

*Cal*



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

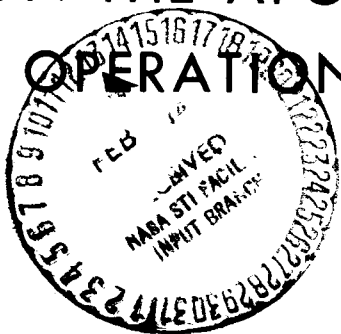
MSC INTERNAL NOTE NO. 69-FM-90

May 14, 1969

Technical Library, Bellcomm, Inc.

JUN 2 1969

LAUNCH WINDOW EFFECTS  
ON THE APOLLO 10 (MISSION F)  
OPERATIONAL ABORT PLANS



Flight Analysis Branch

MISSION PLANNING AND ANALYSIS DIVISION



MANNED SPACECRAFT CENTER  
HOUSTON, TEXAS

(NASA-TM-X-69412) LAUNCH WINDOW EFFECTS  
ON THE APOLLO 10 (MISSION F) OPERATIONAL  
ABORT PLANS (NASA) 85 p

N74-70638

00/99 Unclas  
16200

*Attn: Note No. 69-FM-90*

MSC INTERNAL NOTE NO. 69-FM-90

---

PROJECT APOLLO  
LAUNCH WINDOW EFFECTS ON THE APOLLO 10  
(MISSION F) OPERATIONAL ABORT PLANS

By Contingency Analysis Section  
Flight Analysis Branch

---

May 14, 1969

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

Approved: Charlie C. Allen

Charlie C. Allen, Chief  
Flight Analysis Branch

Approved: John P. Mayer

John P. Mayer, Chief  
for Mission Planning and Analysis Division

## CONTENTS

Section		Page
1.0	SUMMARY . . . . .	1
2.0	INTRODUCTION . . . . .	2
3.0	ABBREVIATIONS . . . . .	3
4.0	LAUNCH PHASE . . . . .	5
5.0	TRANSLUNAR INJECTION AND TRANSLUNAR COAST PHASE . . . . .	6
	5.1 Translunar Injection Monitoring . . . . .	6
	5.2 Aborts from Translunar Injection and Translunar Coast Phase . . . . .	6
	5.2.1 Introduction . . . . .	6
	5.2.2 The 10-minute abort . . . . .	7
	5.2.3 The 90-minute abort . . . . .	7
	5.2.4 Translunar coast aborts . . . . .	7
6.0	LOI AND LUNAR ORBIT PHASE . . . . .	8
	6.1 Aborts During LOI and Lunar Orbit . . . . .	8
	6.1.1 Introduction . . . . .	8
	6.1.2 Abort summary for May 18, 1969, nominal LOI burn . . . . .	8
	6.1.3 Launch window effects on LOI aborts . . . . .	10
	6.1.4 LOI crew chart for May 18, 1969, launch . . . . .	11
7.0	TRANSEARTH INJECTION AND TRANSEARTH COAST PHASE . . . . .	12
	7.1 Aborts from TEI and Transearth Coast . . . . .	12
	7.1.1 Introduction . . . . .	12
	7.1.2 Abort analysis of various TEI burn profiles . . . . .	12

Section		Page
8.0	CONCLUSIONS . . . . .	15
9.0	REFERENCES . . . . .	78

## FIGURES

Figure		Page
2-1	The relationship of the nominal Apollo 10 mission events and the operational abort modes . . . . .	18
2-2	Major Apollo F and G milestones for the Contingency Analysis Section . . . . .	19
4-1	Constant range lines and ground tracks for the Apollo 10 (Mission F) launch phase . . . . .	20
4-2	Landing range history versus velocity at abort for a typical launch azimuth . . . . .	21
5-1	TLI pitch gimbal angle history and attitude deviation limits for first opportunity . . . . .	22
5-2	TLI yaw gimbal angle history and attitude deviation limits	
	(a) First opportunity . . . . .	23
	(b) Second opportunity . . . . .	24
5-3	Envelope of May launch window pitch angle excursions through TLI . . . . .	25
5-4	Envelope of May launch window yaw angle excursions through TLI . . . . .	26
5-5	Ground elapsed time at TLI for the May launch window . . . . .	27
5-6	IMU pitch gimbal angles at TLI for the May launch window . . . . .	28
5-7	Inertial velocity at translunar injection for the May launch window . . . . .	29
5-8	TLI plus 10 minute abort crew chart	
	(a) Abort $\Delta V$ versus inertial velocity . . . . .	30
	(b) Time from abort to entry versus inertial velocity . . . . .	31

Figure		Page
5-9	IMU inner gimbal angle at TLI cutoff plus 10 minutes corresponding to horizon reference attitude for abort . . . . .	32
5-10	Abort delta velocity and ground elapsed time at landing as functions of launch azimuth for TLI plus 90 minute aborts	
	(a) First injection opportunity, May 18, 1969 . . . . .	33
	(b) Second injection opportunity, May 18, 1969 . . . . .	34
	(c) First injection opportunity, May 20, 1969 . . . . .	35
	(d) Second injection opportunity, May 20, 1969 . . . . .	36
	(e) First injection opportunity, May 23, 1969 . . . . .	37
	(f) Second injection opportunity, May 23, 1969 . . . . .	38
	(g) First injection opportunity, May 24, 1969 . . . . .	39
	(h) Second injection opportunity, May 24, 1969 . . . . .	40
	(i) First injection opportunity, May 25, 1969 . . . . .	41
	(j) Second injection opportunity, May 25, 1969 . . . . .	42
5-11	Summary of abort delta velocity and ground elapsed time at landing as functions of launch azimuth for TLI plus 90-minute aborts for the May 1969 launch window	
	(a) Atlantic ocean line . . . . .	43
	(b) Eastern Pacific line . . . . .	44
5-12	Abort delta velocity as a function of launch azimuth and launch day in the May 1969 window for direct returns to the MPL at typical block data times during the translunar coast	
	(a) Ground elapsed time, 7 hr . . . . .	45
	(b) Ground elapsed time, 14 hr . . . . .	46
	(c) Ground elapsed time, 28 hr . . . . .	47
	(d) Ground elapsed time, 38 hr . . . . .	48
	(e) Ground elapsed time, 48 hr . . . . .	49
6-1	Summary of abort capability for premature LOI shutdowns (May 18, 1969 launch, G MCC)	
	(a) Fuel critical, unspecified area returns (FCUA) . . . . .	50
	(b) Return to the mid-Pacific line (MPL) . . . . .	51

Figure	Page	
6-2	Ground elapsed time of landing for FCUA mode I and II aborts for premature LOI shutdowns . . . . .	52
6-3	Nominal mode II corrective maneuver $\Delta V$ magnitude and maximum delay time to ignition . . . . .	53
6-4	Characteristics of intermediate ellipse following nominal mode II corrective maneuver (nominal May 18, 1969, launch) . . . . .	54
6-5	Ground elapsed time of ignition of mode II second burn following nominal corrective maneuver . . . . .	55
6-6	Ground elapsed time of ignition of mode II abort maneuver . . . . .	56
6-7	Mode I/II overlap region based on nominal May 17, 1969, corrective maneuver (FCUA returns)	
	(a) May 18 launch, 72 degree azimuth, first opportunity . . . . .	57
	(b) May 18 launch, 108 degree azimuth, second opportunity . . . . .	58
	(c) May 20 launch, 72 degree azimuth, first opportunity . . . . .	59
	(d) May 23 launch, 72 degree azimuth, first opportunity . . . . .	60
	(d) May 25 launch, 72 degree azimuth, first opportunity . . . . .	61
6-8	Nominal May 17, 1969, corrective maneuver . . . . .	62
6-9	Characteristics of intermediate ellipse following nominal May 17 corrective maneuver	
	(a) May 18 launch, 72 degree azimuth, first opportunity . . . . .	63
	(b) May 18 launch, 108 degree azimuth, second opportunity . . . . .	64
	(c) May 20 launch, 72 degree azimuth, first opportunity . . . . .	65
	(d) May 23 launch, 72 degree azimuth, first opportunity . . . . .	66
	(e) May 25 launch, 72 degree azimuth, first opportunity . . . . .	67

Figure		Page
6-10	Nominal 15 minute LOI crew chart for a May 18 lunar mission . . . . .	68
7-1	Summary of FCUA abort capability for various TEI burn profiles	
	(a) Case 1, transearth flight time = 79 hours . . . . .	69
	(b) Case 2, transearth flight time = 63 hours . . . . .	70
	(c) Case 3 (nominal TEI), transearth flight time = 55 hours . . . . .	71
	(d) Case 4, transearth flight time = 48 hours . . . . .	72
7-2	Mode II abort characteristics for various TEI burns	
	(a) Case 2, corrective maneuver $\Delta V$ and maximum allowable delay time . . . . .	73
	(b) Case 2, time to pericyynthion, pericynthion altitude of intermediate ellipse . . . . .	73
	(c) Case 3 (nominal TEI), corrective maneuver $\Delta V$ and maximum allowable delay time . . . . .	74
	(d) Case 4 (nominal TEI), time to pericynthion, pericynthion altitude of intermediate ellipse ellipse . . . . .	74
	(e) Case 4, corrective maneuver $\Delta V$ and maximum allowable delay time . . . . .	75
	(f) Case 4, time to pericynthion, pericynthion altitude of intermediate ellipse . . . . .	76
7-3	Summary of MPL abort capability for case 3, nominal Apollo 10 TEI burn . . . . .	77



# LAUNCH WINDOW EFFECTS ON THE APOLLO 10 (MISSION F)

## OPERATIONAL ABORT PLAN

By Contingency Analysis Section

### 1.0 SUMMARY

The purpose of this document is to present an analysis of abort maneuver requirements and of abort trajectories that result from simulated abort maneuvers for aborts which occur from various nominal lunar trajectories. Nominal lunar trajectories that are considered were simulations of required Apollo 10 (Mission F) trajectories of various launch azimuths and injection opportunities for the May 1969 launch window.

Sufficient data are shown for each launch day to provide preliminary updates to abort maneuver requirements. Where possible, summary data are provided to show the effect on abort maneuver requirements of changing the launch day, launch azimuth, and injection opportunities.

Operational abort trajectory data that would not normally have been updated between the time of publication of the operational abort plan and mission time are included in this document to account for the change in the planned launch day from May 17 to May 18.

The results of the analysis indicate that neither the abort plan nor the accepted contingency techniques are compromised in any way. Therefore, it is concluded that a continuous abort capability exists for all mission phases of the entire May 1969 launch window.

## 2.0 INTRODUCTION

The purpose of this document is to illustrate the changes in the Apollo 10 (Mission F) abort maneuver requirements when other injection opportunities are considered. Because the primary mission and abort plans are based on a May 18, 1969, 72° launch azimuth, first opportunity TLI, and because either of the latter variables may change, mission abort capability must be investigated to insure that it exists and is compatible with preplanned procedures and constraints. Note that after reference 1 had been published, several changes were made to the planned mission. In particular, the launch date was changed from May 17 to May 18. Significant operational abort trajectory data not normally presented in a document of this type are included and may be considered to be revisions to the operational abort document.

The variables investigated are the day of launch (during May 1969), the launch azimuth, and translunar injection opportunity. This document supplements the basic abort plan (ref. 1); therefore, to avoid needless repetition, explanations will not be repeated.

In general, the topics discussed in this document include maneuver monitoring considerations prior to an abort and necessary trajectory tradeoff information such as return to earth flight times, fuel cost, and landing location. The overall relationship of the various methods of abort during any mission phase and the nominal mission events are repeated from reference 1 in figure 2-1. This document and other major F and G mission milestones for the Contingency Analysis Section are shown in figure 2-2.

Normally, abort maneuvers would be performed by use of the PGNCs. When the PGNCs is not available for use, maneuver attitude may be established with external visual references.

An investigation of possible uses of the sun, earth, moon, and stars for contingency or for backup attitude reference for the major thrust maneuvers has been documented (ref. 2).

## 3.0 ABBREVIATIONS

AOL	Atlantic Ocean line (recovery)
COI	contingency orbit insertion
CSM	command and service module
DPS	descent propulsion system
DSKY	display keyboard
EPL	Eastern Pacific line (recovery)
EPO	earth parking orbit
FCUA	fuel-critical unspecified area
G MCC	midcourse maneuver in the TLC to approximate the lunar orbital geometry of the planned G mission
G.m.t.	Greenwich mean time
g	entry load
g.e.t.	ground elapsed time
IMU	inertial measurement unit
IOL	Indian Ocean line (recovery)
LEV	launch escape vehicle
LOI	lunar orbit insertion
LOI-1	LOI into a 60- by 170-n. mi. altitude orbit
LOI-2	lunar orbit circularization into a 60-n. mi. altitude orbit
LPO	lunar parking orbit
MPL	mid-Pacific line (recovery)
PGNCS	primary guidance and navigation control system
REFSMMAT	transformation matrix from inertial to stable member (IMU)

RTCC Real-Time Computer Complex

SC spacecraft

S-IVB launch vehicle third stage

SPS service propulsion subsystem

TB6 timebase 6 - second S-IVB burn initiation sequence

TEI transearth injection

TFT total flight time from TLI, LOI, or TEI shutdown to landing

TLC translunar coast

TLI translunar injection

WPL West Pacific line (recovery)

$\Delta R$  difference between the onboard predicted landing point and  
the mode III target point

$\Delta V$  total sensed velocity change

#### 4.0 LAUNCH PHASE

The launch phase abort data are not affected by the change in launch day. Changes do occur within the daily launch window by variation of the launch azimuth to meet the required targeting conditions. As illustrated in references 3 and 4, the only significant effect of the variable launch azimuth on launch aborts concerns the associated abort landing coordinates (longitude, latitude). Therefore, all of the data for the launch phase presented in reference 1 for the  $72^\circ$  launch azimuth is representative of any of the planned flight azimuths, except that the landing coordinates must be shifted to correspond to the correct azimuth.

The launch abort landing coordinates for aborts from different flight azimuths can be estimated by correlation of the landing range and the actual flight azimuth. To facilitate this correlation, constant range lines for the launch azimuths representative of the lunar launch window are shown in figure 4-1. When the launch azimuth has been defined (after launch), the associated groundtrack can be determined from figure 4-1. To help determine the landing range as a function of abort conditions, figure 4-2 is included. When the inertial velocity or time at abort is known, the landing range can be determined from figure 4-2. Then by use of the appropriate launch azimuth trace on figure 4-1, the landing coordinates can be approximated. Also shown on figure 4-2 is the instantaneous vacuum impact point trace which can be compared to the actual mode I and mode II landing traces. A detailed analysis of the effects of variable launch azimuth on the CSM launch aborts is presented in reference 4.

## 5.0 TRANSLUNAR INJECTION AND TRANSLUNAR COAST PHASE

### 5.1 Translunar Injection Monitoring

The crew must have monitoring procedures to evaluate the progress of the translunar injection maneuver without ground aid. As described in reference 1, the procedures consist in part of detection and verification of a failure and shutting down the S-IVB if vehicle rates exceed 10 deg/sec or if attitude deviations of  $45^\circ$  from nominal develop during the burn. Before the mission, the crew is provided pitch and yaw attitude charts with the nominal inertial excursion and shutdown limits shown (figs. 5-1 and 5-2). Maximum variations in inertial attitudes caused by opportunity, day, and launch azimuth are shown in figures 5-3 and 5-4. Because the variations are within  $4^\circ$  to  $5^\circ$  of each other and because the limits are so wide, only one set of charts (May 18,  $72^\circ$  launch azimuth) is required. However, because the IMU pitch gimbal angle on the SC attitude indicator at TLI ignition changes with the three launch window variables, ground control must provide this angle during EPO. The times of ignition, TB6, and guidance cutoff are shown for the May launch days and for the first and second opportunities for various launch azimuths in figure 5-5. The IMU pitch angles at ignition and at injection are shown for the same variables in figure 5-6. This information was obtained from reference 5.

Inertial velocity is used in the crew procedures to back up the S-IVB guidance cutoff (ref. 6). Inertial velocity at injection for the three variables is shown in figure 5-7.

### 5.2 Aborts from Translunar Injection and Translunar Coast Phase

5.2.1 Introduction.- In this section is presented an analysis of the effect of various launch opportunities during May 1969 on abort trajectories for aborts initiated during the second S-IVB burn, for aborts initiated immediately after this burn, and for aborts initiated on the TLC leg of Apollo 10 (Mission F).

The trajectory data are compatible with the data presented in references 1 and 7. After reference 1 was published, the planned launch day was changed from May 17 to May 18. Significant changes to the operational abort plan caused by the launch day change are noted in this section.

5.2.2. The 10-minute abort.- Although there were no significant changes (except for the required pitch gibal angle) in the crew charts prepared for May 17, the charts were regenerated and are included in this document [figs. 5-8(a) and 5-8(b)]. While the SC is in EPO, the ground controllers will compute a pitch (inner) gibal angle to be used for the initial attitude maneuvers for the 10-minute abort. The angle is a function of geographic position of TLI and, therefore, of the day and azimuth of launch. The IMU inner gibal angle is shown in figure 5-9 as a function of launch azimuth for days in the May 1969 launch window.

At the nominal TLI burnout state, the abort  $\Delta V$  difference from azimuth to azimuth remains almost constant throughout the launch window for either injection opportunity. The abort  $\Delta V$  requirements for a particular azimuth increase by approximately 20 fps from a May 18 to May 25 launch, and increase approximately 20 fps from first to second injection opportunity. Thus, an abort from a second injection opportunity on May 25 would require approximately 40 fps more  $\Delta V$  than an abort from a first injection opportunity on May 18 for a particular azimuth. The total difference of 40 fps is considered negligible because the abort maneuvers can be performed successfully (considering abort  $\Delta V$  only) with inaccuracies of approximately  $\pm 700$  fps.

5.2.3 The 90-minute abort.- The abort  $\Delta V$  and the g.e.t. at landing are shown in figures 5-10(a) through 5-10(j) for aborts initiated at TLI plus 90 minutes and targeted to two of the five Apollo contingency landing areas. The figures show all possible abort solutions within the constraints noted in reference 8 for the May 1969 window.

5.2.4 Translunar coast aborts.- The data are summarized in figures 5-11(a) and 5-11(b) to show more effectively the effect of launch variations on the abort maneuver requirements. The changes in abort  $\Delta V$  requirements are indicated in figure 5-12 for typical constant abort times (block data times). All the simulated abort maneuvers were targeted to land at the MPL. Note that the g.e.t. of the abort maneuver was held constant from the first injection opportunity to the second injection opportunity. Therefore, the aborts for the second opportunity were initiated approximately 1.5 hours closer to TLI.

## 6.0 LOI AND LUNAR ORBIT PHASE

### 6.1 Aborts During LOI and Lunar Orbit

6.1.1 Introduction.- This section is a supplement to section 8.2 of reference 1. Variations in launch azimuth, translunar injection opportunity, or launch date have no significant effect on the referenced discussions of preabort classes of trajectories, abort modes, or abort ground rules. However, it should be noted that the specific regions of the abort modes vary slightly from those in reference 1.

The LOI burn used in the reference was for a May 17, 1969 launch (72° launch azimuth, first opportunity). However, the nominal launch date has been moved to May 18, 1969. In addition, a midcourse maneuver has been included in the TLC to approximate the lunar orbital geometry of the planned G mission.

The following sections first will update the data included in reference 1 for the new LOI burn (May 18, G MCC) and then will illustrate the primary effects of launching throughout the May 1969 launch window.

Data for an LOI burn that would follow the midcourse maneuver for the G mission lunar orbital orientation was available only for the May 18 launch (May 18, G MCC). Therefore, the launch window effects are based on the original Apollo 10 (Mission F) LOI burns which are compatible with the LOI burn for May 17, 1969, used in reference 1.

6.1.2 Abort summary for May 18, 1969, nominal LOI burn.- In this section is summarized the abort capability that exists after premature LOI shutdown during the nominal LOI burn. The data are for a mission that is launched May 18, 1969, and that includes the midcourse maneuver to approximate the G mission lunar orbital geometry.

The FCUA abort  $\Delta V$  requirements for the entire LOI burn are shown in figure 6-1(a). Shown in the figure is the  $\Delta V$  available for the SPS engine, CSM only, for the SPS engine, docked configuration, and for the DPS engine, docked configuration. Of primary interest is the fact that a DPS backup is available throughout the LOI burn. Basically, the abort mode regions are as follows.



Abort mode	Applicable LOI region
Mode I at $LOI_{IG}$ plus 2 hr	$0^m00^s$ to $2^m00^s$
Mode II at $LOI_{IG}$ plus 2 hr	$2^m00^s$ to $3^m00^s$
Mode III	$3^m00^s$ to end of LOI-1

The abort  $\Delta V$  required for returns to the MPL for premature LOI shutdowns is presented in figure 6-1(b). Several total mission times are included (g.e.t. of landing = 118 hr, 142 hr, and 166 hr). Again, the DPS abort is available throughout the LOI burn, although no  $\Delta V$  remains following aborts near  $2^m00^s$ .

Comparison of figures 6-1(a) and 6-1(b) indicates that the FCUA mode III solutions approximates the mode III MPL solution for a g.e.t. of landing of 166 hours. However, the g.e.t. of landing for the mode I and mode II FCUA solutions vary significantly. These times are shown in figure 6-2. Mode I aborts that are delayed 2 hours, 4 hours, and 6 hours after LOI ignition are shown. The mode II aborts consist of a corrective maneuver nominally performed at  $LOI_{IG}$  plus 2 hours and a  $\Delta V$  magnitude directed along the negative selenocentric radius vector. The corrective maneuver is required to provide an intermediate ellipse with a clear pericyynthion and reasonable period (less than 40 hr). The corrective  $\Delta V$  magnitude is shown in figure 6-3 along with the maximum delay time possible so that initiation of the nominal corrective  $\Delta V$  magnitude will keep the intermediate orbital period below 40 hours (which provides a stable ellipse).

After application of the nominal corrective maneuver, the SC completes one revolution in the resultant intermediate lunar orbit. The time from the corrective maneuver to pericyynthion and the altitude of pericyynthion are shown in figure 6-4. The second mode II DPS burn occurs near pericyynthion of the intermediate ellipse. The g.e.t.'s of ignition for mode II aborts for FCUA and MPL returns are shown in figure 6-5.

The mode III aborts occur one or more revolutions after premature LOI shutdown. The periods of the preabort ellipses are from 2 hours to 15 hours. The g.e.t.'s of ignition for mode III aborts for FCUA and MPL returns are shown in figure 6-6.

Note that although the abort burns were simulated by an impulse and although the transearth coasts used patched-conic trajectories, all intermediate lunar orbits were precision integrated. To summarize this

section, a complete DPS backup exists for premature LOI terminations that occur after a nominal May 18, 1969, launch of Apollo 10 (Mission F) which is targeted to approximate the G mission lunar orbital geometry.

6.1.3 Launch window effects on LOI aborts.- It was stated in the introduction (section 6.1.1) that the launch window effects would be based on the original Apollo 10 (Mission F) LOI burns which do not include a midcourse maneuver during TLC to approximate the G mission lunar orbital geometry. Therefore, the LOI burn in reference 1 is compatible with these LOI burns for various launch dates.

Two major areas are of primary interest when the effects of launch date are investigated. These are as follows.

1. The mode I/mode II abort overlap availability
2. DPS abort capability from the resultant 60- by 60-n. mi. lunar orbit

The mode I/mode II abort overlap that results from the nominal mode II corrective maneuver for a May 18 launch date is shown in figures 6-7(a) and 6-7(b) for a 72° azimuth, first opportunity launch and for a 108° azimuth, second opportunity launch, respectively. Data for a 72° azimuth launch and first opportunity translunar injection on May 20, 23, and 25 are shown in figures 6-7(c) through 6-7(e). In all cases, the corrective maneuver was taken from the nominal May 17, 1969, abort data presented in reference 1 and reproduced here as figure 6-8.

Comparison of figures 6-7(a) through 6-7(e) indicates that a mode I/mode II overlap results from use of the nominal May 17 LOI corrective maneuver (fig. 6-8) for a major portion of the May launch window. The exception occurs during the LOI burn of a lunar mission launched May 25, 1969. However, note that a mode II abort which will permit a mode I/mode II overlap can be developed. For simplicity, only one point of the mode II curve is included in figure 6-7(e). This point is at an LOI burn time of 1<sup>m</sup>50<sup>s</sup>, with a corrective maneuver of 900 fps, as opposed to a nominal corrective maneuver of 770 fps. Other than the  $\Delta V$  magnitude, the corrective maneuver is executed identically to the nominal corrective maneuver. The pericyynthion altitude and time to pericyynthion in the intermediate ellipse are presented in figures 6-9(a) through 6-9(e) for the dates shown in figures 6-7(a) through 6-7(e).

The primary conclusion concerning the mode I/mode II abort overlap is that the nominal corrective maneuver developed for the first day of the launch window can be used for a majority of possible launch days. For days late in the monthly window, new values of the corrective maneuver must be used to permit a mode I/mode II overlap.

The effects of the daily launch window on FCUA aborts after a premature LOI termination are quite small. For example, the mode I abort  $\Delta V$  increases by up to 25 fps from the  $72^\circ$  launch azimuth, first opportunity to the  $108^\circ$  launch azimuth, second opportunity. Individual effects of azimuth or opportunity were not investigated because their resultant effect on LOI is to change the time of LOI ignition; thus, the two effects can be considered together.

The effects of the monthly launch window are more pronounced. During the first 2 days of the launch window (May 18 and May 20), the mode I  $\Delta V$  for a given time of LOI shutdown differ at the most by only 25 fps. During the remaining 3 days (May 23, May 24, and May 25), the mode I abort  $\Delta V$  for a given time of shutdown may decrease by up to 100 to 200 fps. The decrease in mode I abort  $\Delta V$  is accompanied by a corresponding increase of 200 to 300 fps in mode II abort  $\Delta V$ . The overall effect of this  $\Delta V$  change is that the mode I/mode II crossover region is shifted later in the burn by 5 to 10 seconds for launch days in the latter part of the window.

The second launch window effect considered here is the DPS abort capability from the 60-n. mi. LPO. A summary of mode III aborts initiated one revolution past termination of LOI-2 is presented in table 6-I.

Returns are shown in table 6-I to the mid-Pacific and Atlantic recovery areas. Solutions for three different days of landing are presented for each launch opportunity. In each case, the third day of landing requires the least abort  $\Delta V$ . Therefore, because the DPS  $\Delta V$  available at the end of LOI-2 is approximately 2900 fps, it can be seen from the third column of table 6-I that returns to the MPL and the AOL are available throughout the May 1969 launch window. The nominal May 18 LOI burn which is targeted to approximate the G mission lunar orbital geometry is included in table 6-I as well as the original May 18 LOI burns compatible with those in reference 1.

6.1.4 LOI crew chart for May 18, 1969, launch.- The nominal May 17 15-minute LOI crew chart presented in reference 1 is updated here for the May 18 lunar mission targeted to achieve G mission lunar orbital geometry. The crew chart is presented in figure 6-10.

## 7.0 TRANSEARTH INJECTION AND TRANSEARTH COAST PHASE

### 7.1 Aborts from TEI and Transearth Coast

7.1.1 Introduction.- The discussion of the preabort classes of trajectories, abort modes, and abort ground rules contained in section 9.0 of reference 1 applies here. Because the TEI burns for various launch dates are targeted to the MPL, they differ primarily in the transearth flight time; that is, the preburn orbit is a 60-n. mi. LPO, and the post-TEI burn is a hyperbola with the correct transearth flight time to achieve an MPL return. Therefore, the analysis of this section is limited to the abort capability from various TEI burns of different flight times, rather than on a daily basis throughout the May window.

7.1.2 Abort analysis of various TEI burn profiles.- All the TEI burns considered in this section are for a May 18, 1969, launch date and are listed below.

Case	Azimuth/ opportunity	Approximate time in lunar orbit, hr	Nominal g.e.t. of earth landing, hr	TEC flight time, hr	TEI $\Delta V$ , fps
1	72°/1	61	216	79	2819
2	72°/1	51	192	63	3199
3	72°/1	61	192	55	3623
4	108°/2	62	188	48	4150

Case 3 corresponds to the nominal TEI burn currently planned for Apollo 10 (Mission F). The FCUA abort capability for the above four cases is shown in figure 7-1. The region of the TEI burn considered is limited to the mode I/mode II overlap region, except for figure 7-1(c), which analyzes the nominal Apollo 10 (Mission F) TEI burn. It can be seen from figure 7-1(a) that a mode I/mode III overlap exists when the TEI burn is targeted to a relatively long transearth flight time (79 hr).

However, as the flight time is reduced (cases 2, 3, and 4), a gap appears between mode I and mode III, and a mode II abort is required. The mode II region becomes larger as flight time is reduced, until a gap occurs between mode I and mode II [fig. 7-1(d)]. For each TEI that requires a mode II (cases 2, 3, and 4), it was necessary to develop a new plot for the corrective maneuver  $\Delta V$  versus burn time. These plots are shown for cases 2, 3, and 4 in figures 7-2(a), 7-2(c), and 7-2(e), respectively. Also shown in each figure is the maximum delay time possible for the corrective maneuver to result in an intermediate orbit with a pericyynthion altitude of greater than 40 n. mi. (This constraint keeps the preabort period less than 40 hr.) The time to pericynthion and pericynthion altitude of the intermediate ellipse after performing the corrective maneuver for cases 2, 3, and 4 are shown in figures 7-2(b), 7-2(d), and 7-2(f), respectively. Finally, the TEI abort capability for case 3, the nominal TEI burn for MPL returns, is presented in figure 7-3.

Note that the main effect of the launch window on TEI is the difference in transearth flight time, which is directly proportional to the  $\Delta V$  magnitude of TEI. For example, performance of TEI on the second opportunity rather than on the first means that TEI will be approximately 1.5 hours later; thus, the transearth flight time must be reduced by 1.5 hours for the SC to be able to land at the same landing site. This later performance of TEI could mean an increase in TEI  $\Delta V$  of nearly 100 fps. For a launch on a  $108^\circ$  azimuth instead of a  $72^\circ$  azimuth, the transearth coast time must be shortened by 4 hours with approximately a 300-fps increase in the TEI  $\Delta V$  magnitude. When the launch is delayed by 1 or more days, the motion of the moon about the earth becomes significant. A 1-day delay of the launch increases the return flight time to a given landing area by 1.5 to 2 hours through the May 1969 launch window. This increased flight time results in a reduction of 100 fps in TEI  $\Delta V$ . In each of the previously discussed cases, the  $\Delta V$ 's given were for a TEI of approximately 3600 fps, and the values would vary significantly for much larger or smaller TEI  $\Delta V$  magnitudes.

However, the launch window effect on TEI is small compared to effects expected from some of the recent decisions to shorten the transearth flight time by 24 hours. An example would be the case of a TEI to the MPL with a transearth flight time of 66 hours and a  $\Delta V$  magnitude of 3030 fps. To land at the MPL 24 hours earlier, an additional 1600 fps would be required; to land there 24 hours later, 300 fps less would be required. The daily launch window effect may also be negated if TEI is performed a number of revolutions early or late. For each revolution TEI is delayed, the transearth flight time must be increased by 2 hours and the TEI  $\Delta V$  increased by up to 200 fps, based on the return time.

In conclusion, the TEI abort problem differs from the LOI abort problem in that large variations may occur in the TEI burn time, based on changes in (1) the launch time, (2) the revolution during which TEI occurs, or (3) the return flight time which is chosen. For these reasons, abort studies were made on four TEI's chosen for their characteristic transearth flight times rather than from strictly launch window considerations.

## 8.0 CONCLUSIONS

The launch phase abort data are not affected by the change in launch day or injection opportunity. Changes do occur within the daily launch window by variation of the launch azimuth to meet the required targeting conditions. The only significant effect of the variable launch azimuth on launch aborts concerns the associated abort landing coordinates. These landing coordinates can be determined, as shown in the text, based on the actual flight azimuth and the range at landings for the particular abort.

The effect of launch variations on the 10-minute abort from TLI can be considered negligible. Significant differences in abort maneuver requirements for aborts after TLI caused by launch variations are apparent in the enclosed figures. However, the maneuver requirement changes in no way affect the abort plan.

## LOI

For a nominal mission launched on a  $72^\circ$  launch azimuth, first opportunity, May 18, 1969, a continuous DPS backup abort capability for returns to the MPL exists for premature LOI terminations and for the 60-n. mi. LPO.

A continuous DPS backup abort capability for FCUA returns exists in the mode I/mode II crossover region for every launch opportunity in the May 1969 launch window.

The plot of mode II corrective maneuver  $\Delta V$  versus burn time which was prepared for the nominal launch opportunity is adequate for nearly every day in the launch window. However, for days late in the launch window, it is possible to develop another plot for that day which will work.

DPS abort capability to the MPL and AOL from the 60- by 60-n. mi. lunar orbit exists for all launch opportunities in the May 1969 launch window.

## TEI

For a nominal mission launched on a  $72^\circ$  launch azimuth, first opportunity, May 18, 1969, a continuous SPS abort capability for FCUA returns exists for premature TEI shutdowns. However, there is no mode I/mode III abort overlap and mode II aborts are required.

A TEI with a  $\Delta V$  magnitude of 4150 fps and a transearth flight time of 48 hours does not have continuous abort capability for premature TEI shutdowns. A gap appears between mode I and mode II.

TEI maneuvers can be greatly affected by a large number of variables; therefore, it is more meaningful to choose TEI for an abort study by the transearth flight time rather than by launch window considerations.



