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APOLLO 10 (MISSION F)
SPACECRAFT OPERATIONAL
ALTERNATE MISSION PLANS
VOLUME II
ALTERNATE LUNAR MISSIONS

Lunar Mission Analysis Branch
MISSION PLANNING AND ANALYSIS DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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PROJECT APOLLO

APOLLO 10 (MISSION F) SPACECRAFT OPERATIONAL ALTERNATE MISSION PLANS VOLUME II - ALTERNATE LUNAR MISSIONS

By Rocky D. Duncan
Lunar Mission Analysis Branch

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OPERATIONAL ALTERNATE MISSION PLANS

VOLUME II - ALTERNATE LUNAR MISSIONS

By Rocky D. Duncan

1.0 SUMMARY AND INTRODUCTION

This document is the second of three volumes entitled Apollo 10 (Mission F) Spacecraft Operational Alternate Mission Plans. Specifically, this document presents the alternate lunar missions for Apollo 10 (Mission F) exclusive of the lunar rendezvous plans.

The guidelines used for the lunar alternate missions were the following.

1. Priority of LM testing over CSM testing

2. Operations within the lunar mission time line as closely as possible

3. No requirement for additional crew training

The alternate missions presented in this document are summarized in the following paragraphs. Decision logic for the alternate lunar missions is presented in flow chart 1.

1.1 Alternate 1

1.1.1 <u>Nonnominal TLI requirement for an MCC which would preclude the nominal mission profile</u>.-

1. Alternate 1a - CSM/LM lunar orbital mission with DPS LOI

2. Alternate 1b - LM testing during translunar coast with CSM-only lunar orbital mission

3. Alternate 1c - CSM/LM flyby

1.2 Alternate 2

1.2.1 Failure to perform T, D, and E.- Alternate 2 is a CSM-only lunar orbital mission.

1.3 Alternate 3

1.3.1 LM NO-GO for undocking and rendezvous.-

1. Alternate 3a - Docked DPS TEI

2. Alternate 3b - APS burn to depletion in lunar orbit.

1.4 Alternate 4

1.4.1 CSM communications failure in lunar orbit.- Alternate 4 is an SPS TEI with APS stage.

Of prime consideration for the alternate missions presented in this document are the crossovers between the use of one alternate instead of another. For example, what is the deciding factor between a CSM-only lunar orbital mission and a flyby mission? The decision depends on the end of mission ΔV reserve philosophy. This philosophy was never resolved for Apollo 8 and prior to publication of this document had not been resolved for Apollo 10 (Mission F). It is the purpose of this document not only to present the alternates but also to present data so that the decision logic between alternates can be resolved for this mission.

2.0 ABBREVIATIONS

APS	ascent propulsion system
CDH	constant differential height
CLA	contingency landing area
CSI	coelliptic sequence initiation
CSM	command and service modules
DOI	descent orbit insertion
DPS	descent propulsion system
EI	entry interface
FCSD	Flight Crew Support Division
FTP	full throttle position
g.e.t.	ground elapsed time
G&N	guidance and navigation
I_{sp}	specific impulse
LM	lunar module
LOI	lunar orbit insertion
LOS	loss of signal
LPO	lunar parking orbit
MCC	midcourse correction
MSC	Manned Spacecraft Center
NAR	North American Rockwell
PC	pericynthion
RCS	reaction control system
SPS	service propulsion system

T, D, and E	transposition, docking, and extraction
TEC	transearth coast
TEI	transearth injection
TLC	translunar coast
TLI	translunar insertion
TPI	terminal phase initialization
ΔV	change in velocity

3.0 DISCUSSION

3.1 Alternate 1 - Contingency: Nonnominal TLI Requirement for MCC Which Would Preclude the Nominal Mission Profile

Alternates 1a, 1b, and 1c are concerned with the nonnominal TLI situations from which it would not be possible to do an MCC to return to the nominal mission. In this case, T, D, and E would be performed, as in the nominal time line. After T, D, and E had been performed, a docked SPS maneuver of up to 4000 fps would be made to place the CSM/LM on a free-return circumlunar trajectory. Based on a burn of this magnitude, the resultant CSM/LM weight configuration would result in a DPS abort capability of approximately 3000 fps. An additional 3300 fps abort capability is available by jettison of the LM.

3.1.1 Alternate 1a - CSM/LM lunar orbital mission with DPS LOI.- Alternate 1a would be used for a situation in which the first SPS MCC would preclude an SPS, LOI-1, LOI-2, and TEI.

The decision to perform an SPS LOI would be a function of the end of mission ΔV reserve philosophy.

The following ΔV requirements were taken from reference 1 for the May 1969 launch window.[a]

1. Range of LOI-1, ΔV ≃ 2950 fps to 3040 fps

2. LOI-2 ΔV ≃ 138 fps

3. Range of TEI ΔV ≃ 2658 fps to 4150 fps

The TEI ΔV requirements are based on transearth flight times from approximately 47 to 126 hours. Other considerations in the reserve budget are as follows.[b]

1. CSM rescue in lunar orbit = 790 fps

2. Translunar MCC ΔV = 120 fps

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[a]The nominal transearth flight time for the May 18 window ranges from 47 to 53 hours. This time is not reflected in reference 2.

[b]These would not be totaled since this would be allowing for double failure or contingencies (i.e., CSM rescue and weather avoidance requirements).

3. Weather avoidance at EI minus 24 hours = 800 fps

4. G&N failure in lunar orbit ≈ 120 fps

If a large SPS MCC were required because of a nonnominal TLI, then the items listed on the previous page would have to be traded off before commitment to an SPS LOI. The major consideration in the ΔV reserve philosophy is the transearth flight time requirement. The other absolute ΔV requirements (LOI-1 and LOI-2) are relatively inflexible.

The CSM-only ΔV capability following any docked SPS burn is presented in figure 1, and ΔV requirements compared to transearth flight time across the May 1969 launch window are presented in figure 2.[a] If the docked SPS burns (MCC, LOI-1, and LOI-2) are summed and if the sums are used with figures 1 and 2, the transearth flight times that can be achieved can be defined. Because the discrete solutions to the 165° W CLA for each launch day also are shown in figure 2, the approximate end of mission ΔV reserves can be derived based on a return to this landing site. The end of mission ΔV reserve philosophy was not resolved for Apollo 8 in the mission rules and has not yet been resolved for Apollo 10 (Mission F).

If for any one of the considerations listed above it were decided not to do an SPS LOI, then a docked DPS LOI could be performed. The DPS LOI profile would be to burn the DPS to insert the SC into a high apocynthion lunar orbit. Subsequently, the SPS would be used to circularize the orbit to the nominal 60-n. mi. orbit. The following constraints and guidelines apply to using the DPS for LOI.

1. The LOI-I maneuver should be targeted such that the subsequent SPS burn is a minimum of 40 seconds in duration. This condition is based on the constraint in reference 2 which states that after a docked SPS burn, the next SPS burn must be at least 40 seconds in duration to guarantee SPS multirestart capability. The constraint will insure that any helium will be cleared out which might have accumulated in the SPS feed lines because of the large negative ullage. The CSM-only ΔV that results from a 40-second burn is compared to mass at burn initiation in figure 3.

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[a] A mean curve of transearth flight time compared with ΔV for the May launch window is presented in figure 2. The curve is in error up to 50 fps for some days. The data have been generated in detail across each daily launch window and will be documented in an MSC internal note.

2. In addition to the first constraint, NR has further recommended that because of the criticality of the SPS in lunar orbit the DPS LOI should not be performed unless the SPS sump tanks are full. The storage and sump tank configurations are generally illustrated in figure 4. Because the storage tanks are depleted first and they contain about one-half of the SPS fuel, for the sump tanks to be full at LOI requires that no more than one-half of the SPS fuel can be burned prior to LOI. Based on F mission loading, half of the SPS fuel is 20 108 pounds, which corresponds to a docked SPS ΔV of approximately 2400 fps prior to LOI.

3. The DPS should not be burned to depletion. Enough fuel should be held in reserve to perform the nominal mission rendezvous profile. The rendezvous ΔV requirements are as follows.

Burn	ΔV, fps	Propulsion system
DOI	73	DPS
Phasing	193	DPS
Insertion	213	APS
CSI	50	RCS
CDH	6	RCS
TPI	25	RCS
Total	560	

It is recommended that 1000 pounds of DPS fuel be reserved for rendezvous. This allotment is quite conservative because based on even a low DPS I_{sp} of 300 seconds it will yield approximately 685 fps, which is more than sufficient to fly the entire rendezvous profile with the DPS if required. If a smaller reserve were considered, the DPS ΔV capability based on a low fuel loading (0 to 1200 lb) can be determined from figure 5.

Apogee altitude compared to burn time for a typical TLI burn is presented in figure 6. Because apogee altitude increases so rapidly near the end of the burn, a very small premature shutdown can result in a large MCC to return to the nominal trajectory. Typical MCC ΔV requirements at 2, 3, 5, and 7 hours after TLI cutoff are shown in figure 7 for various apogee ellipses that result from premature S-IVB shutdowns during TLI.[a]

The SPS fuel used and the mass that results after docked SPS burn are presented in figure 8. Finally, docked DPS ΔV capability based on CSM/LM mass at burn initiation is presented in figure 9. The resultant DPS ΔV capability for LOI can be ascertained from these curves, based on SPS propellant required to correct a nonnominal TLI.

All the curves are presented so that the ΔV tradeoffs involved in commitment to a DPS LOI can be shown. This commitment would involve some very complicated decision logic if it were not for constraint 2 listed above; that is, LOI will not be performed with the DPS unless the SPS sump tanks are full. The constraint dictates that no more than half of the SPS fuel be used prior to LOI (20 108 lb) and that the total pre-LOI SPS ΔV be less than 2421 fps. The resultant CSM/LM mass would produce a docked DPS ΔV capability of 2460 fps with 1000 pounds of propellant reserved for rendezvous.

The ΔV and resultant apogee altitudes are presented in figure 10 as a function of burn time for an LOI burn on the May 17 launch window. The previously described DPS ΔV would insert the CSM/LM into approximately a 60- by 700-n. mi. orbit (fig. 10). It also can be seen from figure 10 that even with the minimum DPS ΔV of 1950 fps (full SPS tanks) the LM would be capable of insertion into a 60- by 1600-n. mi. orbit. Therefore, based on the previously listed ground rules the range of lunar orbits of which the DPS is capable are from 60 by 700 n. mi. to 60 by 1600 n. mi.

The cutoff point for the decision to perform an SPS burn or a LM DPS LOI will depend on the end of mission ΔV reserve philosophy.

For this document, a DPS LOI for the May 17 launch window was simulated based on the following profile.

