MSC Internal Note No. 69-FM-121

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MSC INTERNAL NOTE NO. 69-FM-121

May 2, 1969

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APOLLO 10 (MISSION F) OPERATIONS REVIEW PRESENTED AT MSC ON APRIL 29, 1969

MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

(NASA-TM-X-69658) APOLLO 10 (MISSION F) OPERATIONS REVIEW (NASA) 56 p

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MSC INTERNAL NOTE NO. 69-FM-121

PROJECT APOLLO

APOLLO 10 (MISSION F) OPERATIONS REVIEW PRESENTED AT MSC ON APRIL 29, 1969

By Mission Planning and Analysis Division

May 2, 1969

MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

Approved: D H Owen
for John P. Mayer, Chief
Mission Planning and Analysis Division

FOREWORD

The purpose of this document is to present the slides used for the Apollo 10 (Mission F) Mission Planning Briefing given at the Operations Review at MSC, April 29, 1969.

The briefing was designed to give a detailed description of the evasive maneuver after TLI and a summary of the lunar orbit rendezvous navigation, mission abort plans, and alternate mission plans.

This document is published for general information; therefore, no detailed explanation of the slides is given. The scheduled Mission Planning and Analysis Division operational documents will explain and redefine this information. Please direct any questions concerning this briefing to D. H. Owen, Jr., Mission Planning and Analysis Division, extension 4101.

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EVASIVE MANEUVER AND LUNAR ORBIT INCLINATION CHANGE

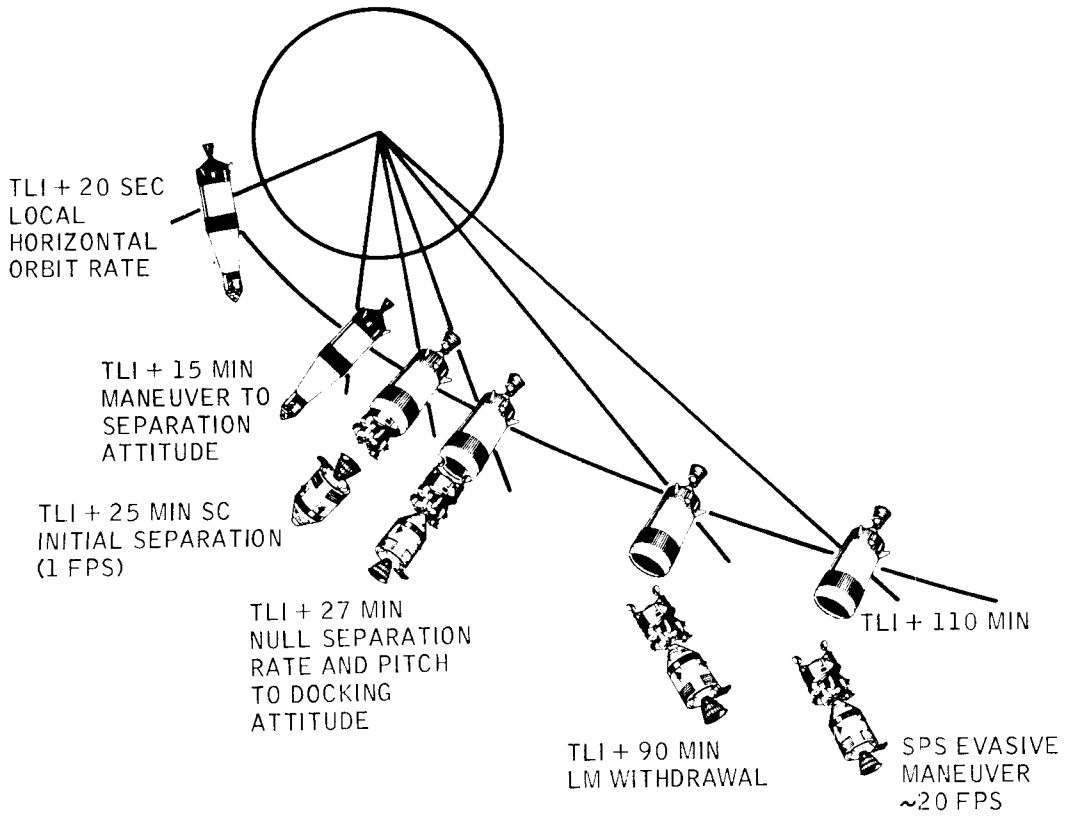
Ronald L. Berry

POST TLI TIMELINE

EVENT	TIME FROM TLI HRS:MIN
TLI CUTOFF	00:00
INITIAL CSM SEPARATION	00:25
EJECTION	01:30
EVASIVE MANEUVER	02:00
INITIATE DUMP SEQUENCE	02:10
DUMP	02:22

MPAD 4807 S (IU)

POST TLI TIMELINE



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G+P SUB PANEL/MARSHALL

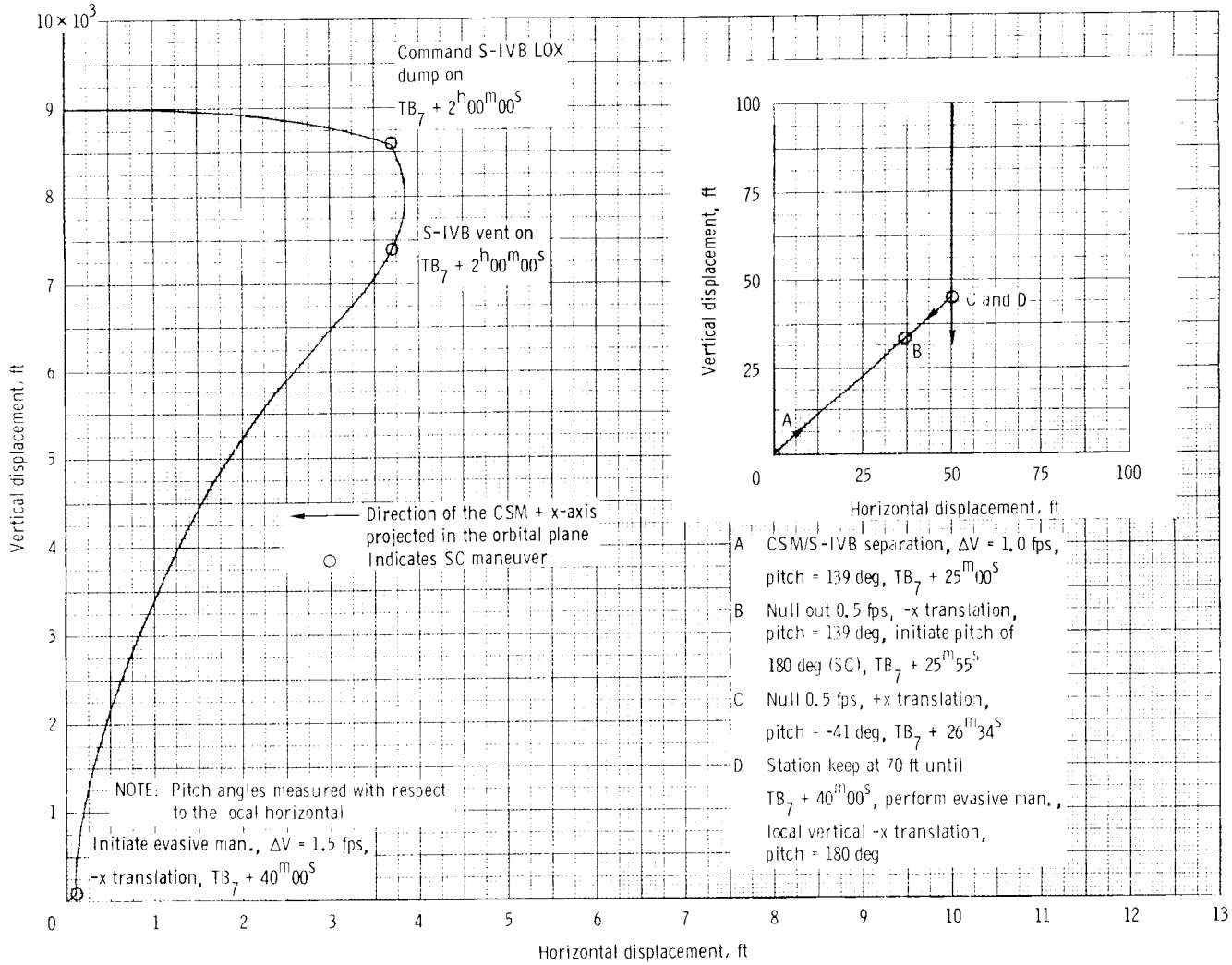


Figure 1. - Planned motion of the CSM relative to the S-IVB for the Apollo 8 evasive maneuver.

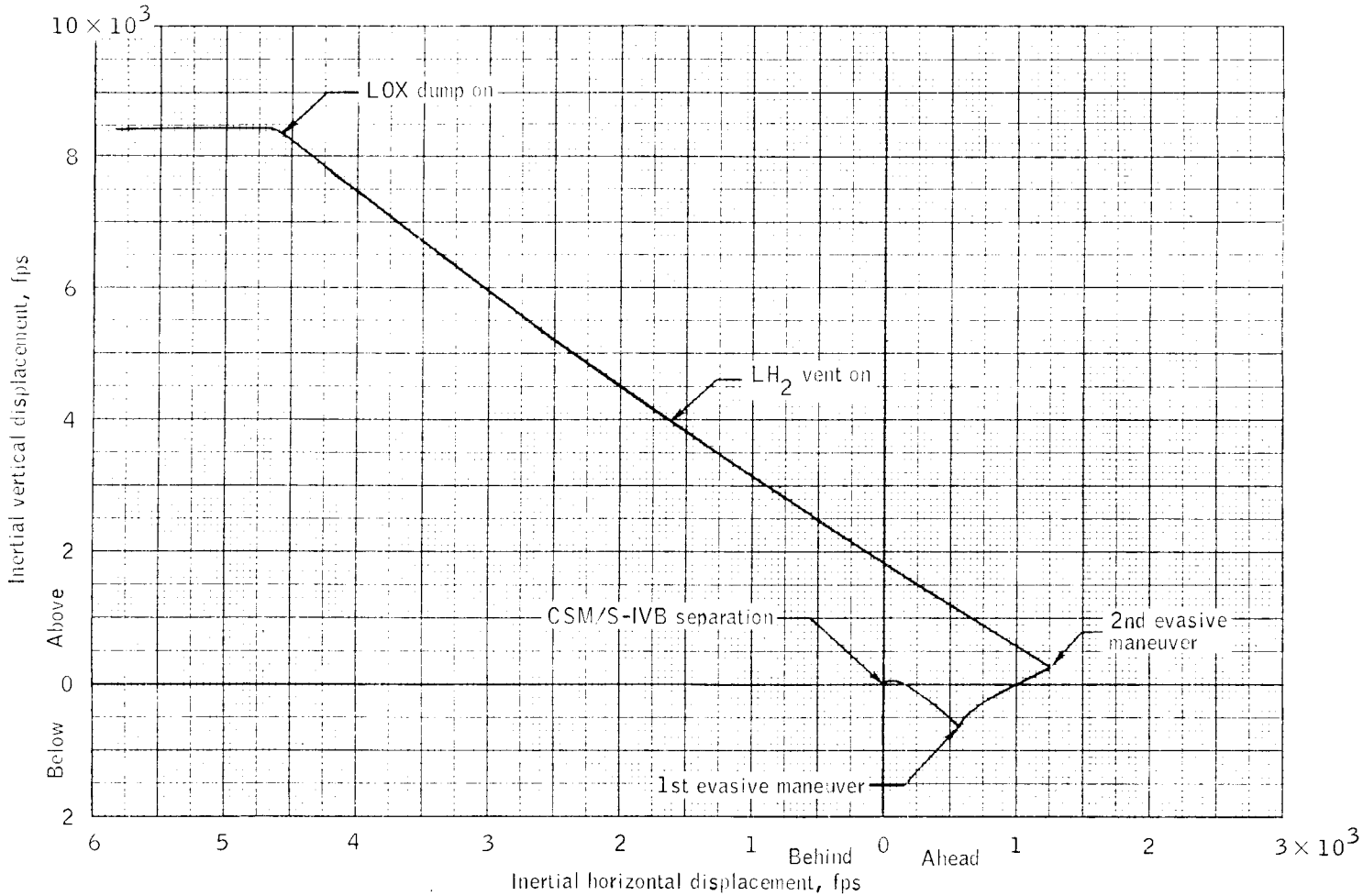


Figure 2.- Actual motion of the CSM relative to the S-IVB for the Apollo 8 evasive maneuver.