TABLE 6-I.- SUMMARY OF MODE III ABORTS ONE REVOLUTION AFTER LOI-2 TERMINATION FOR THE MAY 1969 LAUNCH WINDOW

Launch date	Azimuth opportunity	First day of landing				Second day of landing				Third day of landing								
		G.m.t. launch	G.e.t. LOI-2IG	G.m.t. LOI-2IG	Abort VEI' ΔV, fps	GETL	GMTL	VEI' fps	Abort ΔV, fps	GETL	GMTL	VEI' fps	Abort ΔV, fps					
5/18	Nominal	16:48:35	80:10:46	96:59:21		117:23	134:12	37 056	6357	142:18	159:06	36 253	3379	166:37	183:25	36 094	2761	
	72-1	16:48:58	81:07:22	97:56:19	37 163	117:20	134:09	37 163	6613	142:18	159:07	36 265	3427	166:38	183:27	36 097	2772	
	90-1	19:41:41	80:47:17	100:28:57	37 436	114:22	134:04	37 436	7364	139:27	159:09	36 300	3562	163:49	183:31	36 105	2802	
	108-1	21:09:22	80:57:50	102:07:11	>37 500										162:24	183:33	36 111	2823
	72-2	16:48:58	82:37:18	99:26:16	37 330	117:17	134:06	37 330	7053	142:19	159:08	36 286	3509	166:41	183:29	36 102	2788	
	90-2	19:41:41	82:18:38	102:00:19	>37 500					139:28	159:09	36 324	3654	163:51	183:33	36 111	2818	
108-2	21:09:22	82:26:50	103:36:12	>37 500					138:01	159:10	36 354	3767	162:26	183:35	36 117	2844		
5/20	72-1	17:02:45	80:56:37	97:59:22	36 995	118:47	135:50	36 995	5977	143:36	160:39	36 227	3266	167:52	184:54	36 084	2738	
	108-2	21:24:11	82:10:19	103:34:44	>37 500					139:18	160:42	36 299	3542	163:38	185:02	36 099	2790	
5/23	72-1	17:12:06	77:23:41	94:35:47	36 578	121:09	138:21	36 578	4630	145:40	162:52	36 137	3030	169:57	187:09	36 051	2732	
	108-2	21:35:35	77:55:06	99:30:41	36 812	116:45	138:21	36 812	5436	141:24	163:00	36 174	3173	165:44	187:20	36 058	2760	
5/24	72-1	17:14:15	76:47:02	94:01:55	36 491	122:02	139:16	36 491	4329	146:41	163:55	36 114	2924	170:58	188:12	36 042	2712	
	108-2	21:39:27	77:44:06	99:23:33	36 708	117:34	139:13	36 708	5097	142:24	164:04	36 147	3064	166:47	188:23	36 047	2732	
5/25	72-1	17:19:12	75:17:50	92:37:02	36 390	123:04	140:23	36 390	4010	147:39	164:59	36 089	2890	171:49	189:09	36 032	2723	
	108-2	21:45:00	76:06:02	97:51:02	36 555	118:39	140:24	36 555	4613	143:21	165:06	36 115	2992	167:34	189:19	36 037	2741	
AOL																		
5/18	Nominal	16:48:35	80:10:46	96:59:21	36 418	132:43	149:32	36 418	4022	157:12	174:00	36 131	2898	181:23	198:11	36 065	2663	
	72-1	16:48:58	81:07:22	97:56:19	36 442	132:43	149:32	36 442	4108	157:13	174:02	36 136	2917	181:25	198:14	36 066	2669	
	90-1	19:41:41	80:47:17	100:28:57	36 510	129:50	149:32	36 510	4358	154:23	174:05	36 150	2974	178:35	198:17	36 070	2698	
	108-1	21:09:22	80:57:50	102:07:11	36 563	128:22	149:32	36 563	4522	152:57	174:06	36 160	3009	177:10	198:19	36 072	2704	
	72-2	16:48:58	82:37:18	99:26:16	36 482	132:43	149:32	36 482	4255	157:15	174:03	36 144	2948	181:27	198:16	36 068	2677	
	90-2	19:41:41	82:18:38	102:00:19	36 558	129:50	149:32	36 558	4528	154:25	174:06	36 159	3005	178:37	198:19	36 072	2702	
108-2	21:09:22	82:26:50	103:36:12	36 617	128:22	149:31	36 617	4742	152:59	174:08	36 171	3050	177:12	198:21	36 074	2711		
5/20	72-1	17:02:45	80:56:37	97:59:22	36 378	134:03	151:06	36 378	3842	158:28	173:31	36 117	2848	182:37	199:40	36 058	2661	
	108-2	21:24:11	82:10:19	103:34:44	36 560	129:41	151:06	36 560	4364	154:13	173:37	36 144	2953	178:24	199:48	36 064	2675	
5/23	72-1	17:12:06	77:23:41	94:35:47	36 228	136:15	153:27	36 228	3361	160:33	177:45	36 070	2793	184:43	201:55	36 067	2695	
	108-2	21:35:35	77:55:06	99:30:41	36 298	131:56	153:32	36 298	3637	156:18	177:53	36 084	2848	180:29	202:04	36 039	2704	
5/24	72-1	17:14:15	76:47:02	94:01:55	36 192	137:06	154:21	36 192	3223	161:24	178:38	36 058	2753	185:31	202:45	36 031	2703	
	108-2	21:39:27	77:44:06	99:23:33	36 257	132:47	154:26	36 257	3477	157:07	178:47	36 070	2794	181:15	202:54	36 032	2705	
5/25	72-1	17:19:12	75:17:50	92:37:02	36 154	137:52	155:11	36 154	3125	162:06	179:25	36 045	2752	186:14	203:33	36 025	2715	
	108-2	21:45:00	76:06:02	97:51:02	36 206	133:32	155:17	36 206	3331	157:50	179:35	36 054	2787	182:00	203:45	36 025	2727	

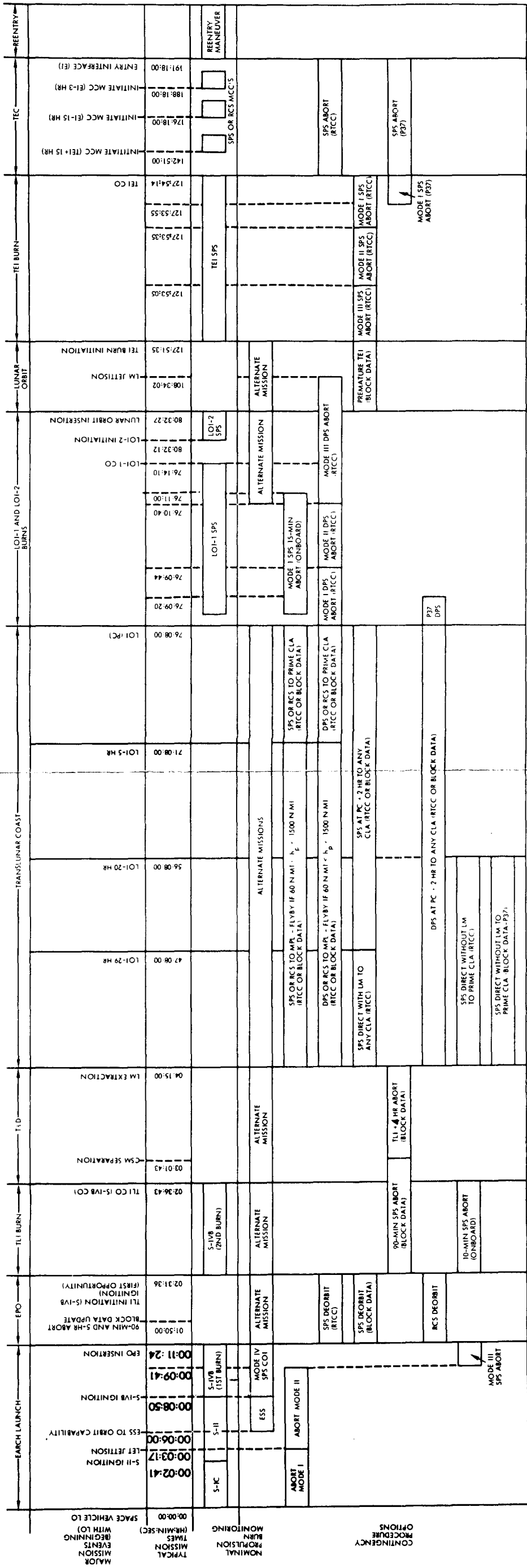
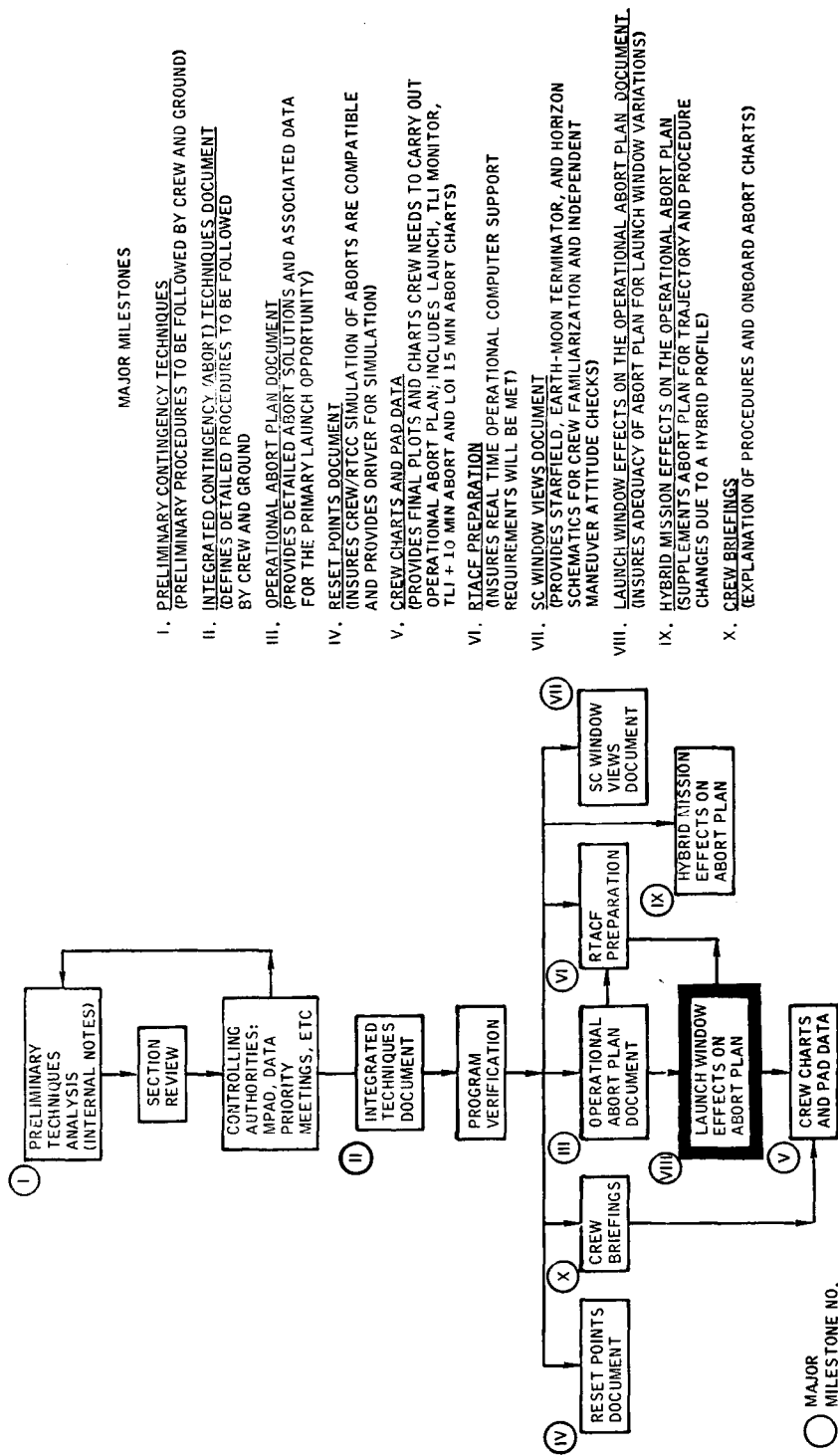


Figure 2-1.- The relationship of the nominal Apollo 10 mission events and the operational abort modes.



- I. PRELIMINARY CONTINGENCY TECHNIQUES  
(PRELIMINARY PROCEDURES TO BE FOLLOWED BY CREW AND GROUND)
- II. INTEGRATED CONTINGENCY (ABORT) TECHNIQUES DOCUMENT  
(DEFINES DETAILED PROCEDURES TO BE FOLLOWED BY CREW AND GROUND)
- III. OPERATIONAL ABORT PLAN DOCUMENT  
(PROVIDES DETAILED ABORT SOLUTIONS AND ASSOCIATED DATA FOR THE PRIMARY LAUNCH OPPORTUNITY)
- IV. RESET POINTS DOCUMENT  
(INSURES CREW/RTCC SIMULATION OF ABORTS ARE COMPATIBLE AND PROVIDES DRIVER FOR SIMULATION)
- V. CREW CHARTS AND PAD DATA  
(PROVIDES FINAL PLOTS AND CHARTS CREW NEEDS TO CARRY OUT OPERATIONAL ABORT PLAN; INCLUDES LAUNCH, TLI MONITOR, TLI + 10 MIN ABORT AND LOI 15 MIN ABORT CHARTS)
- VI. RTACF PREPARATION  
(INSURES REAL TIME OPERATIONAL COMPUTER SUPPORT REQUIREMENTS WILL BE MET)
- VII. SC WINDOW VIEWS DOCUMENT  
(PROVIDES STARFIELD, EARTH-MOON TERMINATOR, AND HORIZON SCHEMATICS FOR CREW FAMILIARIZATION AND INDEPENDENT MANEUVER ATTITUDE CHECKS)
- VIII. LAUNCH WINDOW EFFECTS ON THE OPERATIONAL ABORT PLAN DOCUMENT  
(INSURES ADEQUACY OF ABORT PLAN FOR LAUNCH WINDOW VARIATIONS)
- IX. HYBRID MISSION EFFECTS ON THE OPERATIONAL ABORT PLAN  
(SUPPLEMENTS ABORT PLAN FOR TRAJECTORY AND PROCEDURE CHANGES DUE TO A HYBRID PROFILE)
- X. CREW BRIEFINGS  
(EXPLANATION OF PROCEDURES AND ONBOARD ABORT CHARTS)

Figure 2-2.- Major Apollo F and G milestones for the Contingency Analysis Section.

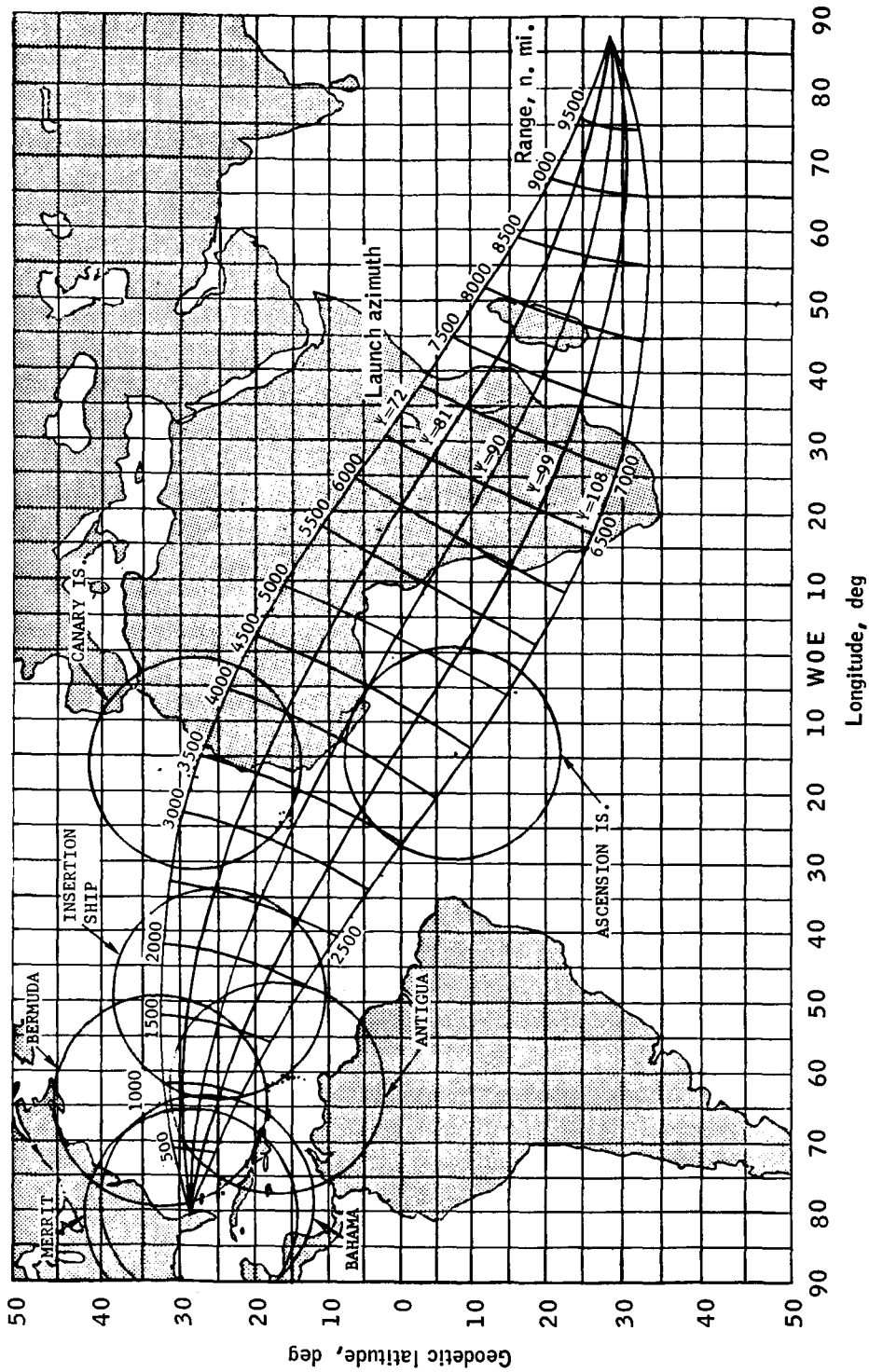


Figure 4-1.- Constant range lines and ground tracks for the Apollo 10 (Mission F) launch phase.

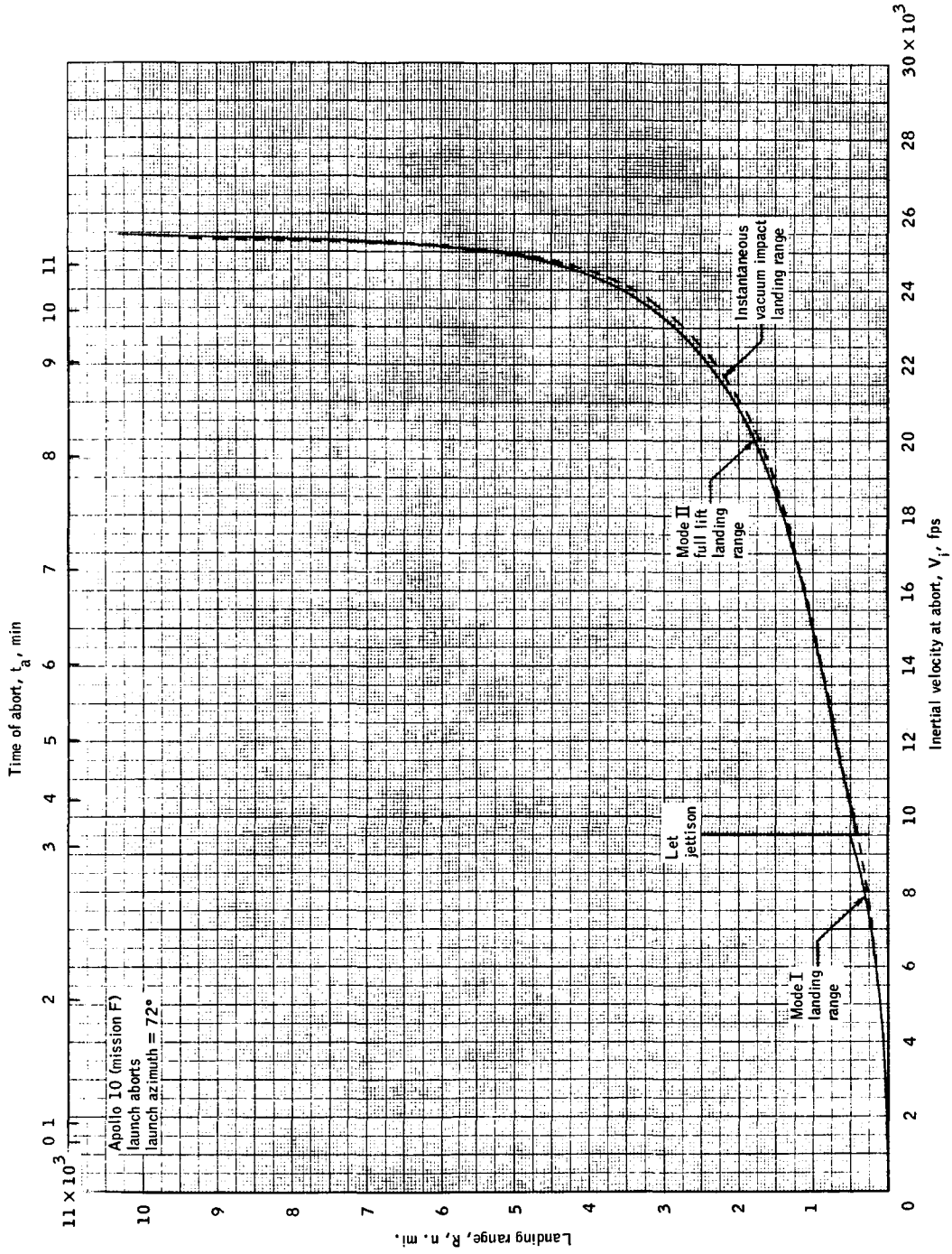


Figure 4-2.- Landing range history versus velocity at abort for a typical launch azimuth.

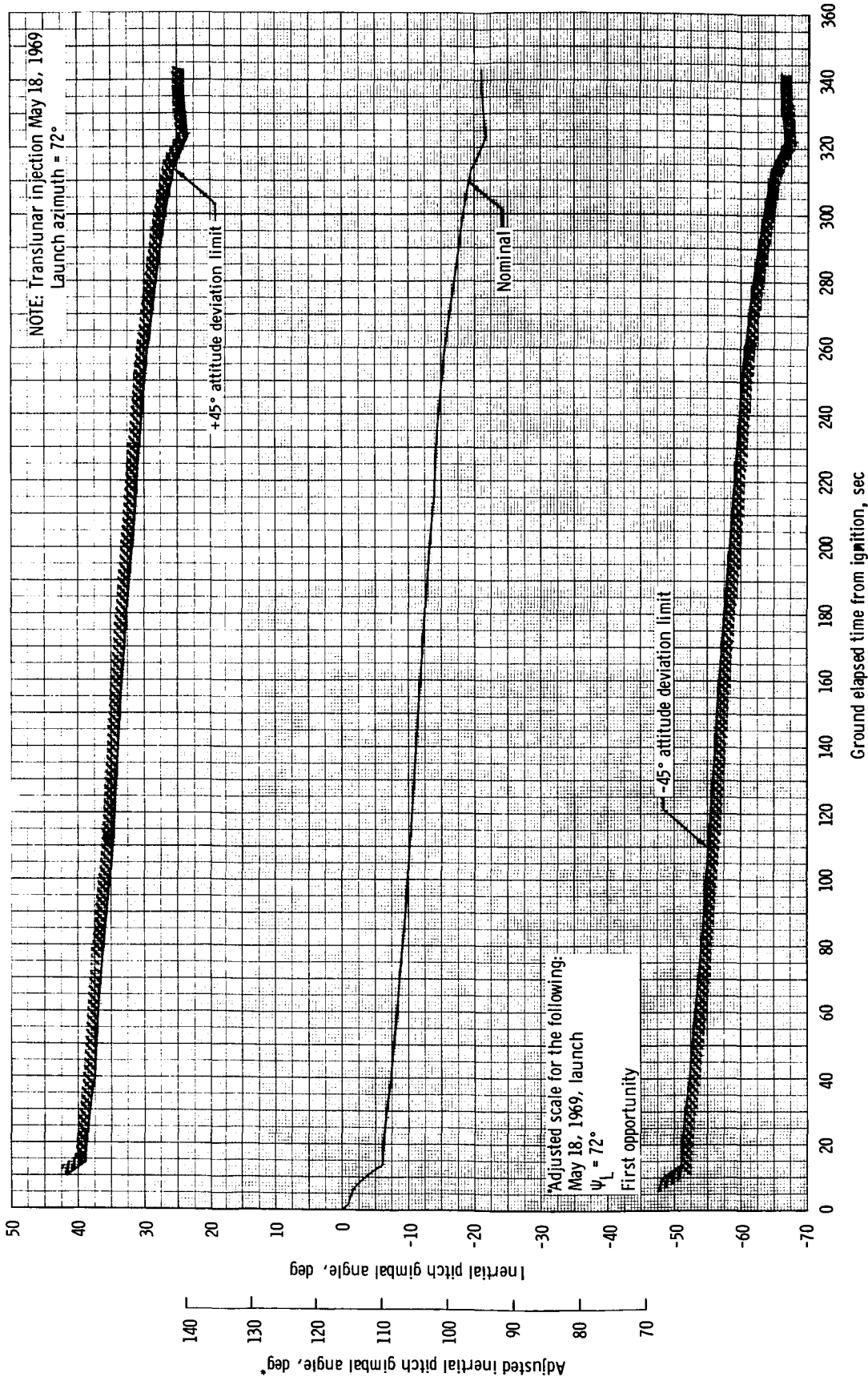
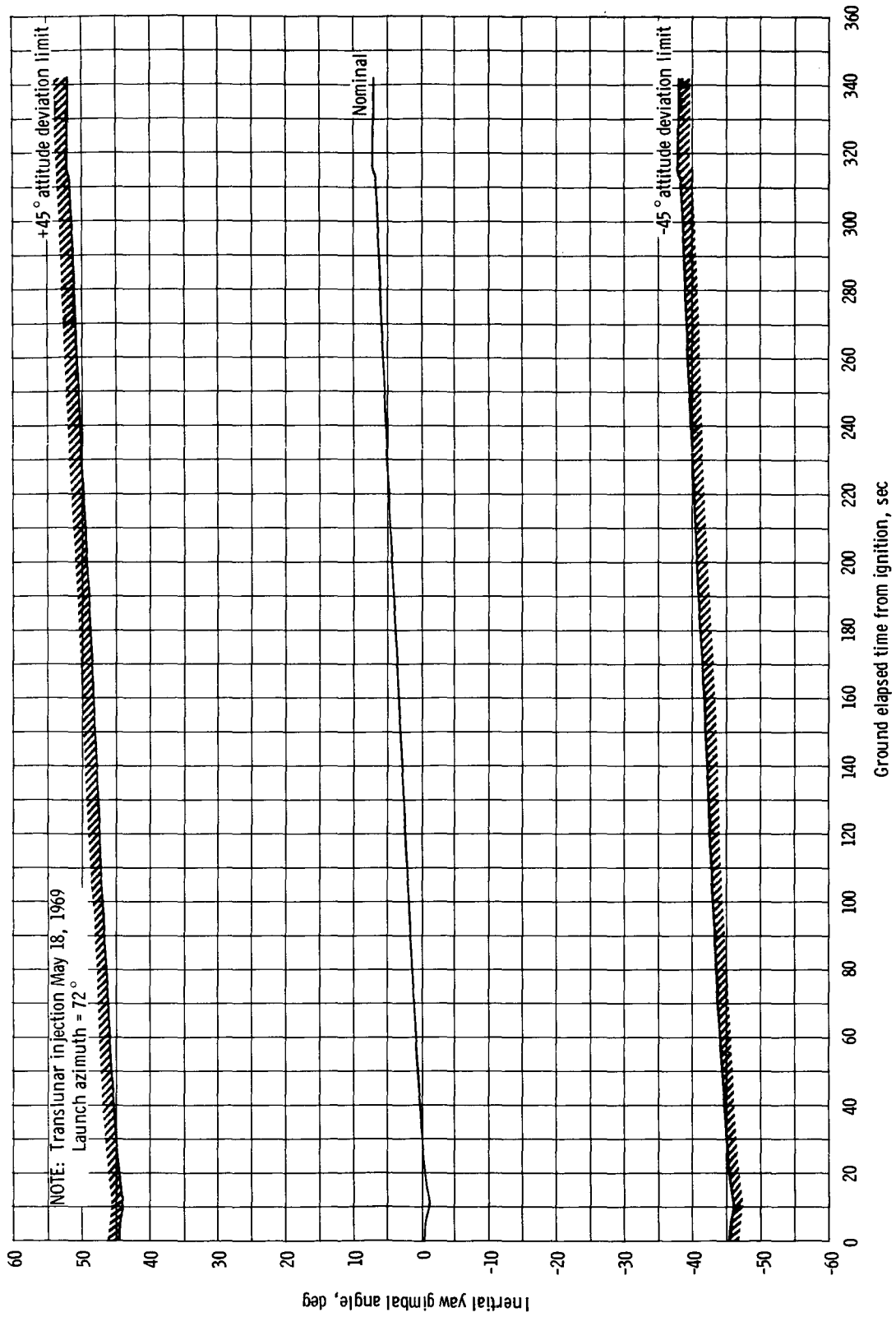
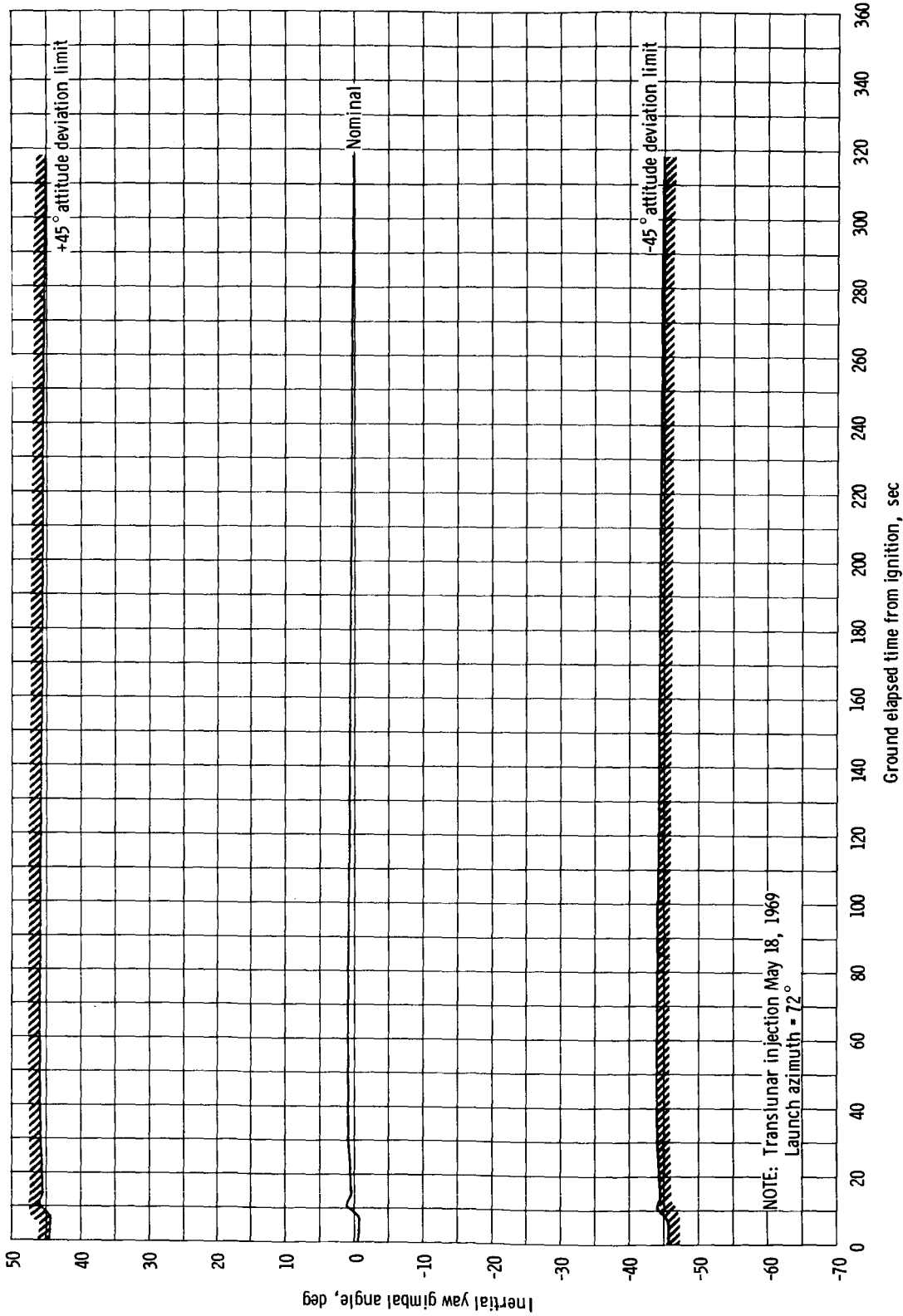


Figure 5-1. - TL1 pitch gimbal angle history and attitude deviation limits for first opportunity.



(a) First opportunity.

Figure 5-2. - TLI yaw gimbal angle history and attitude deviation limits.



(b) Second opportunity.

Figure 5-2.- Concluded.