1. The first MCC used half of the SPS fuel (ΔV = 2421 fps).

2. The CSM/LM mass at LOI was 74 488 pounds.

3. The DPS lunar ΔV was near the maximum capability while a 1000-pound fuel reserve was maintained for rendezvous.

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[a]These data were based on a premature S-IVB shutdown and do not consider any guidance dispersions. The data are provided as typical data and can be expected to vary somewhat for different launch azimuths and launch days.

4. The burn profile was 10 percent thrust for 15 seconds, and the remainder of the burn was performed at FTP.

5. The average I_{sp} was assumed to be 302.1

A summary of the DPS LOI burn is presented in the following table.

Time of LOI initiation, hr:min:sec, g.e.t.	76:09:20.38
Selenographic longitude of initiation, deg W	165.2
Burn duration, sec	521
Burn arc, deg	35.0
ΔV, fps	2398
DPS propellant used, lb	16 421.3
Selenographic longitude of burn termination, deg E	159.9
Period of LPO, hr	3.02
Altitude of pericynthion of LPO, n. mi.	58.3
Altitude of apocynthion of LPO, n. mi.	707.0

Certain key parameters for this burn are plotted in figure 11. Because the period of this orbit is approximately 3 hours, the SPS circularization burn was performed near the first pericynthion. If an additional revolution of tracking were required prior to circularization, then some adjustments would have to be made in the postcircularization time line, for example, reduce the rest period or change the time for initiation of the DOI-day activities.

A brief summary of the SPS circularization burn is presented in the following table

Time of ignition, hr:min:sec, g.e.t.	7:10:24
Selenographic longitude of burn initiation, deg W . . .	176.6
Burn duration, sec	43.1
Burn arc, deg	2.8

ΔV, fps 620.9

SPS propellant used, lb 3460

Note that this burn would have the shortest SPS burn duration based on the ground rules established for this alternate.

3.1.2 Alternate 1b - LM testing during translunar coast with CSM-only lunar orbital mission.- If the DPS LOI is not performed, then the second priority alternate is a CSM-only lunar orbital mission. The LM testing would be performed during the translunar coast phase of the mission. The following guidelines are recommended for alternate 1b.

1. The LM testing should be performed early in translunar coast to avoid any trajectory perturbations caused by the activities associated with the LM burns (separation, evasive maneuvers, etc.) close to the critical pre-LOI tracking.

2. No DPS burn will be performed.

3. An unmanned APS burn to depletion will be performed. This burn will be targeted to place the ascent stage in a heliocentric orbit.

The earliest opportunity to perform LM checkout and testing is at approximately TLI plus 19 hours. This time corresponds to the second crew activity period after TLI. The nominal F mission LM checkout procedures would be followed as closely as possible. Between approximately TLI plus 23 hours and TLI plus 25 hours, the DPS is staged and an unmanned APS burn to depletion is performed. The APS burn targeting that is designed to place the ascent stage into a heliocentric orbit is very insensitive to the local horizontal burn attitude (fig. 12). It is arbitrarily recommended that the APS burn to depletion be made pitched up 45° from the local horizontal. This attitude will provide good LM high-gain communications during the burn, and the ascent stage should easily go into an orbit about the sun.

After the APS burn, the CSM returns to the nominal TLC time line. The CSM then will fly a CSM-only lunar orbital mission as described in detail in alternate 2.

3.1.3 Alternate 1c - CSM/LM flyby.- If neither alternate 1a nor 1b can be flown, then a CSM/LM flyby is flown with LM testing performed near pericynthion. At PC minus 5 hours after LM checkout, a DPS burn is made to raise pericynthion and to establish a free return to a CLA. The ΔV of the burn will be up to 500 fps (ref. 3).

Shortly after pericynthion, the DPS is staged and an unmanned APS burn to depletion is performed. The APS burn is targeted along the velocity vector, and the resultant ΔV of approximately 3866 fps should place the ascent stage in an orbit about the sun.

The APS burn to depletion was made near pericynthion for several reasons.

1. The LM was powered up and checked out and ready for a burn.

2. After jettison of the ascent stage, the CSM is capable of a greater ΔV for the subsequent MCC and for any weather avoidance problems.

3. All activities associated with an APS burn to depletion (LM jettison, evasive maneuvers, etc.) would be performed early in TEC and would not be a source of trajectory perturbations. If these arguments are not felt to be valid, then the option exists to keep the LM as a communications backup until shortly peior to entry.

After sufficient tracking of the CSM, an SPS maneuver is made to return in the shortest possible flight time to a landing at the Pacific CLA.

3.2 Alternate 2: CSM-only Lunar Orbital Mission

If T, D, and E cannot be performed after TLI, then a CSM-only lunar orbital mission will be flown. This alternate would also be used for a nonnominal TLI as described in alternate 1b. The philosophy would be to follow the nominal Mission F time line work-rest cycles. In lunar orbit, the times nominally scheduled for LM checkout, rendezvous, and the APS burn to depletion would be used for landmark tracking and for lunar surface photography. Included in the profile are several revolutions of MSFN tracking of the CSM in a low pericynthion orbit. Because alternate 2 is a radical departure from the nominal lunar orbit time line and because the lunar orbit events required careful scheduling, a more detailed time line is being generated for it than were generated for the other alternate missions. This effort presently is being coordinated with FCSD.

The event time line is illustrated in figures 13 and 14. On the LOI day, the major portion of the time available is allotted to lunar surface photography. The photography consists of oblique target of opportunity coverage to the north and to the south of the lunar groundtrack. Photography is performed on revolutions 2, 3, and 4 (fig. 13). Photography takes up considerably less than half of revolution 3 because of LOI-2 and the associated activities. Landmark tracking is performed near the sunset terminator on revolutions 3, 4, and 5.

Consistent with the nominal time line, a rest period is begun during the fifth revolution after LOI.

At a g.e.t. of approximately 94 hours or near the end of revolution 9, the crew ends an 8-hour rest period. Two hours are allotted for eating and for landmark tracking preparations. Near the beginning of revolution 11, landmark tracking is performed at CP1 near the sunrise terminator, at CP2 near the subsolar point of the sun, and at B1 near the sunset terminator. These landmarks for the May 18 launch window are shown below.[a]

Site designation	Selenographic latitude	Selenographic longitude
CP1	0°53'N	170°09'E
CP2	4°46'N	138°14'E
B1	2°31'N	35°02'E

The sequence is repeated for revolutions 12, 13, and 14. Near the end of revolution 14, at 130.7° W, an SPS DOI maneuver is performed to insert the CSM into a 60- by 8-n. mi. orbit. The burn is targeted to place the pericynthion 15° up range of the landing site as in the nominal descent profile. Burn time is compared in figure 15 with ΔV and resultant pericynthion altitude for the maneuver.

The CSM will remain in this orbit for three revolutions. On the first two pericynthion passes, landmark tracking is attempted on landmark B1. The geometry and attitude requirements associated with these passes over the site are shown in figure 16. Because the LOS rate to the landmark is so rapid in this low orbit, it is not expected that the crew will be able to perform more than two or three marks. The third pericynthion pass is used for vertical stereo photography.

Near the third apocynthion of the 60- by 8-n. mi. orbit, the CSM is circularized in 60-n. mi. orbit. A crew rest period which is started shortly thereafter consititutes a return to the nominal mission profile.

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[a]The landmarks for subsequent days have not yet been selected. The choice is being coordinated between FCSD and the Lunar Mapping Sciences Division.

3.3 Alternate 3 - Contingency: LM NO-GO for Undocking and Rendezvous

3.3.1 Alternate 3a - DPS TEI.- If the LM checkout indicates that the LM was NO-GO for the undocking but that the DPS was GO for a burn, then basically the alternate mission would consist of a DPS TEI. The docked DPS capability compared with the CSM/LM weight is shown in figure 17. Normally, the CSM/LM weight after LOI-2 is approximately 70 000 pounds. This weight will result in a DPS ΔV capability of approximately 2800 fps (fig. 9). The transearth flight time capability based on this ΔV is shown in figure 2 for the May launch windows.

The scheduling of the DPS TEI is a major consideration for alternate 3. A tradeoff exists between performance of a DPS TEI near the nominal time of the first DPS burn (DOI) and delay of the maneuver until after the landmark tracking scheduled for the third crew activity period in lunar orbit. This tradeoff, in turn, is a function of the buildup of the supercritical helium pressure.

If the supercritical helium pressure were within the required limits, then the time which was formerly used for rendezvous and for the APS burn to depletion may be used for four revolutions of landmark tracking and for a DPS TEI. Based on the nominal flight plan, undocking occurs at 98^h30^m g.e.t. The APS burn occurs at 109^h00^m g.e.t., which allows approximately 10 hours and 30 minutes or a little over five complete revolutions to perform landmark tracking and to perform TEI. An illustration of this profile is shown in figure 17.

After the four revolutions of landmark tracking, a real-time decision would have to be made as to whether to stage the DPS and remain in orbit for next day's activities or to burn TEI. If the supercritical helium pressure is such that the previously outlined profile cannot be flown, it is recommended that the DPS be staged. The landmark tracking would be performed during the period outlined above and also if required on the next day as in the nominal flight plan. As APS burn to depletion would be performed as in the nominal time line and landmark tracking would be performed during the remainder of the crew day. The mission would then revert to the nominal timeline.

If the DPS were used for TEI, an unmanned APS burn to depletion would be performed as soon as possible after TEI. This timing would allow the maximum amount of unperturbed tracking for the first transearth MCC which occurs at approximately TEI plus 15 hours. The APS is targeted along the velocity vector to maximize the chances of the ascent stage going into an orbit about the sun. The MCC at TLI plus 15 hours would be an SPS maneuver to return to earth in a minimum transit time consistent with landing at 165° W within entry velocity limits.

3.3.2 Alternate 3b - LM APS burn to depletion in lunar orbit.- If the LM were NO-GO for undocking and if the DPS were NO-GO for a burn, then an APS burn to depletion would be performed. The nominal time line procedures would be simulated as closely as possible until the nominal time of the phasing burn. After this time, two additional revolutions of LM testing could be performed. The DPS stage would then be jettisoned and the APS burn to depletion performed as in the nominal time line.

Based on the time used to perform further LM checkout beyond the nominal time line, landmark tracking could be performed in the time period formerly used for rendezvous.

3.4 Alternate 4 - SPS TEI with Docked APS Stage

If there is a CSM communications failure in lunar orbit, the alternate would be to perform TEI and to keep the LM as a communications system. If the DPS is available, the DPS TEI could be performed as described in alternate 3. If the DPS has been staged, then an SPS TEI with the ascent stage attached will be performed. Based on a nominal fuel loading after LOI-2, the SPS should have the capability to achieve approximately 2800 fps, which would provide a slow transearth flight time capability (fig. 3).