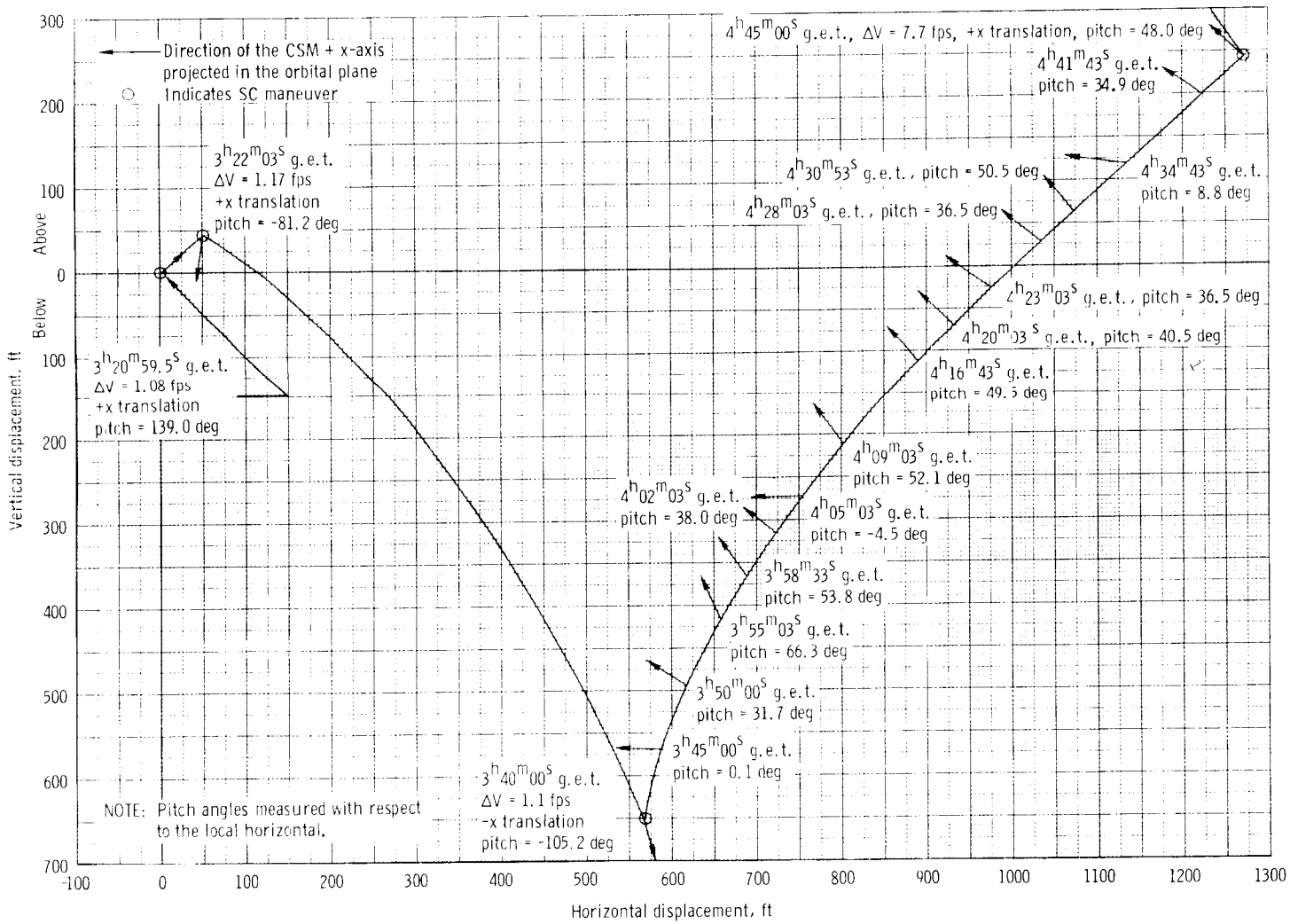


Figure 3.- Actual motion of the CSM relative to the S-IVB for the Apollo 8 evasive maneuver.

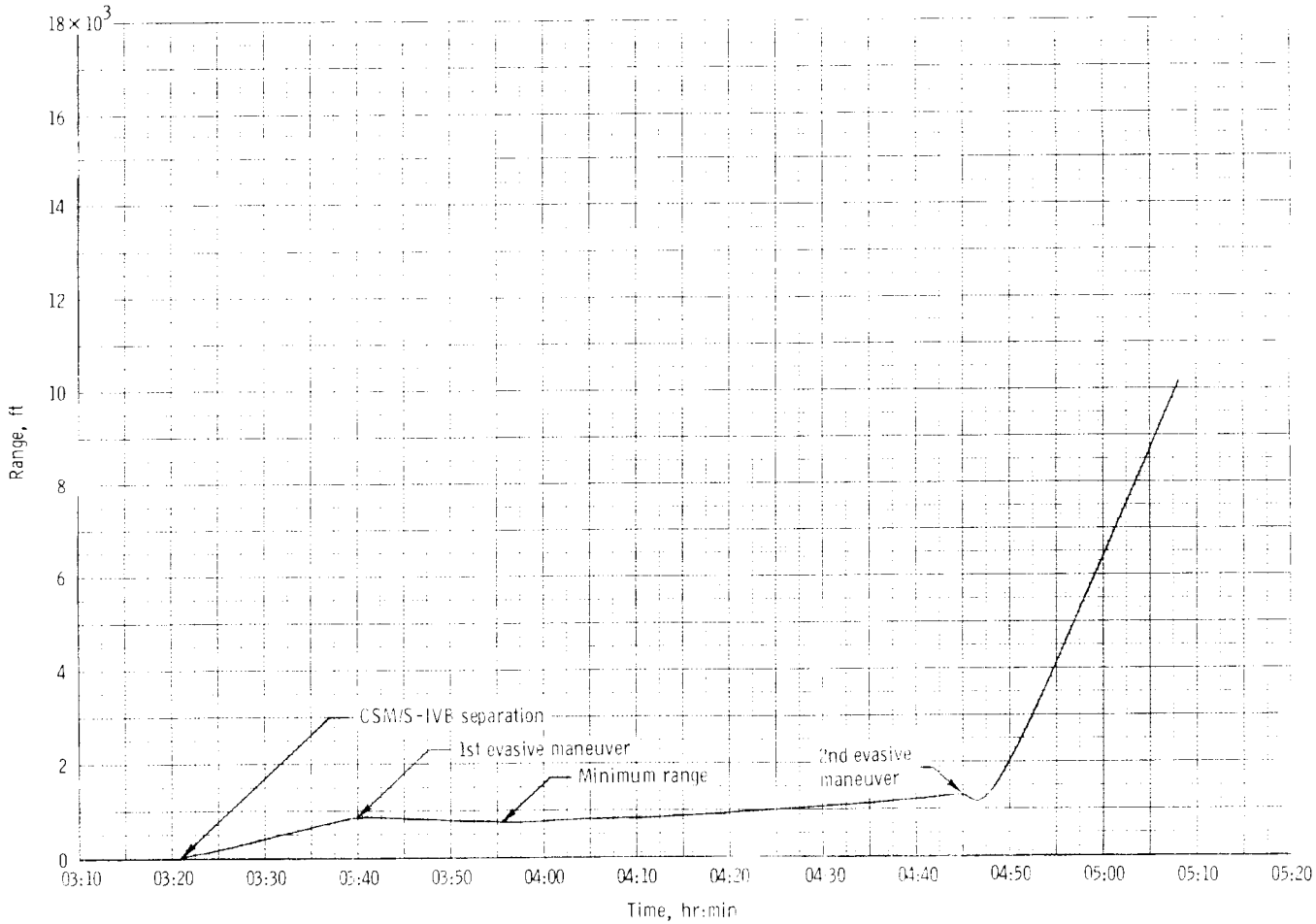
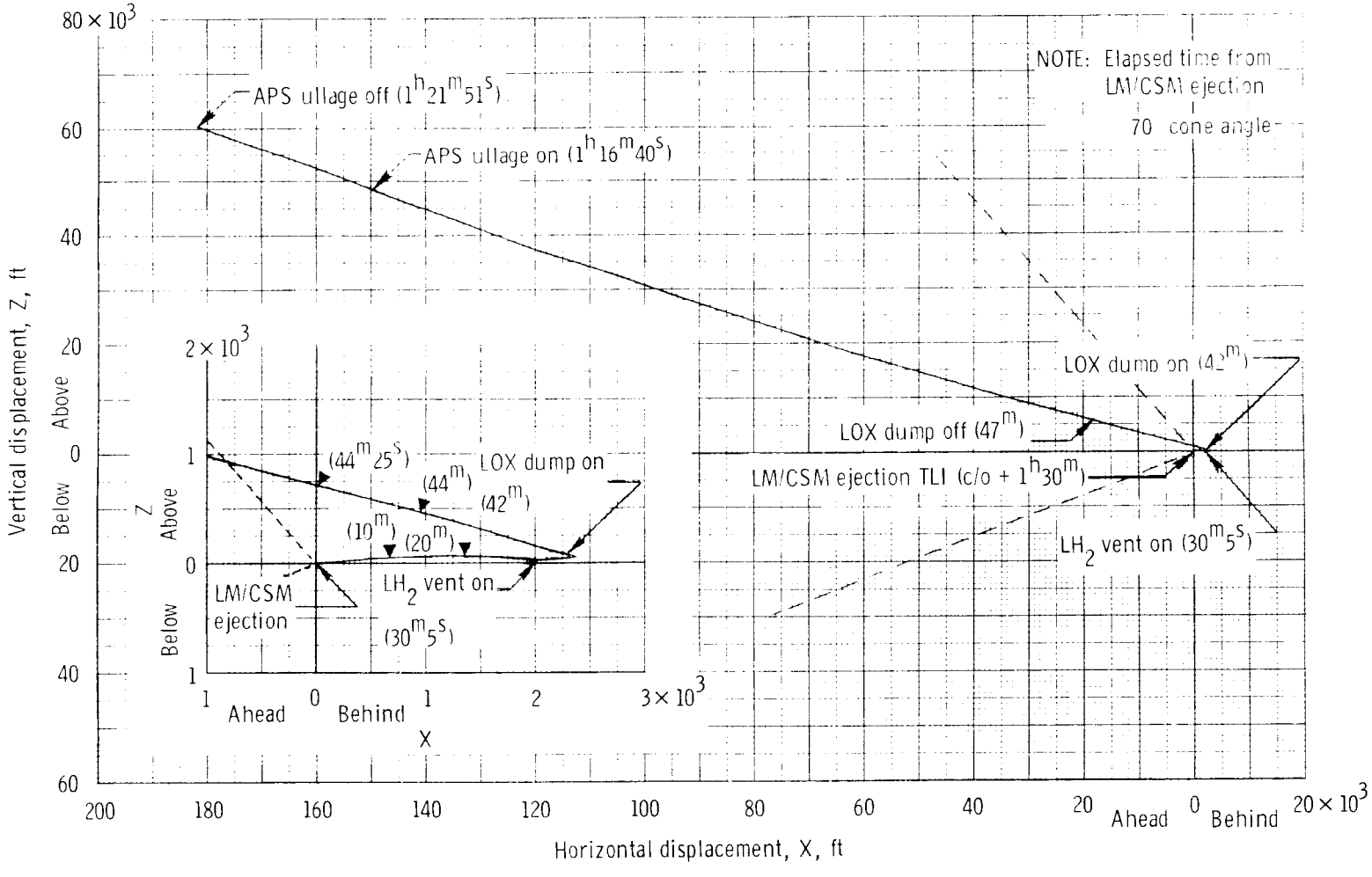


Figure 4. - CSM range from the S-IVB for actual evasive maneuver of the Apollo 8 mission.