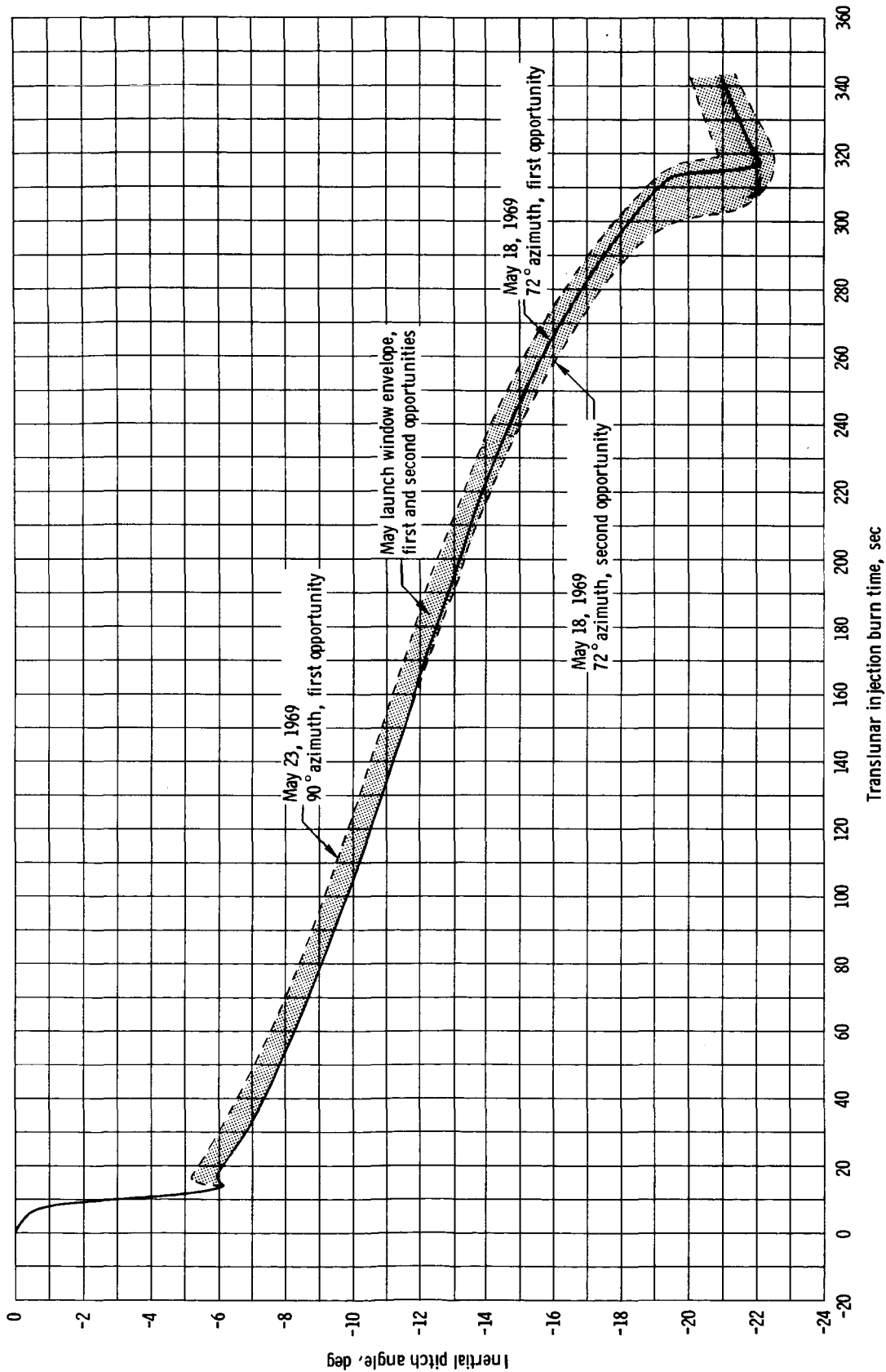


Figure 5-3. - Envelope of May launch window pitch angle excursions through TLI.

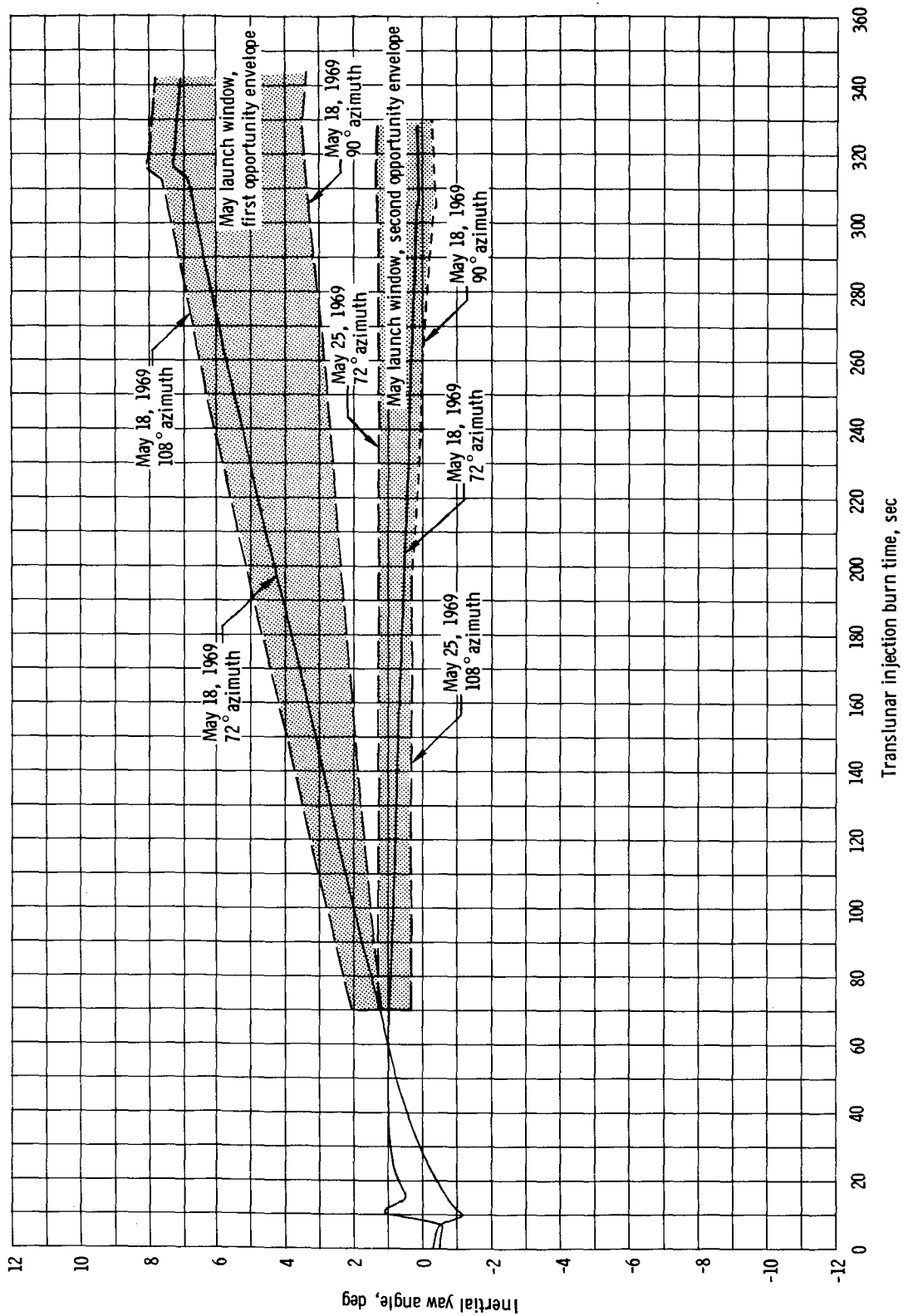


Figure 5. - 4. - Envelope of May launch window yaw angle excursions through TLI.

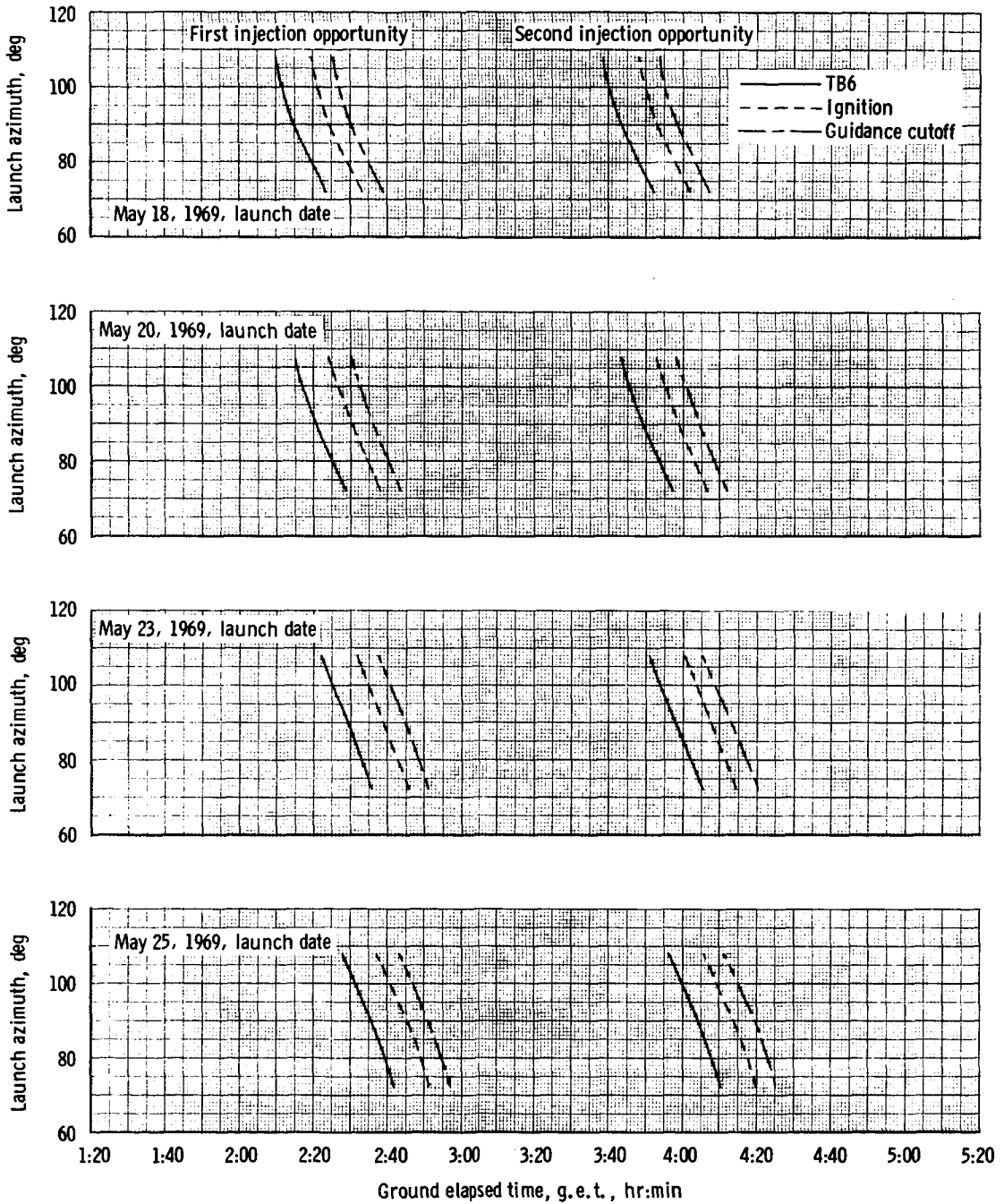


Figure 5-5. - Ground elapsed time at TLI for the May launch window.

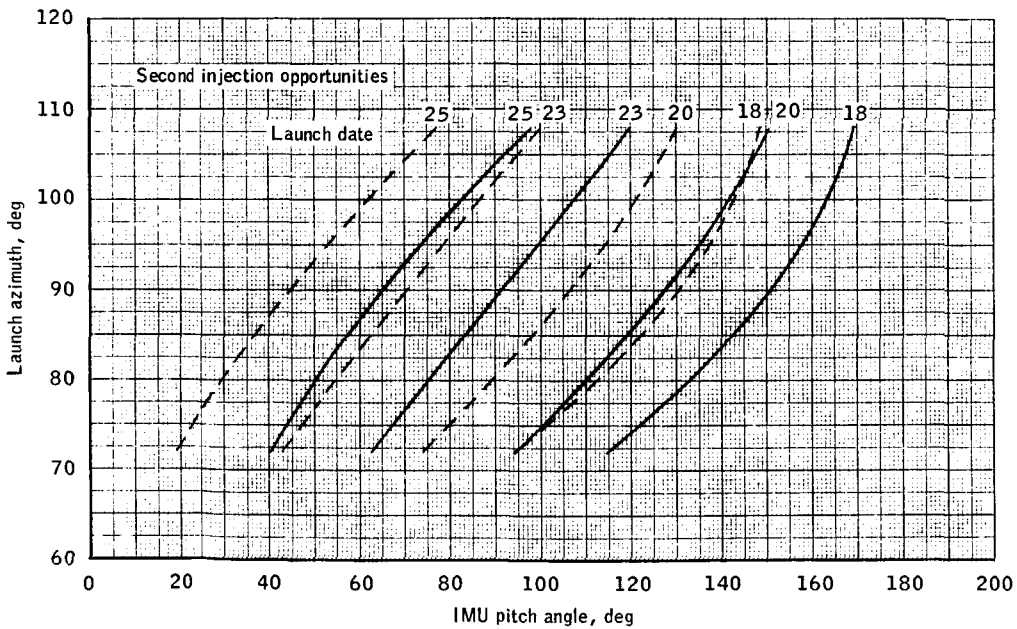
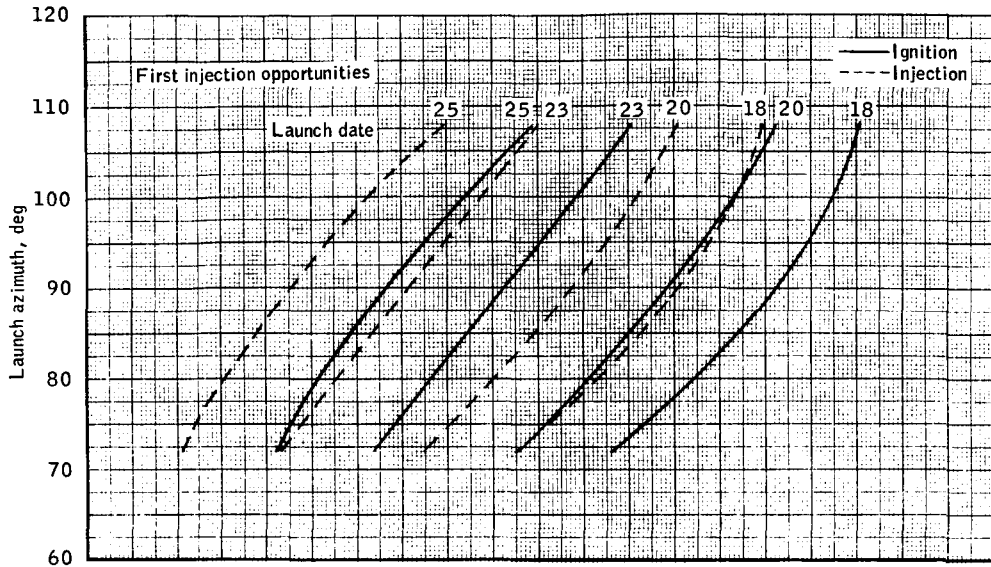


Figure 5-6.- IMU pitch gimbal angles at TLI for the May launch window.

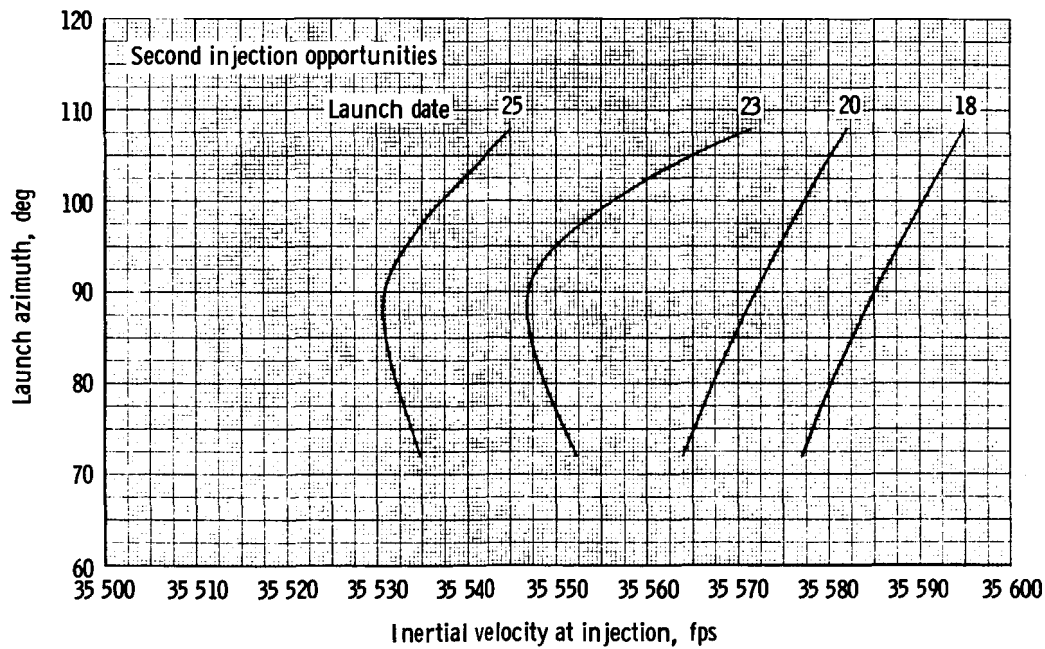
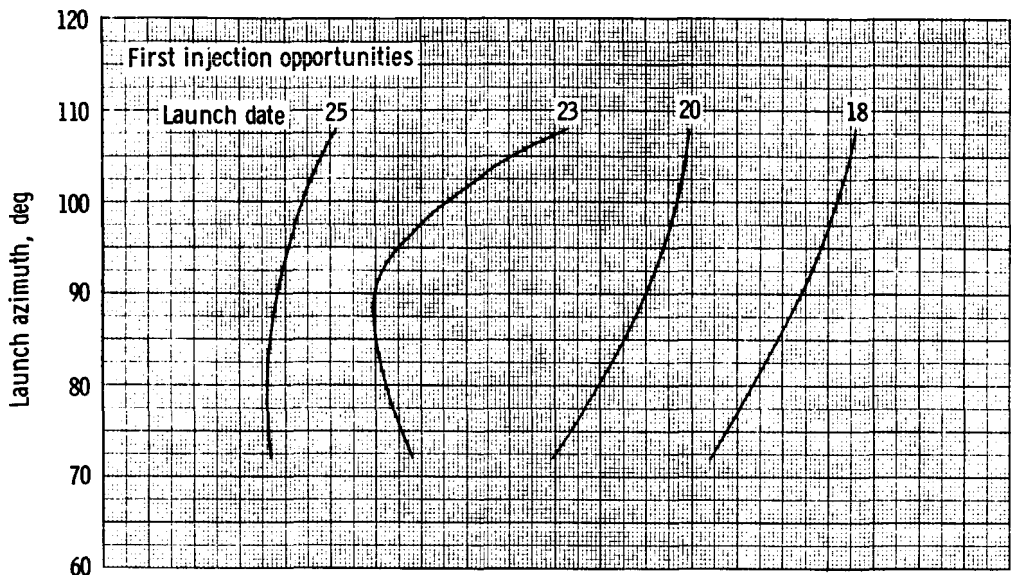
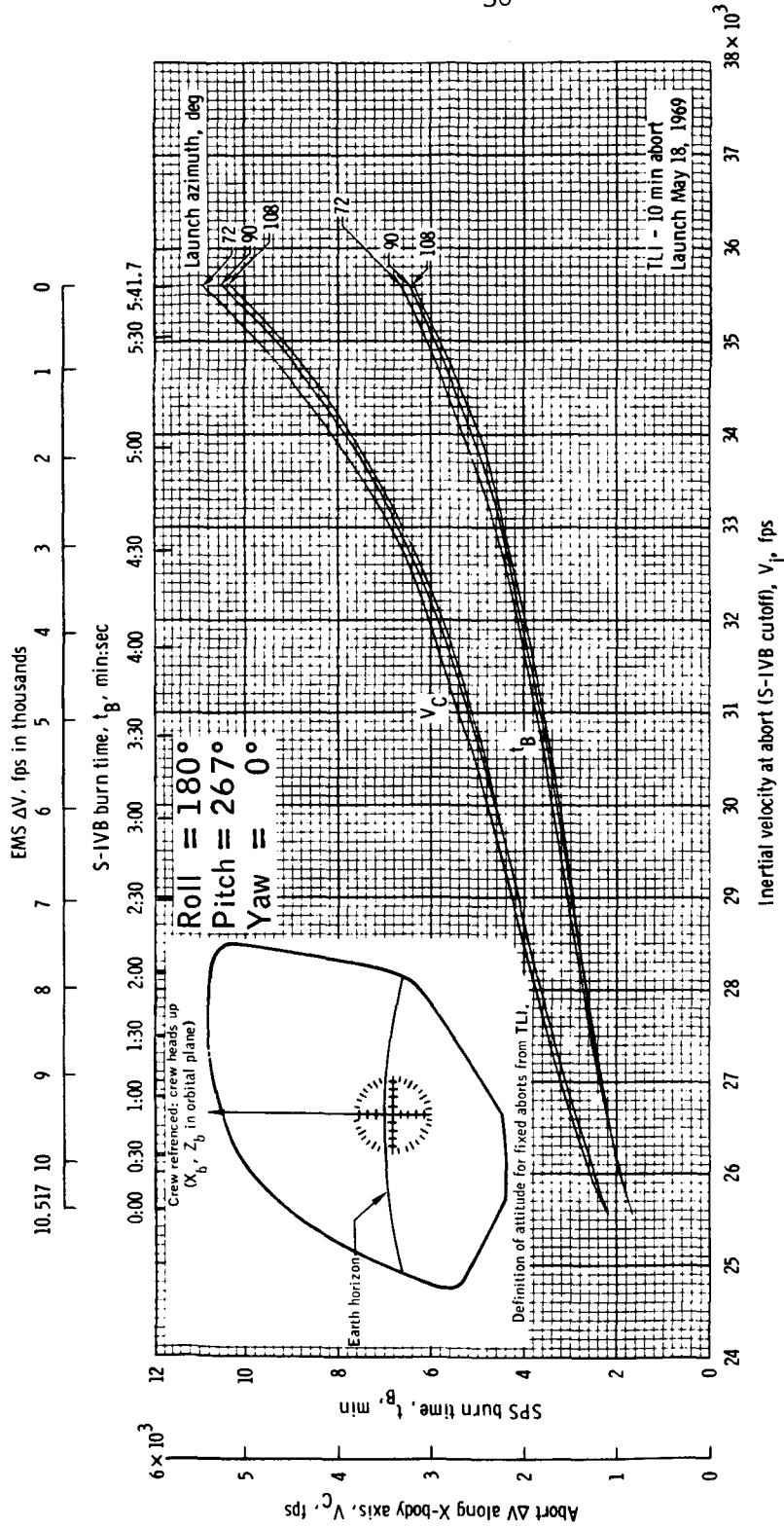
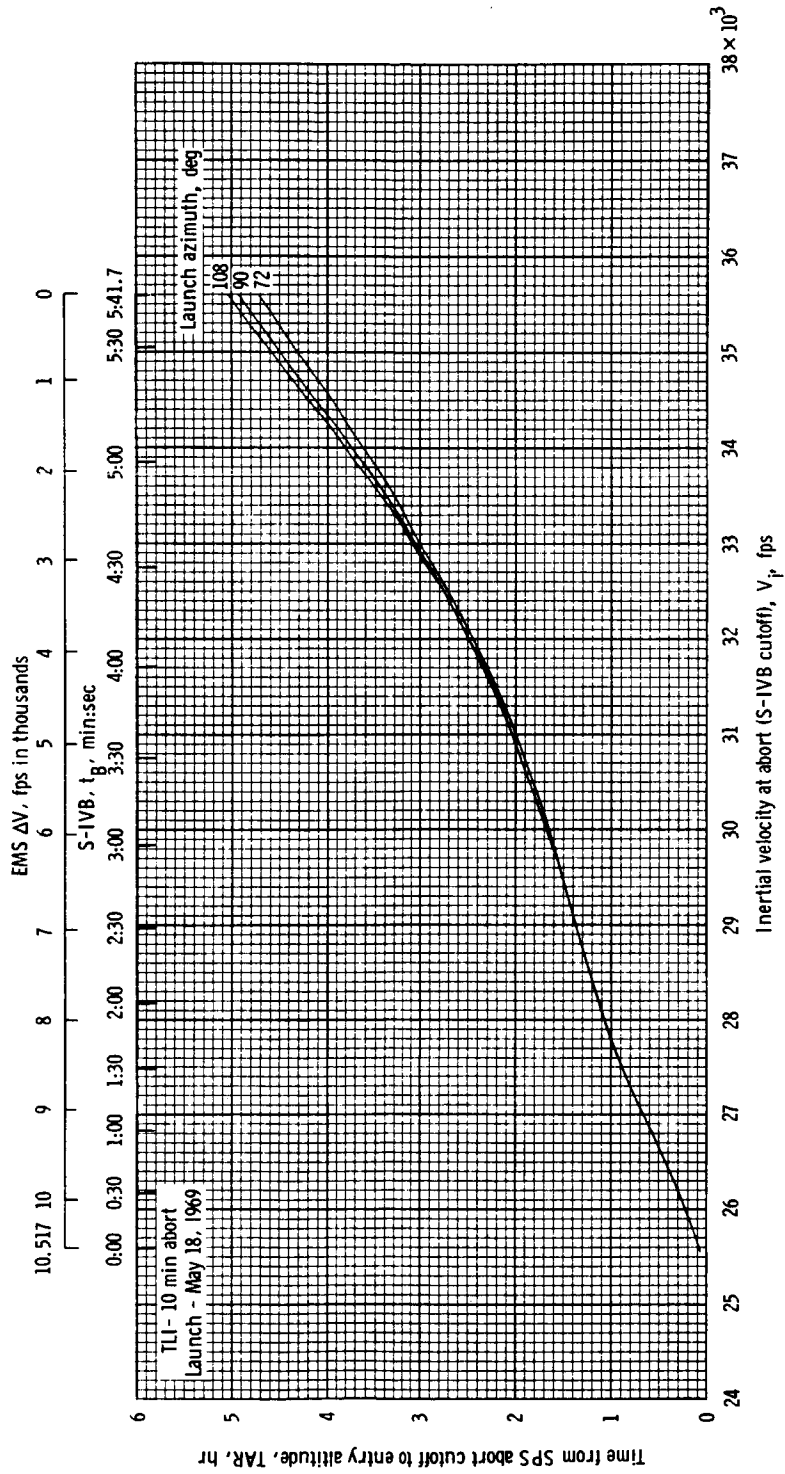


Figure 5-7. - Inertial velocity at translunar injection for the May launch window.



(a) Abort  $\Delta V$  versus inertial velocity.

Figure 5-8.- TLI plus 10 minute abort crew chart.



(b) Time from abort to entry versus inertial velocity.

Figure 5-8.- Concluded.

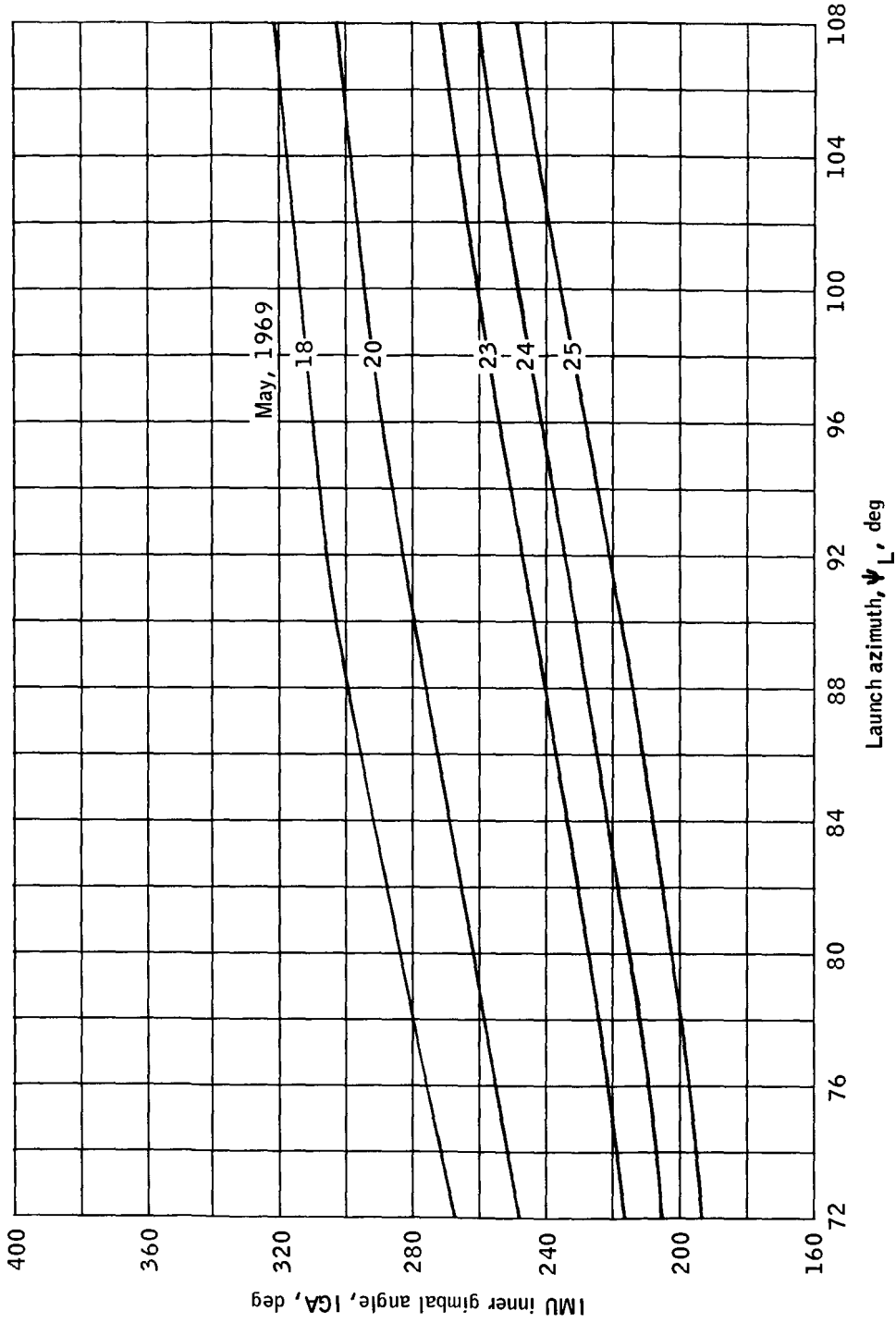
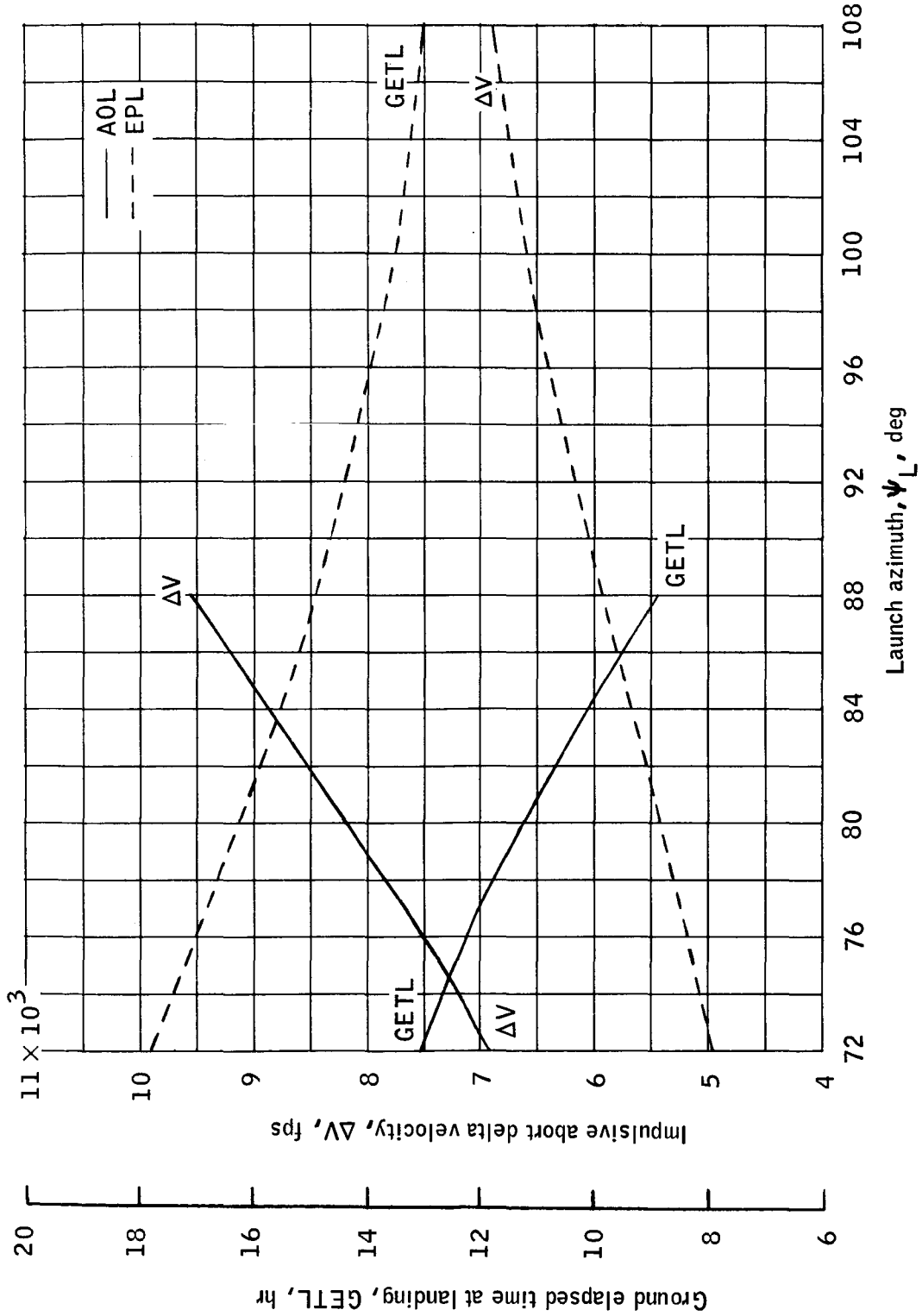


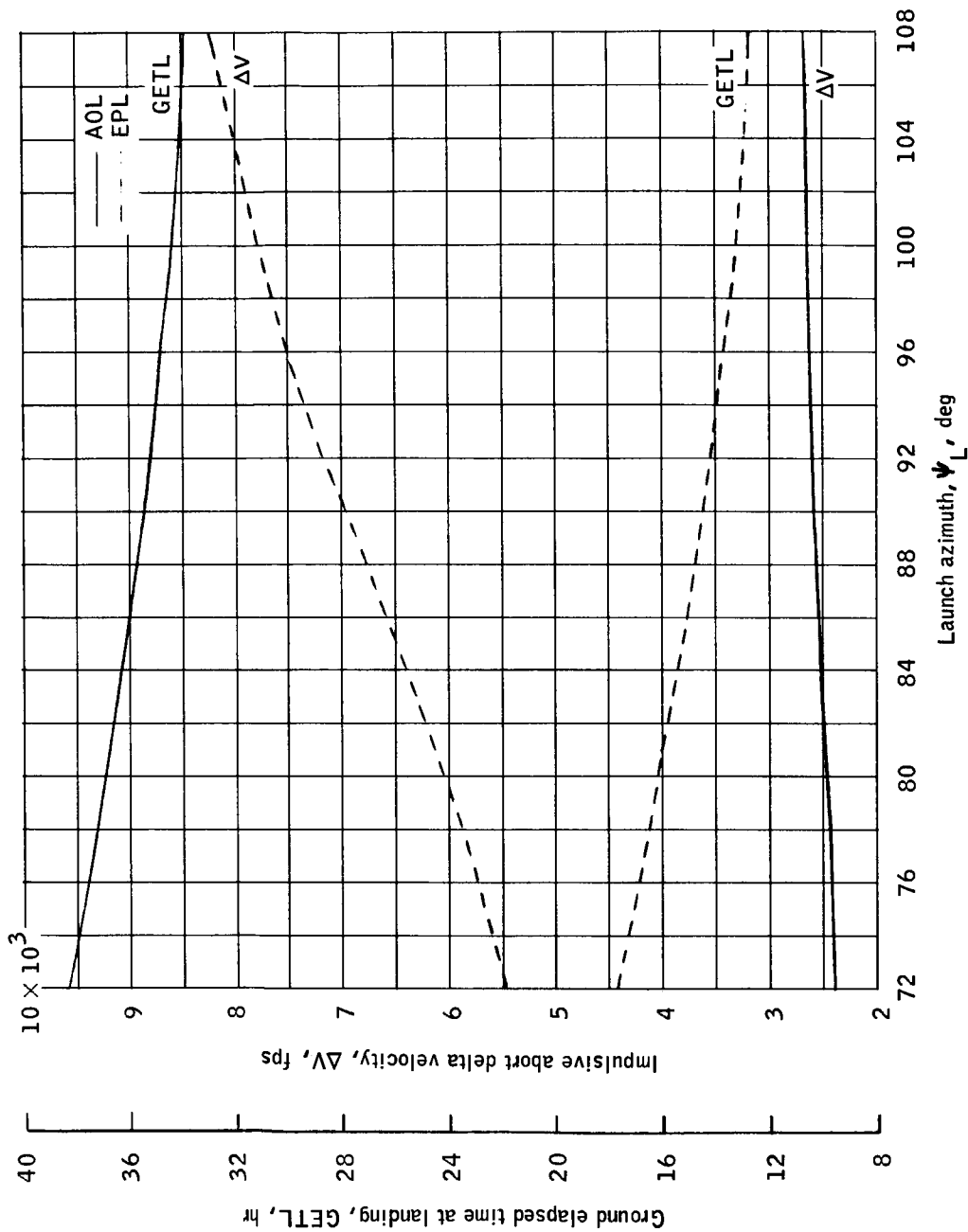
Figure 5-9.- IMU inner gimbal angle at TLI cutoff plus 10 minutes corresponding to horizon reference attitude for abort.