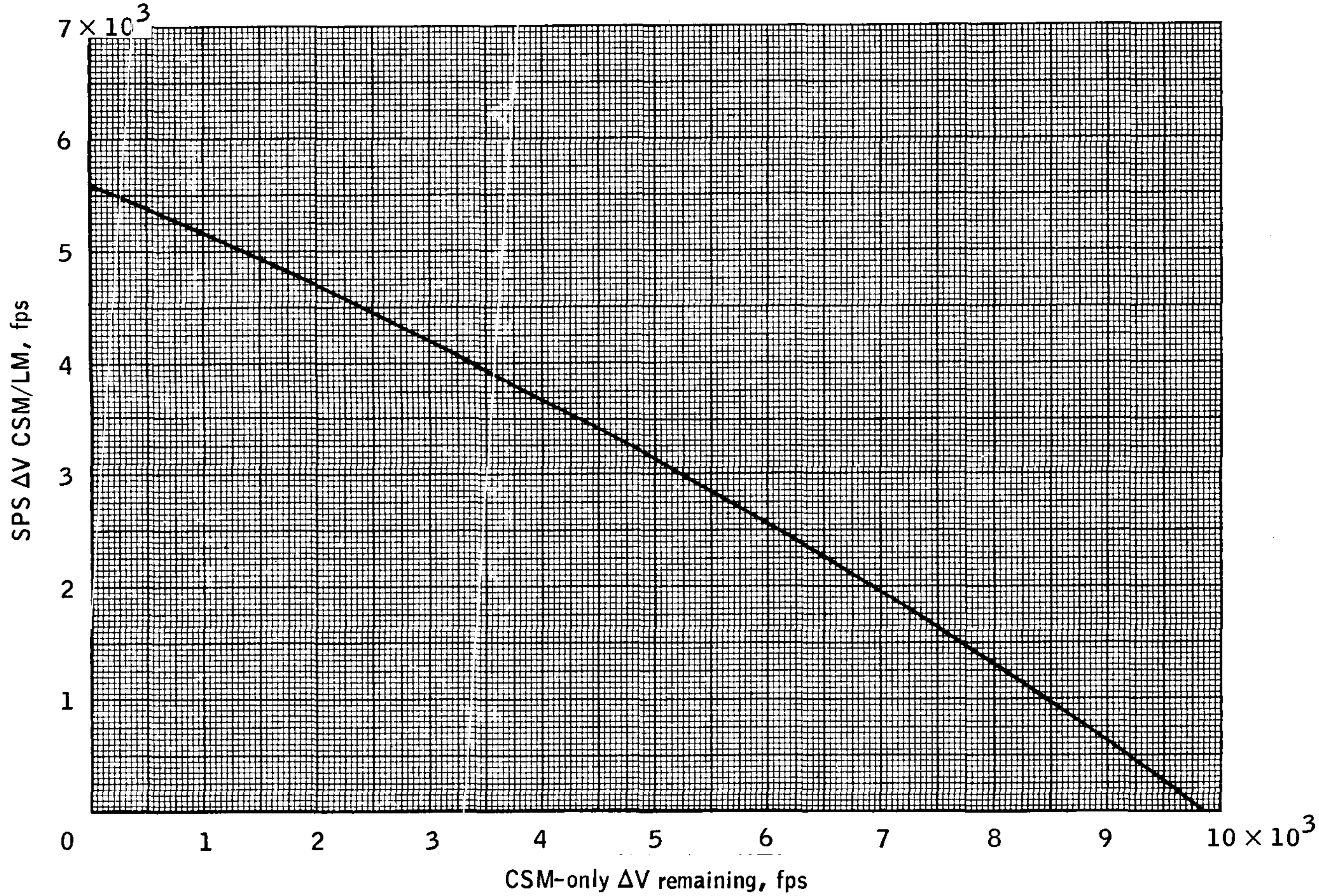


Figure 1.- CSM-only ΔV remaining following a CSM/LM SPS burn.

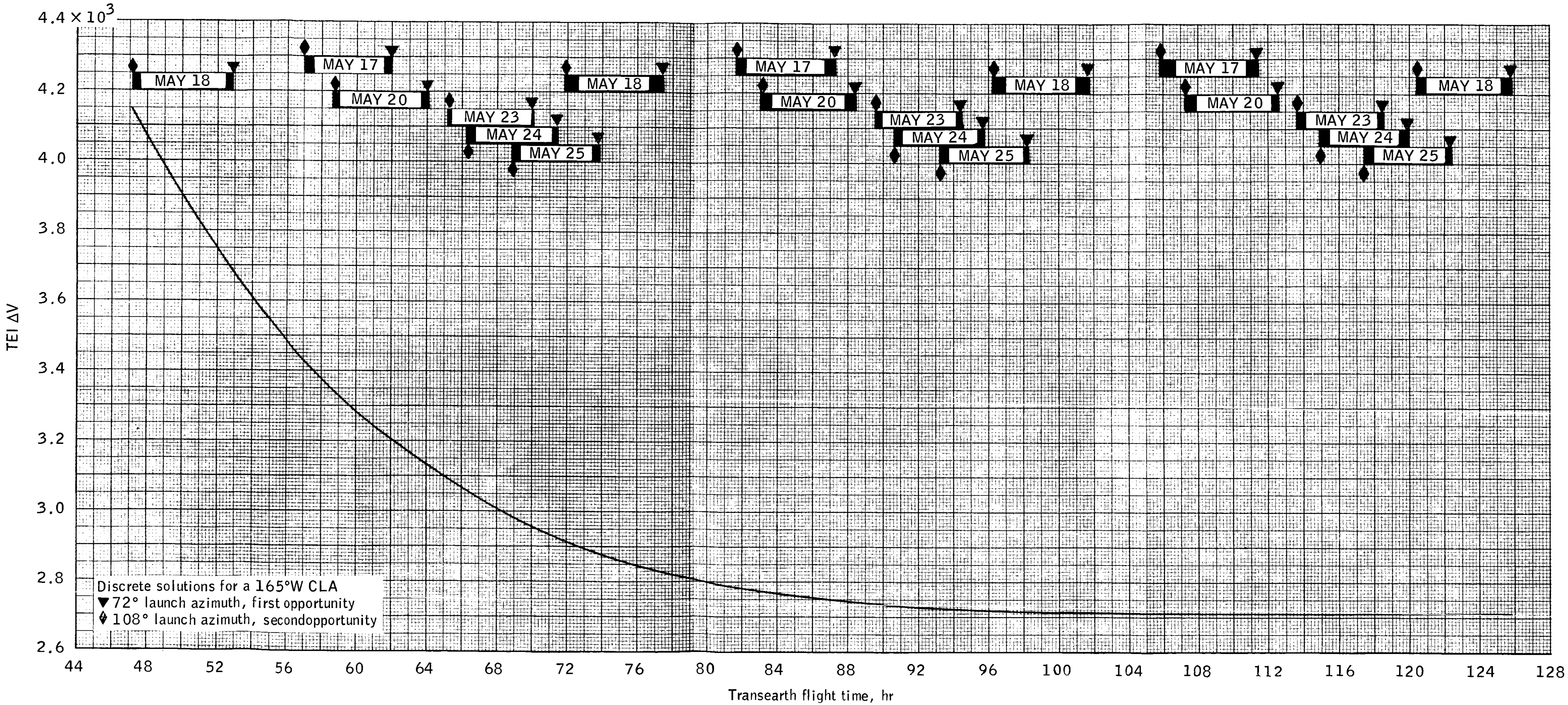


Figure 2.- Mean TEI ΔV requirements versus TE flight time for May 1969 launch window.

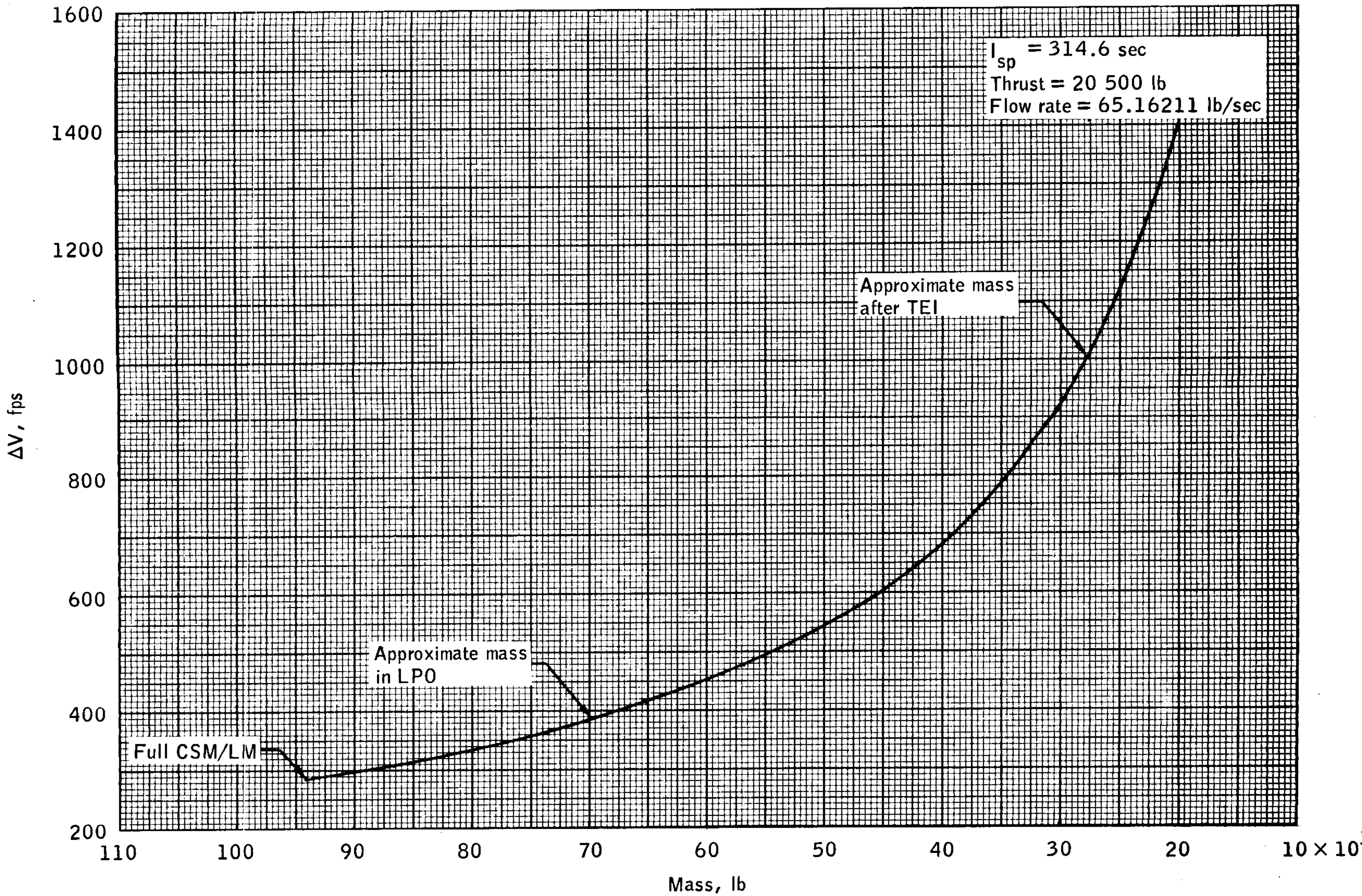


Figure 3.- ΔV resulting from a 40-second SPS burn versus mass at burn initiation.