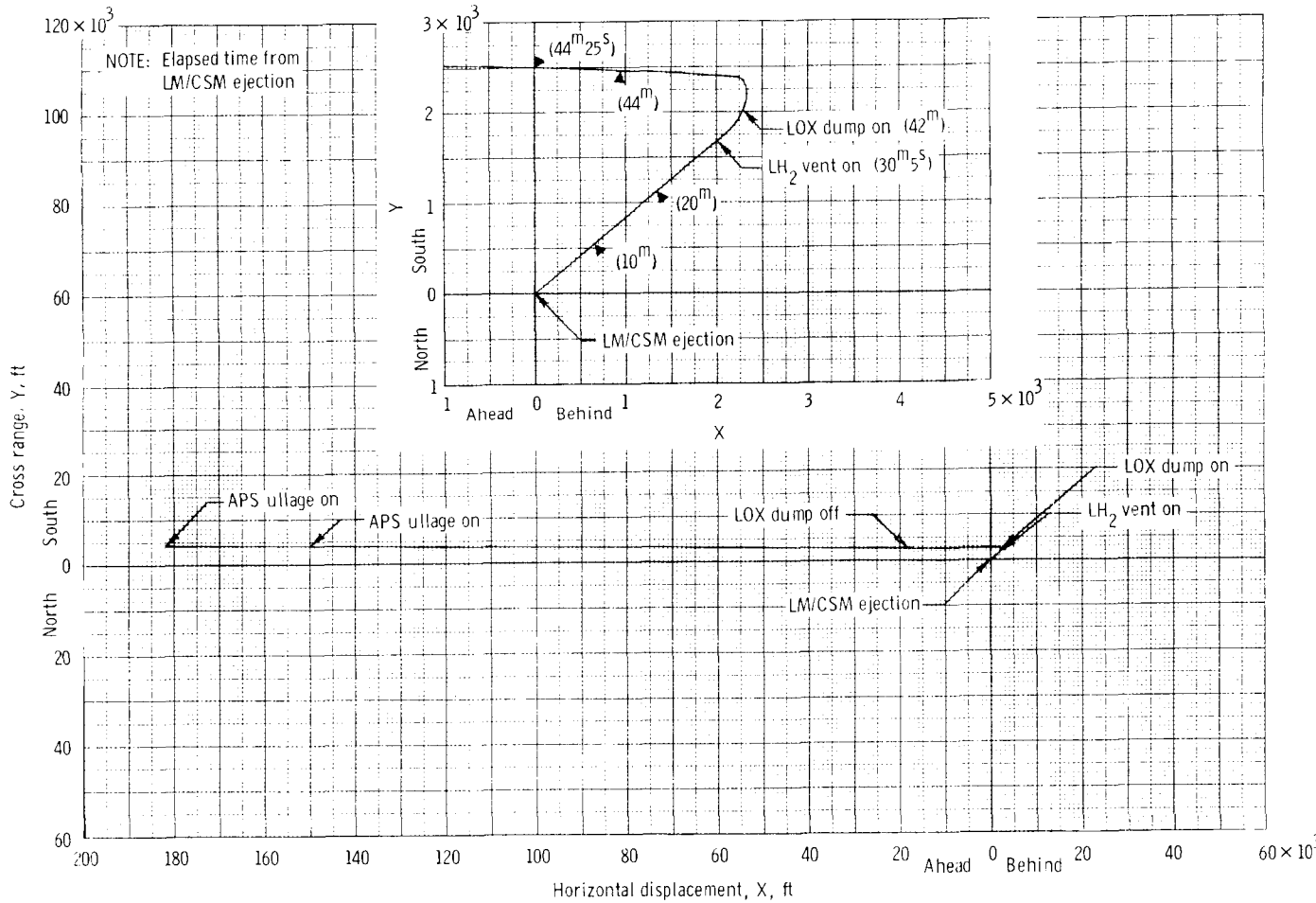
APOLLO 10 POST T, D, AND E EVASIVE MANEUVER DESIGN CONSIDERATIONS

- MINIMIZE RCS FUEL
- AVOID APOLLO 8 PROBLEMS
- EARLY SPS CONFIDENCE BURN DESIRABLE
- AVOID LOX SOLID PARTICLE CLOUD



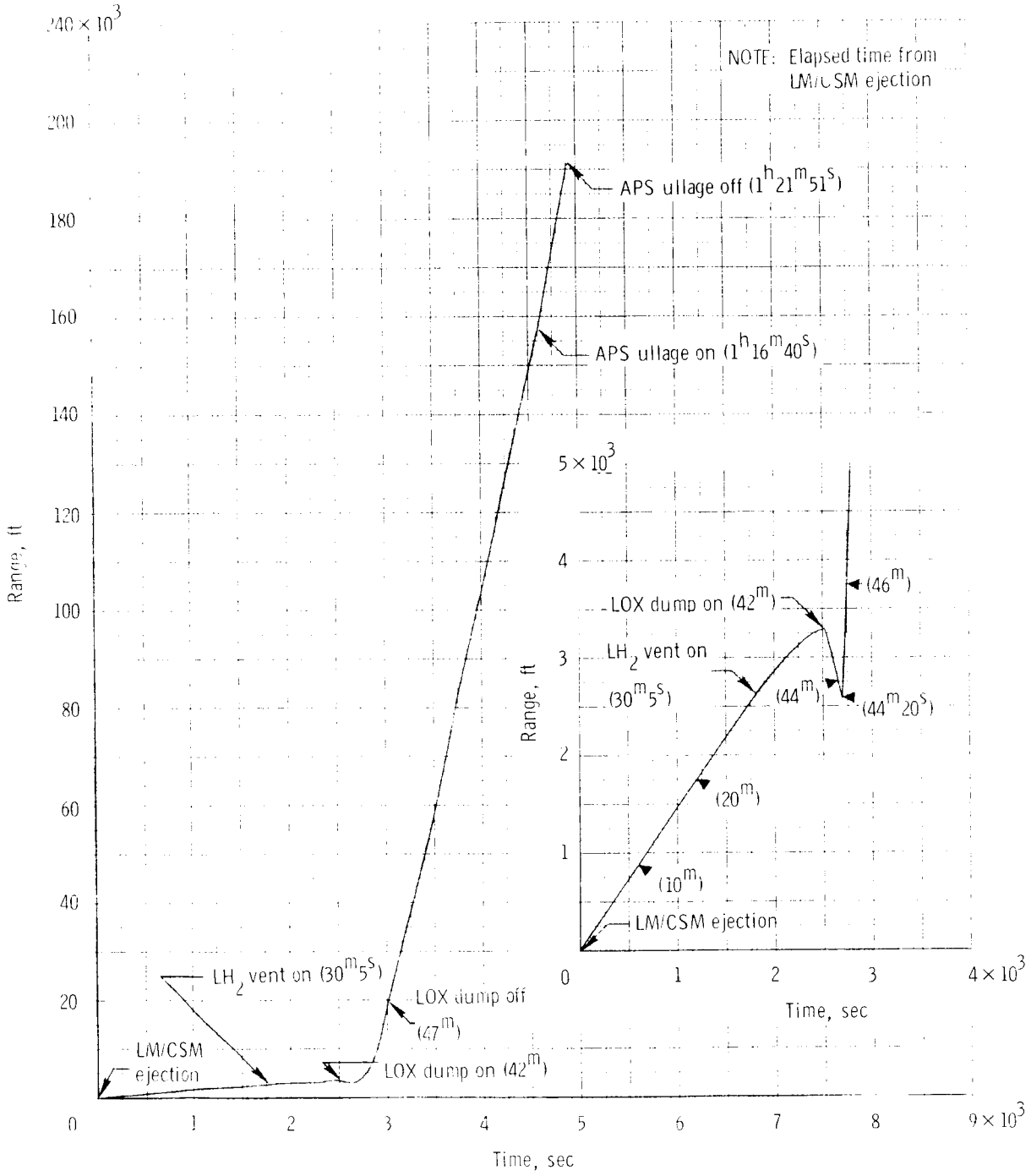
(a) Vertical displacement versus horizontal displacement.

Figure 3. - RCS evasive maneuver, dump sequence begins at 2^h00^m.



(b) Cross range versus horizontal displacement.

Figure 3. - Continued.

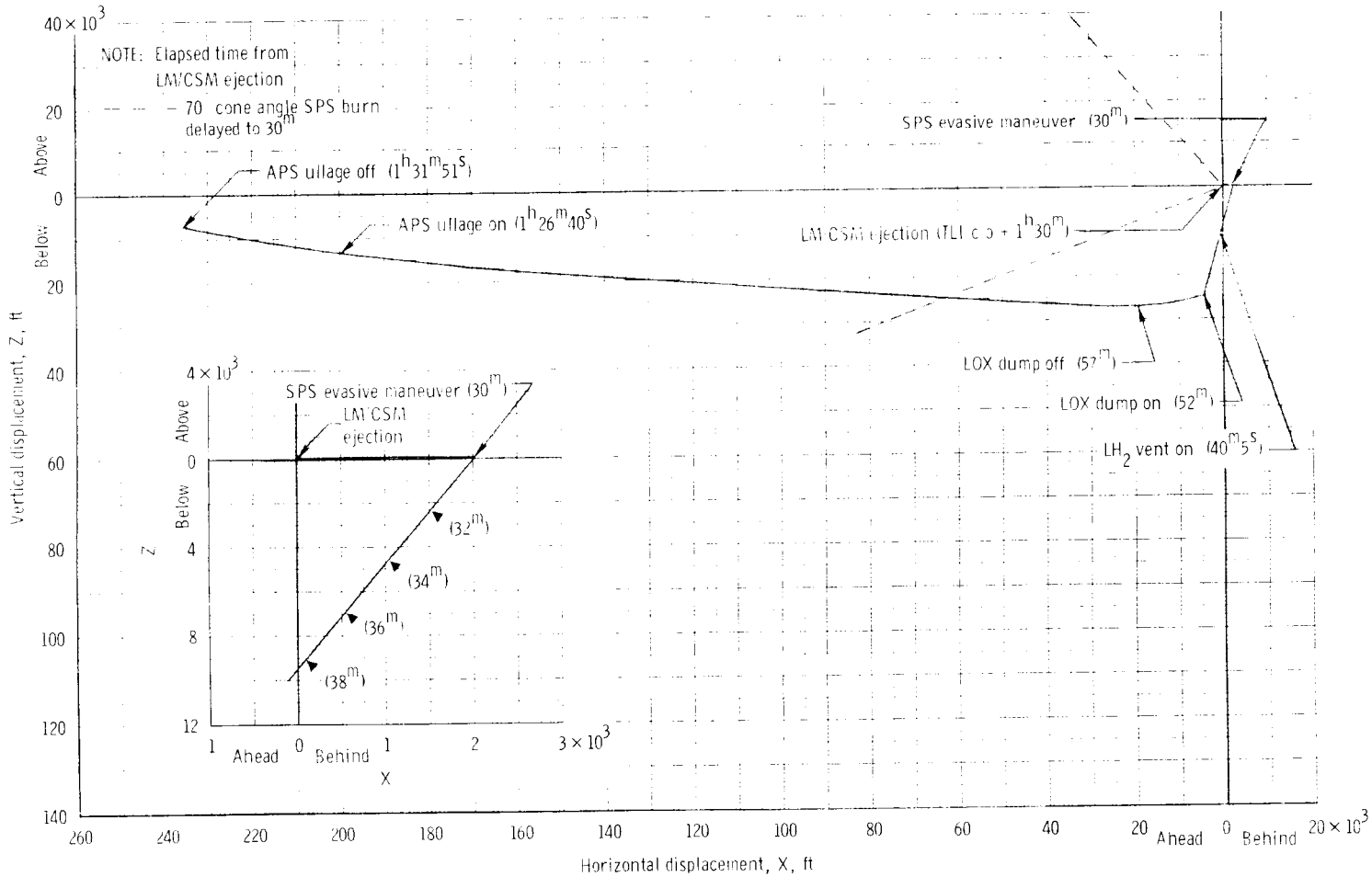


(c) Range versus time.

