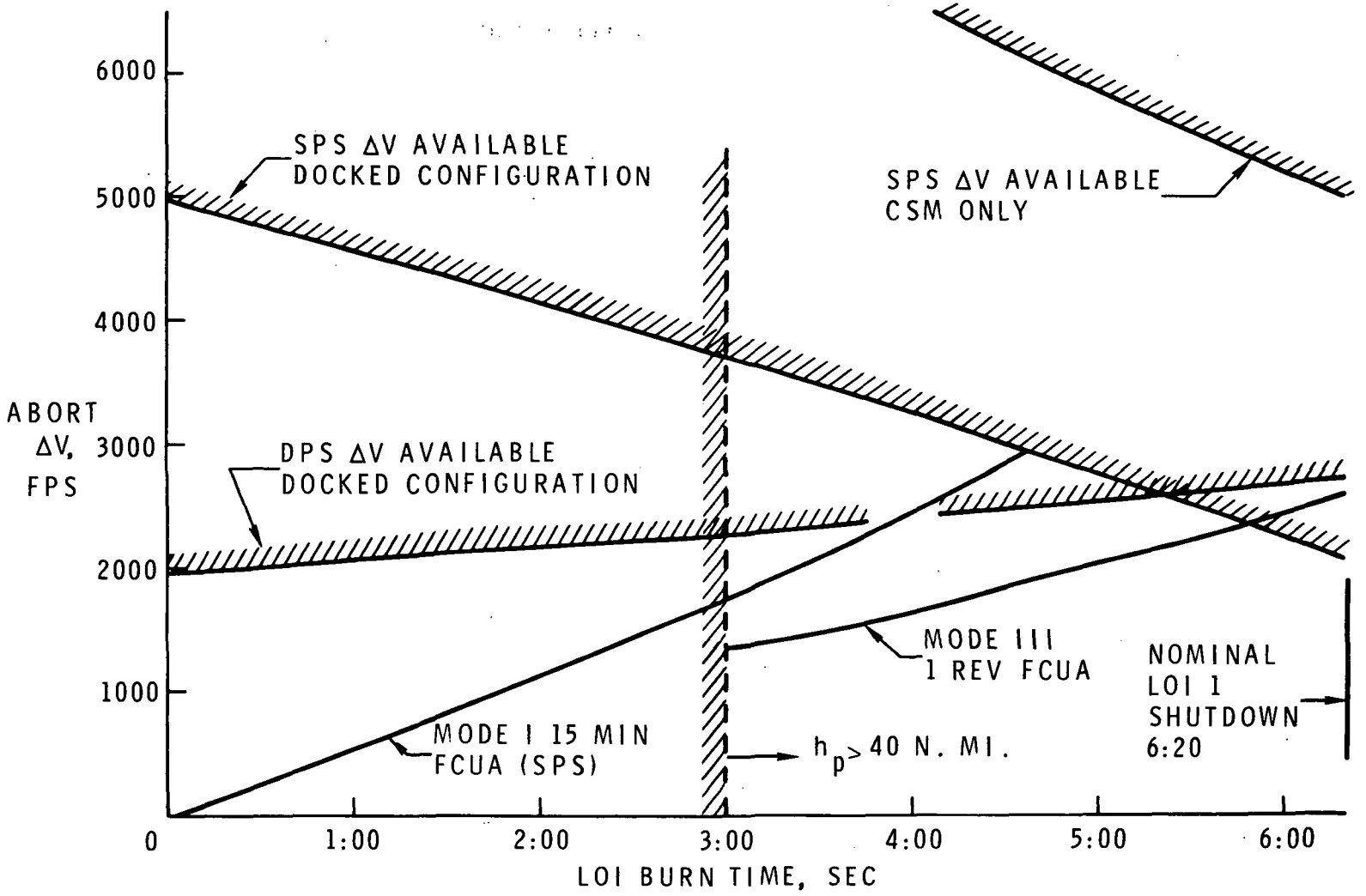
PRE-ABORT TRAJECTORY FAMILIES DURING LOI



SUMMARY OF LOI ABORT MODES



LUNAR ORBIT INSERTION ABORT MODES
MANUAL SPS SHUTDOWN



LUNAR ORBIT INSERTION ABORT MODES
INADVERTENT SPS SHUTDOWN