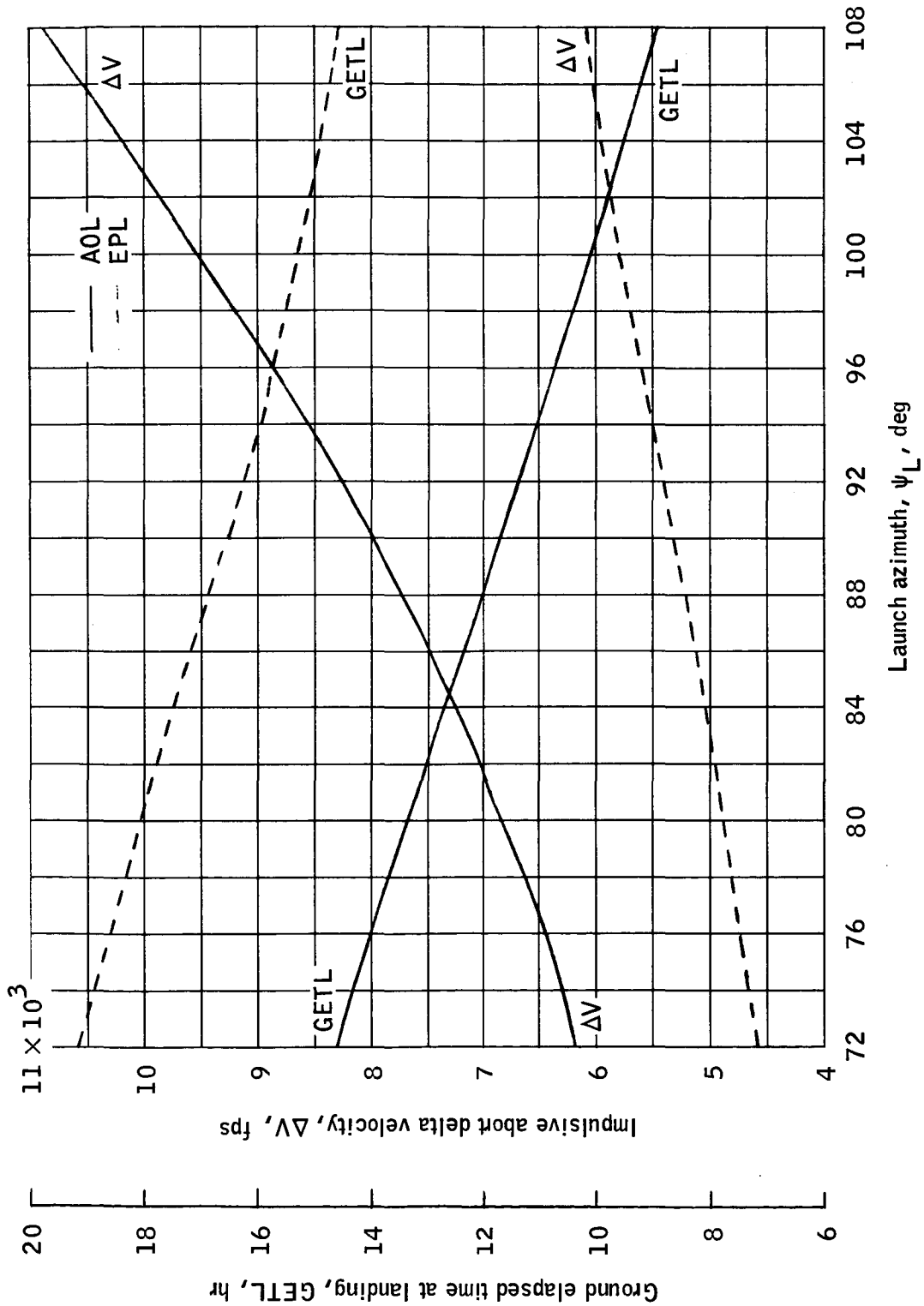
(a) First injection opportunity, May 18, 1969.

Figure 5-10.- Abort delta velocity and ground elapsed time at landing as functions of launch azimuth for TLI plus 90 minute aborts.



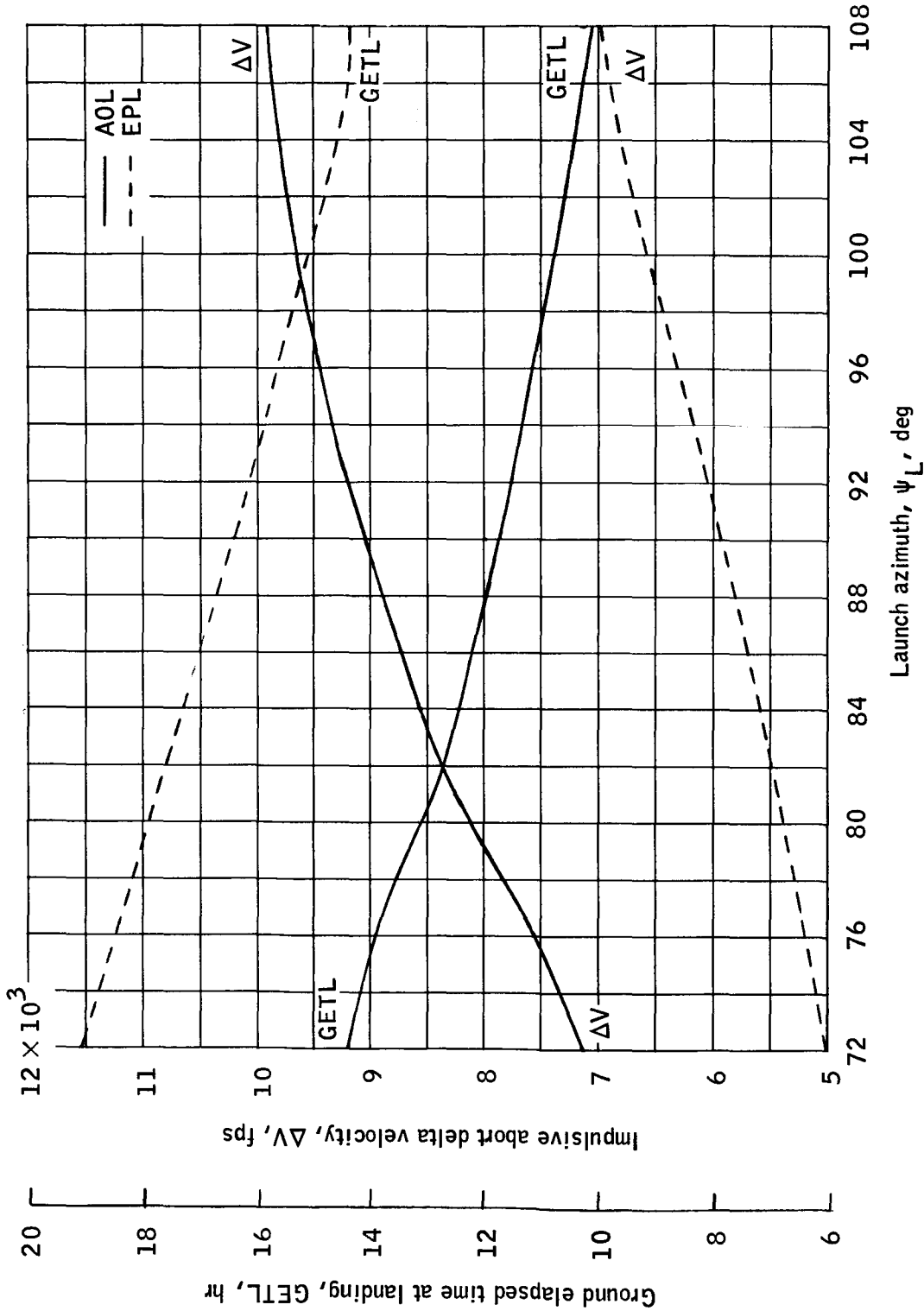
(b) Second injection opportunity, May 18, 1969.

Figure 5-10.- Continued.



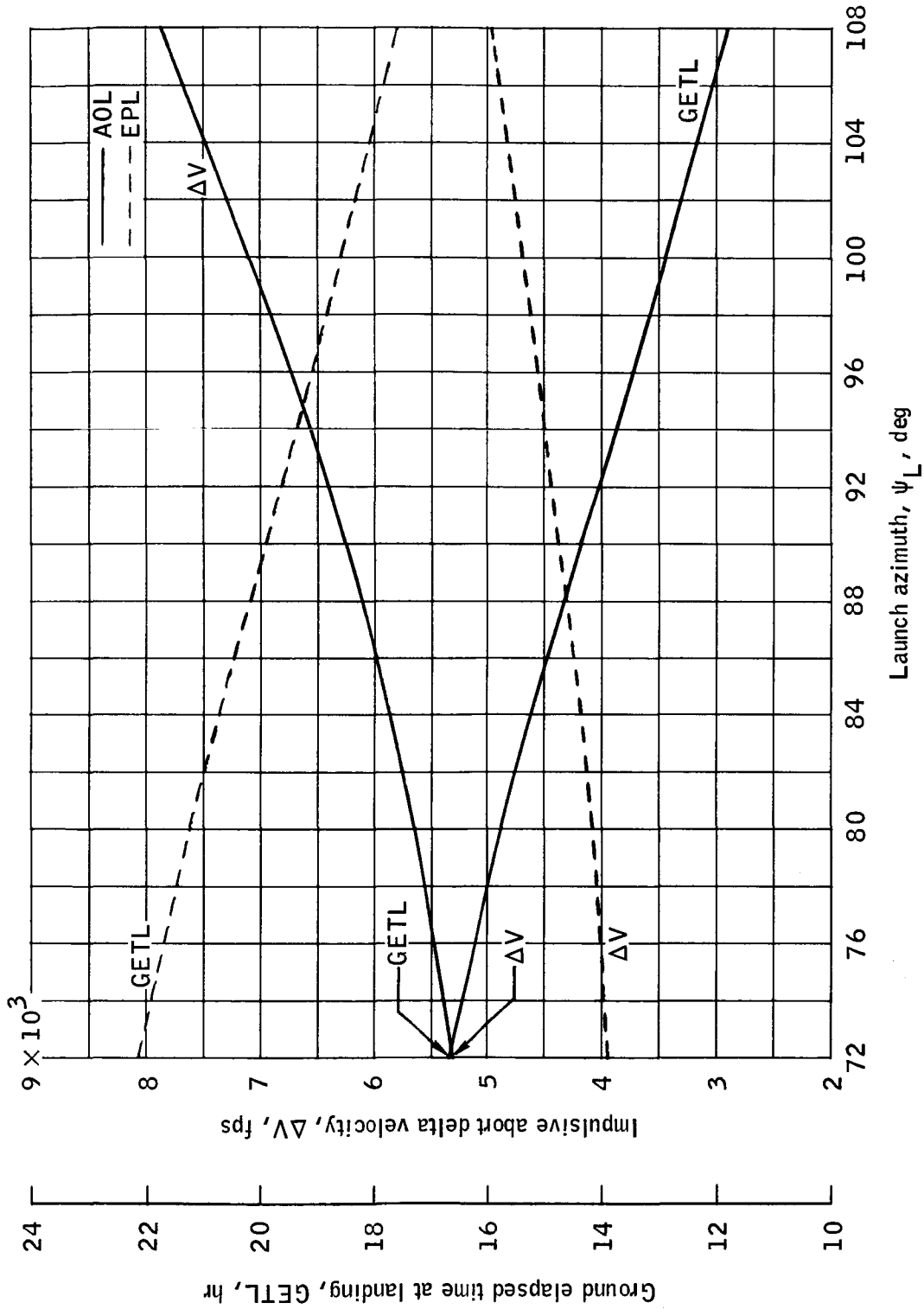
(c) First injection opportunity, May 20, 1969.

Figure 5-10.- Continued.



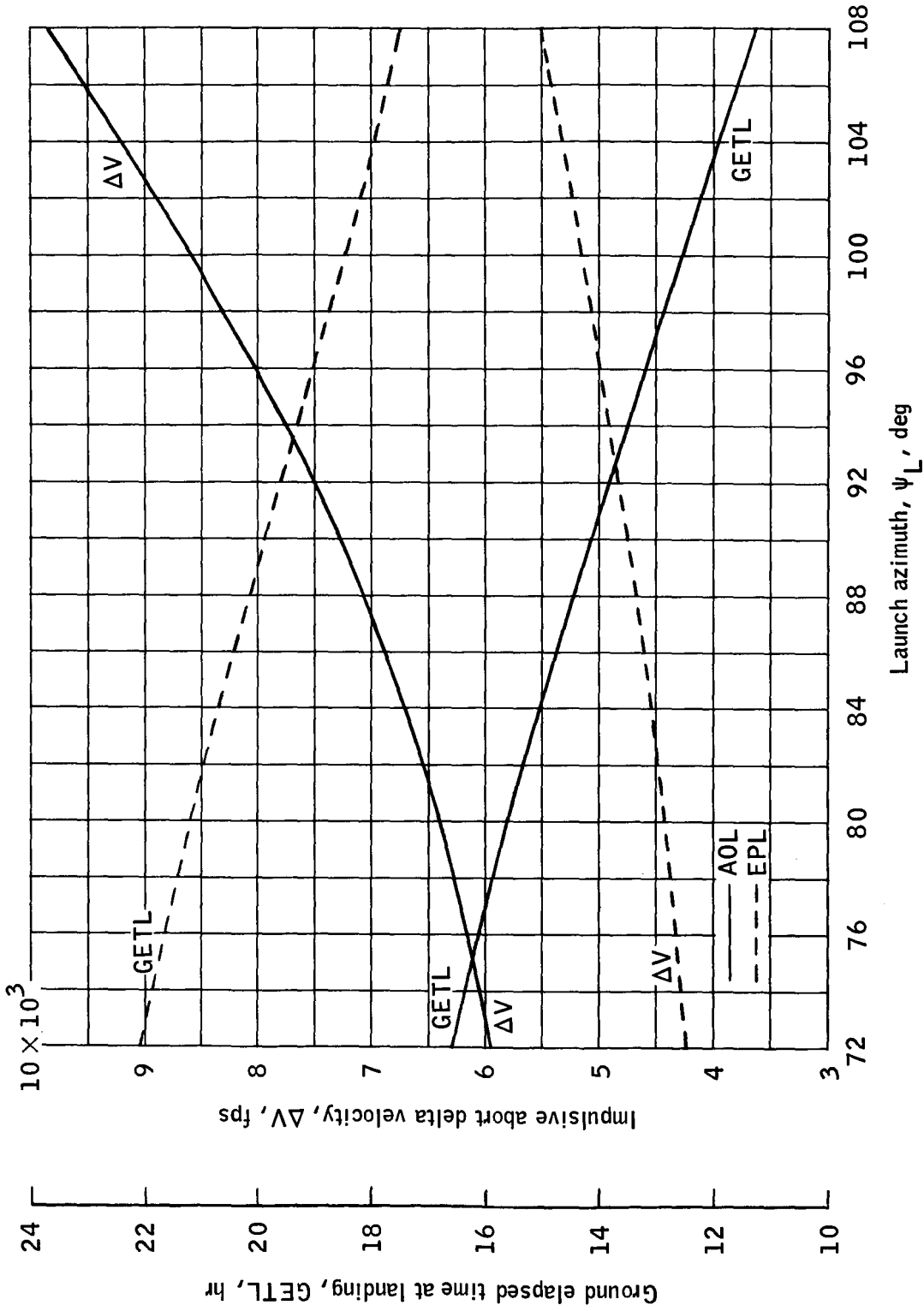
(d) Second injection opportunity, May 20, 1969.

Figure 5-10. - Continued.



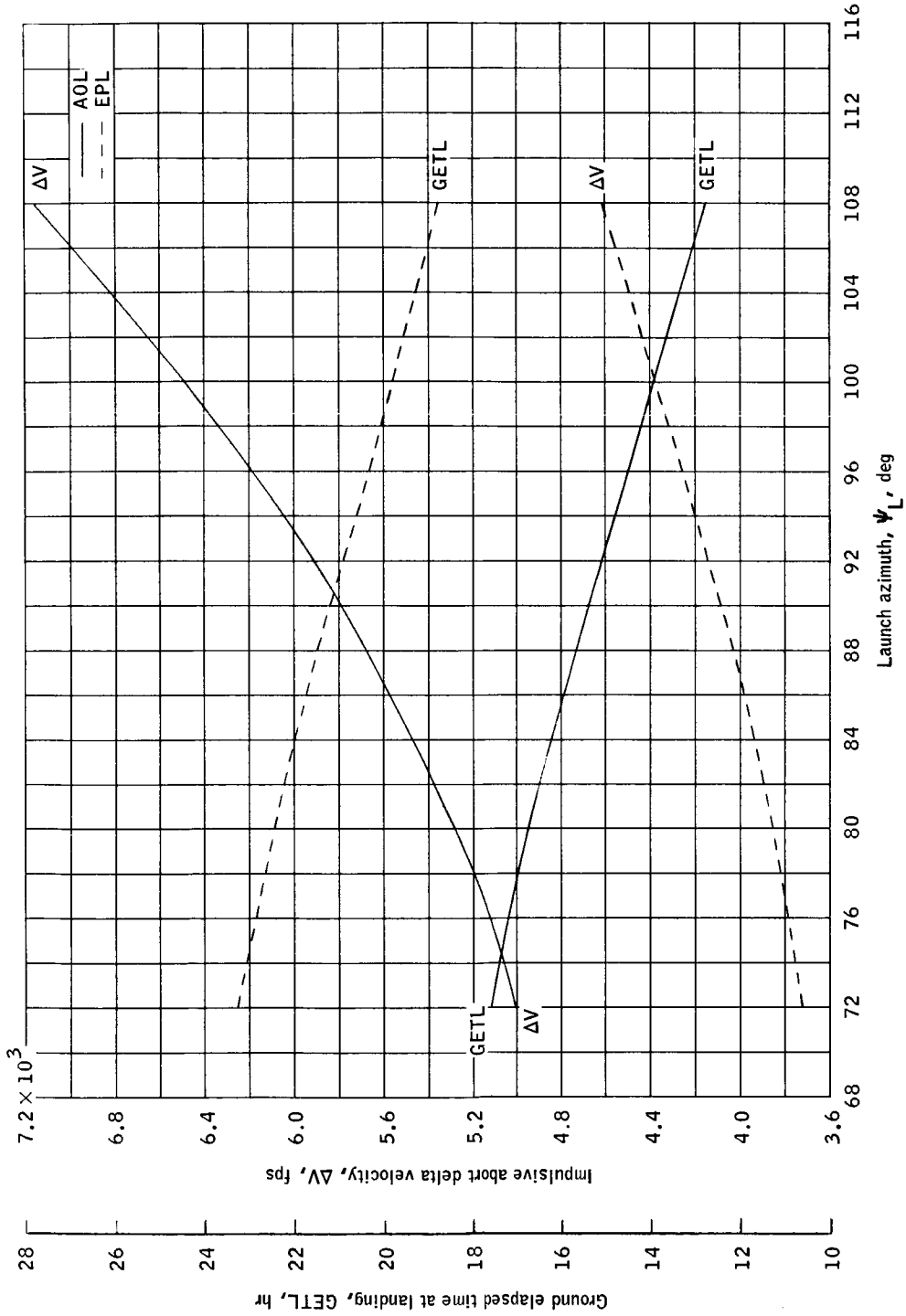
(e) First injection opportunity, May 23, 1969.

Figure 5-10.- Continued.



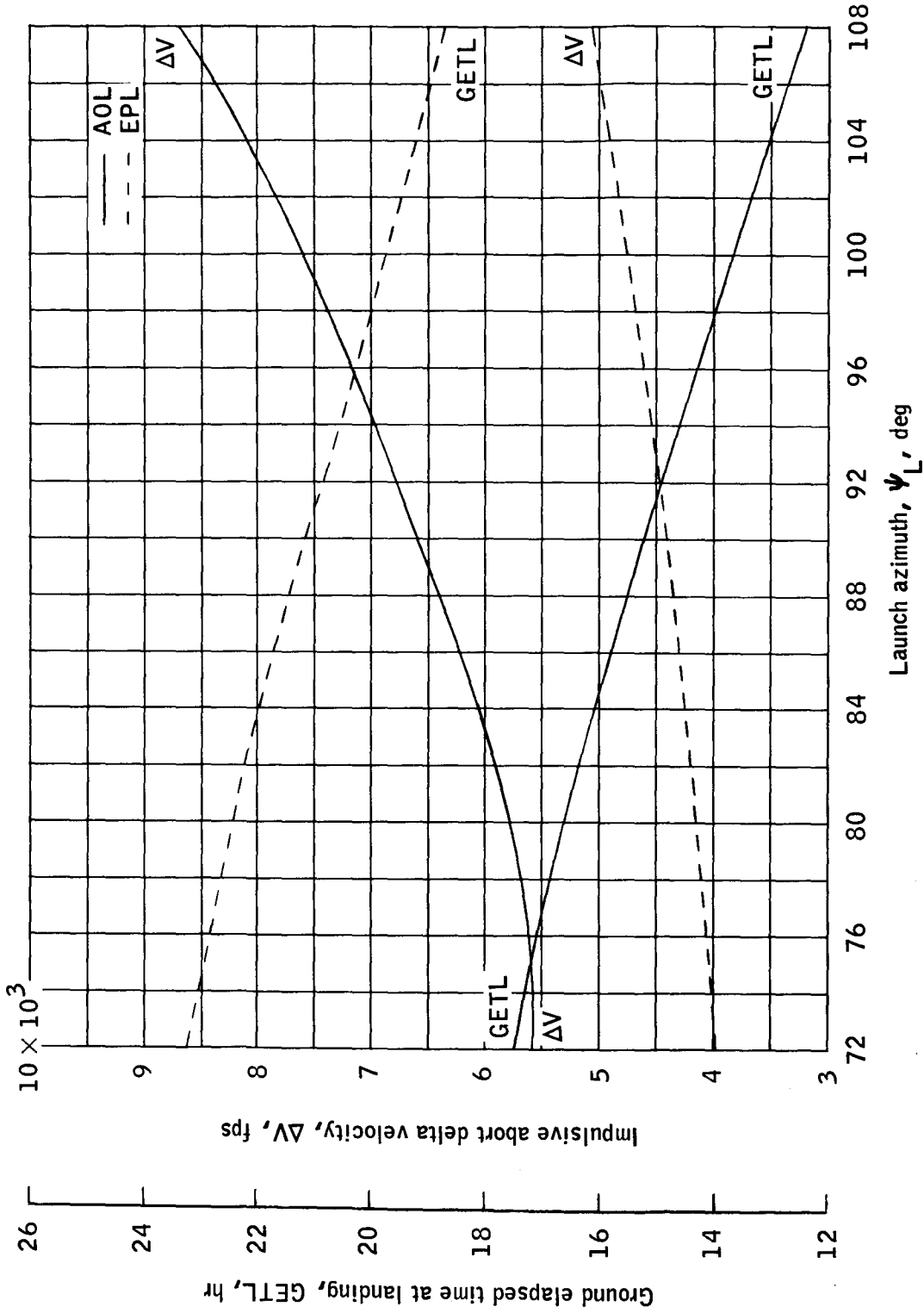
(f) Second injection opportunity, May 23, 1969.

Figure 5-10.- Continued.



(g) First injection opportunity, May 24, 1969.

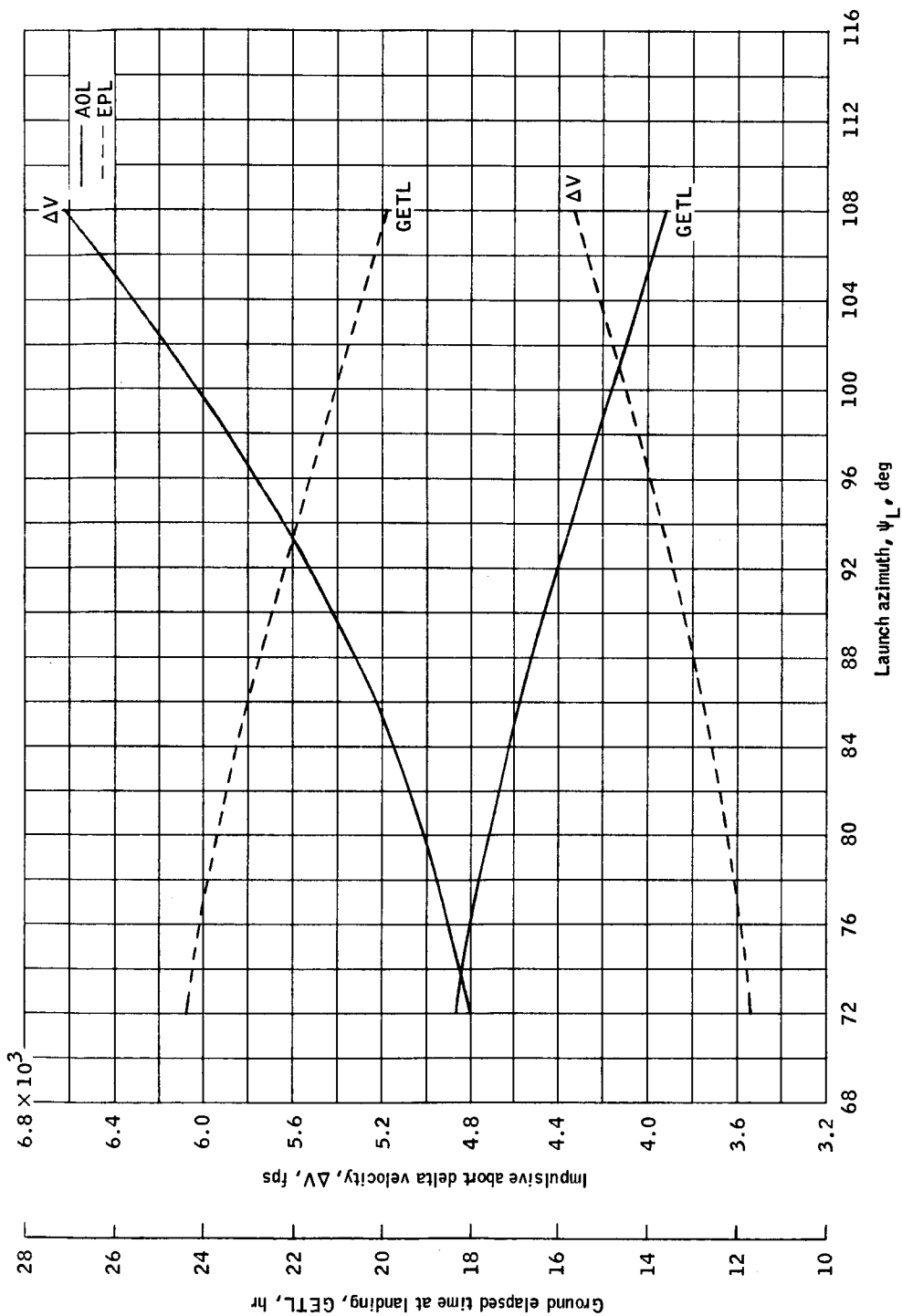
Figure 5-10. - Continued.



(h) Second injection opportunity, May 24, 1969.

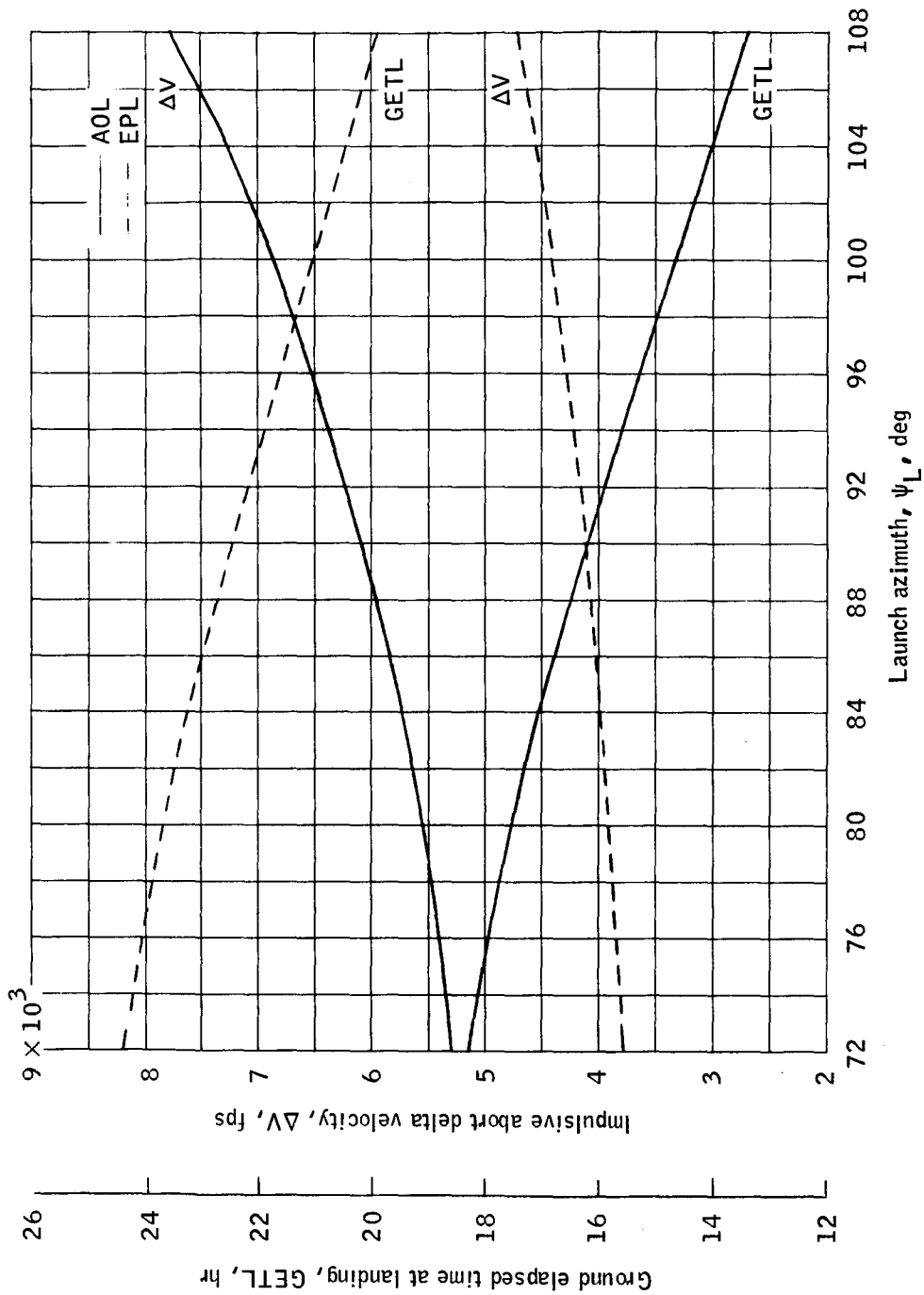
Figure 5-10.- Continued.