Figure 3. - Concluded.

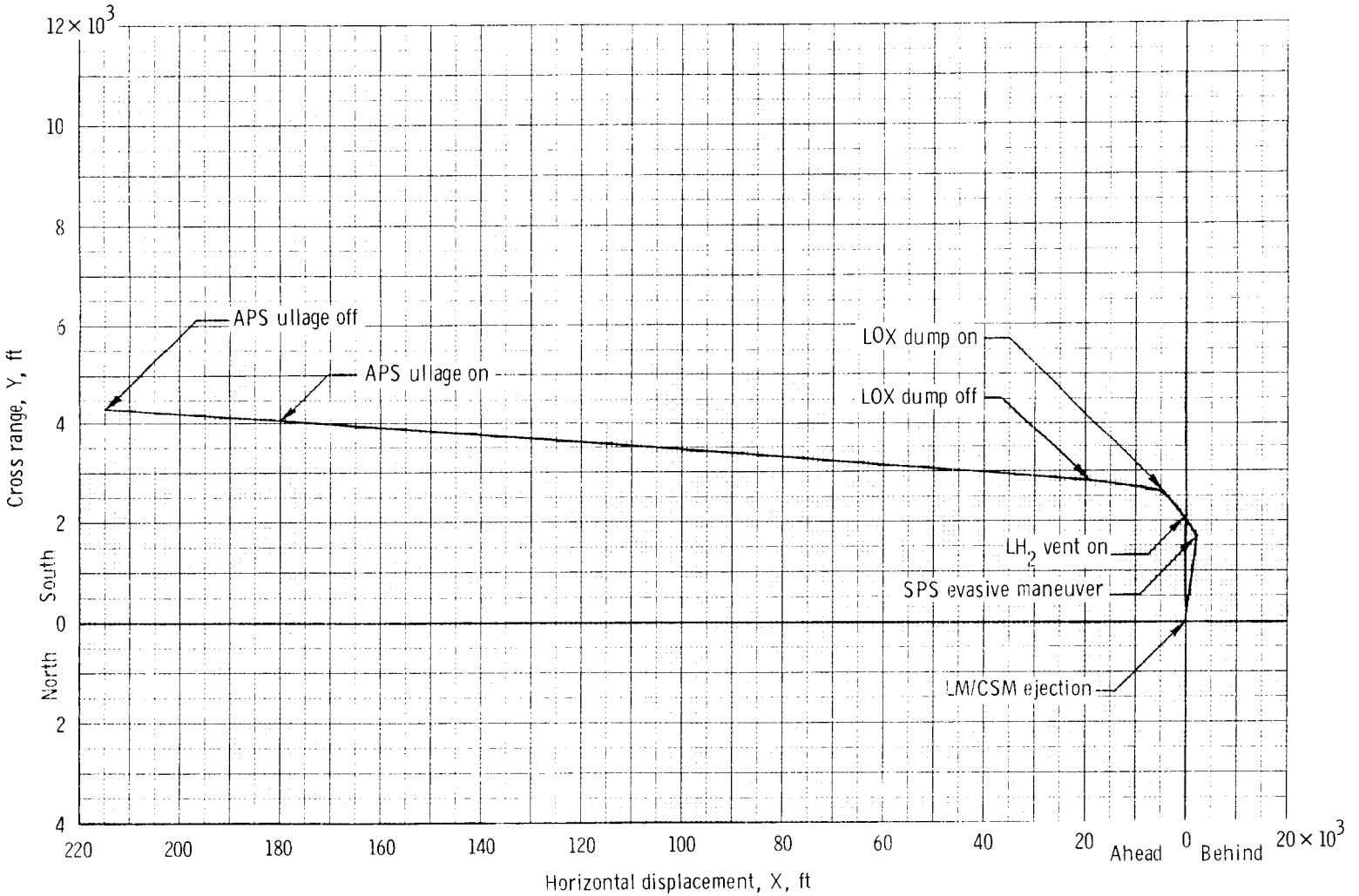
APOLLO 10 POST T, D, AND E EVASIVE MANEUVER DESIGN

- SPS/GNCS/EXT ΔV THREE SECOND BURN (20 FPS)
- 30 MINUTES AFTER EJECTION
- PITCHED DOWN 75° - ALLOWS VISUAL OF S-IVB
- TLI BIASED 6 FPS OVERSPEED TO COMPENSATE



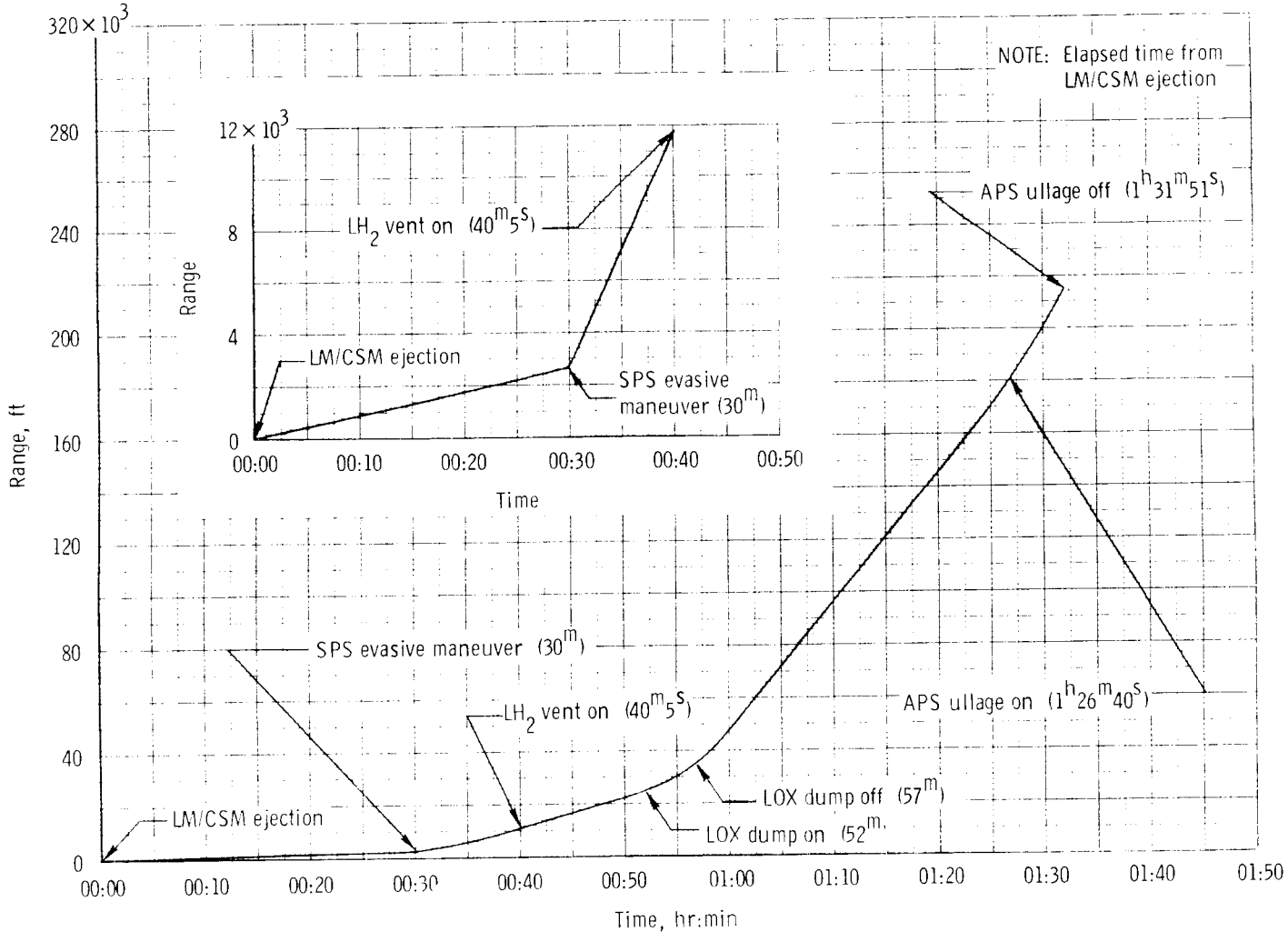
(a) Vertical displacement versus horizontal displacement.

Figure 1. - SPS evasive maneuver, dump sequence begins at 2^h10^m.



(b) Cross range versus horizontal displacement.

Figure 1. - Continued.



(c) Range versus time.

Figure 1. - Concluded.

APOLLO 10 LUNAR ORBIT INCLINATION CHANGE TO MATCH G

- APOLLO 10 LUNAR ORBIT NAVIGATION RESULTS MORE MEANINGFUL FOR G
- CREW OBSERVATIONS AND STRIP PHOTOGRAPHY MORE APPLICABLE FOR G
- SIMPLIFIES FLIGHT PLANNING