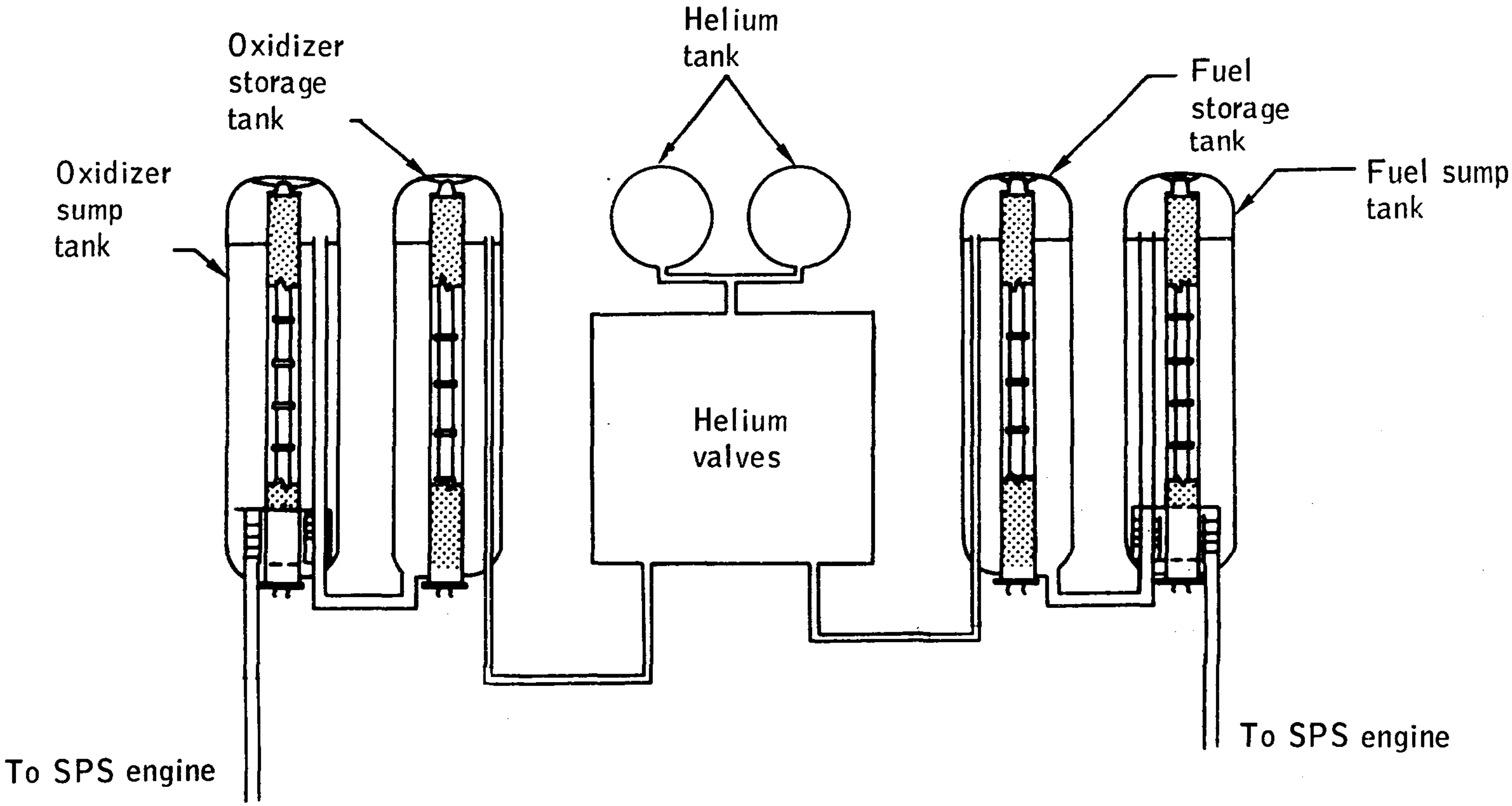


Figure 4 .- Flow of service propulsion propellants.

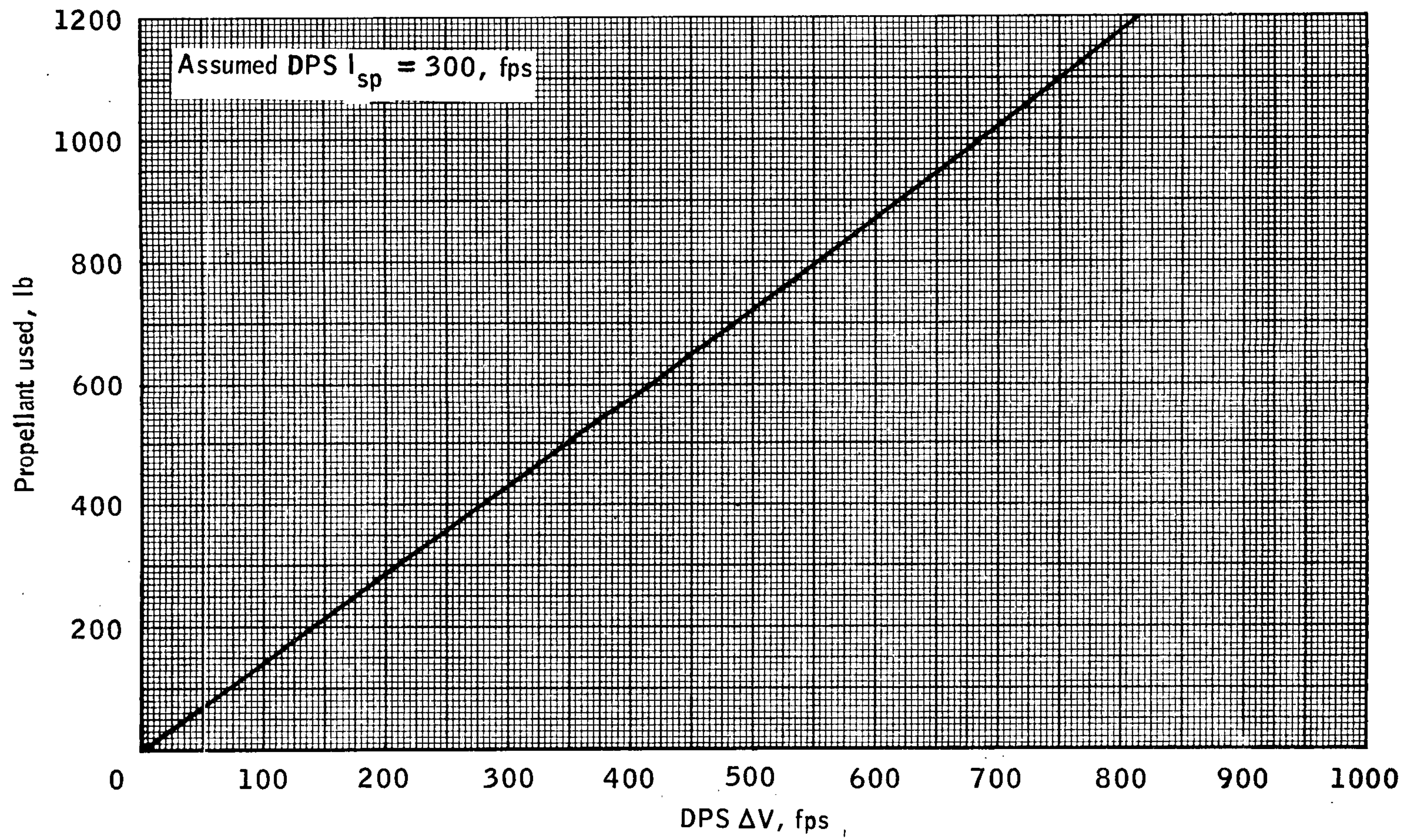


Figure 5.- DPS ΔV capability based on low fuel loadings.