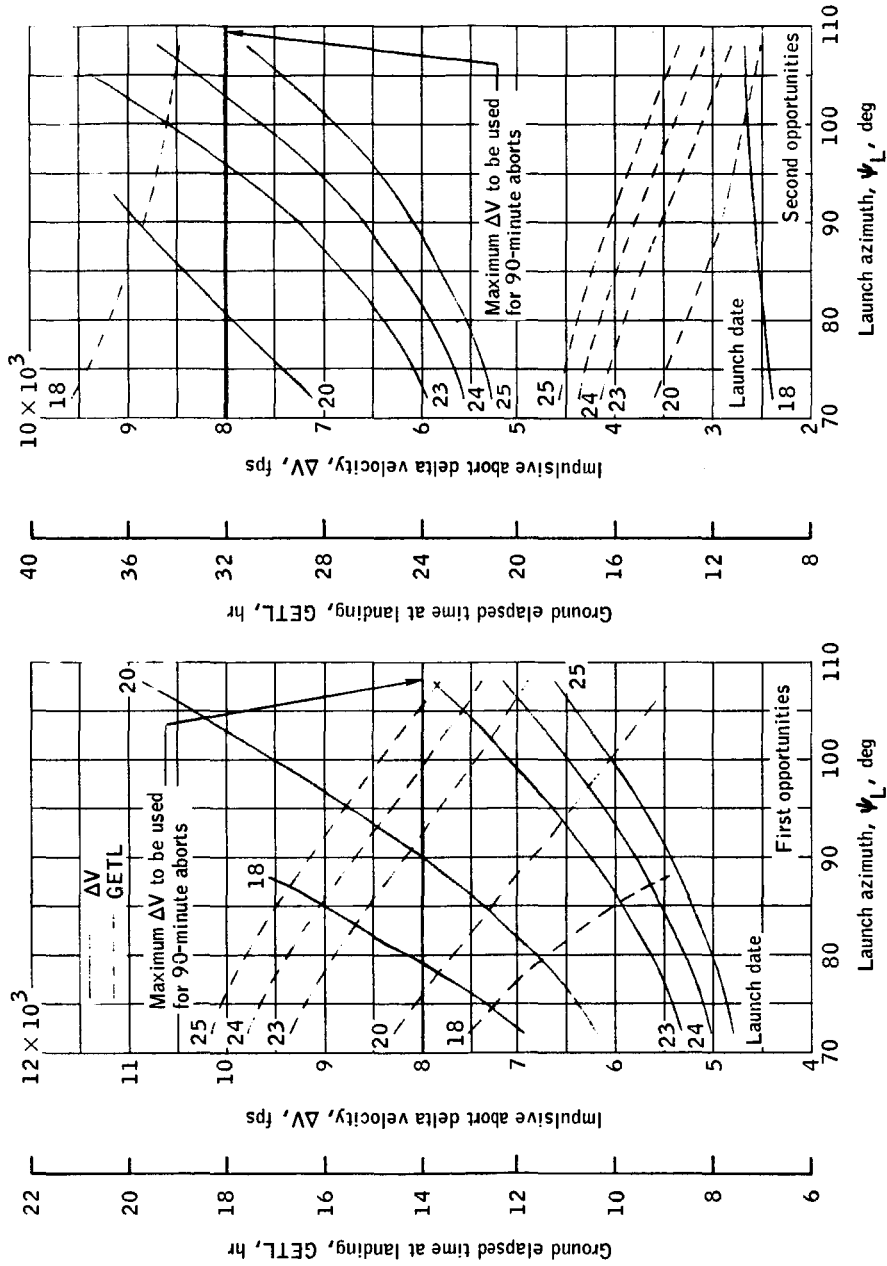
(1) First injection opportunity, May 25, 1969.

Figure 5-10.- Continued.



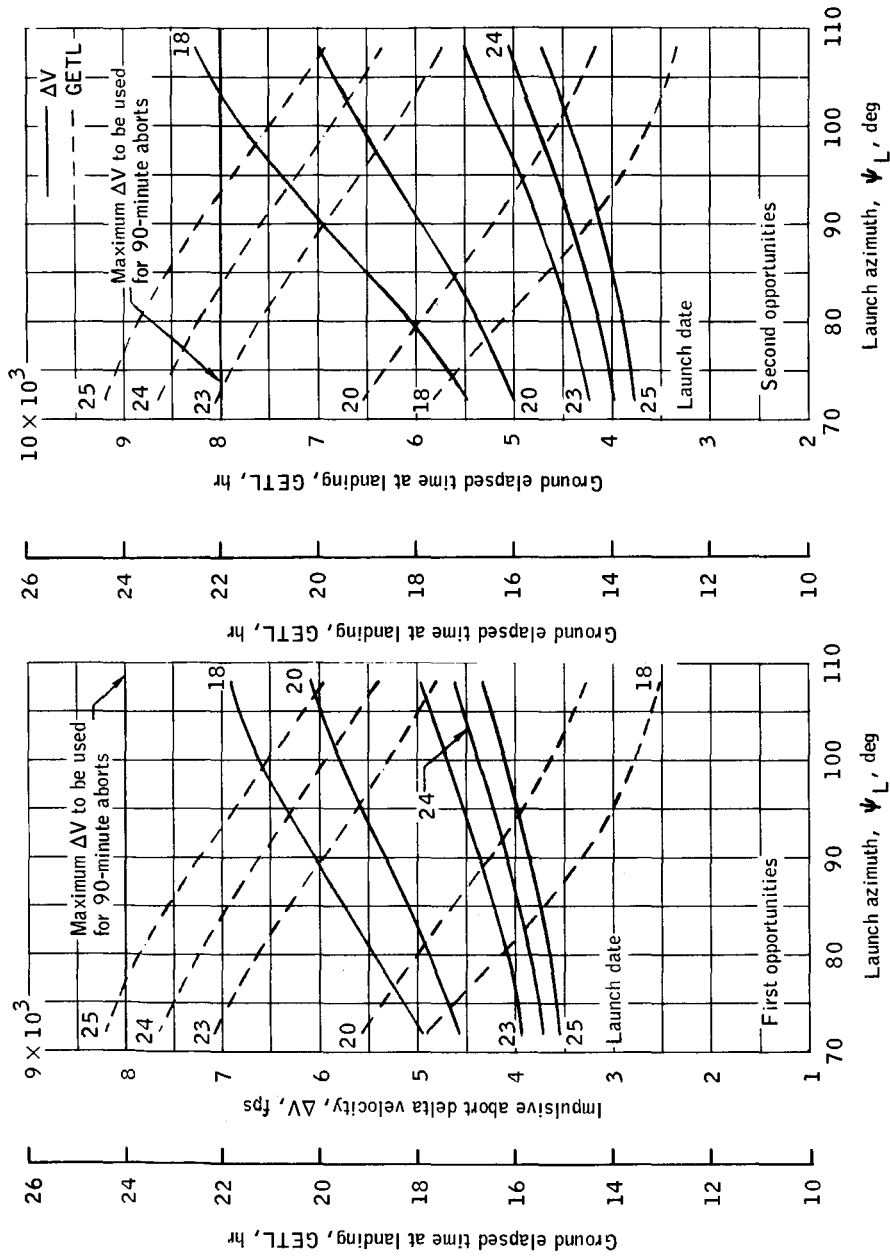
(j) Second injection opportunity, May 25, 1969.

Figure 5-10.- Concluded.

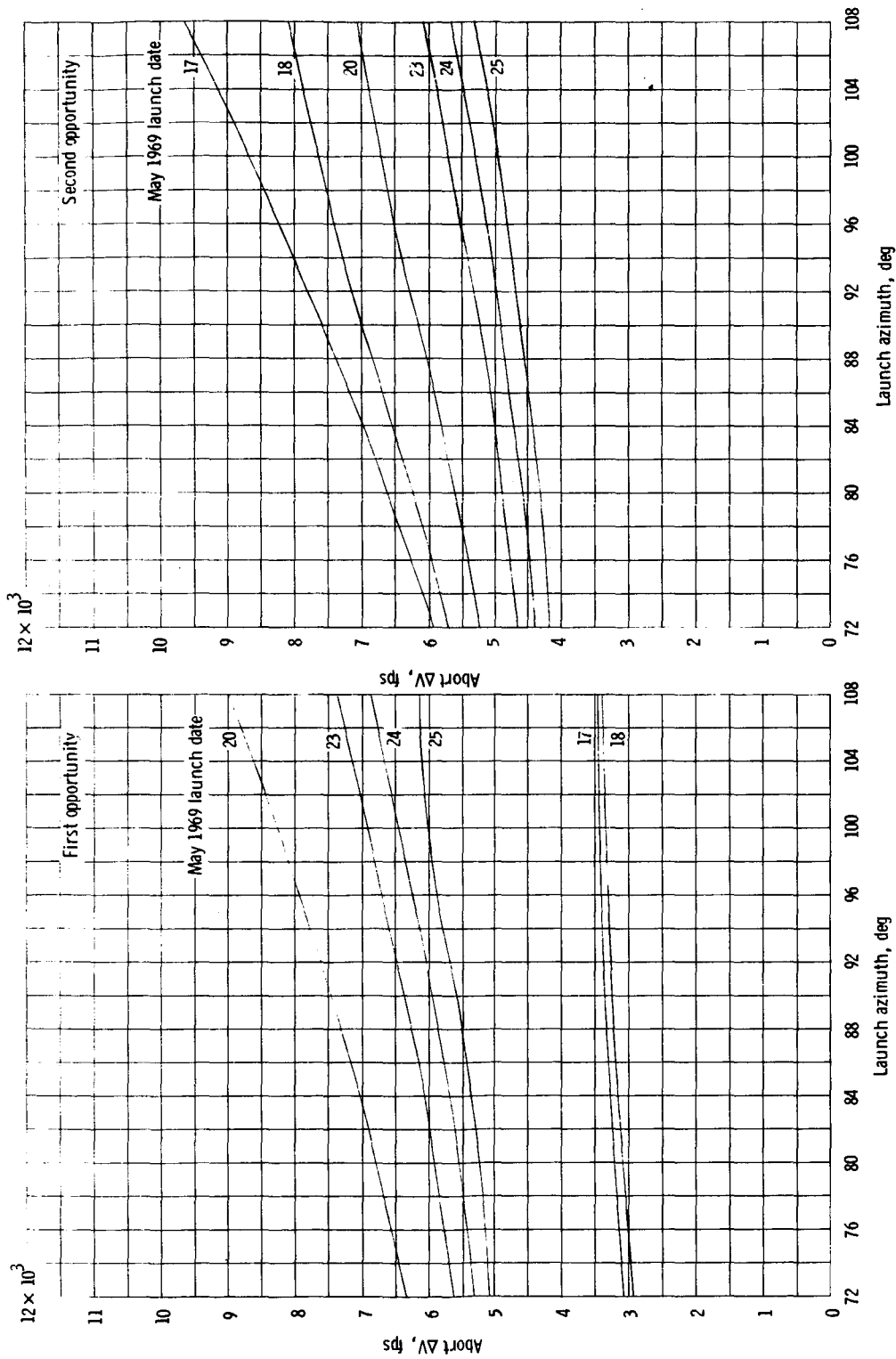


(a) Atlantic ocean line.

Figure 5-11.- Summary of abort delta velocity and ground elapsed time at landing as functions of launch azimuth for TLI plus 90-minute aborts for the May 1969 launch window.

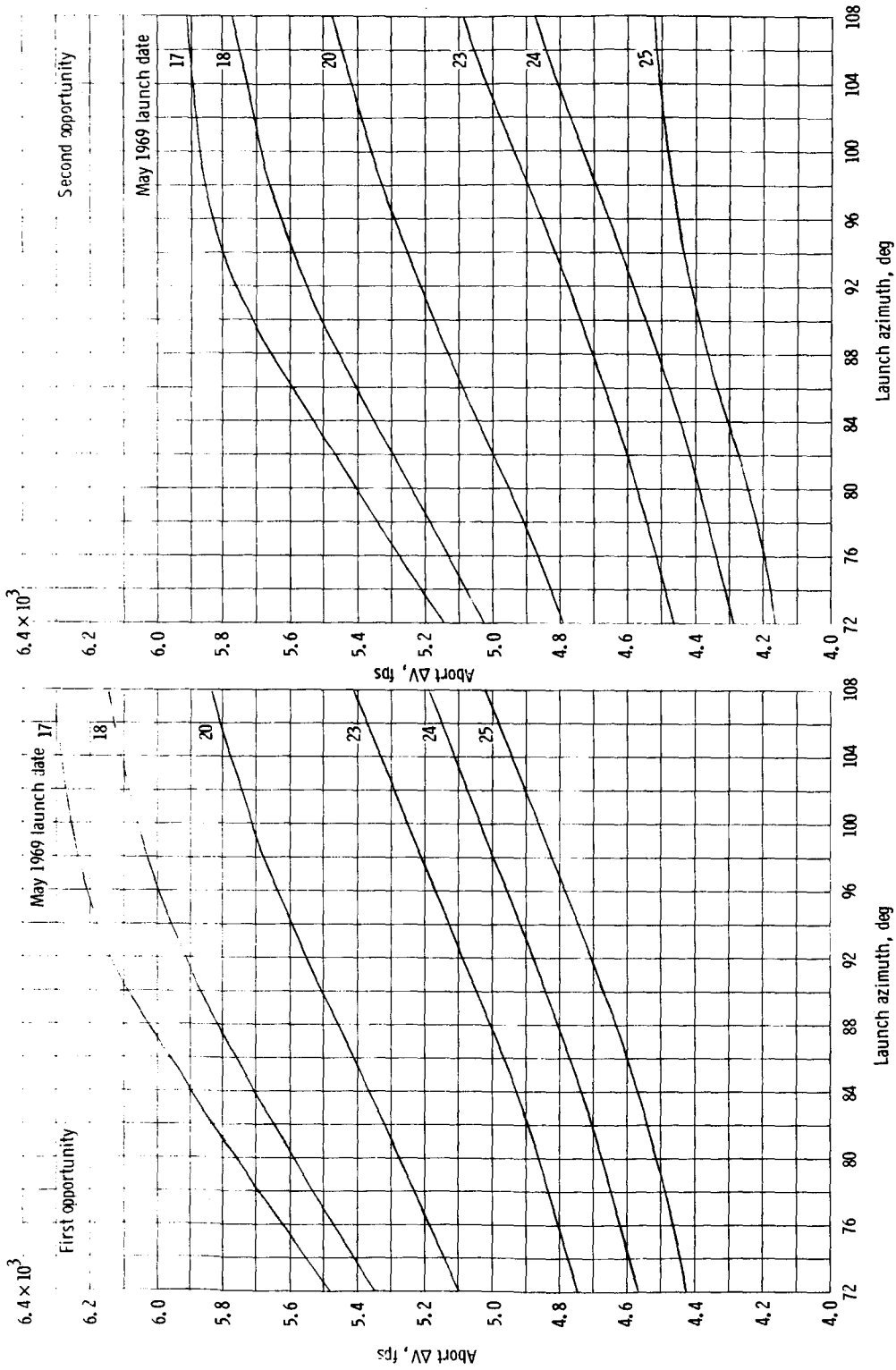


(b) Eastern Pacific line.  
 Figure 5-11. - Concluded.



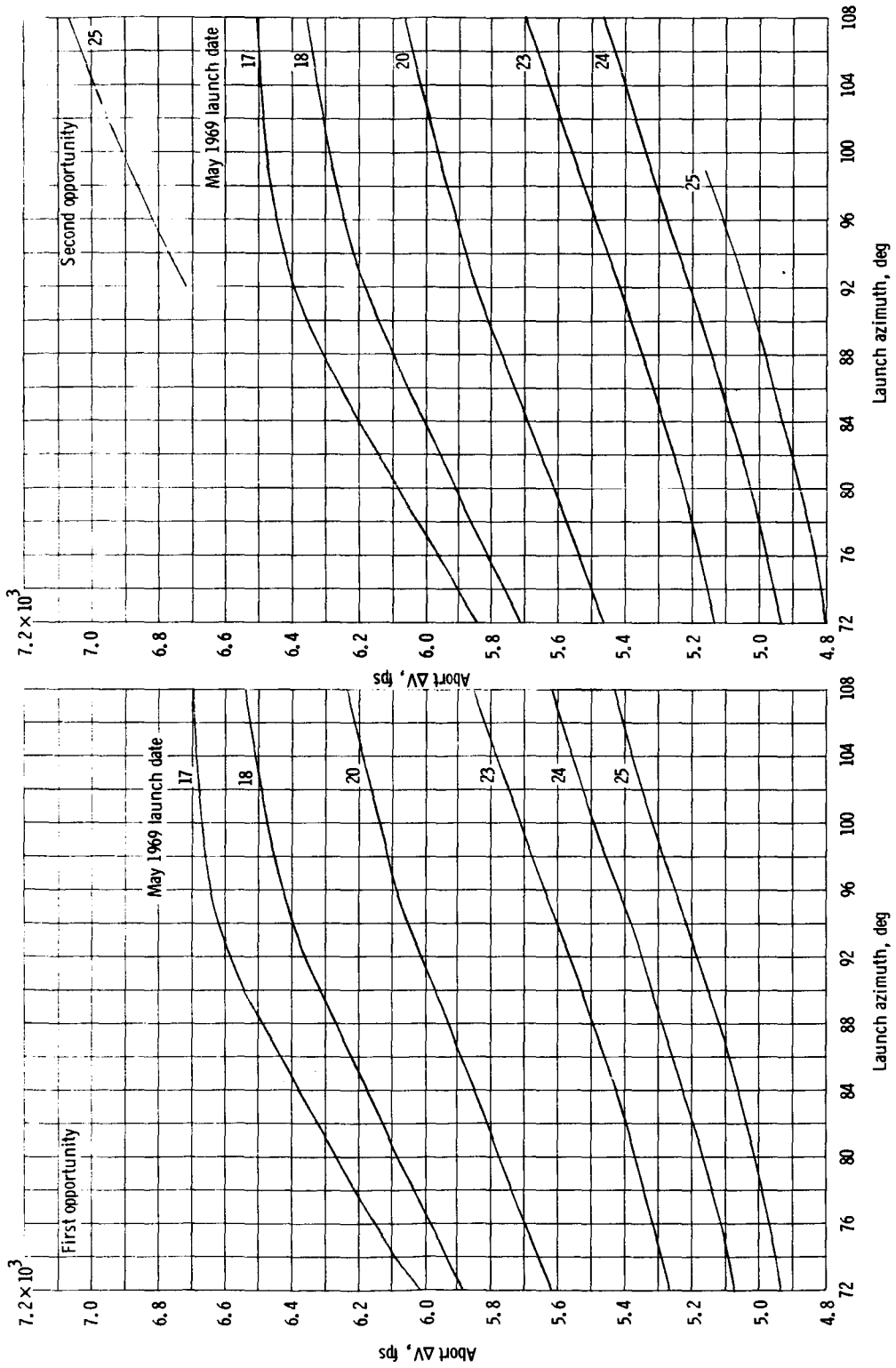
(a) Ground elapsed time, 7 hr.

Figure 5-12. - Abort delta velocity as a function of launch azimuth and launch day in the May 1969 window for direct returns to the MPL at typical block data times during the translunar coast.



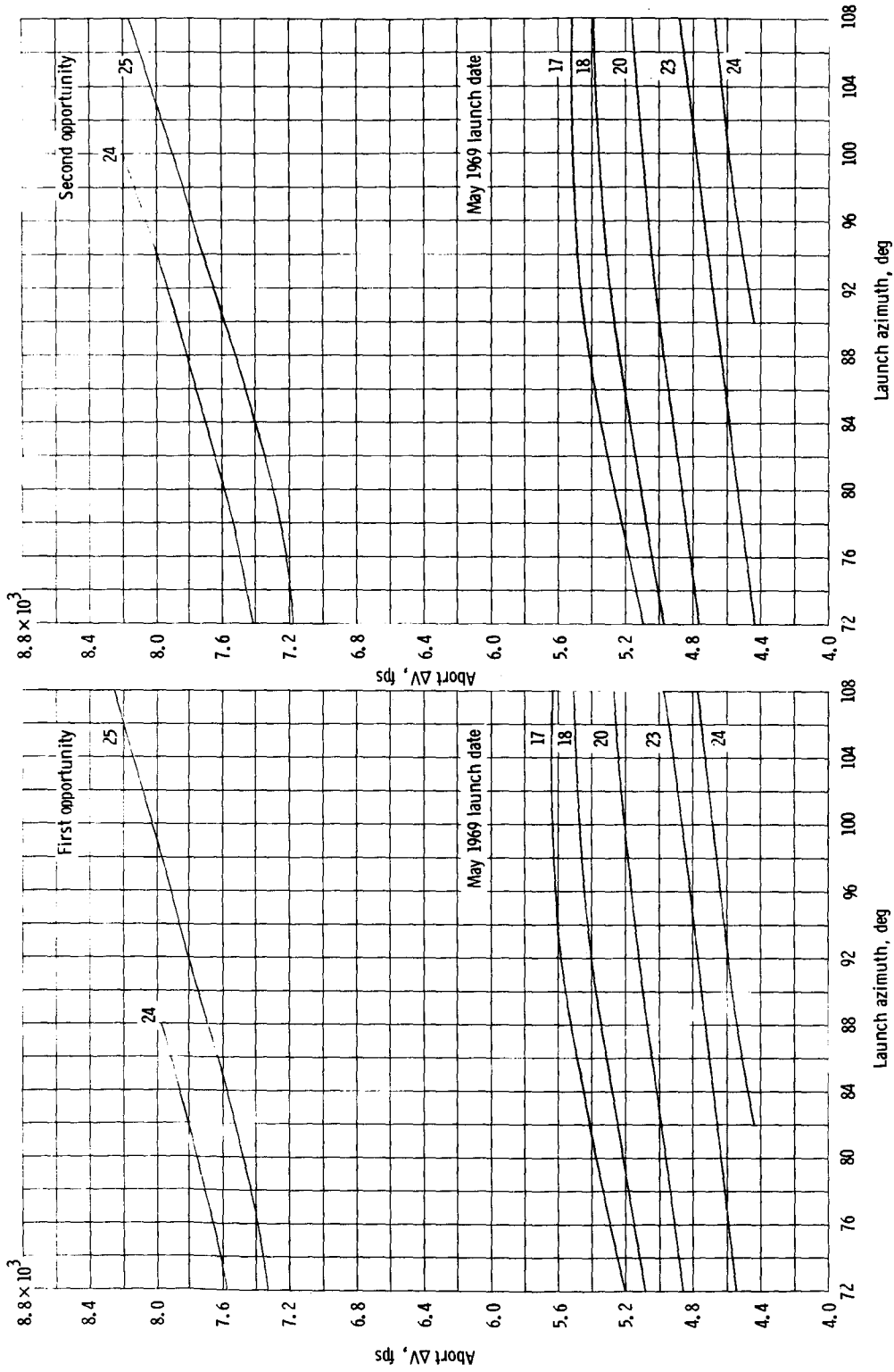
(b) Ground elapsed time, 14 hr.

Figure 5-12. - Continued.



(c) Ground elapsed time, 28 hr.

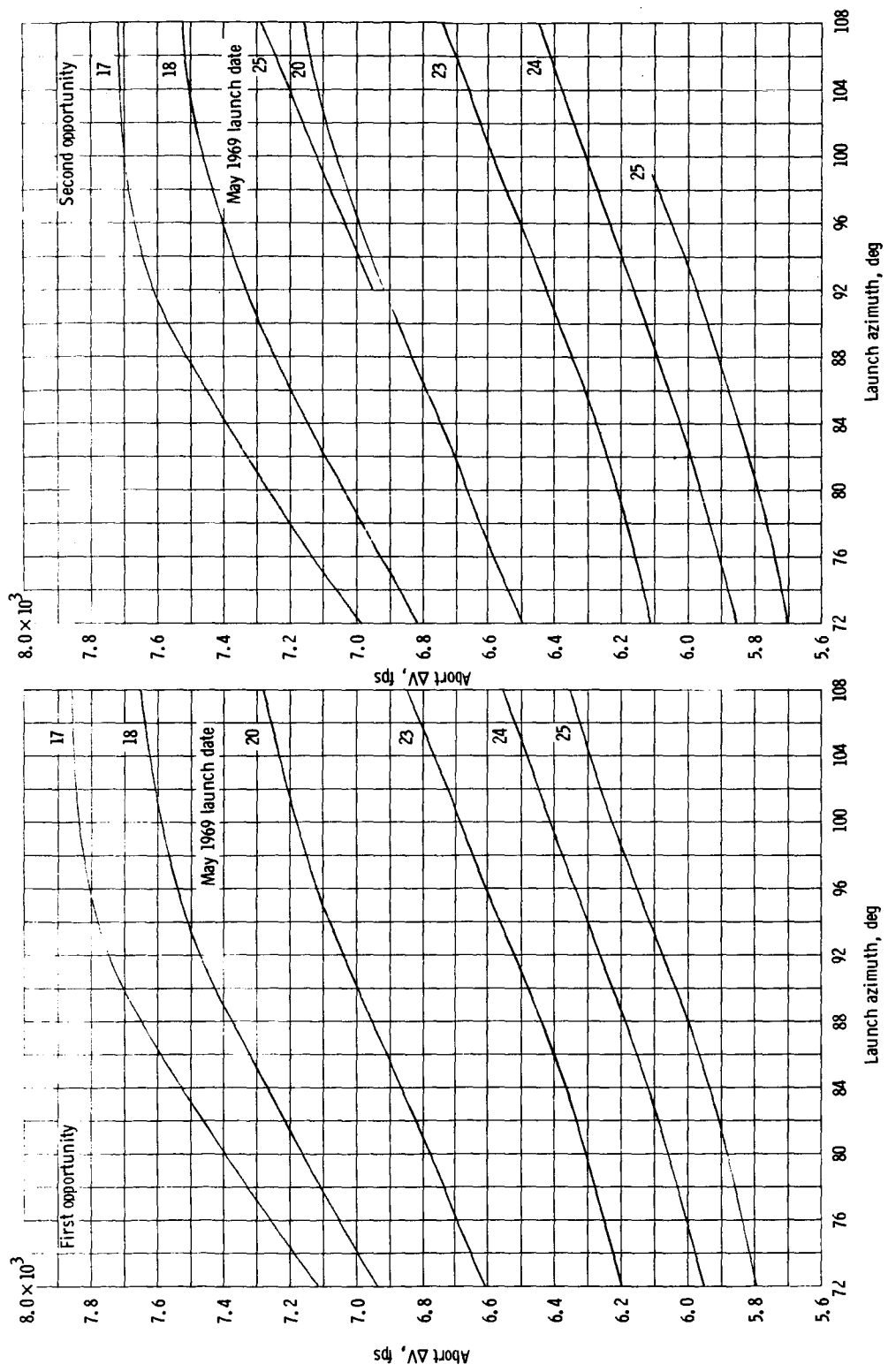
Figure 5-12. - Continued.



(d) Ground elapsed time, 38 hr.

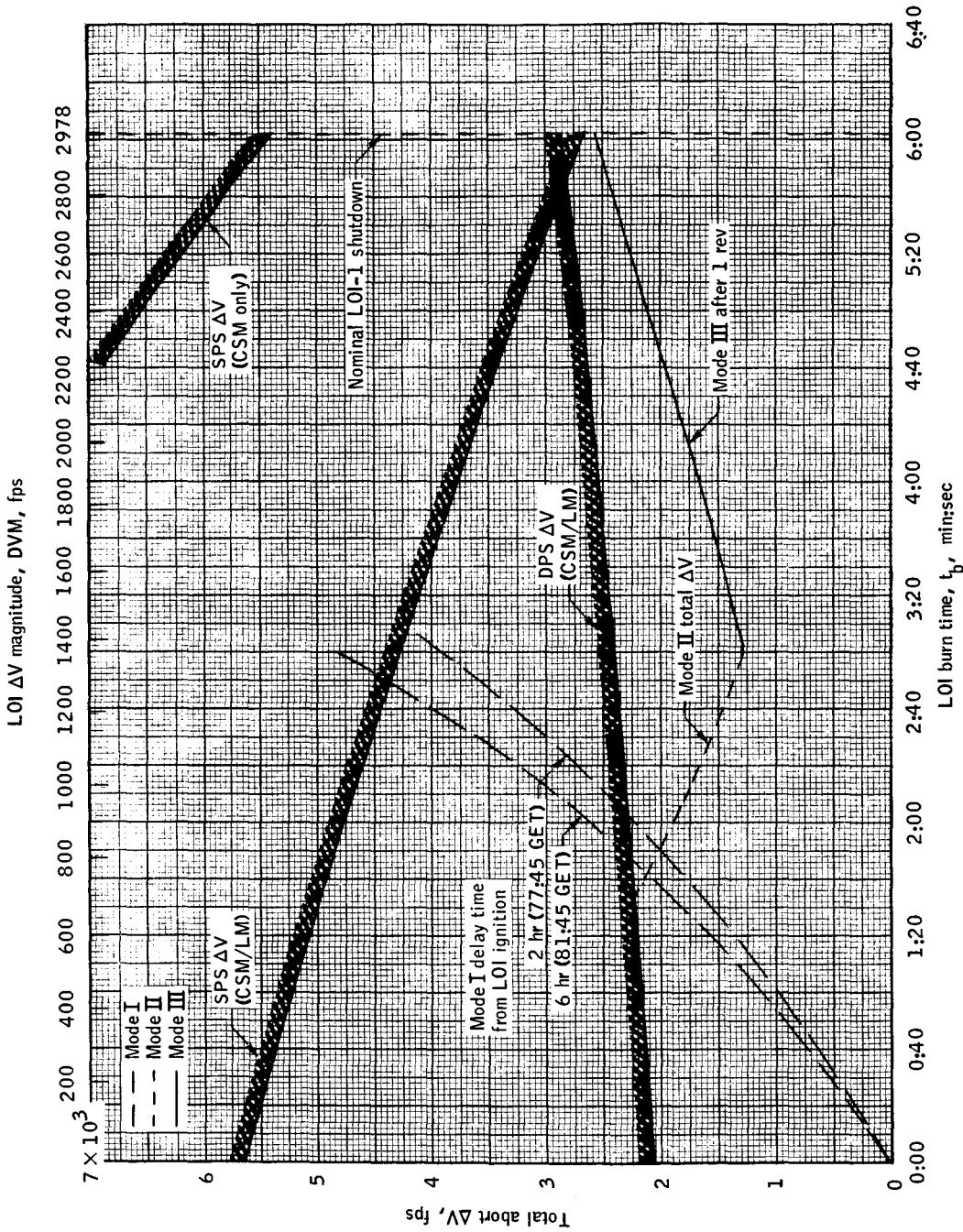
Figure 5-12. - Continued.





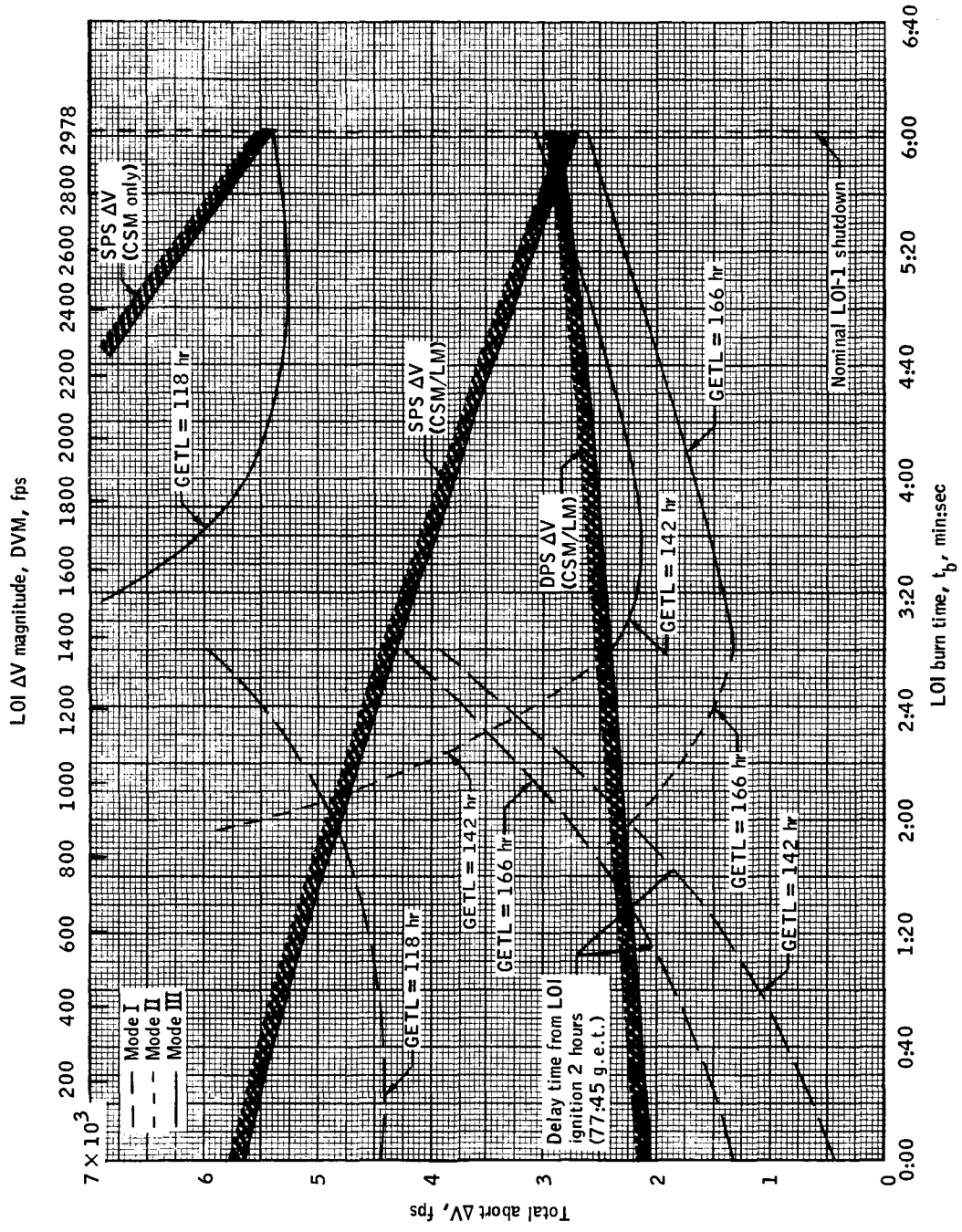
(e) Ground elapsed time, 48 hr.