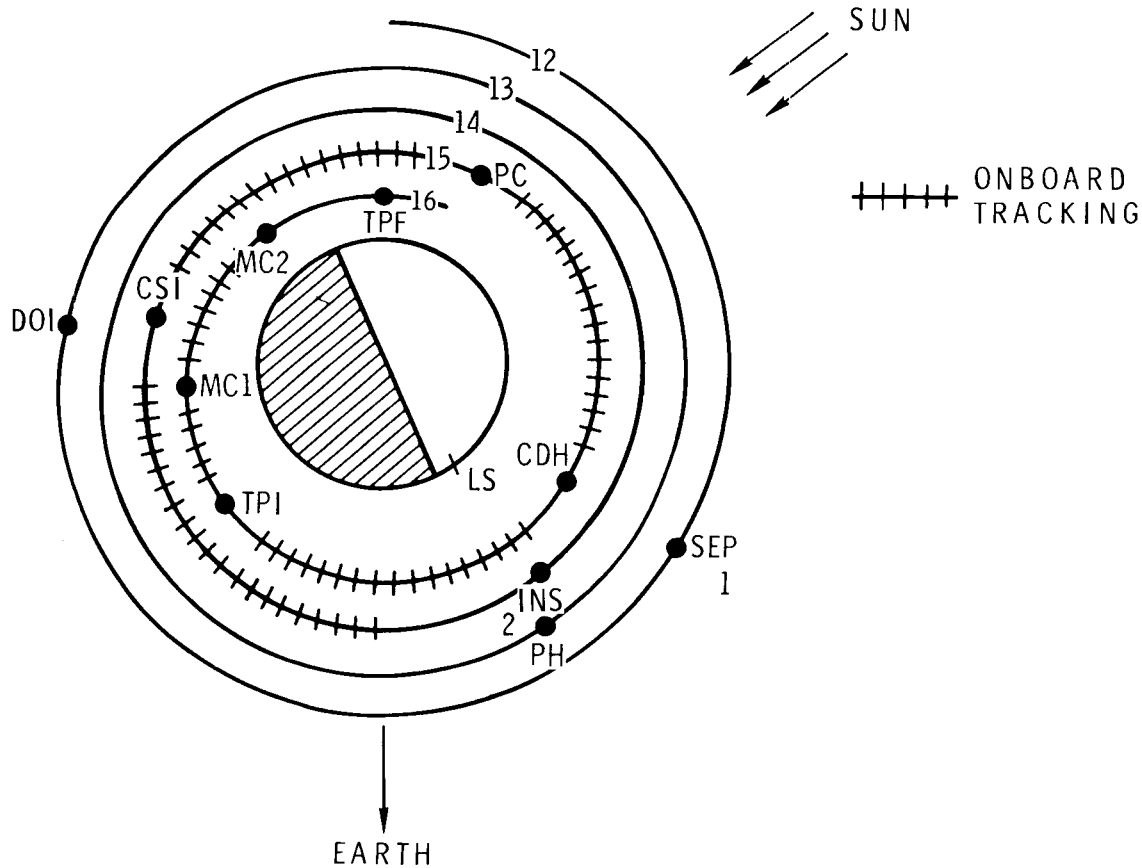
APOLLO 10 LUNAR ORBIT INCLINATION CHANGE

			SITE 2		SITE 3	
			OLD	NEW	OLD	NEW
MAY	72-1 LAUNCH AZIMUTH	LAUNCH DATE	18	18	20	20
		LUNAR APPROACH AZIMUTH, DEG	-95.25	-91.0	-95.75	-89.0
		LUNAR ORBIT INCLINATION, DEG	5.3	1.2	5.8	1.1
		MIDCOURSE ΔV, FPS	—	56	—	21
		LOI-1 ΔV, FPS	2,843	2,965	2,851	3,059
		LOI-1 PLANE CHANGE	0.6	6.1	1.3	9.0
		SPS ΔV RESERVES	1,300	1,000	1,800	1,350
JUNE	72-1 LAUNCH AZIMUTH	LAUNCH DATE	17	17	19	19
		LUNAR APPROACH AZIMUTH, DEG	-95.25	-91.0	-95.75	-89.0
		LUNAR ORBIT INCLINATION, DEG	5.3	1.2	5.8	1.1
		MIDCOURSE ΔV, FPS	—	6	—	16
		LOI-1 ΔV, FPS	2,847	2,940	2,872	2,974
		LOI-1 PLANE CHANGE	0.5	6.1	1.3	6.8
		SPS ΔV RESERVES	1,800	1,600	1,900	1,550

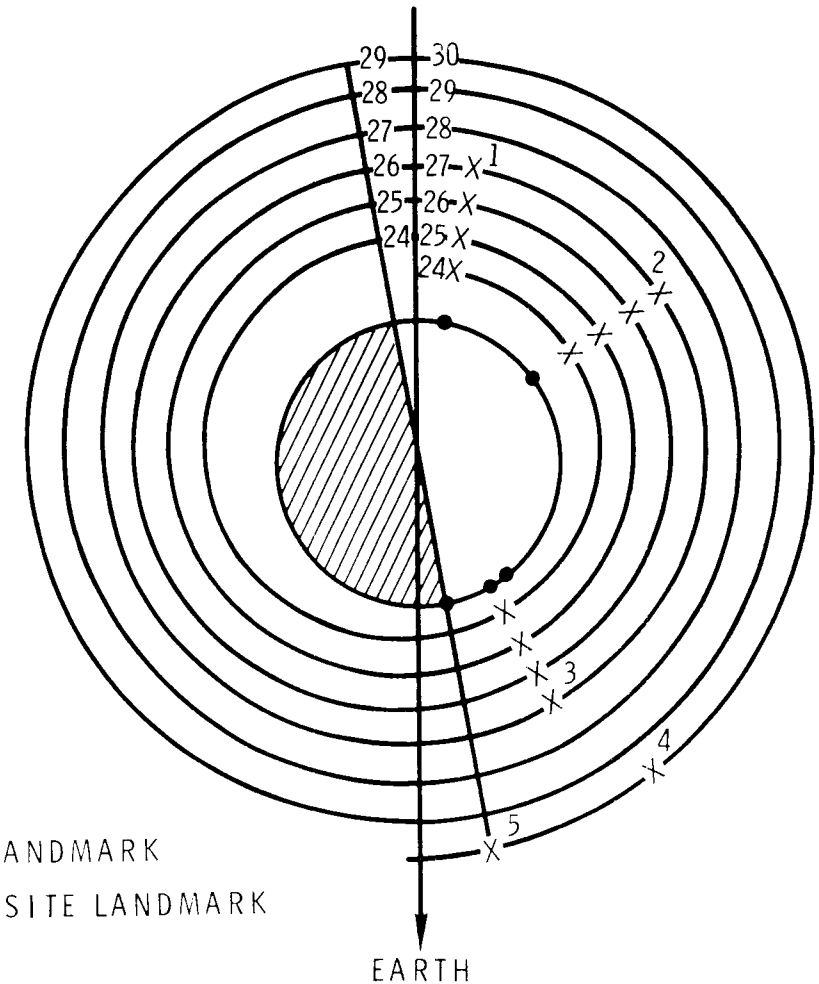
LUNAR ORBIT NAVIGATION

Paul T. Pixley

F MISSION RENDEZVOUS NAVIGATION PLAN



POSTRENDEZVOUS LANDMARK TRACKING



1, 2 UNKNOWN LANDMARK

3, 4, 5 LANDING SITE LANDMARK

ABORT TECHNIQUES

Charles T. Hyle

OPERATIONAL ABORT PLAN
APOLLO 10

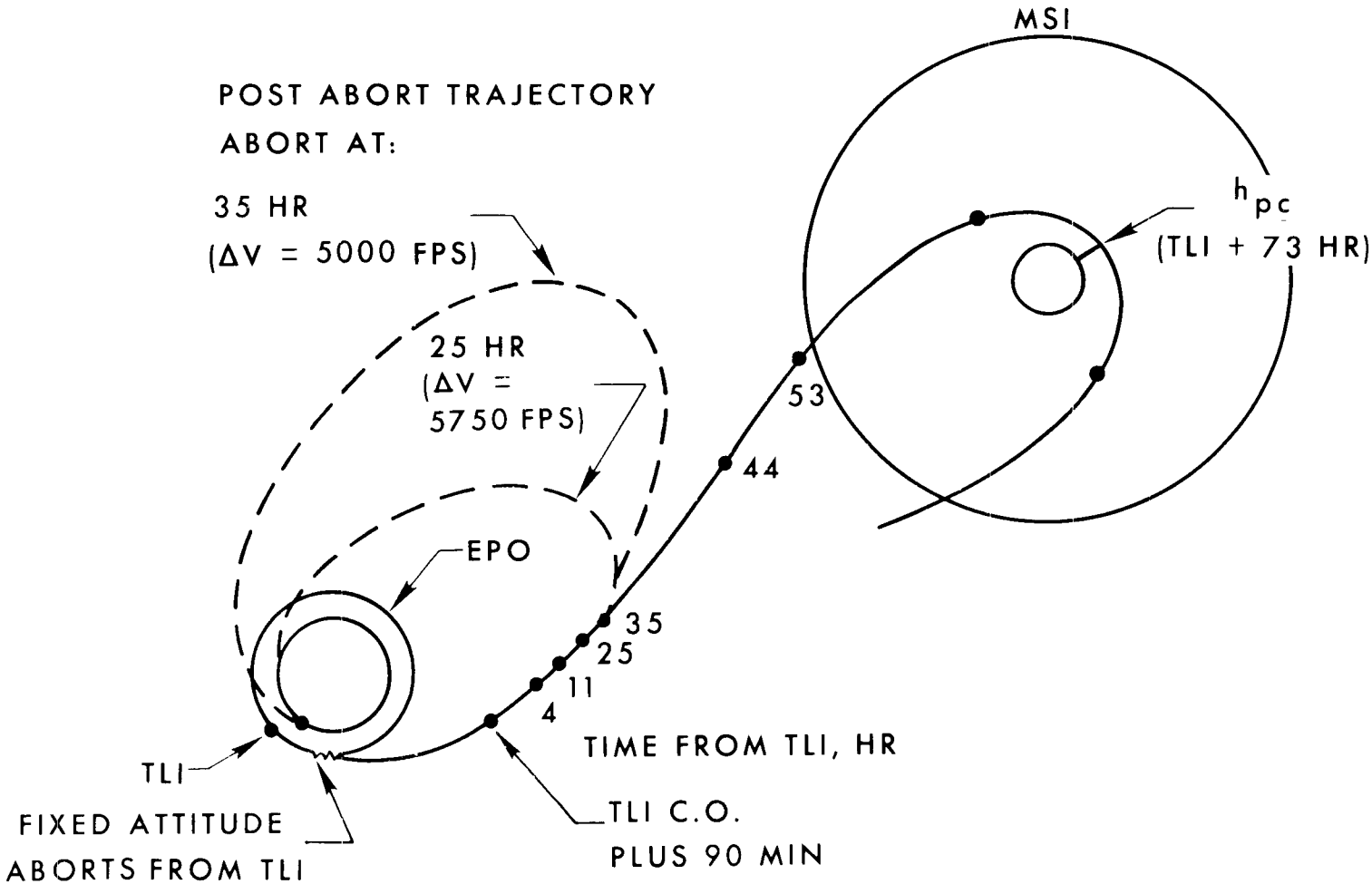
- OBJECTIVES
  - POWERED FLIGHT MONITORING LIMITS
  - PROVIDE ABORT TECHNIQUES WITHIN AVAILABLE ΔV