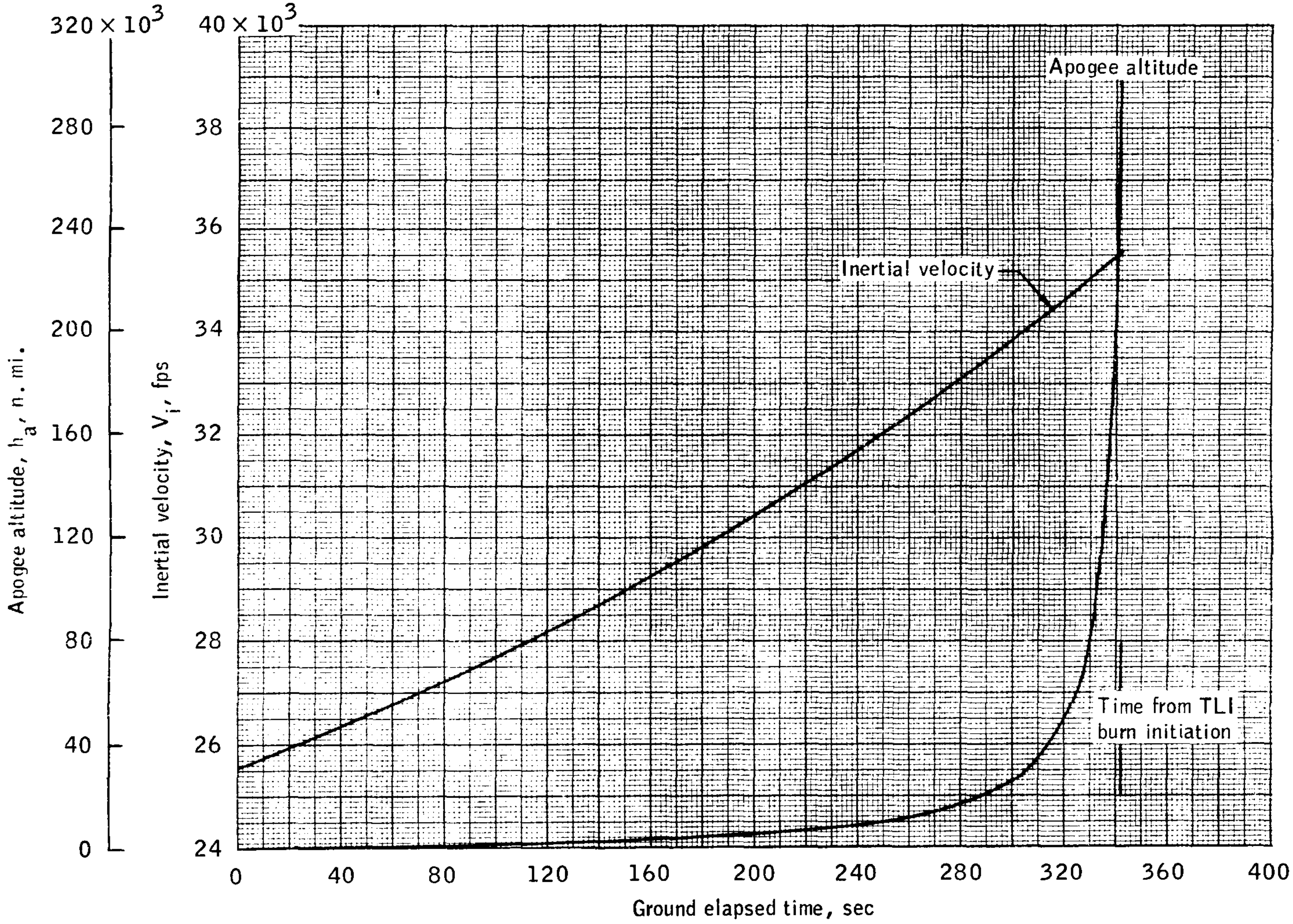


Figure 6.- TLI burn profile for May 17, 1969, 72° launch azimuth first injection opportunity.

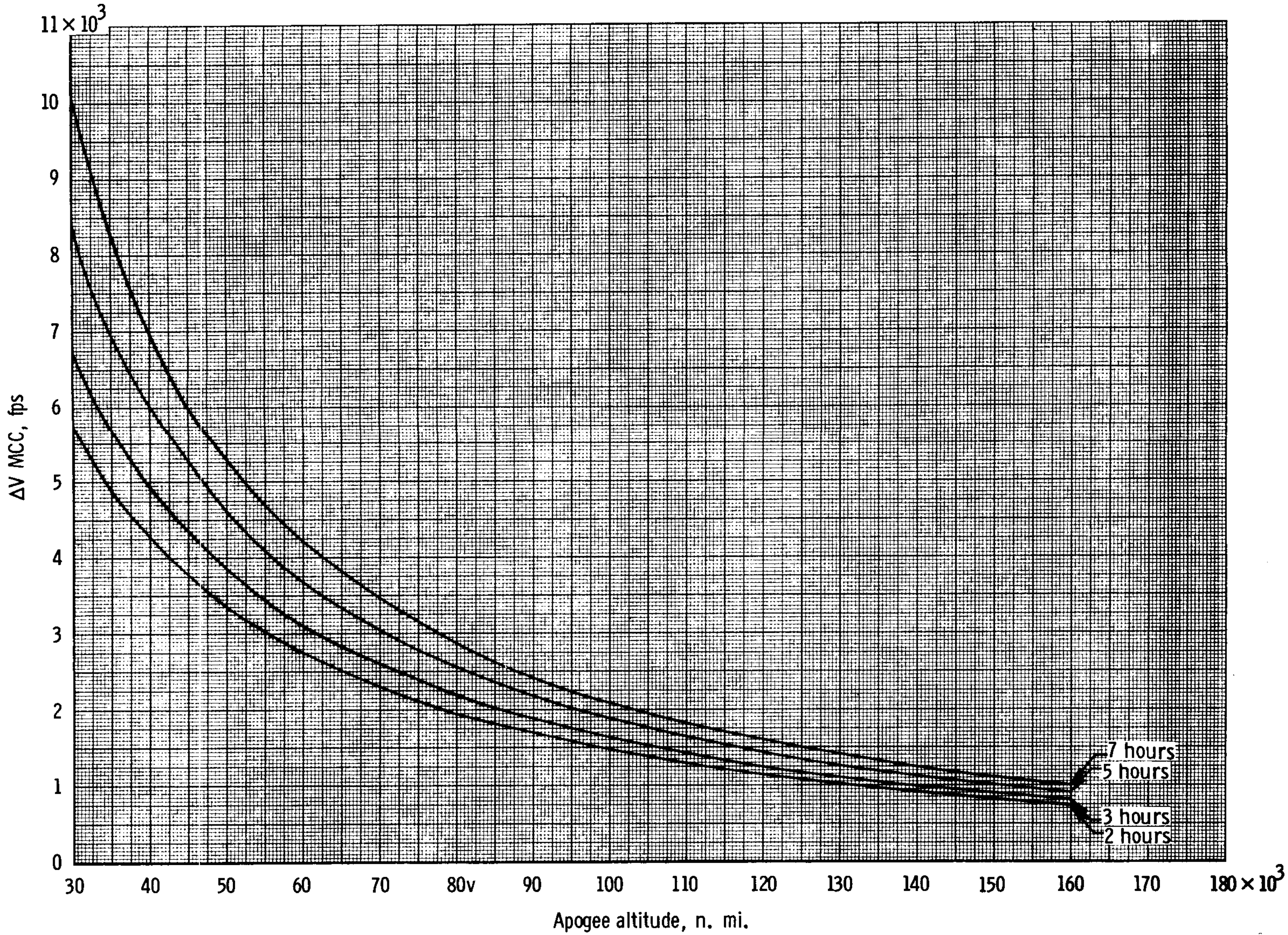


Figure 7. - MCC ΔV requirements for various apogee ellipses resulting from premature S-IVB shutdowns.

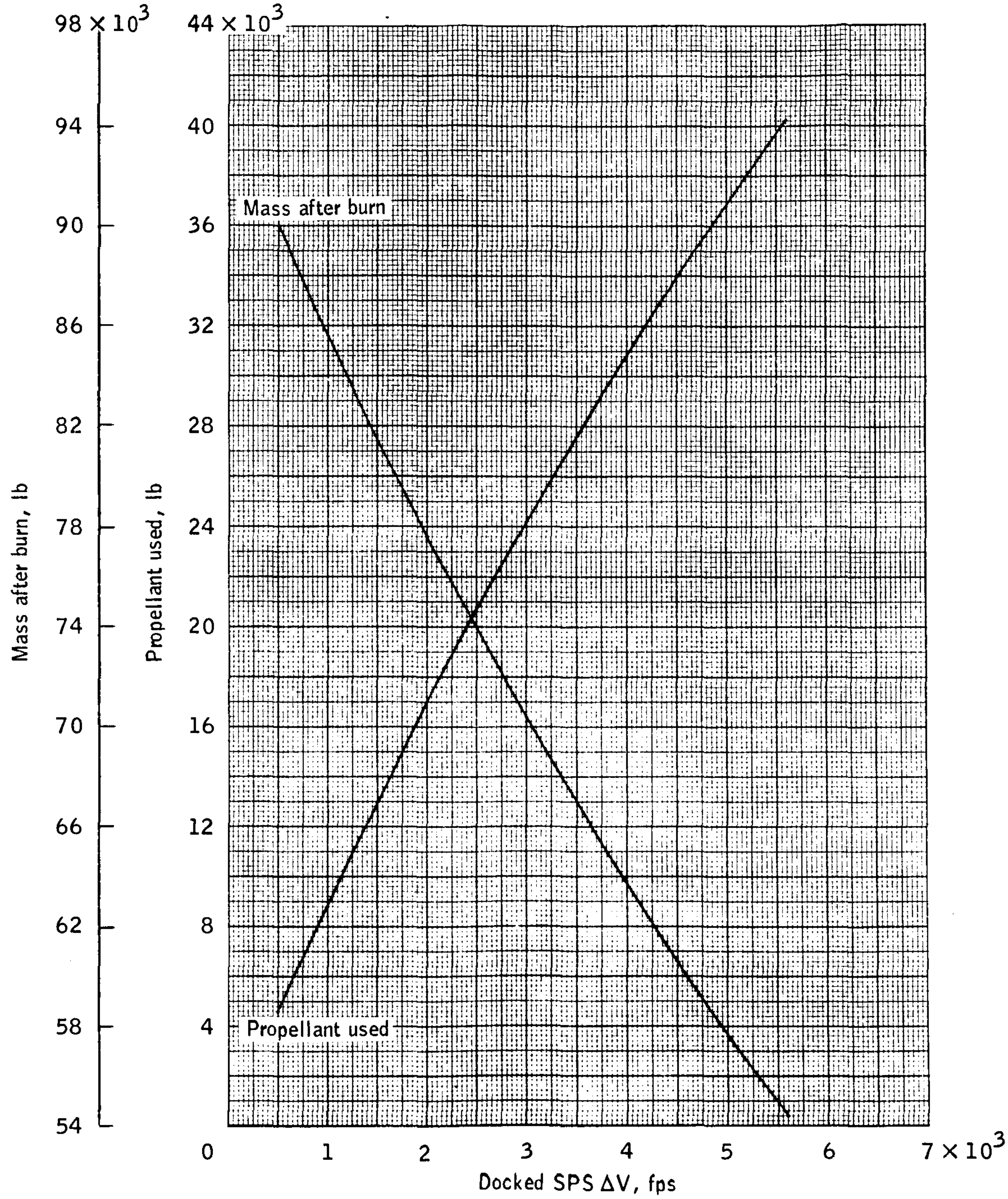


Figure 8.- Propellant used and resultant mass following a docked SPS burn.