Figure 5-12. - Concluded.



(a) Fuel critical, unspecified area returns (FCUA).

Figure 6-1.- Summary of abort capability for premature LOI shutdowns (May 18, 1969 launch, G MCC).



(b) Return to the mid-Pacific line (MPL).

Figure 6-1.- Concluded.

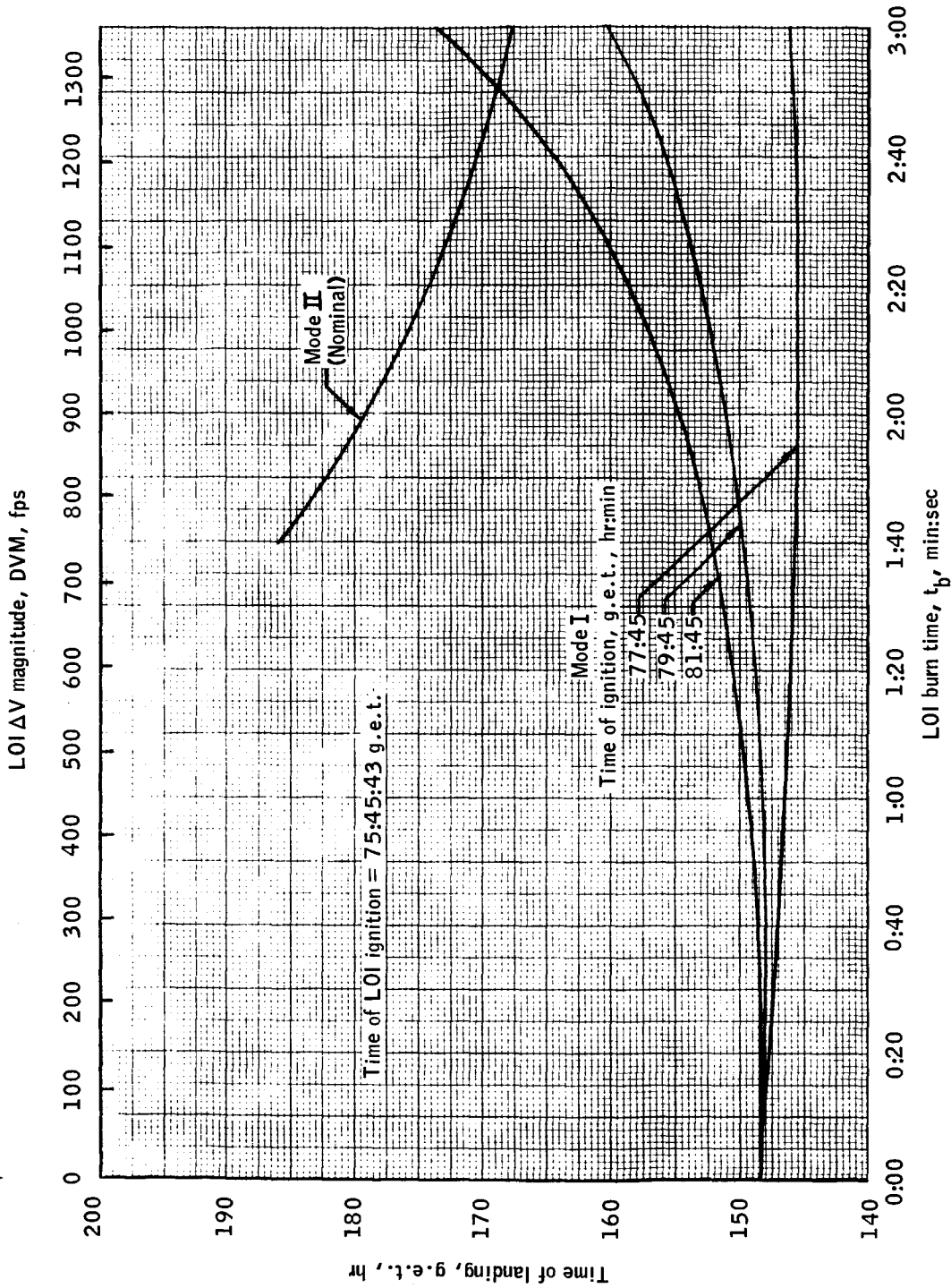


Figure 6-2.- Ground elapsed time of landing for FCUA mode I and II aborts for premature LOI shutdowns.

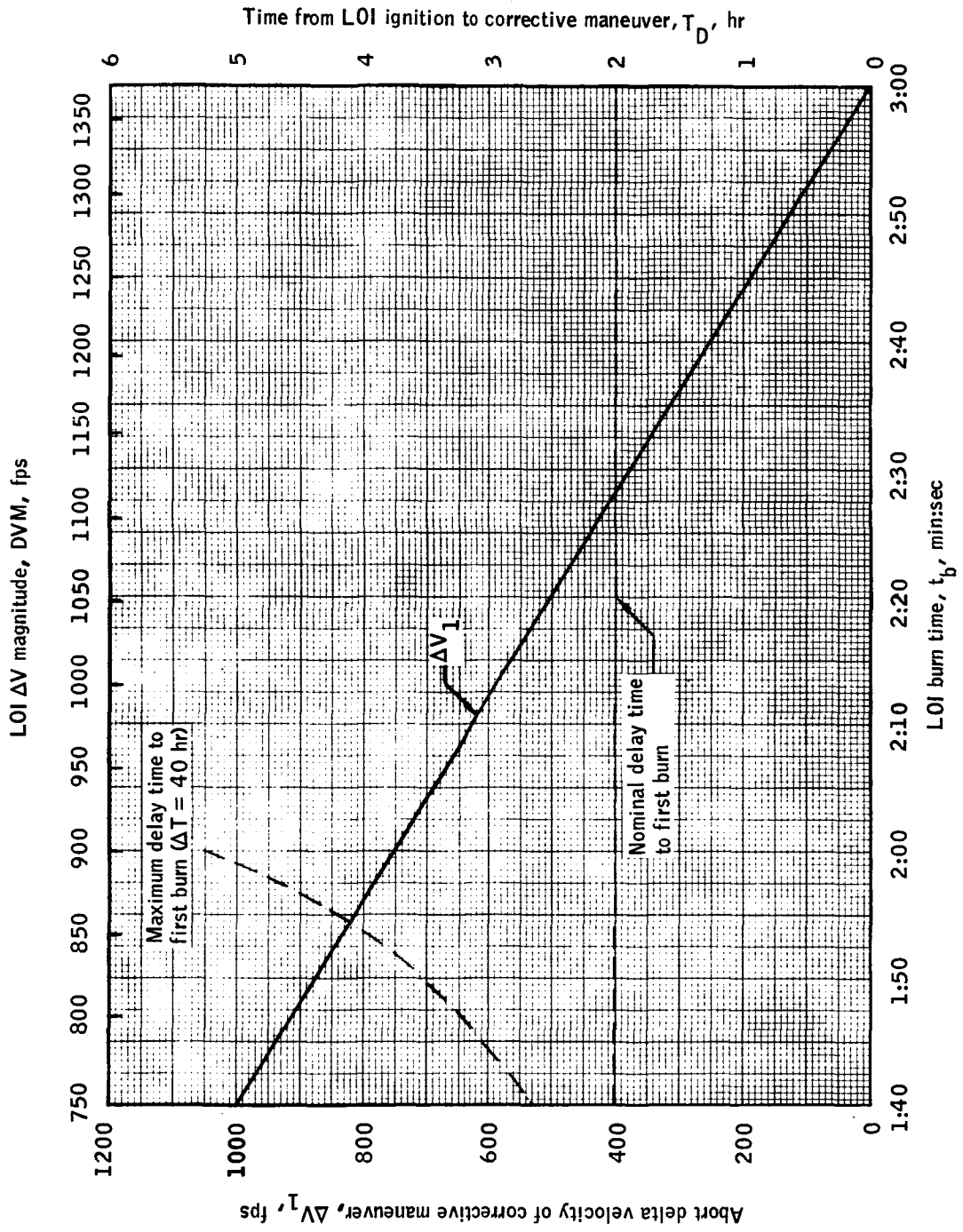


Figure 6-3.- Nominal mode II corrective maneuver  $\Delta V$  magnitude and maximum delay time to ignition.

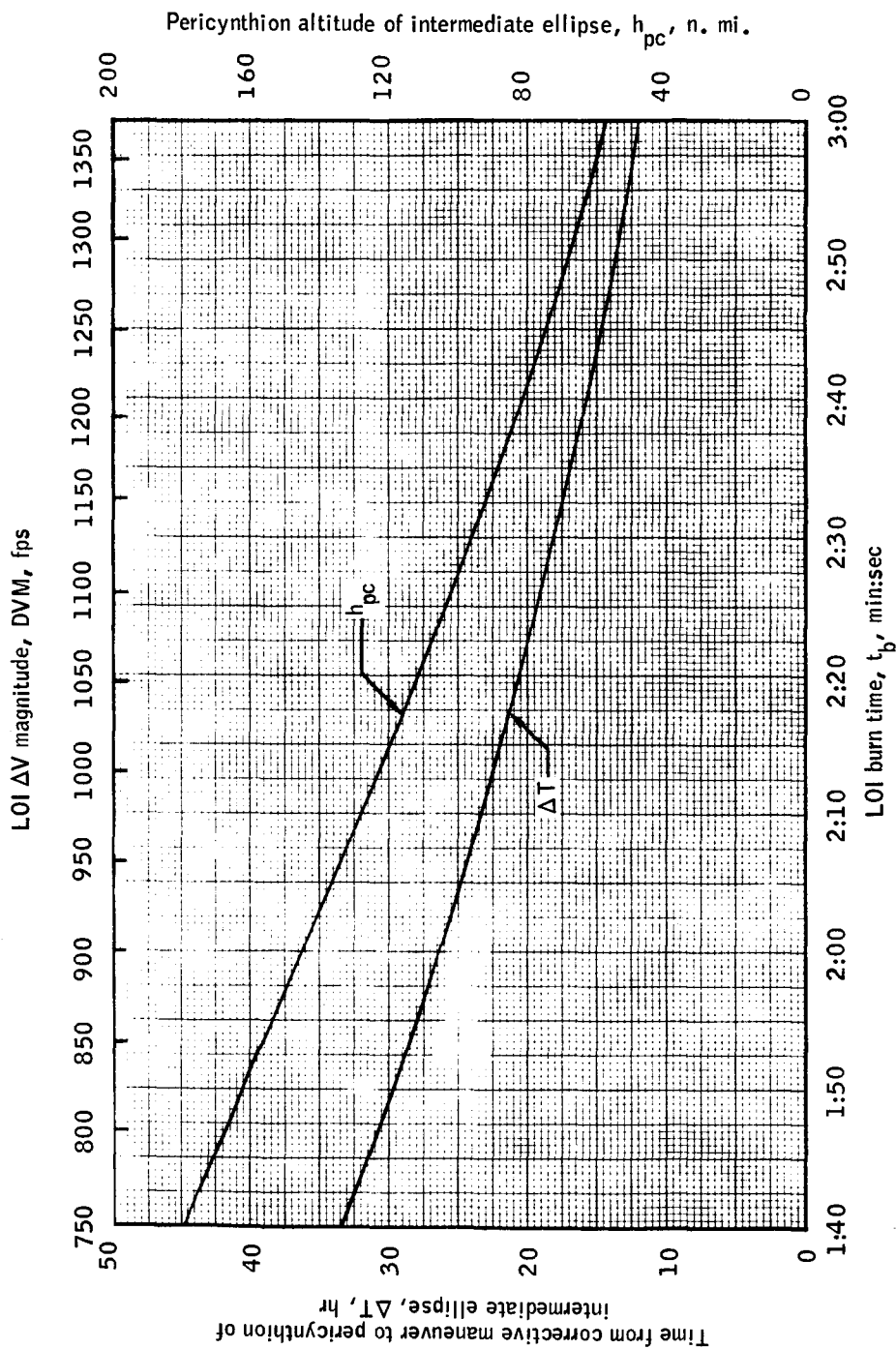


Figure 6-4. - Characteristics of intermediate ellipse following nominal mode II corrective maneuver (nominal May 18, 1969, launch).

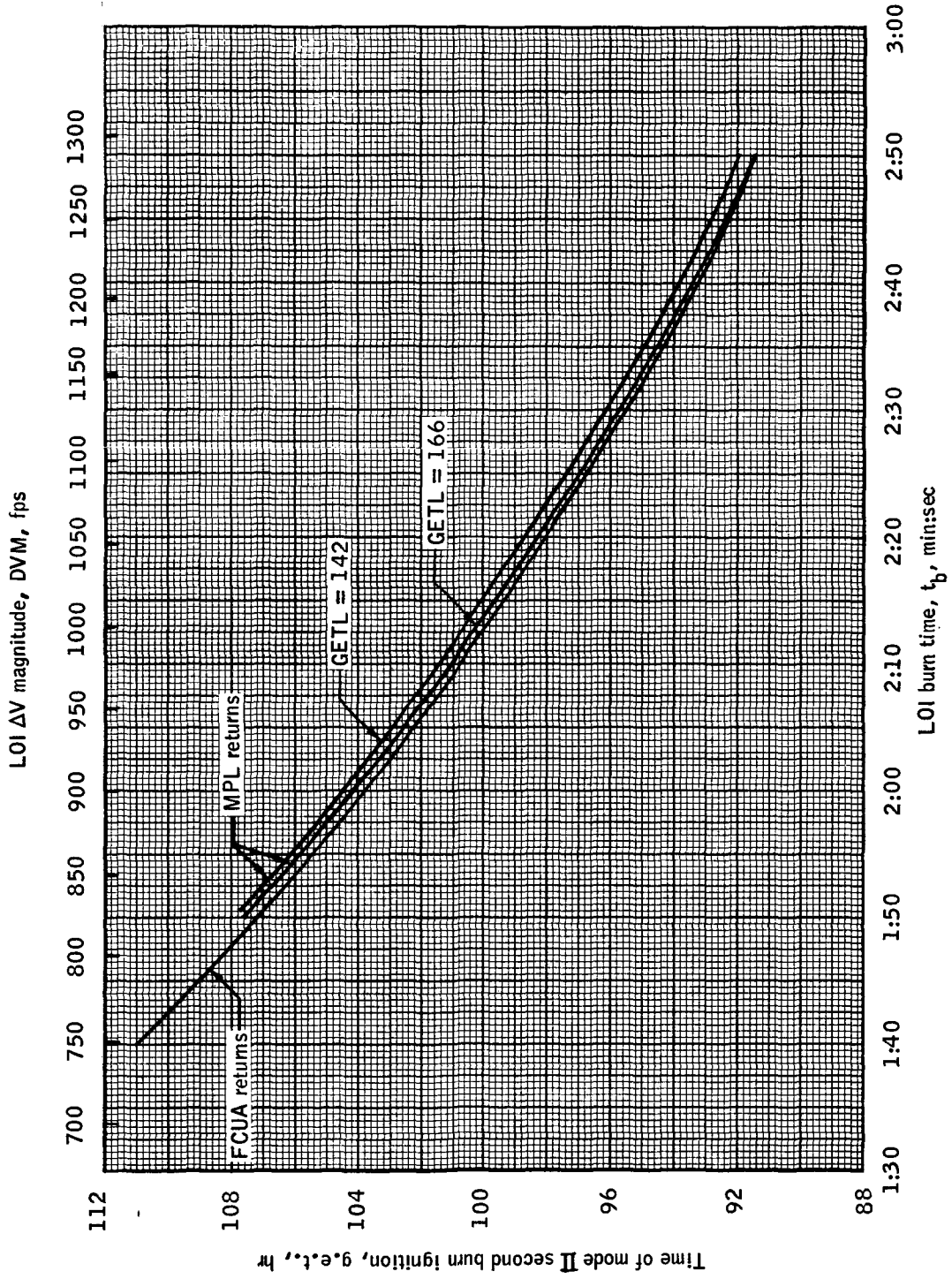


Figure 6-5. - Ground elapsed time of ignition of mode II second burn following nominal corrective maneuver.

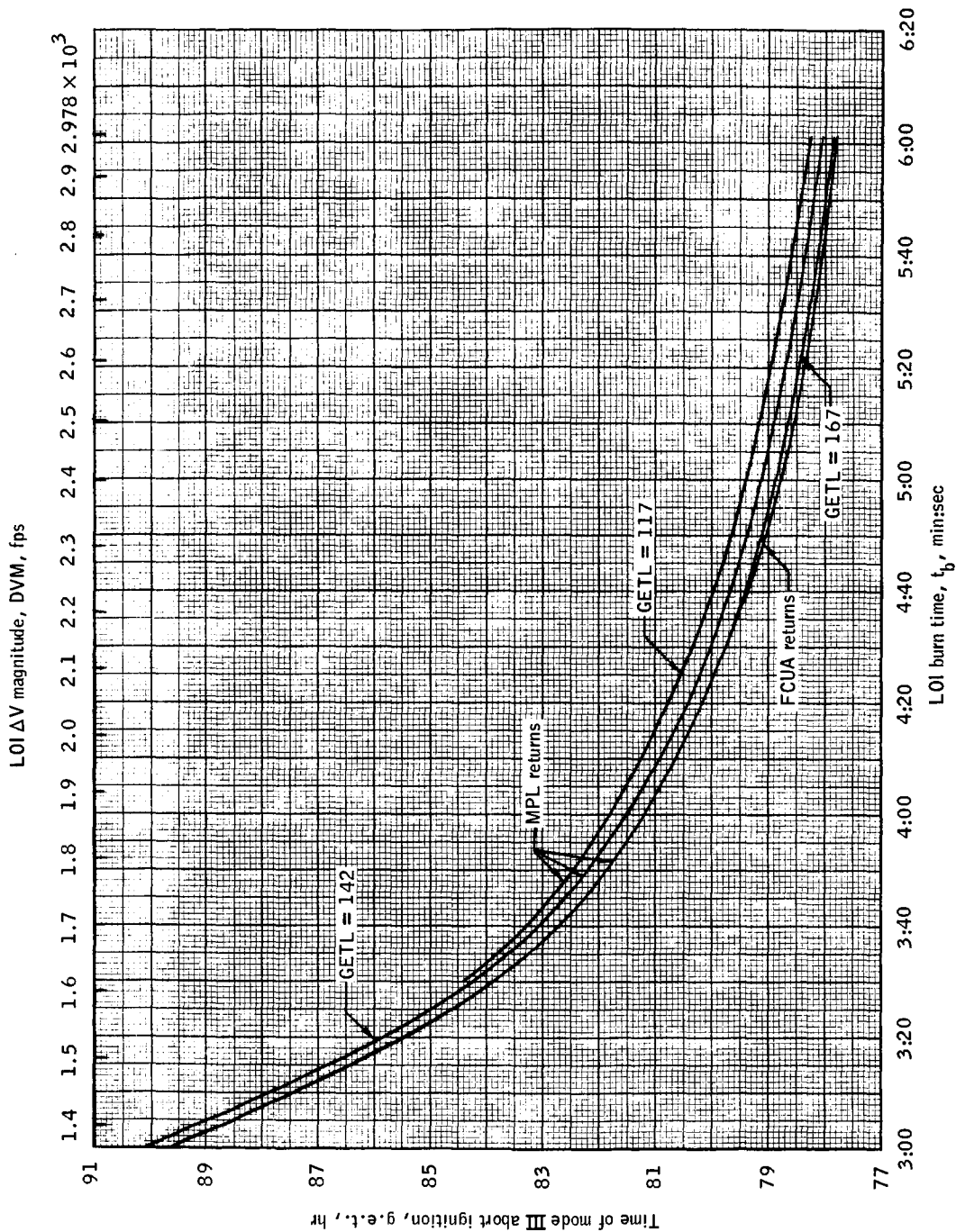
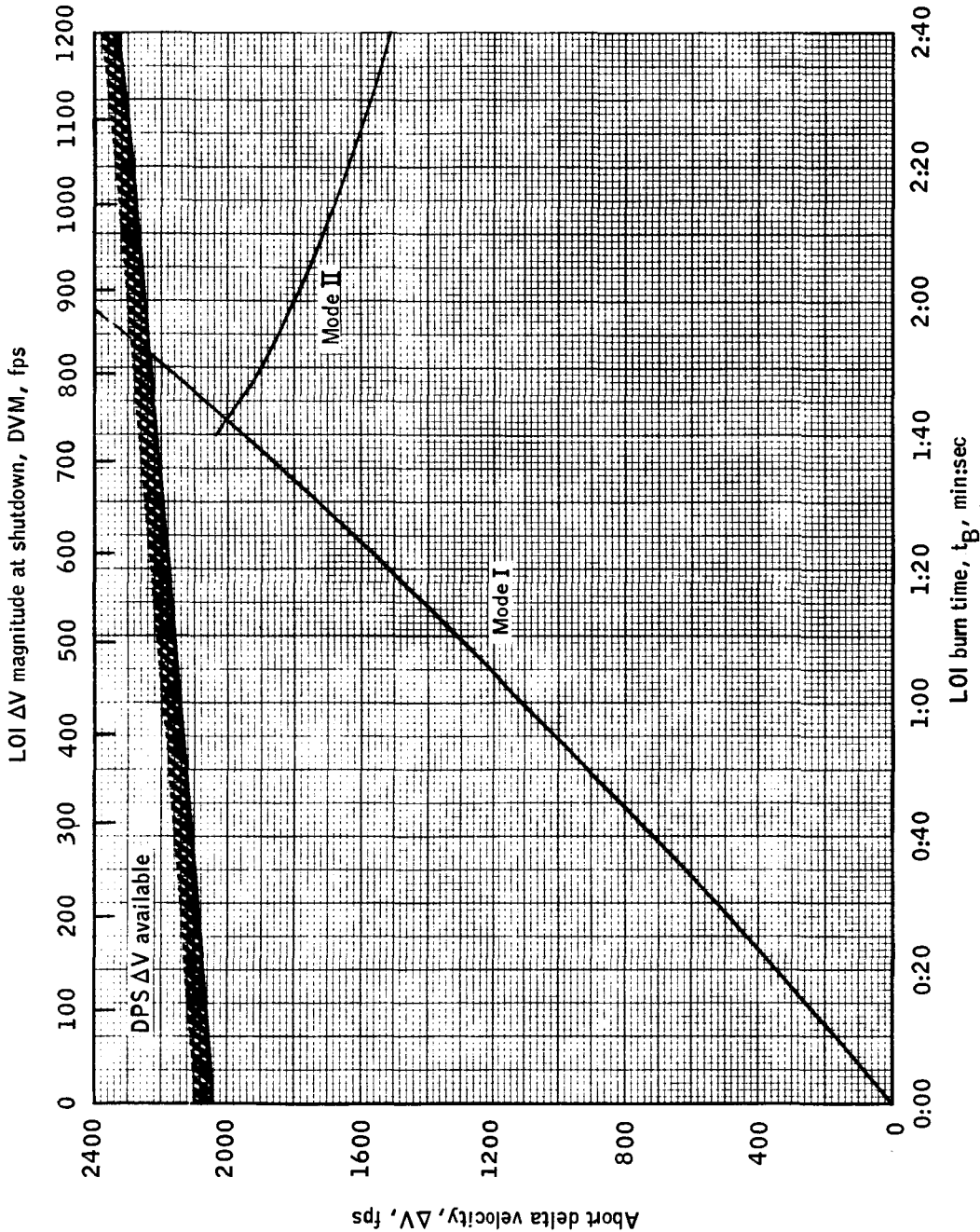


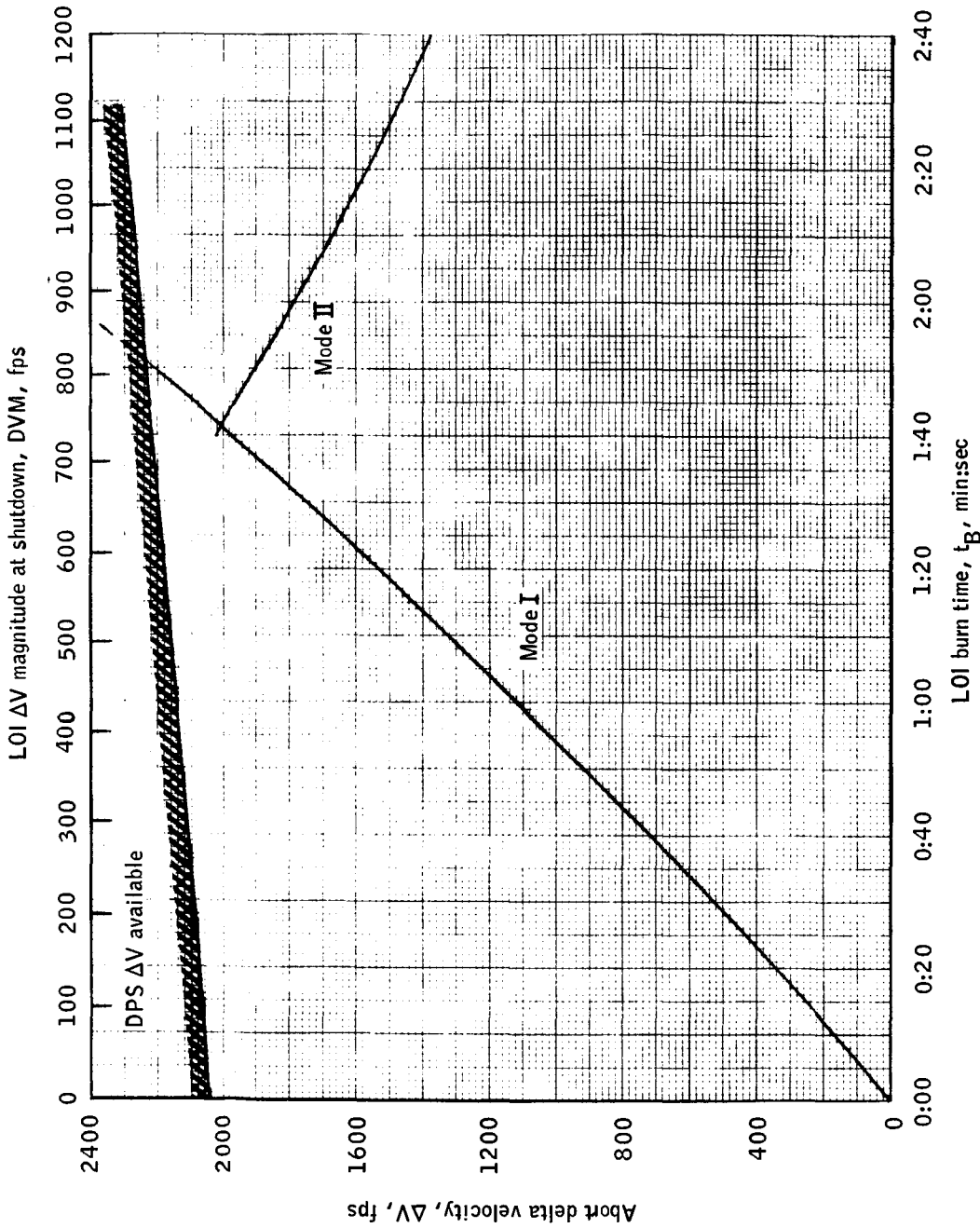
Figure 6-6. - Ground elapsed time of ignition of mode III abort maneuver.





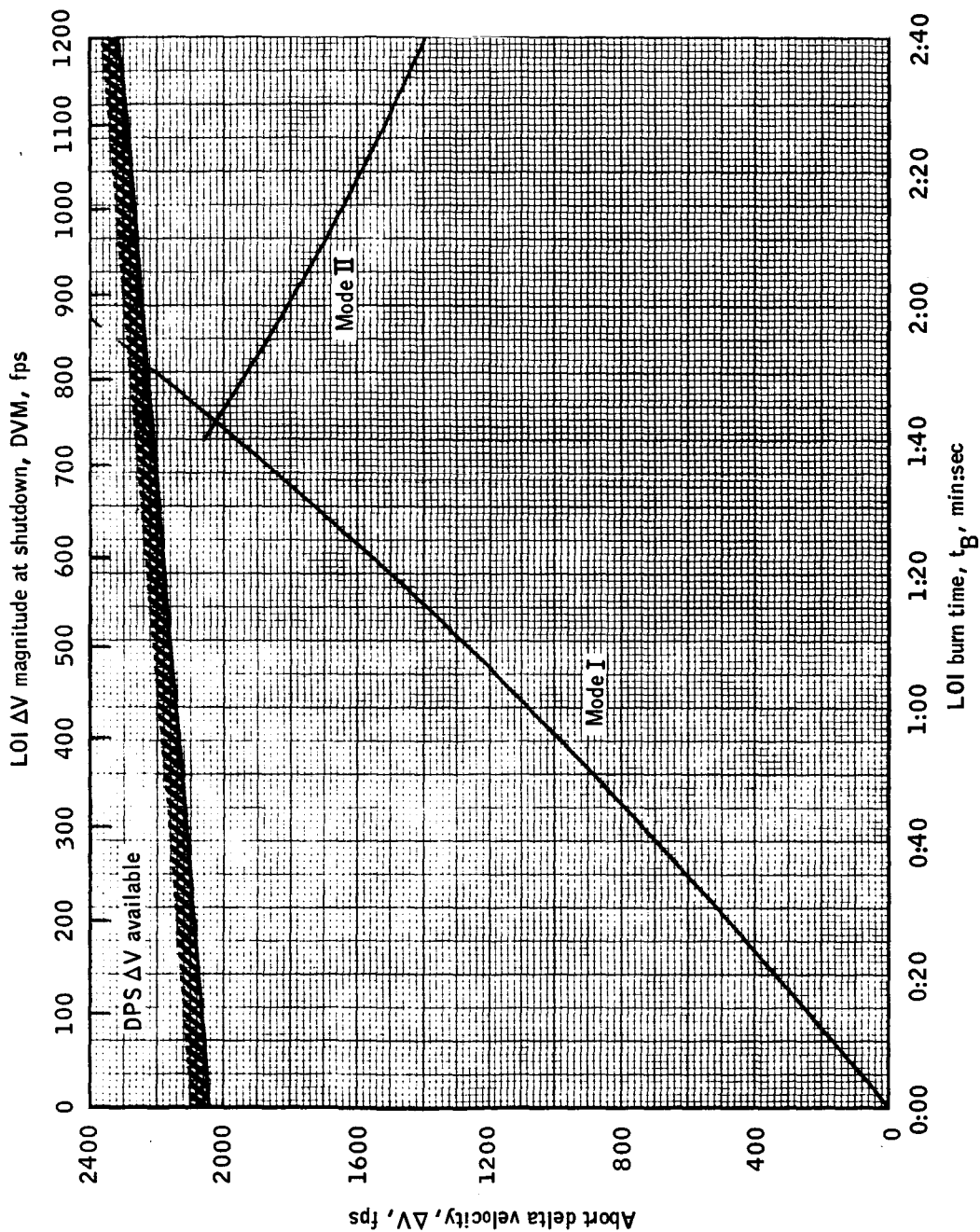
(a) May 18 launch, 72 degree azimuth, first opportunity.

Figure 6-7. - Mode I/II overlap region based on nominal May 17, 1969, corrective maneuver (FCUA returns).



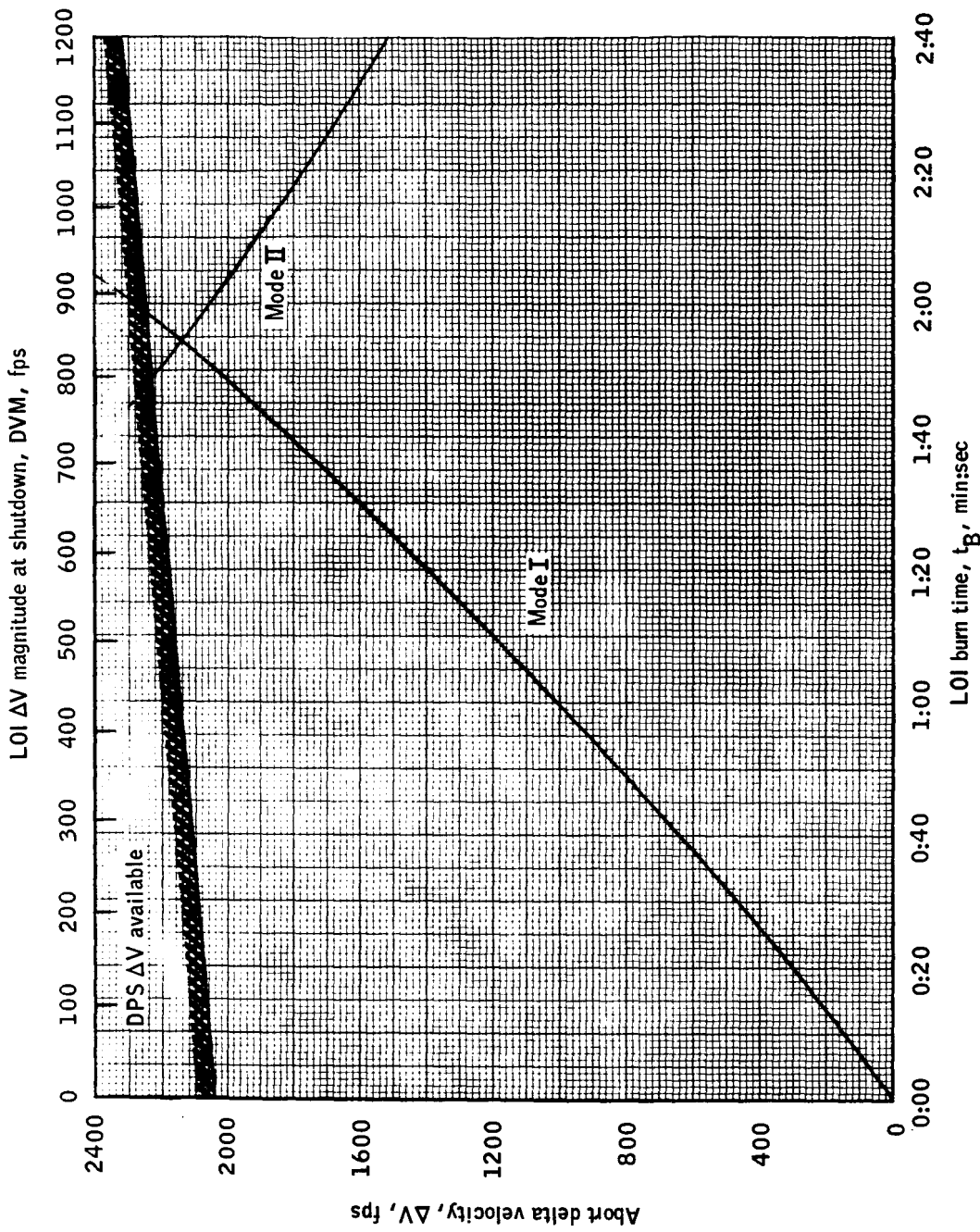
(b) May 18 launch, 108 degree azimuth, second opportunity.