OPERATIONAL ABORT PLAN

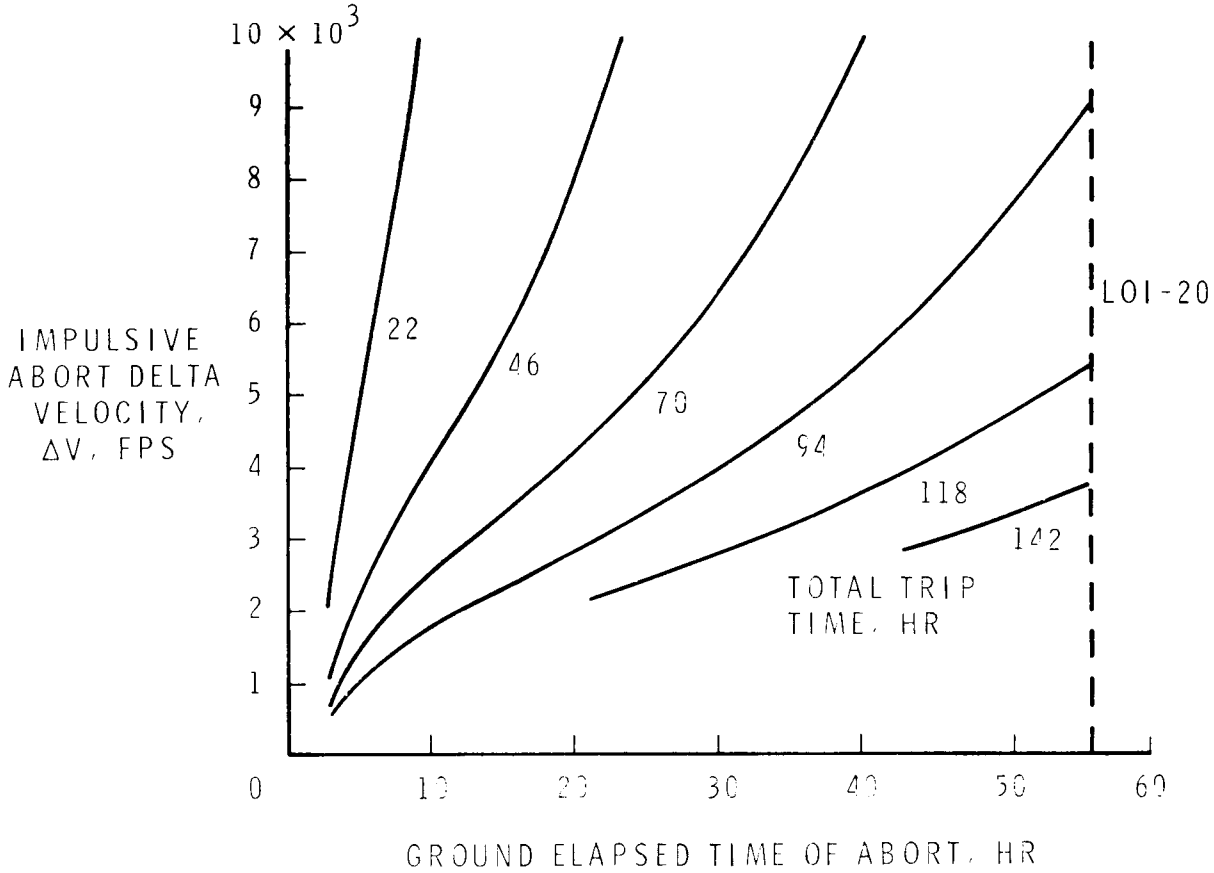
	LAUNCH	EPO	TLI	TLC
MONITORING LIMITS	● EDS ● FDO TRAJECTORY		RATE - 10°/SEC ATT. DEV. - 45° Δt_b - +6 SEC	
CONTINGENCY PROCEDURE OPTION	ESS, MODE IV	ALT. MISS.	ALT. MISS.	ALT. MISS.
	MODE I, II,	SPS DEORBIT		CIRCUMLUNAR
			TLI + 90	DIRECT
		RCS DEORBIT		
	MODE III		TLI + 10	

ABORT GEOMETRY DURING TLI/TLC

TIME OF ABORT MANEUVER



ABORTS TO MPL-F MISSION-LAUNCH: MAY 18, 1969 72-1



OPERATIONAL ABORT PLAN (CONCLUDED)

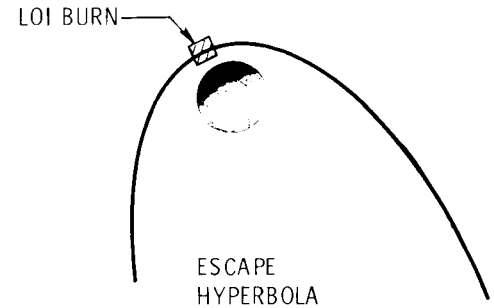
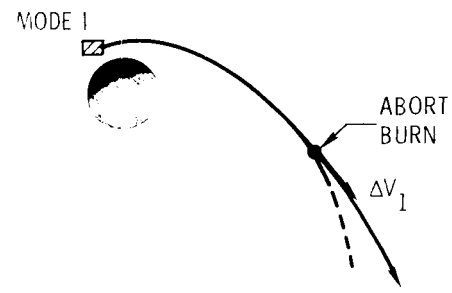
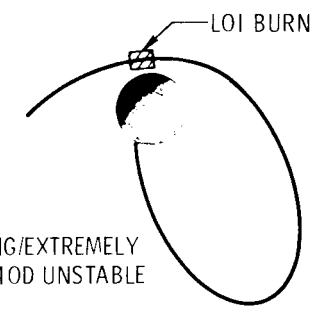
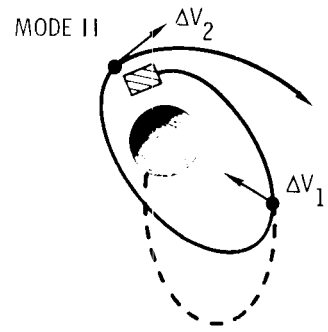
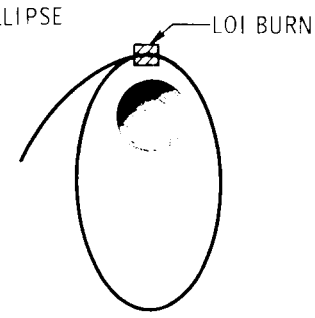
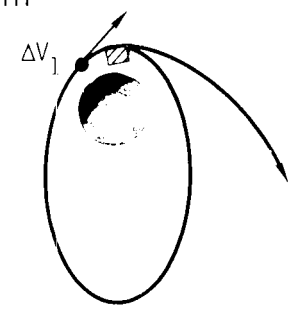
	LOI-1	LOI-2	LUNAR ORBIT	TEI	TEC
MONITORING LIMITS	RATE - 10°/SEC ATT. DEV. - 10° Δt_b			RATE - 10°/SEC ATT. DEV. - 10° Δt_b	
CONTINGENCY PROCEDURE OPTION	ALT. MISS.	ALT. MISS.	ALT. MISS.		SPS (RTCC)
	I (SPS)			MODE III, II, I SPS ABORT	
	MODE I, II, III DPS ABORT	DPS MODE III			
	P37		EARLY TEI		MODE I SPS (P37)

RECOMMENDED ACTION FOR PROBLEMS DURING LOI

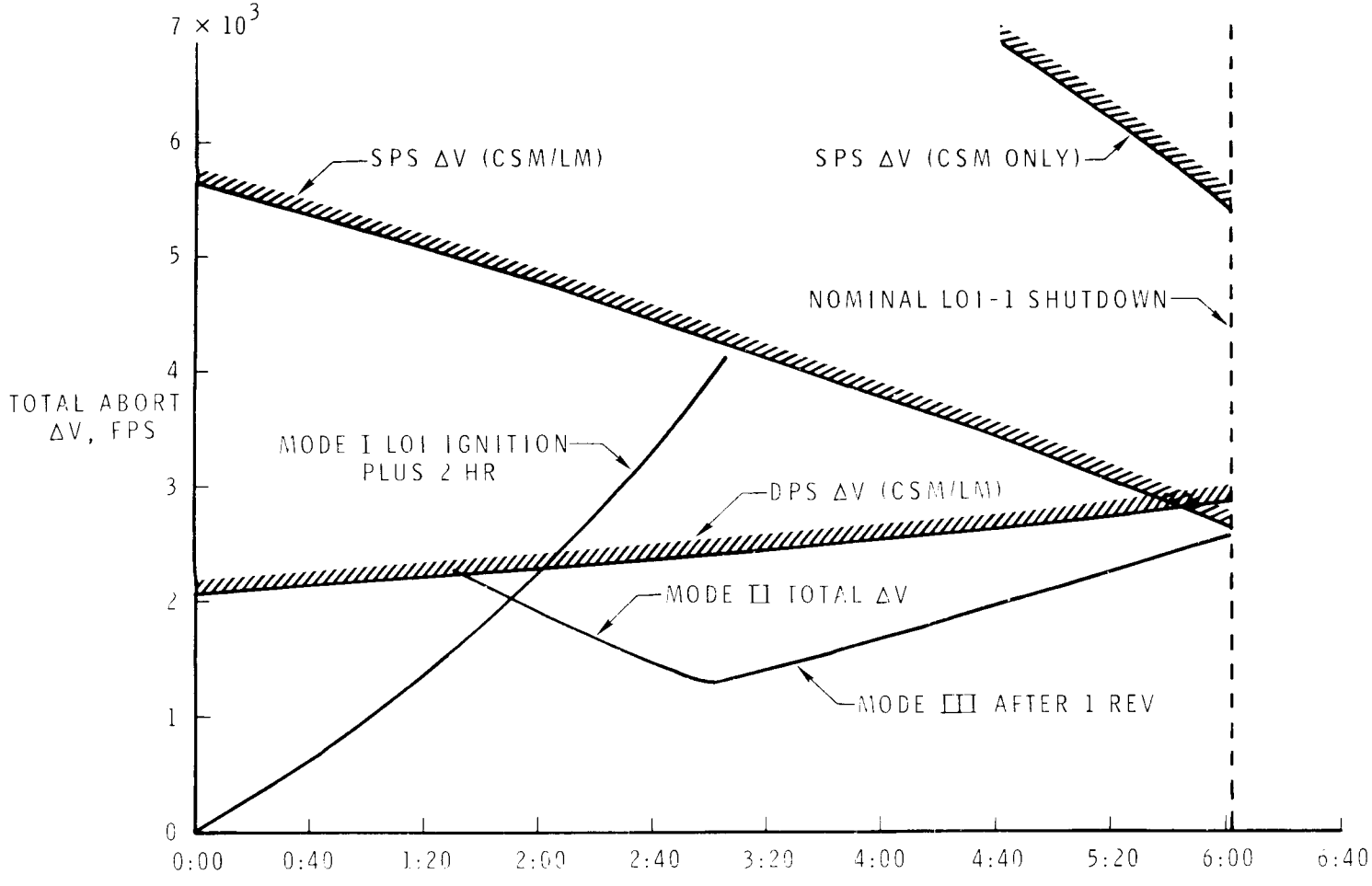
TYPE		
1	GUIDANCE AND CONTROL (IMU DRIFTS, ETC)	MANUAL TAKEOVER AT 10°/SEC OR 10° ATTITUDE DEVIATION AND COMPLETE LOI AT IGNITION ATTITUDE
2	NON-SPS (ECS ETC)	COMPLETE LOI
3	SPS (PRESS ETC)	CREW CHART ABORT SPS AT 15 MINUTES OR DPS AT PERILUNE (RTCC)
4	INADVERTANT SHUTDOWNS (CMC ETC)	DPS ABORT AFTER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

SUMMARY OF LUNAR ORBIT INSERTION ABORT MODES

MPAD 3703 S (10)