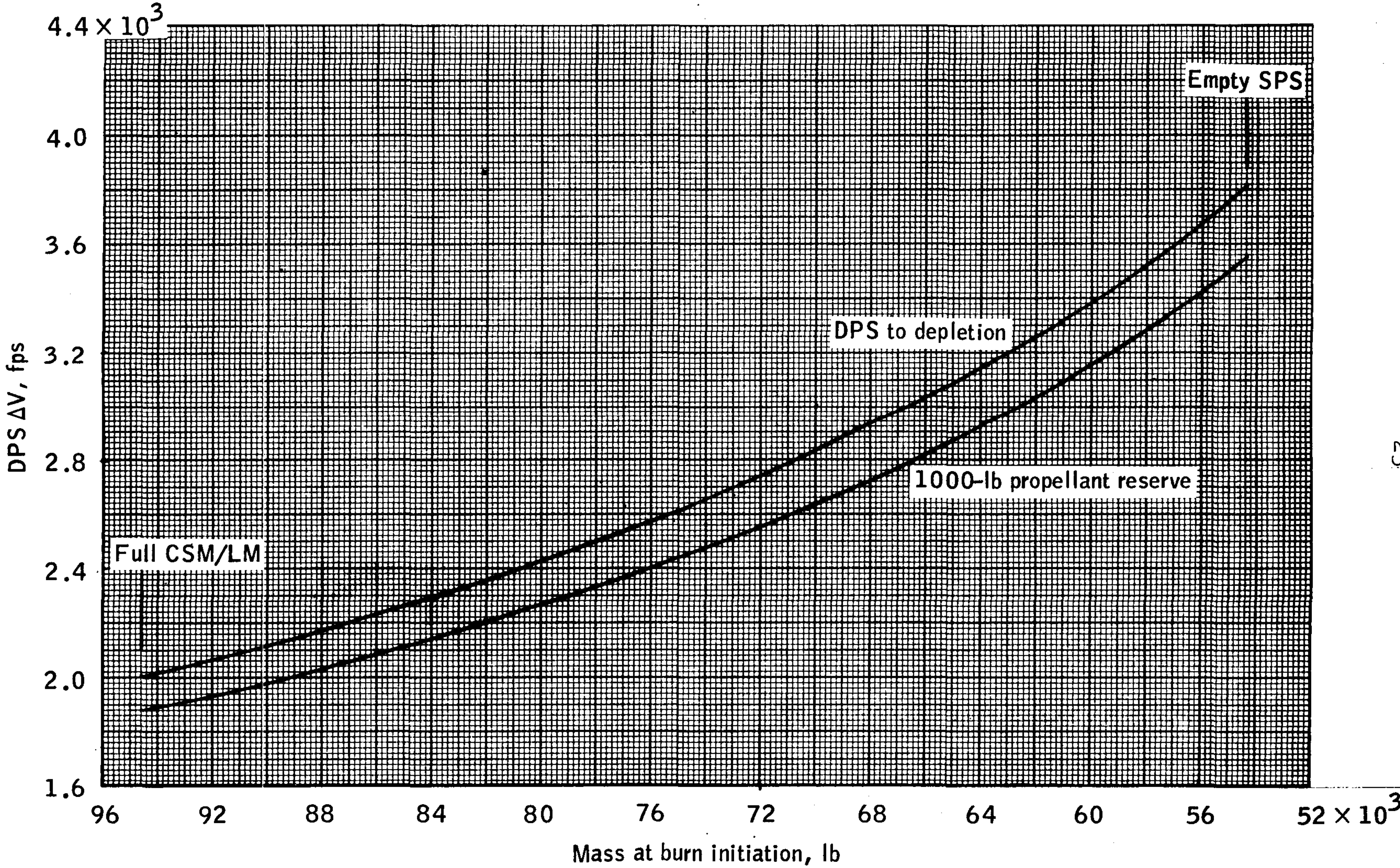


Figure 9.- Docked DPS ΔV capability for various masses at burn initiation.

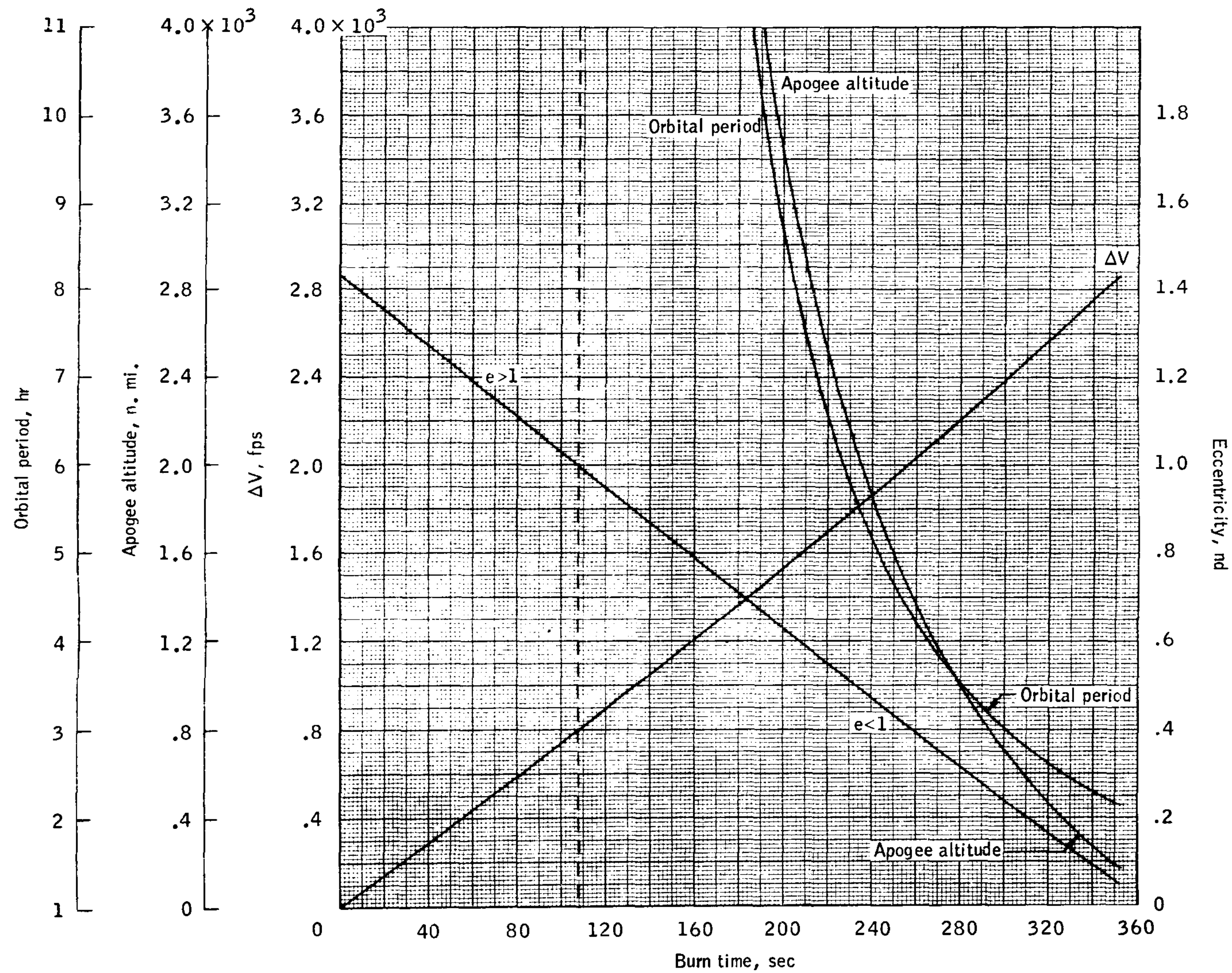


Figure 10.- Nominal SPS LOI for 72° launch azimuth first opportunity for May 17 launch window.

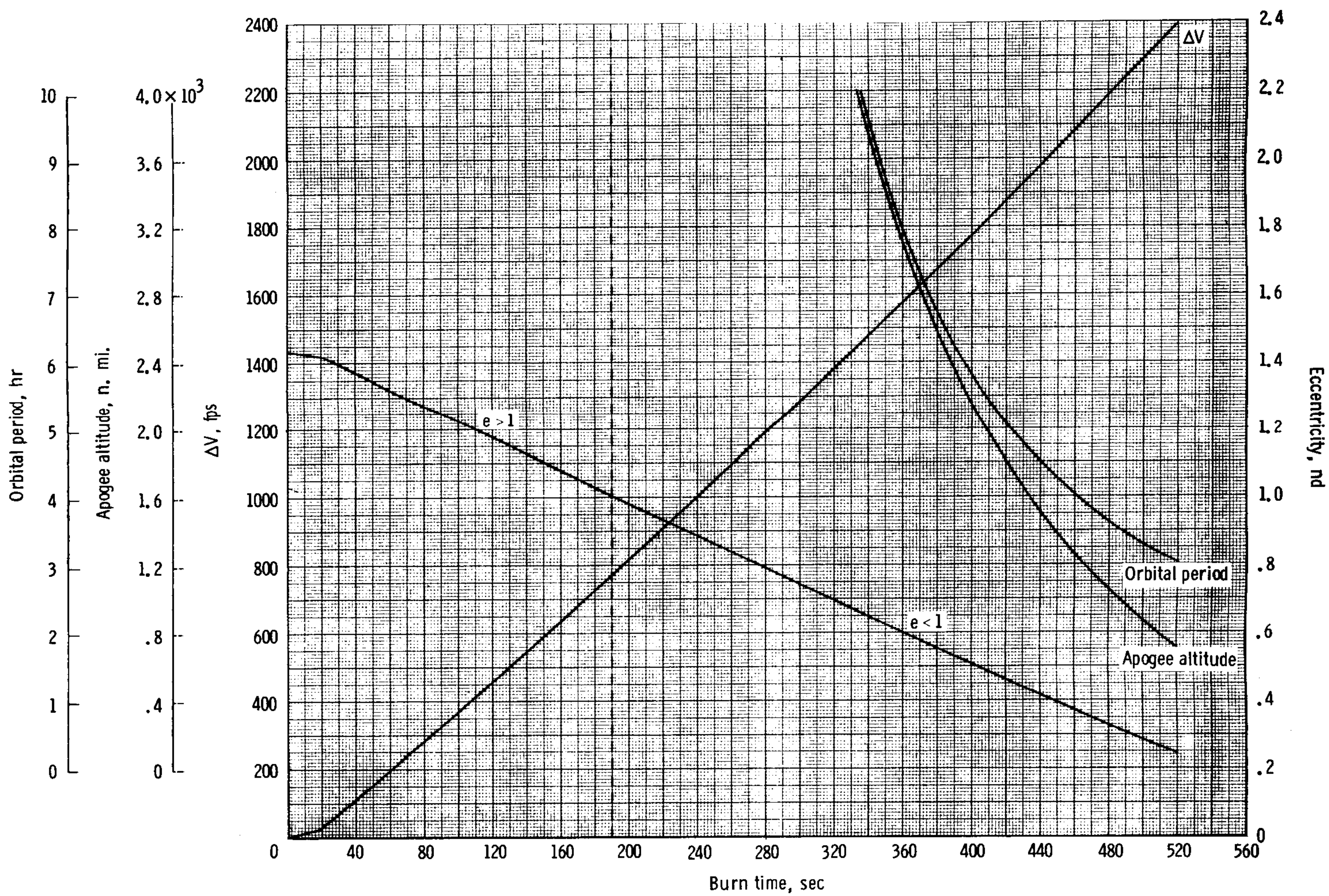


Figure 11. - DPS LOI into a 60-by 707-n. mi. orbit.