Figure 6-7. - Continued.



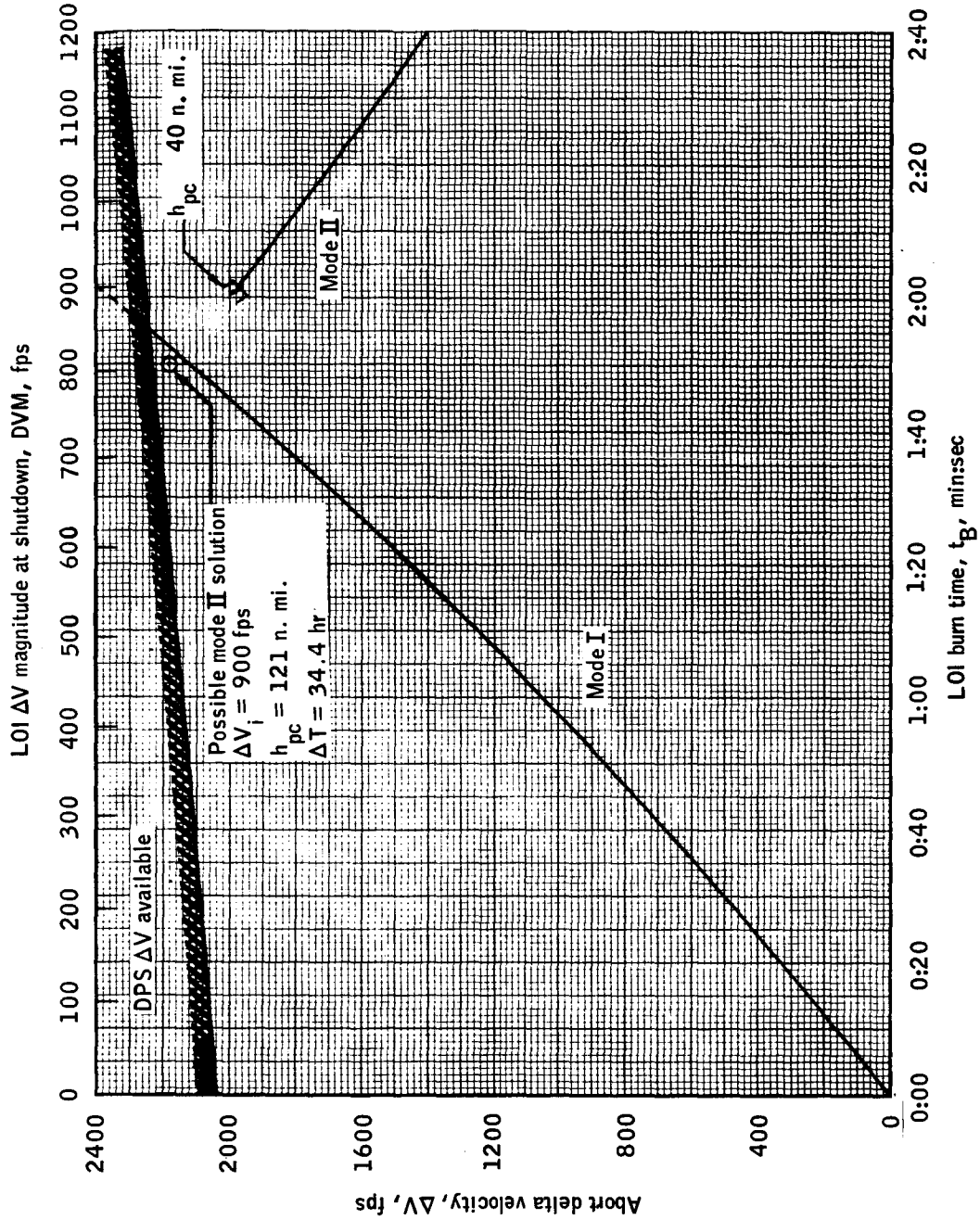
(c) May 20 launch, 72 degree azimuth, first opportunity.

Figure 6-7. - Continued.



(d) May 23 launch, 72 degree azimuth, first opportunity.

Figure 6-7. - Continued.



(e) May 25 launch, 72 degree azimuth, first opportunity.

Figure 6-7.- Concluded.

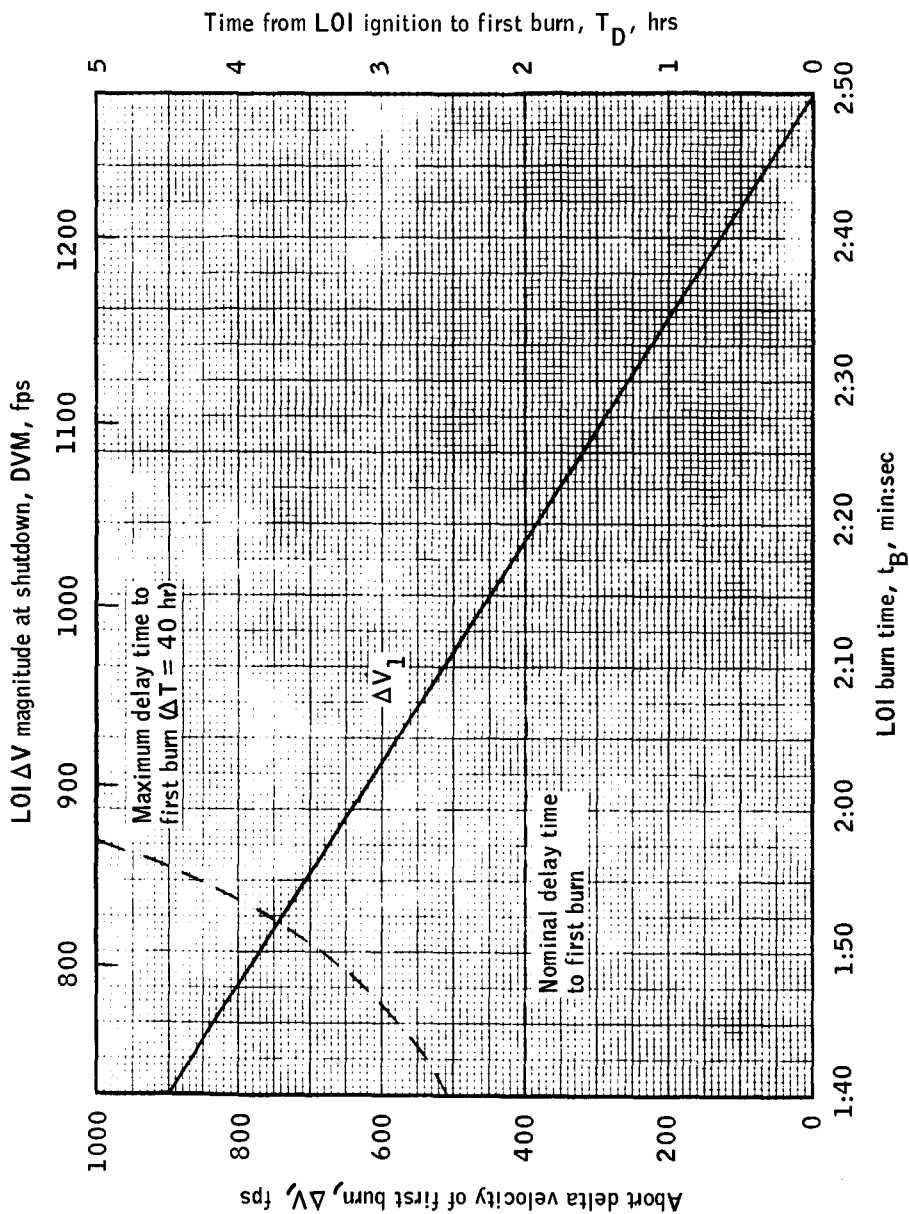
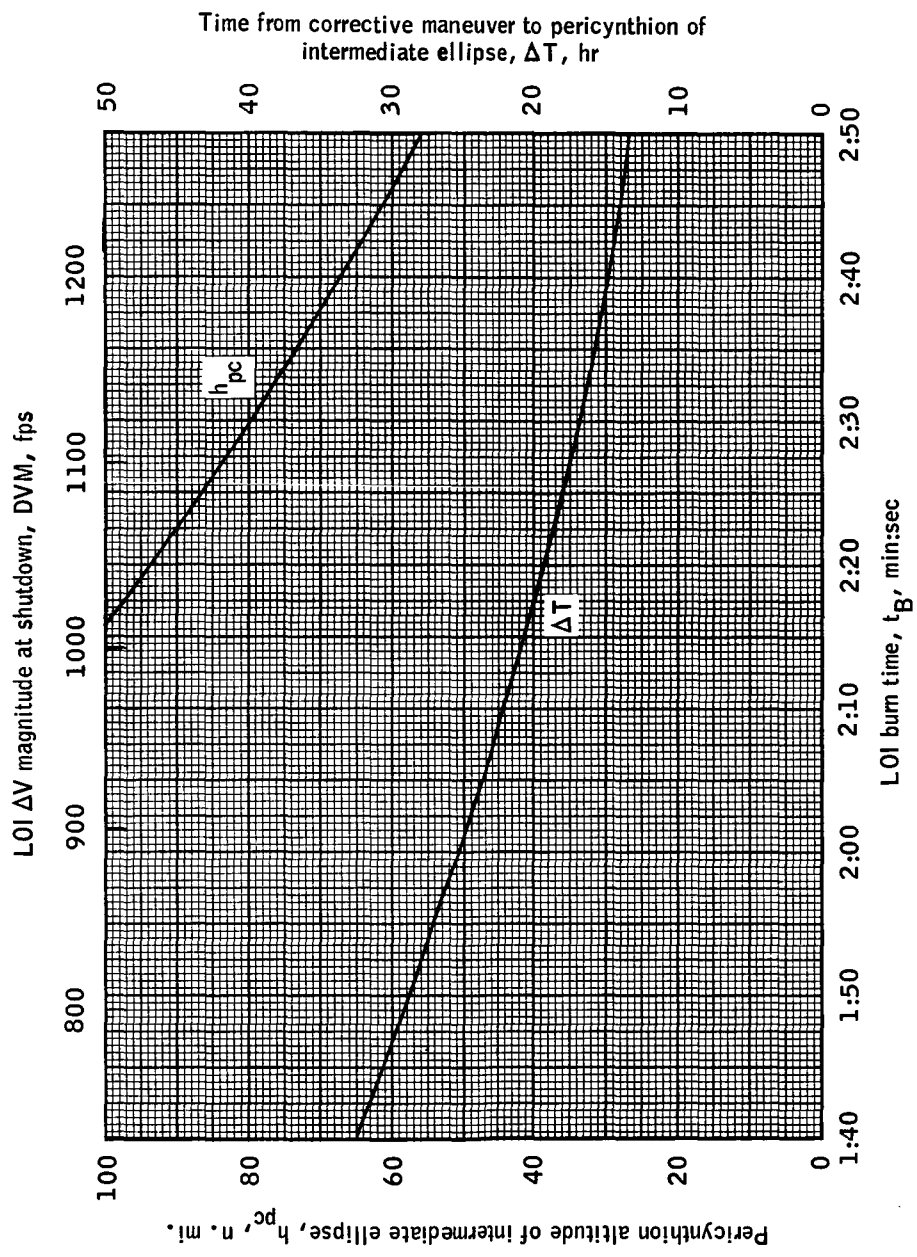
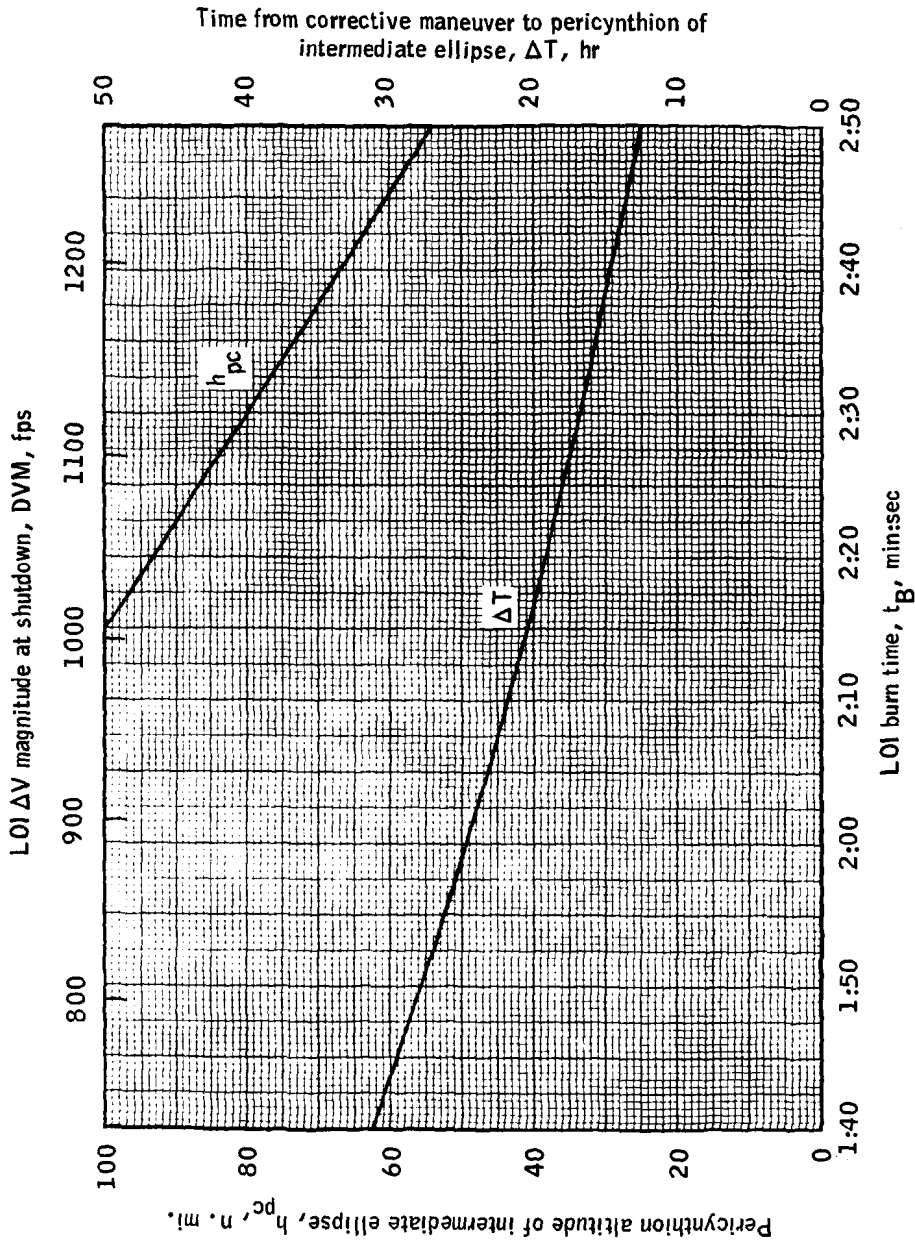


Figure 6-8.- Nominal May 17, 1969, corrective maneuver.



(a) May 18 launch, 72 degree azimuth, first opportunity.

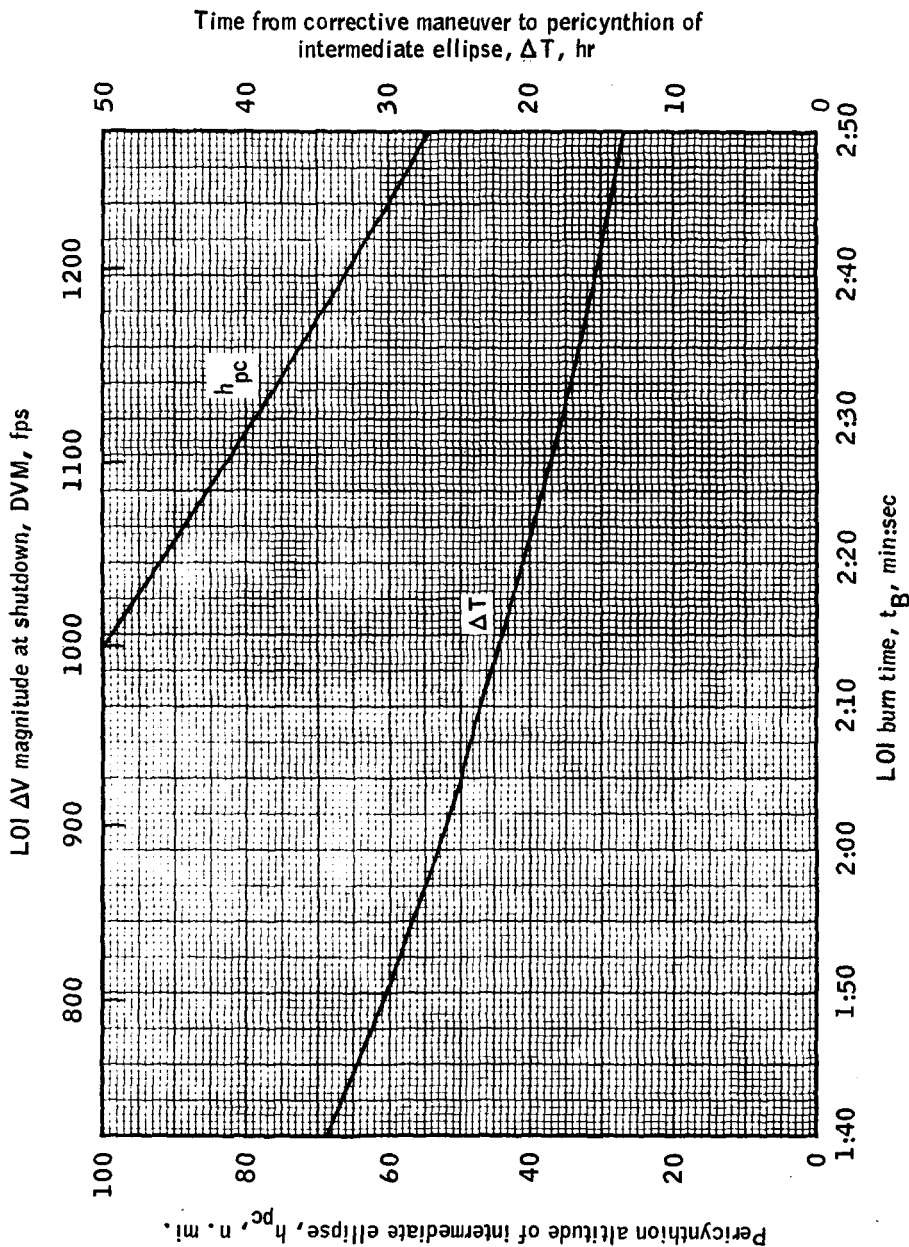
Figure 6-9.- Characteristics of intermediate ellipse following nominal May 17 corrective maneuver.



(b) May 18 launch, 108 degree azimuth, second opportunity.

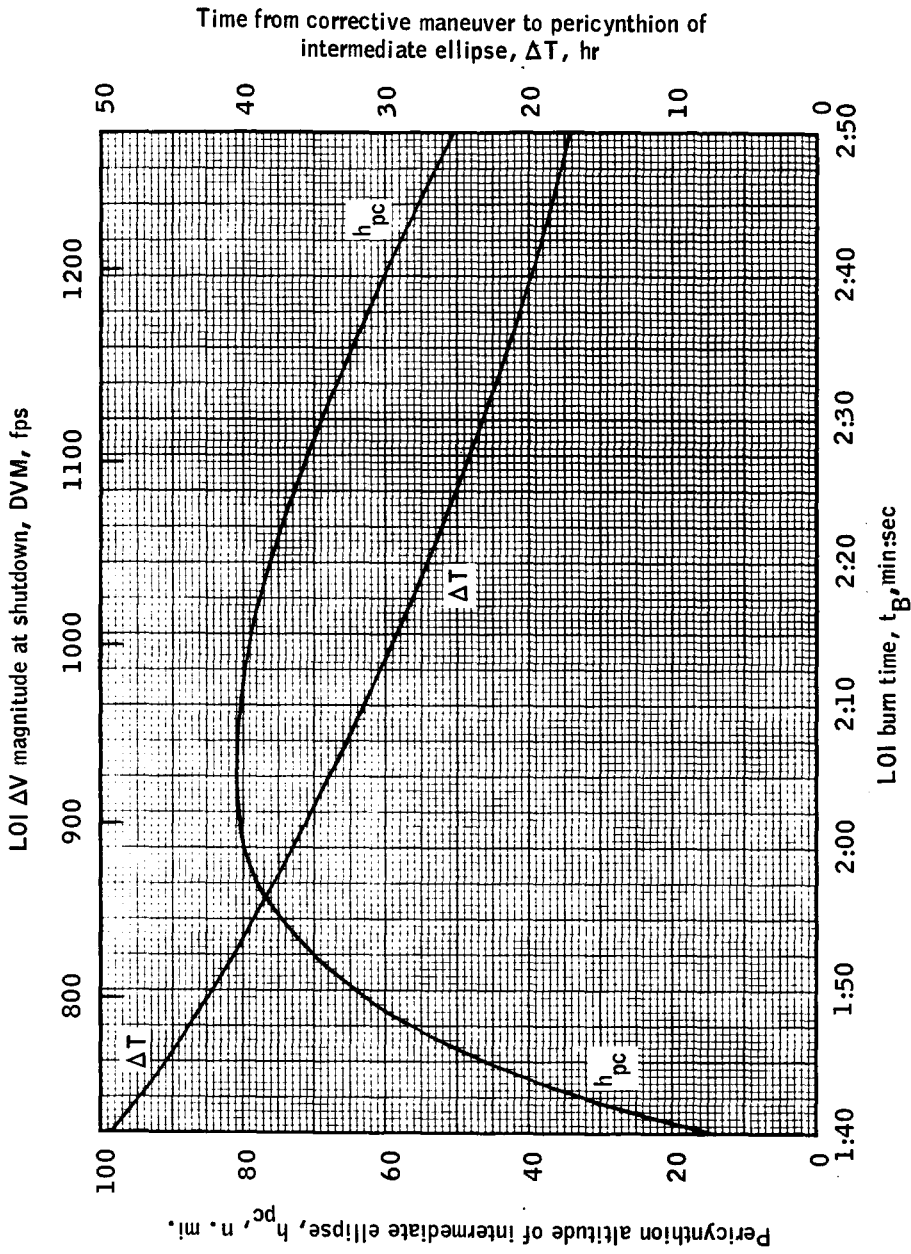
Figure 6-9. - Continued.





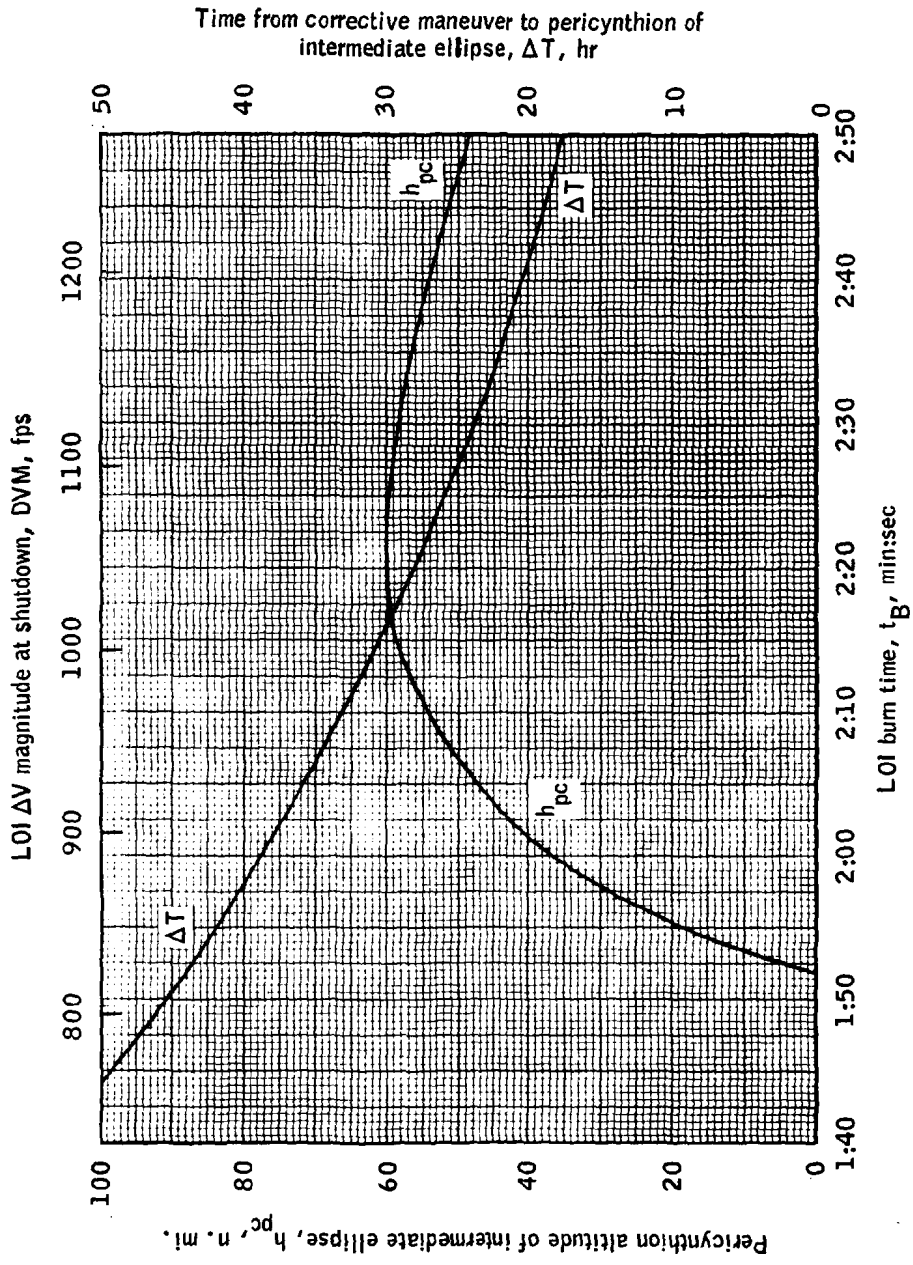
(c) May 20 launch, 72 degree azimuth, first opportunity.

Figure 6-9. - Continued.



(d) May 23 launch, 72 degree azimuth, first opportunity.

Figure 6-9. - Continued.



(e) May 25 launch, 72 degree azimuth, first opportunity.

Figure 6-9. - Concluded.

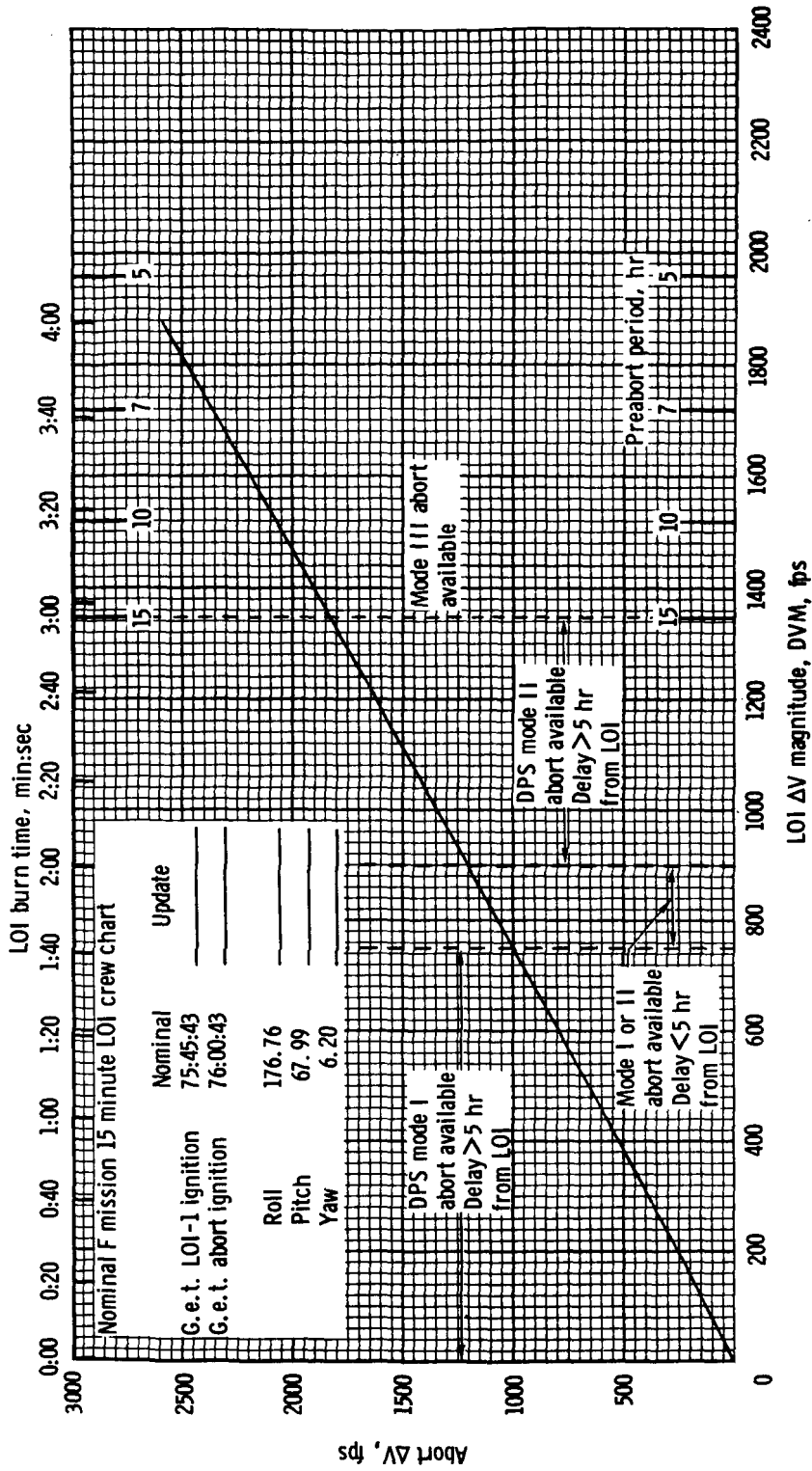
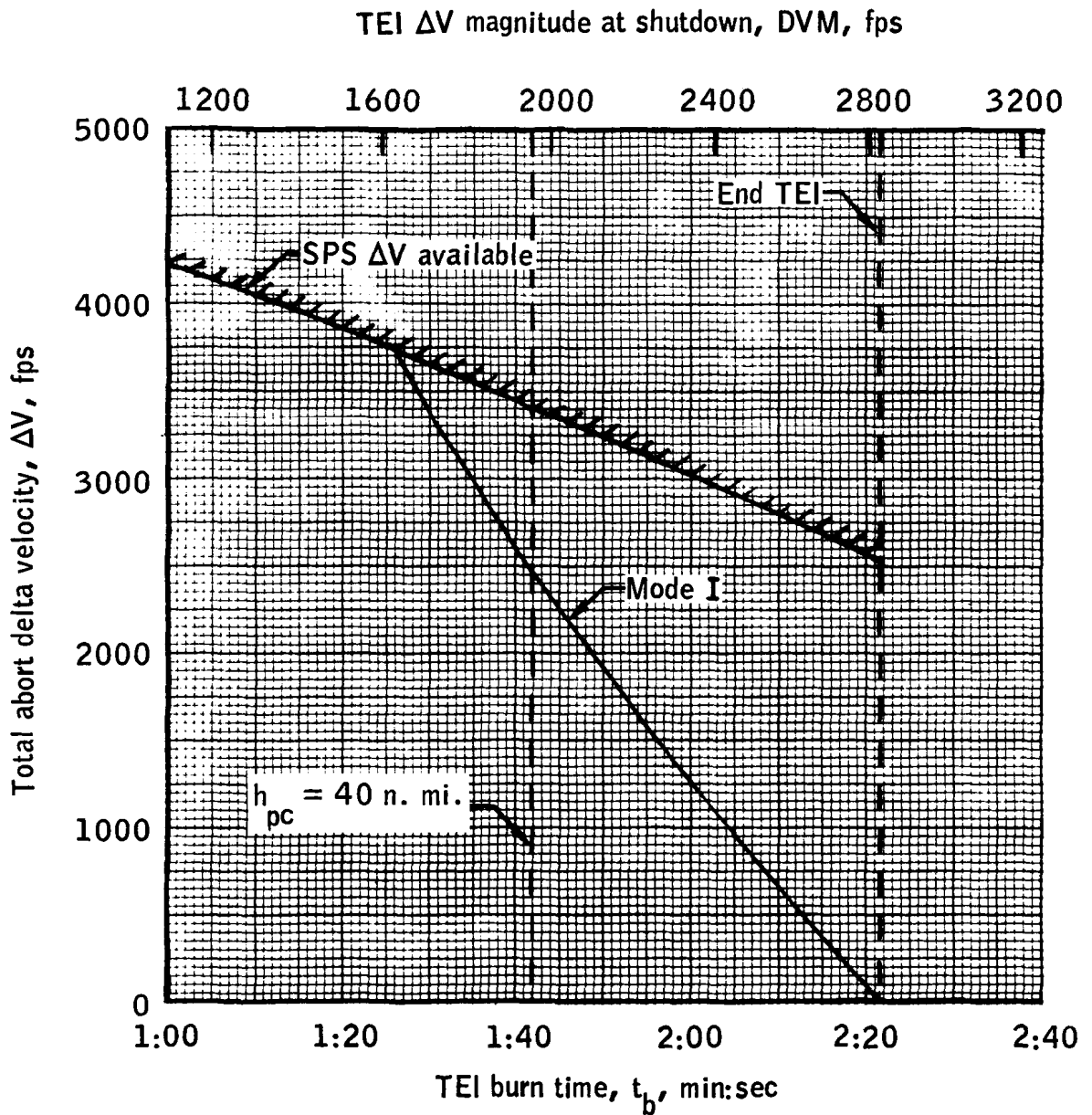
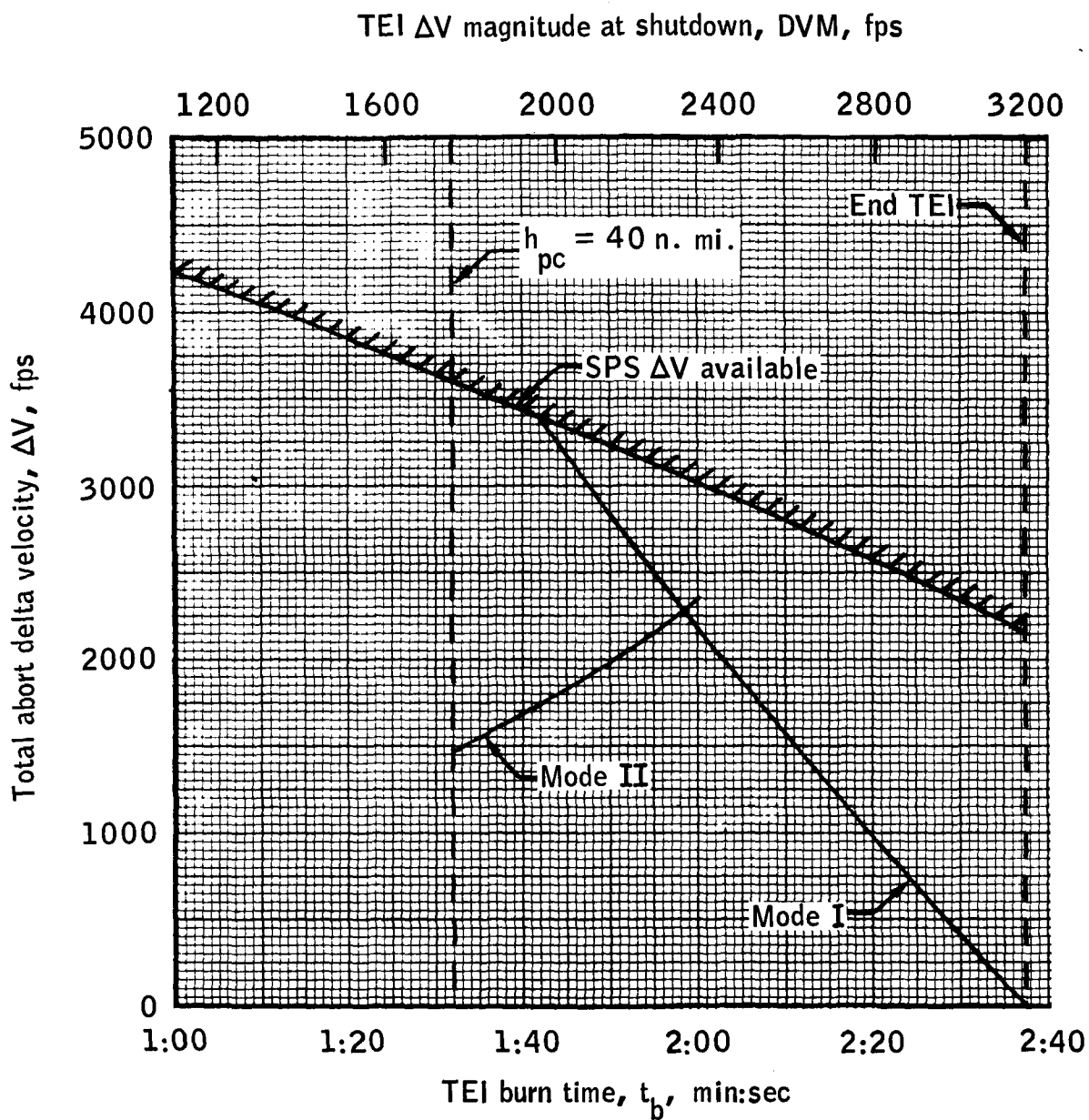