LOI SHUTDOWN RANGE	PREABORT TRAJECTORY	ABORT MODE
0-120 SEC		
120-180 SEC		
180-NOMINAL CUTOFF		

SUMMARY OF ABORT CAPABILITY FOR PREMATURE LOI SHUTDOWNS



ALTERNATE MISSION PLANS

Rocky D. Duncan

LUNAR ALTERNATE MISSIONS

ALTERNATE 1

CONTINGENCY: NON NOMINAL TLI

ALTERNATE 1 A: DPS LOI

1 B: CSM ONLY -- LUNAR ORBITAL MISSION

1 C: CSM/LM FLYBY

ALTERNATE 2

CONTINGENCY: FAILURE TO PERFORM T.D. AND E

ALTERNATE 2: CSM ONLY -- LUNAR ORBITAL MISSION

ALTERNATE 3

CONTINGENCY: LM NO GO FOR RENDEZVOUS

ALTERNATE 3: DPS TEI

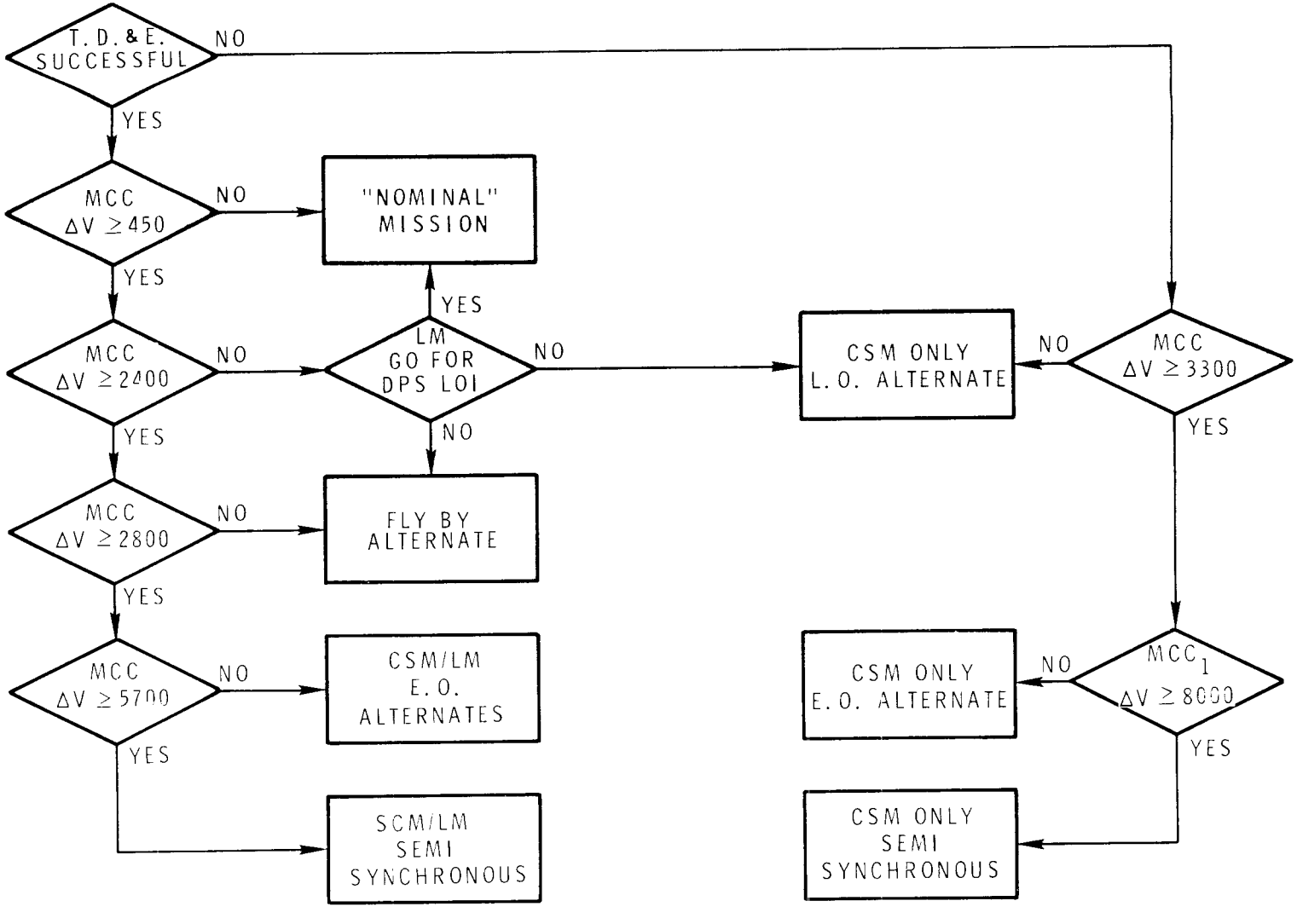
ALTERNATE 4

CONTINGENCY: LM NO GO FOR RENDEZVOUS OR DPS TEI

ALTERNATE 4: APS BURN TO DEPLETION

APOLLO 10 ALTERNATE MISSION LOGIC

MPAD 5288 S



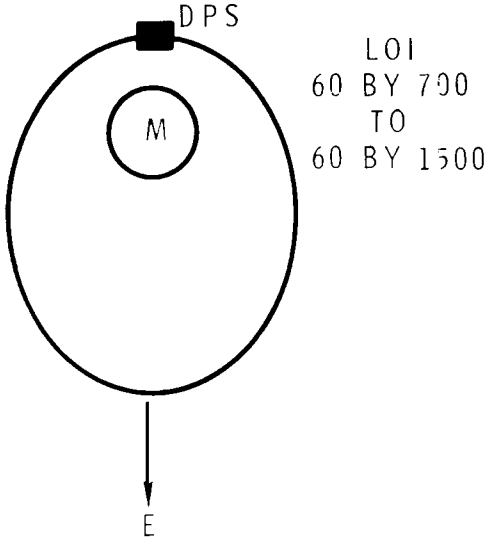
ALTERNATE 1A

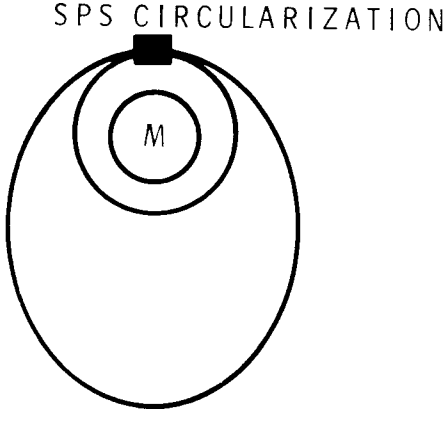
DPS LOI

- CONSTRAINTS
  - LOI-2 MUST BE $\geq$ 40 SEC SPS BURN
  - NAR RECOMMENDS THIS NOT BE PERFORMED UNLESS SPS SUMP TANKS ARE FULL
  - DPS SHOULD BE STAGED OR PROPELLANT VENTED WITHIN 20 MINUTES OF BURN
- IMPLICATIONS
  - CONSIDER DPS LOI IF TL MCC $\Delta V \geq$ 460 FPS AND $\leq$ 2,400 FPS
  - UPPER LIMIT CORRESPONDS TO FULL SPS SUMP TANKS
  - LPO CAPABILITY
    $\approx$ 60 BY 1,500 TO
    60 BY 700
- RECOMMENDATION
  - A LM CHECKOUT EARLY IN TLC

MPAD 5336 S(IU)

DPS LOI

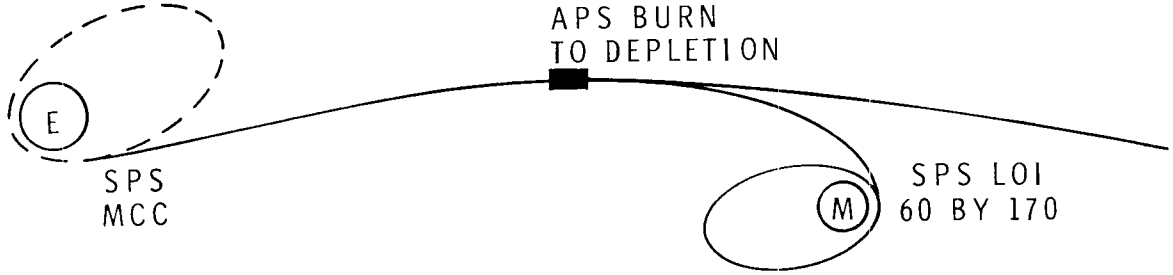




ALTERNATE 1B

CSM - ONLY LUNAR ORBIT MISSION

- PROFILE
  - CSM/LM MCC FOR FREE RETURN
  - LM TESTING DURING TLC
    - NO DPS BURN
    - APS BURN TO DEPLETION
  - IN LPO, FOLLOW NOMINAL CREW REST/WORK CYCLE
  - LOI DAY PRIMARILY DEVOTED TO PHOTOGRAPHY
  - DOI DAY
    - 4 REVS OF LANDMARK TRACKING
    - SPS DOI INTO 60 BY 8 N. MI. ORBIT FOR 3 REVS OF MSFN TRACKING
  - RETURN TO NOMINAL TIMELINE

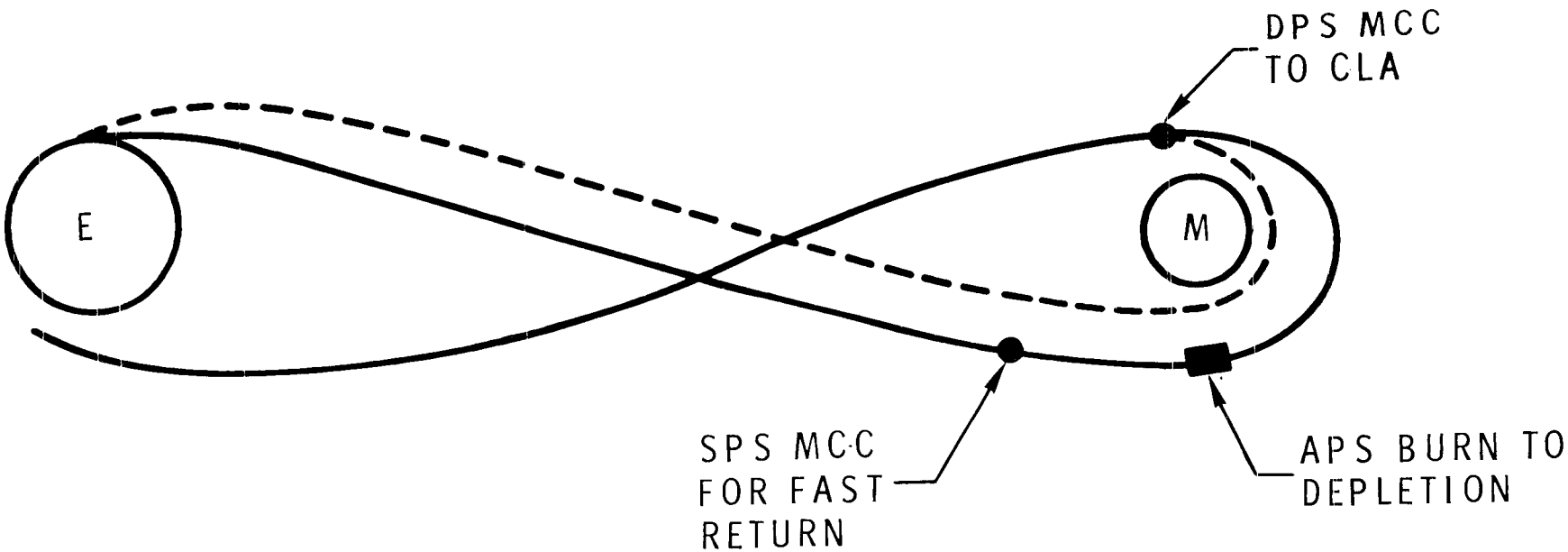


ALTERNATE 1C

CSM/LM FLYBY

- PROFILE
  - DOCKED MCC
  - PC - 5 HR -- DPS MCC TO CLA
  - PC + 2 HR -- UNMANNED APS BURN TO DEPLETION
  - SPS MCC FOR ASAP RETURN