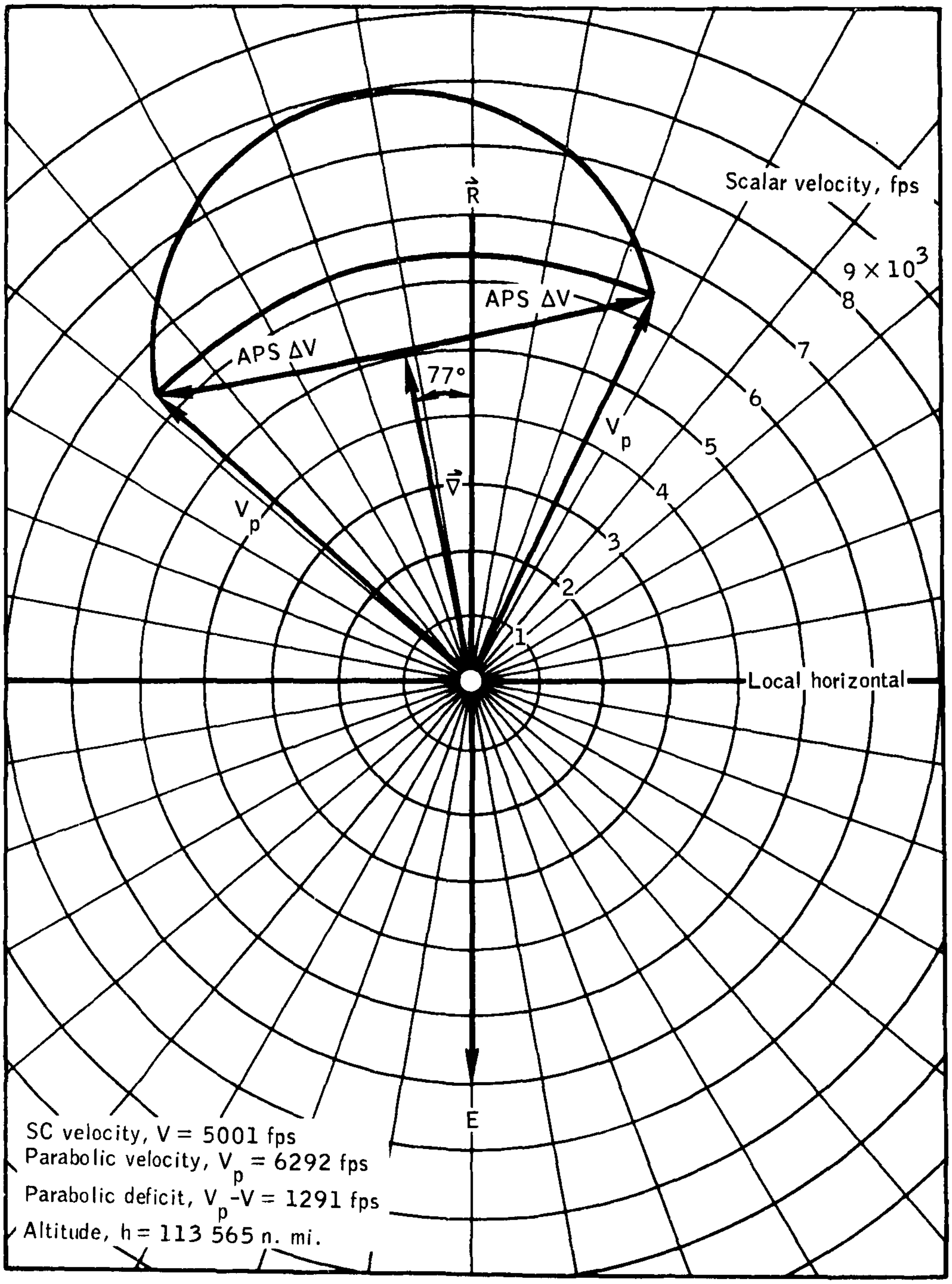


Figure 12.- TLI + 25 hours APS burn to depletion.

LOI-1 ≈ 76 hr
LOI-2 ≈ 80.5 hr
Begin rest ≈ 86 hr

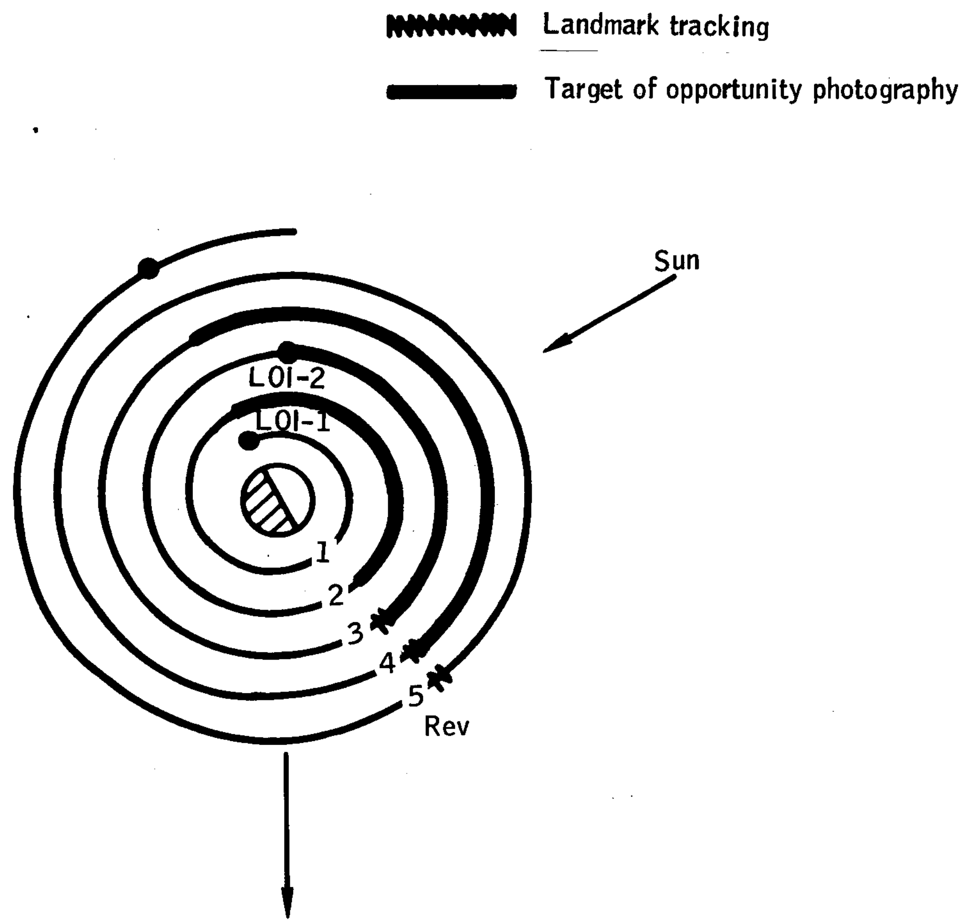
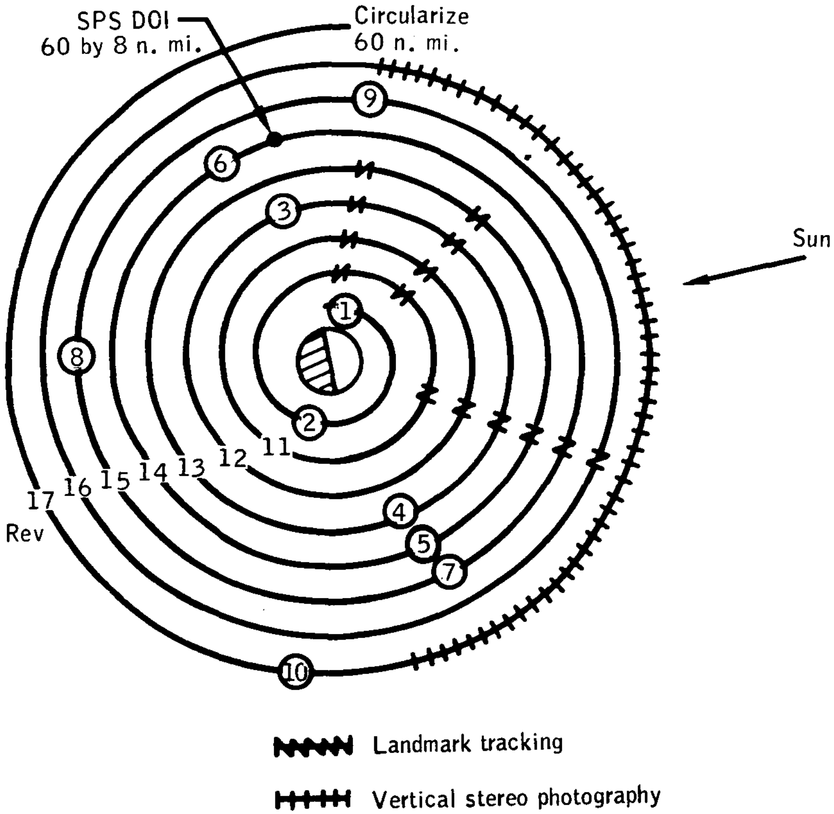


Figure 13.- Events sequence for LOI day.



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

Figure 14. Event sequence for DOI day.