Figure 6-10.- Nominal 15 minute LOI crew chart for a May 18 lunar mission.



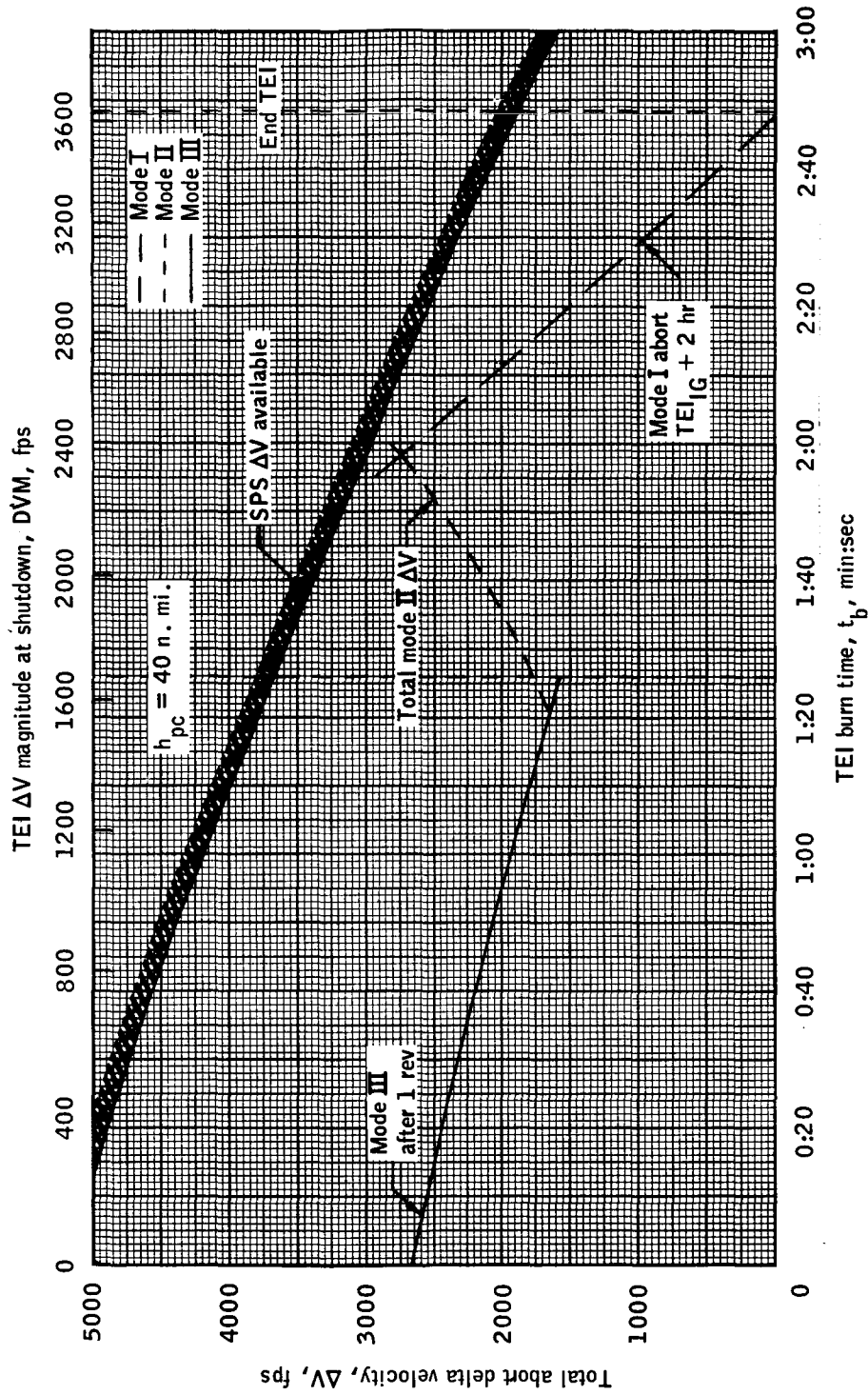
(a) Case 1, transearth flight time  $\approx$  79 hours.

Figure 7-1.- Summary of FCUA abort capability for various TEI burn profiles.



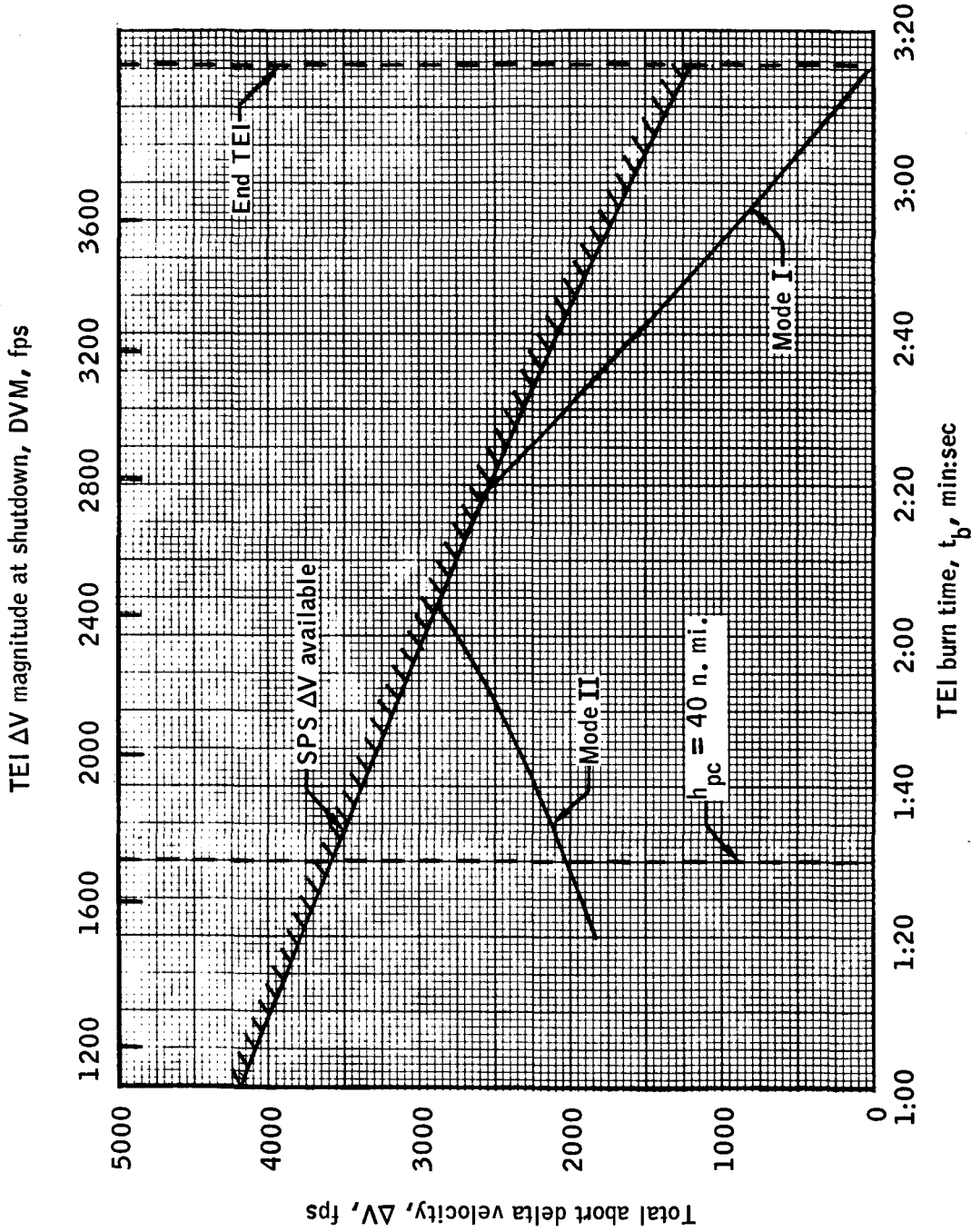
(b) Case 2, transearth flight time = 63 hours.

Figure 7-1.- Continued.



(c) Case 3 (nominal TEI), transearth flight time = 55 hours.

Figure 7-1.- Continued.



(d) Case 4, transearth flight time = 48 hours.

Figure 7-1.- Concluded.



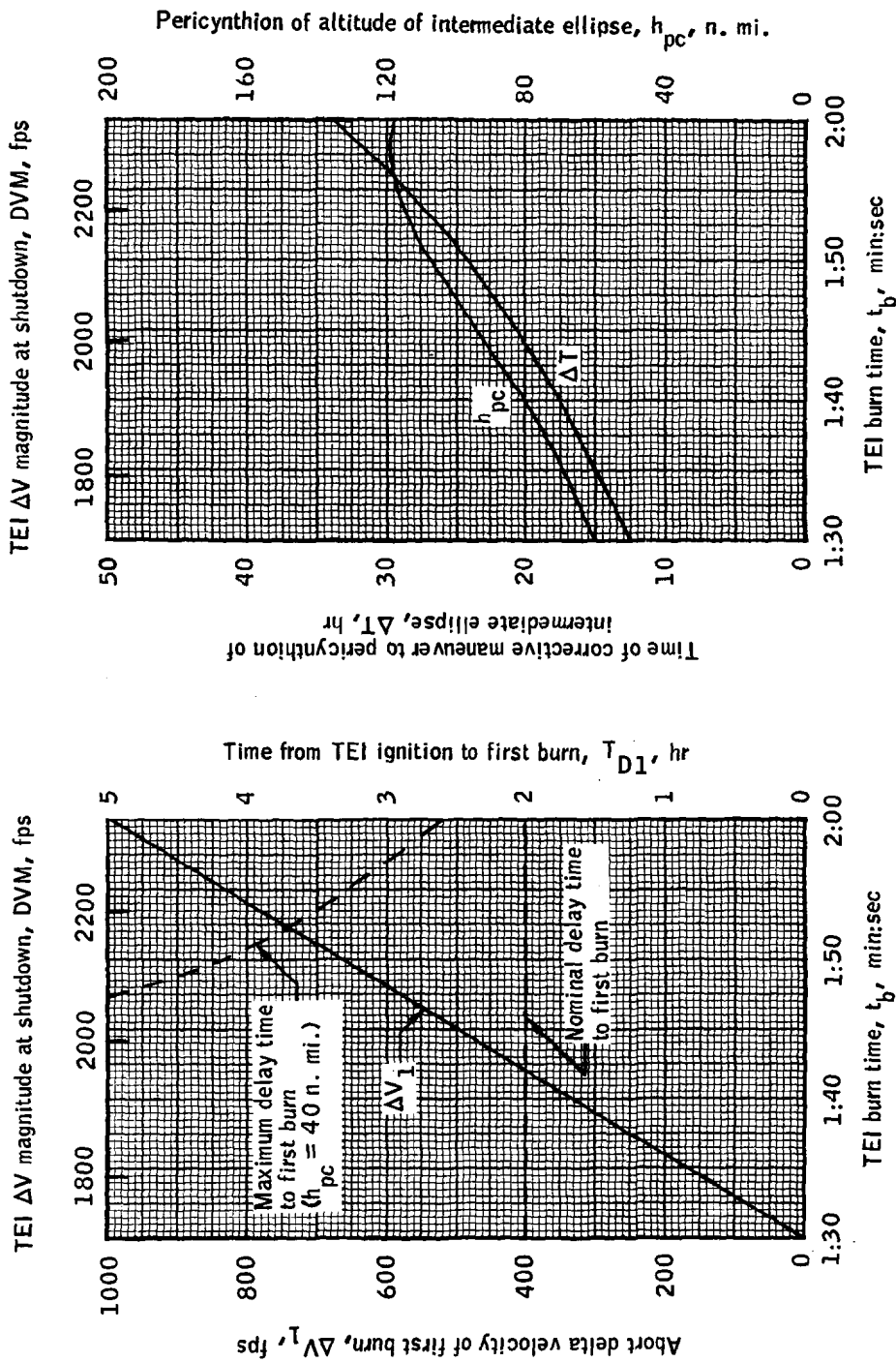
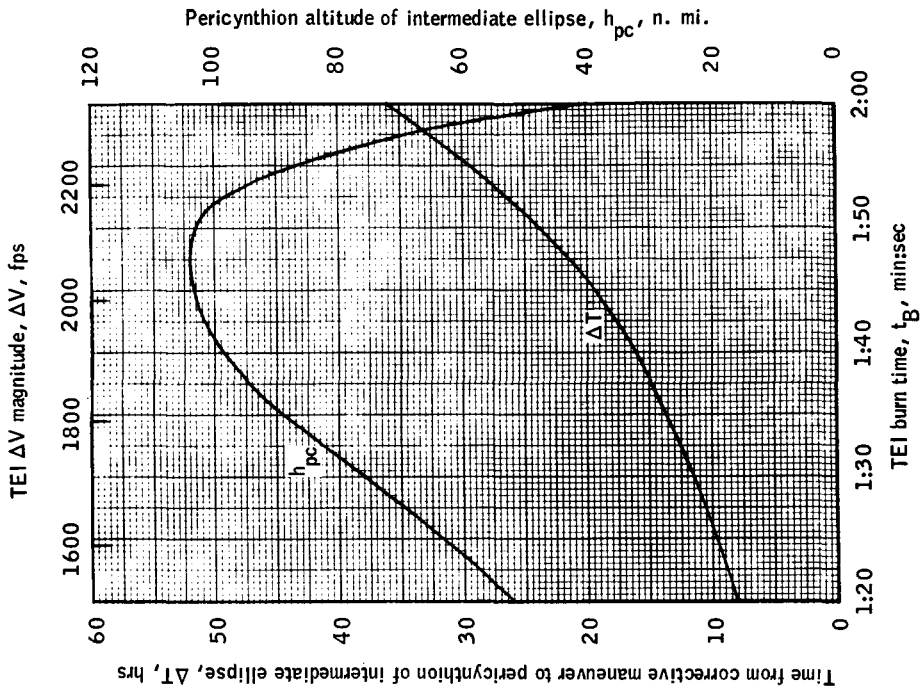
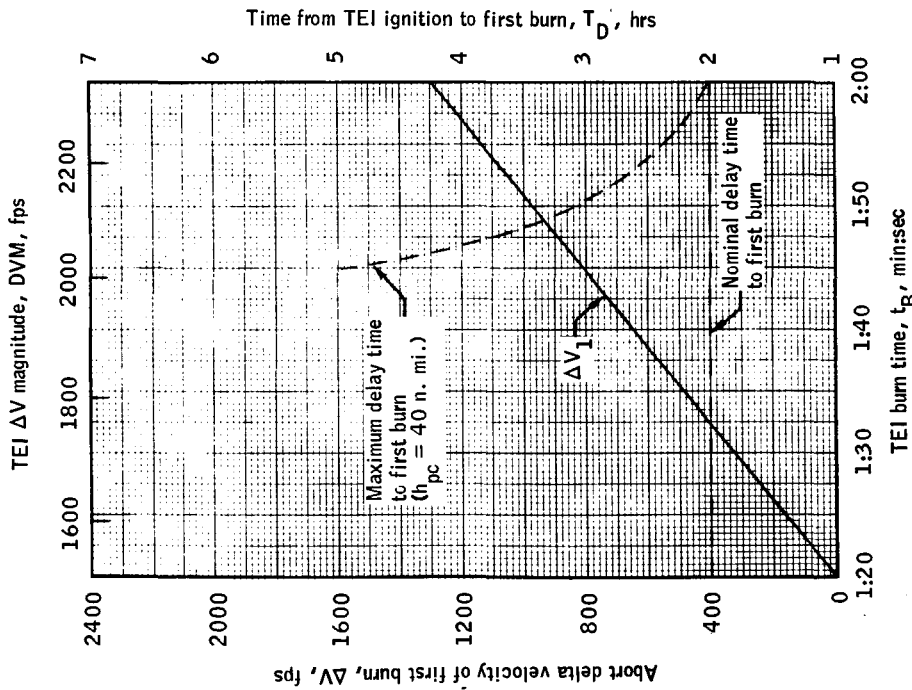


Figure 7-2.- Mode II abort characteristics for various TEI burns.



(d) Case 3 (nominal TEI), time to pericythion, pericythion altitude of intermediate ellipse.



(c) Case 3 (nominal TEI), corrective maneuver  $\Delta V$  and maximum allowable delay time.

Figure 7-2.- Continued.

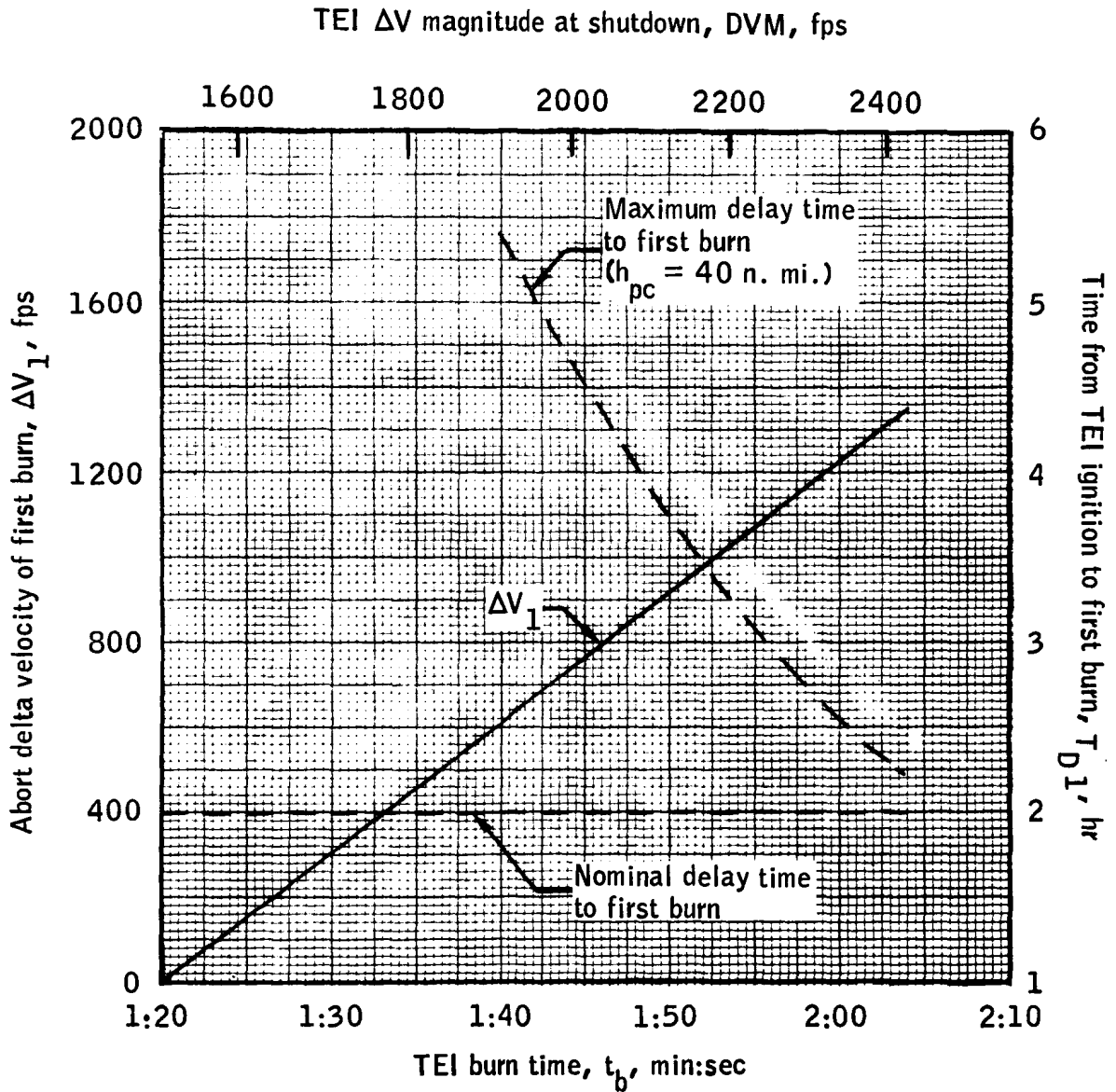
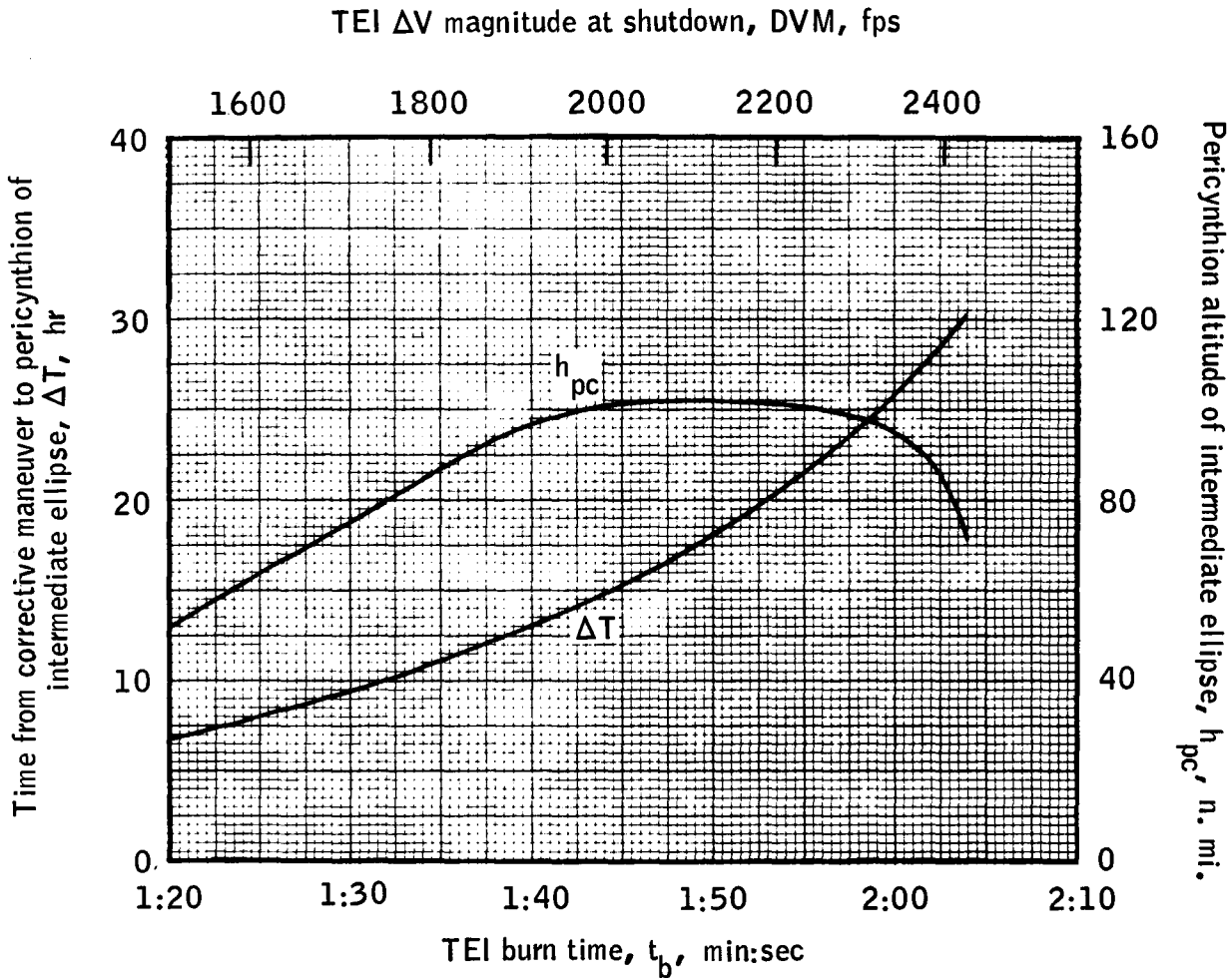
(e) Case 4, corrective maneuver  $\Delta V$  and maximum allowable delay time.

Figure 7-2.- Continued.



(f) Case 4, time to pericynthion, pericynthion altitude of intermediate ellipse.

Figure 7-2.- Concluded.

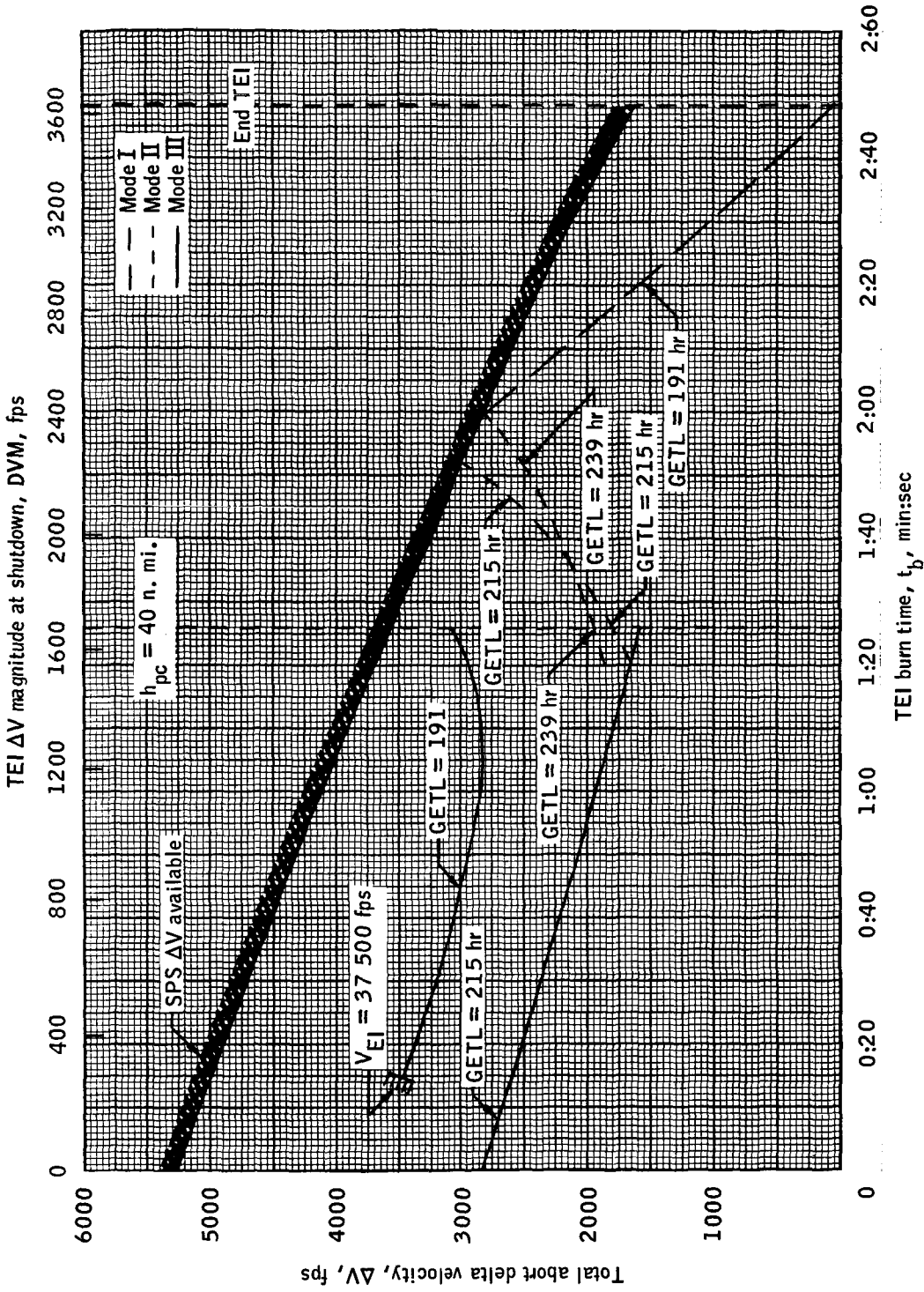


Figure 7-3.- Summary of MPL abort capability for Case 3, nominal Apollo 10 TEI burn.

## 9.0 REFERENCES

1. Contingency Analysis Section: Operational Abort Plan for Apollo 10 (Mission F). MSC IN 69-FM-78, March 28, 1969.
2. Lunde, Alfred N.: Views from the Spacecraft During Apollo 10 (Mission F). MSC IN 69-FM-74, March 21, 1969.
3. Contingency Analysis Section: Launch Window Effects on the Apollo 8 Mission Operational Abort Plan. MSC IN 68-FM-291, December 9, 1968.
4. Henderson, Edward M.: General Apollo-Saturn V CSM Launch Abort Analysis. MSC IN 68-FM-232, December 4, 1968.
5. Wittenstein, Gerald: AS-505 Operational Trajectory. MSFC memo R-AERO-FMT-43-69, February 24, 1969.
6. Hyle, Charles T.: Detailed Crew Procedures for a Powered Flight Evaluation of the Translunar Injection Maneuver. MSC IN 68-FM-212, August 28, 1968.
7. Contingency Analysis Section: Abort Reset Points for Apollo 10 (Mission F). MSC IN 69-FM-71, March 21, 1969.
8. Apollo Mission Techniques, Missions F and G Contingency Procedures, Techniques Description. MSC IN S-PA-9T-043, March 24, 1969.