CSM/LM FLYBY


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

ALTERNATE 2

CSM - ONLY LUNAR ORBIT MISSION

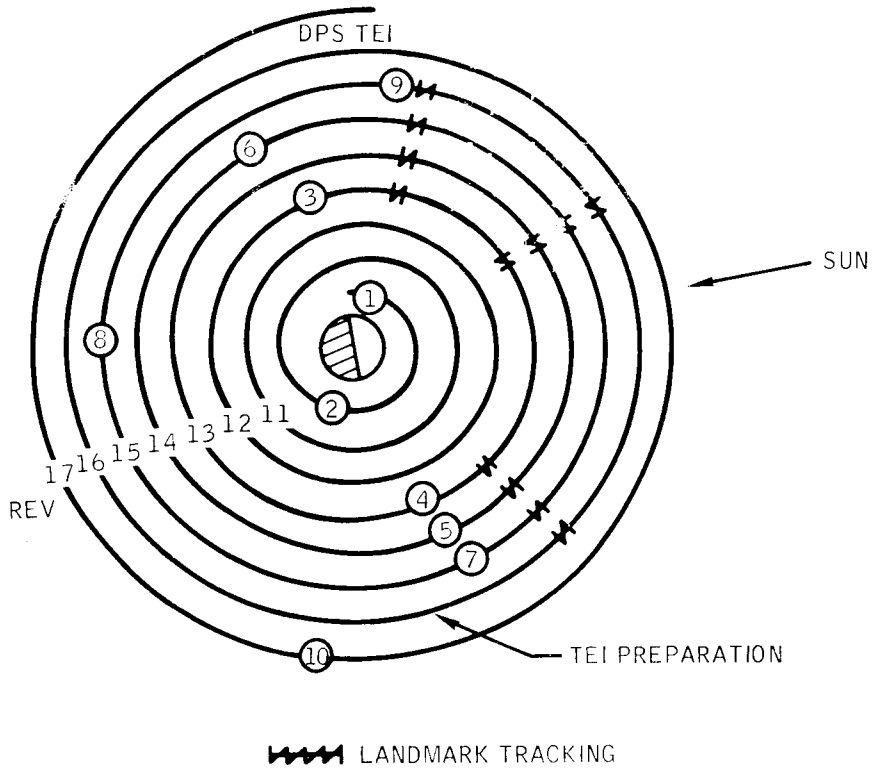
- SAME AS ALTERNATE EXCEPT BROUGHT ABOUT BY FAILURE TO PREFORM T, D, AND E

ALTERNATE 3

DPS TEI

- PROFILE
  - LANDMARK TRACKING DURING NOMINAL TIMELINE RENDEZVOUS
  - DPS TEI NEAR END OF DOI DAY
  - DPS TEI ≈ 2,800 FPS FOR SLOW TE FLIGHT TIME
  - APS BURN TO DEPLETION FOLLOWING TEI
  - SPS MCC FOR FAST RETURN
- RECOMMENDATION
  - IF SUPERCRITICAL HELIUM REQUIRES EARLY TEI, THEN STAGE DPS AND RETURN TO NOMINAL TIMELINE

DPS TEI ON DOI DAY



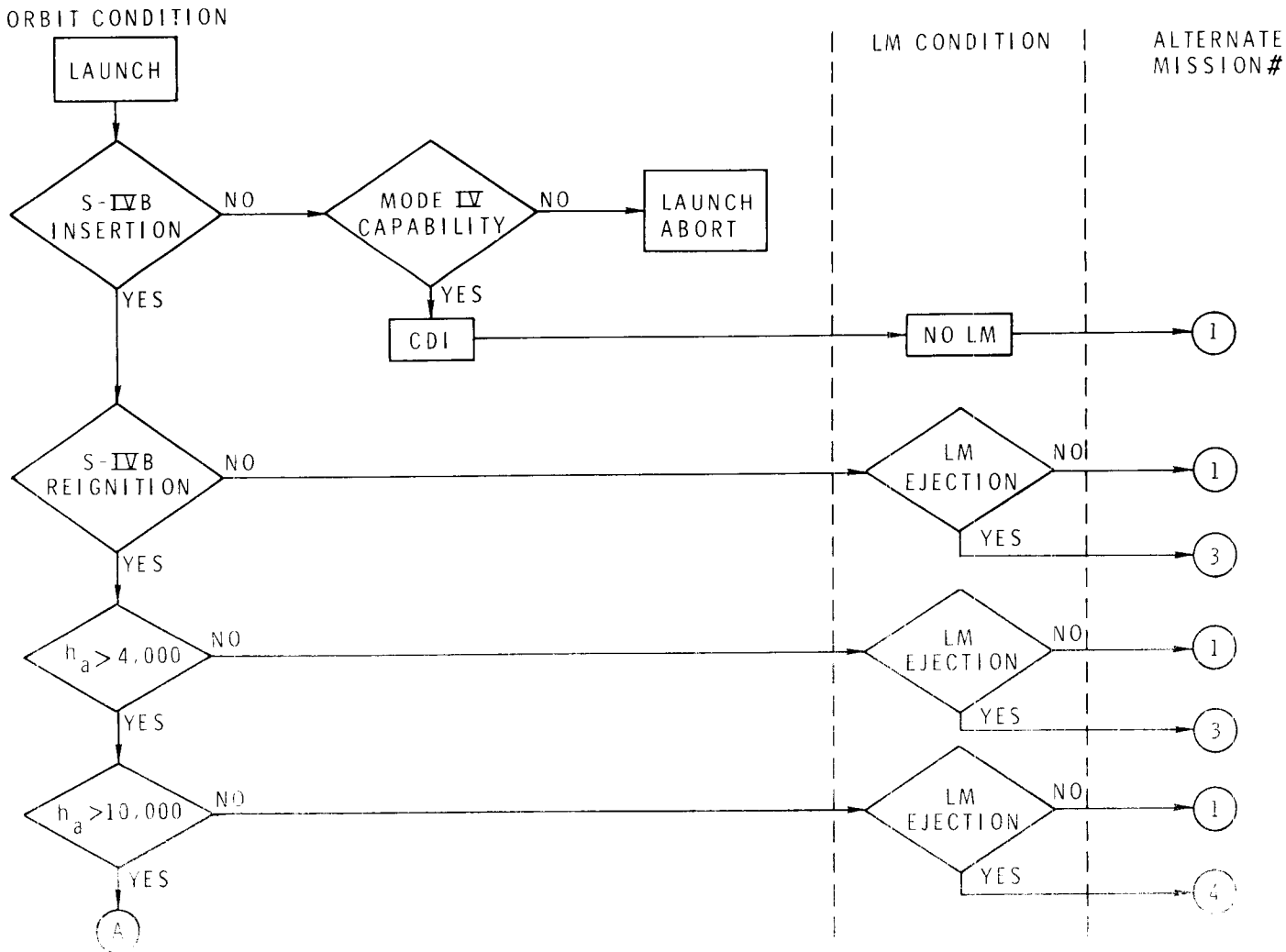
NOMINAL TIMELINE EVENTS

EVENT	TIME, G.E.T.
1 - AWAKE AND EAT	94:00
2 - BEGIN LM CHECKOUT	95:00
3 - DOI	99:54
4 - PHASING	101:06
5 - INSERTION	103:03
6 - CSI	103:54
7 - CDH	104:52
8 - TPI	105:59
9 - DOCKING	106:40
10 - APS BURN TO DEPLETION	109:04

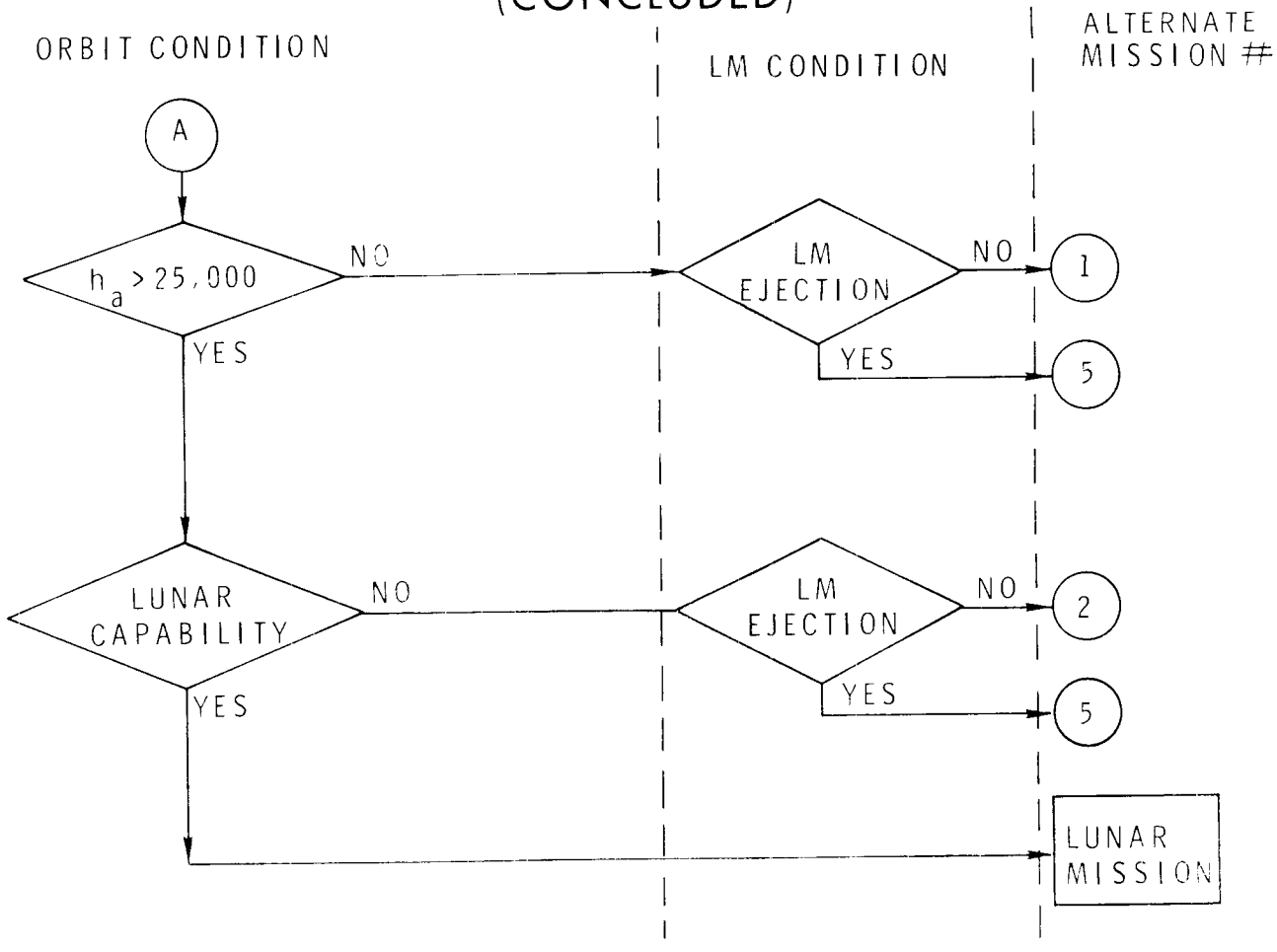
RENDEZVOUS AND SEMISYNCHRONOUS ALTERNATE MISSION PLANS

Kenneth A. Young

"F" EARTH ORBIT ALTERNATE MISSION FLOW CHART



"F" EARTH ORBIT ALTERNATE MISSION FLOW CHART (CONCLUDED)



MPAD 5279 S

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

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

POSSIBLE LUNAR RENDEZVOUS ALTERNATES

RENDEZVOUS ALTERNATE	CONTINGENCY SITUATION	DURATION OF RENDEZVOUS SEQUENCE
DPS - ONLY (1) CSM DOES BRAKING (2) STAGE AFTER CDH, LM DOES TERMINAL PHASE	(1) UNABLE TO STAGE OR APS POWER LIMITED (2) NO USABLE APS	7 1/2 HOURS (NOMINAL)
APS - ONLY MAXIMUM RANGE = 100 N. MI.	DPS INOPERATIVE	5 1/2 HOURS (LIKE PDI ABORT)
FOOTBALL MAXIMUM RANGE = 60 N. MI.	APS AND DPS IN-OPERATIVE	3 1/2 HOURS