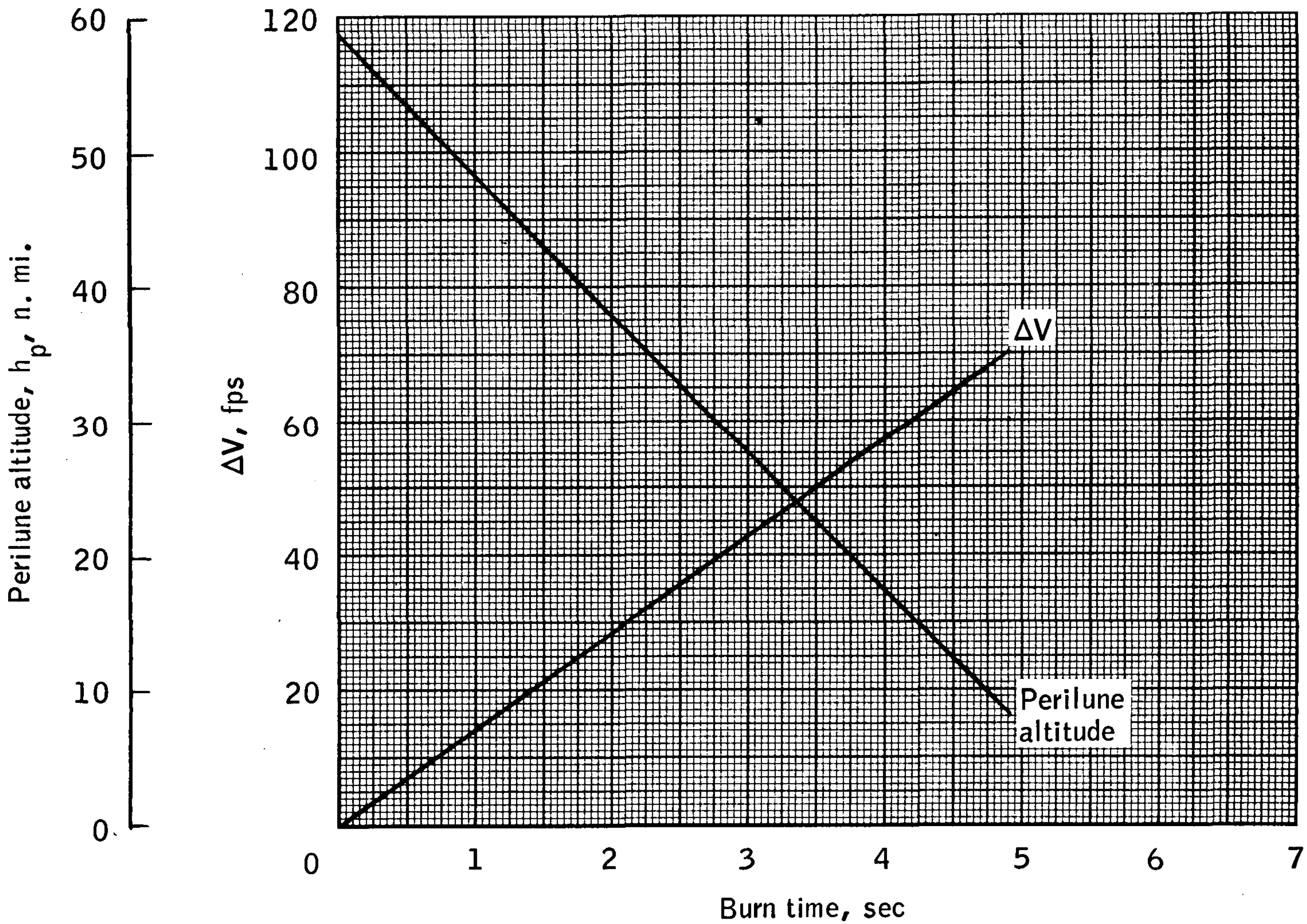
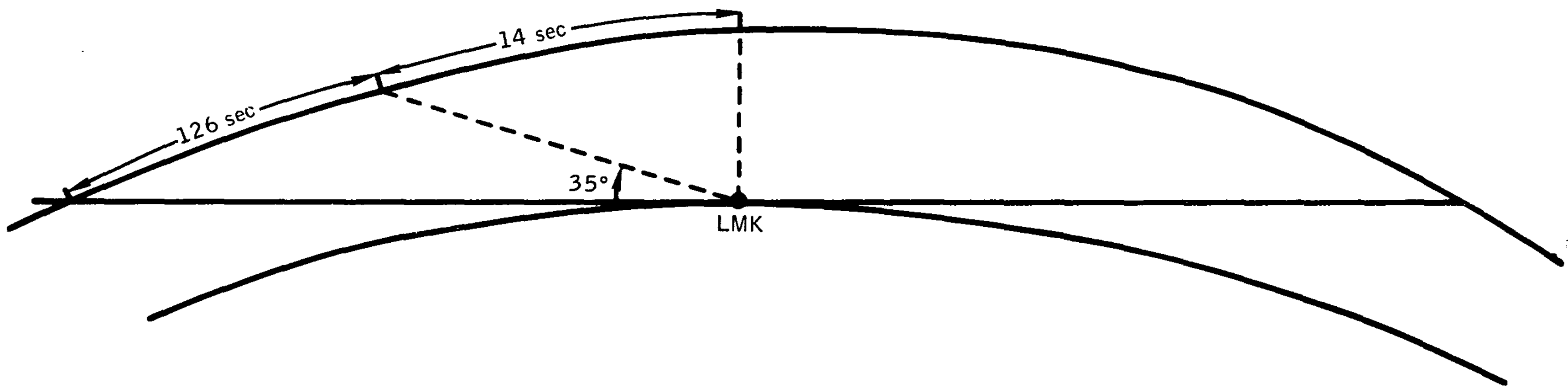
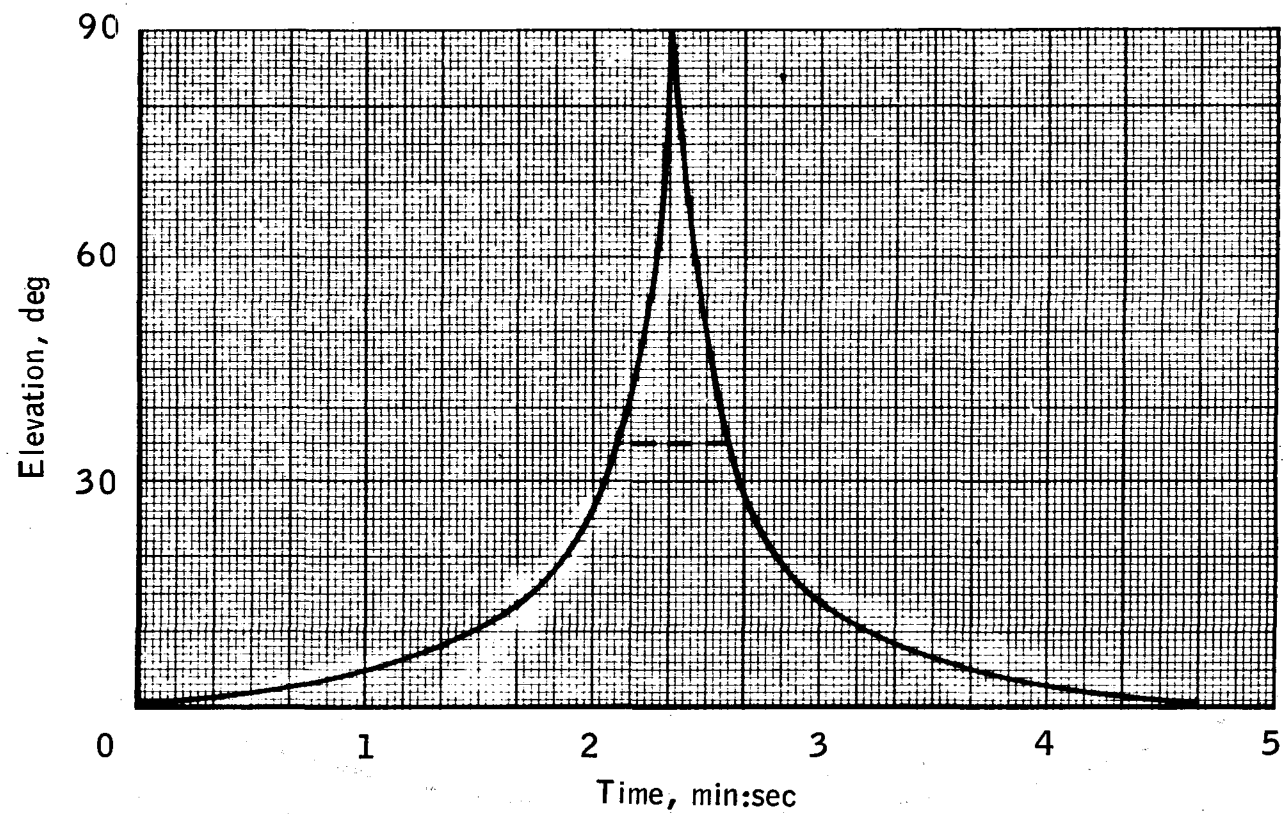


Figure 15.- SPS DOI.



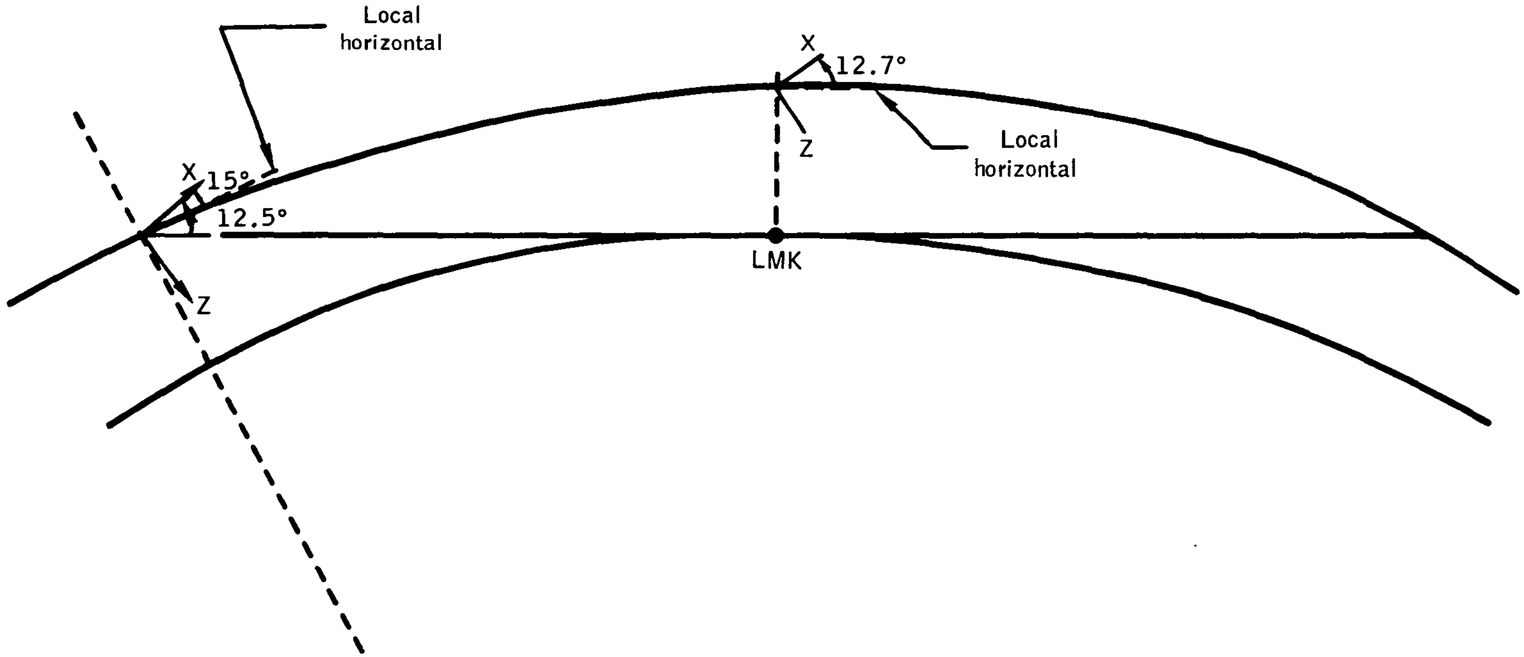
(a) Perilune 16° behind landmark.

Figure 16.- Landmark geometry for 8-by 60-n. mi. lunar orbit.



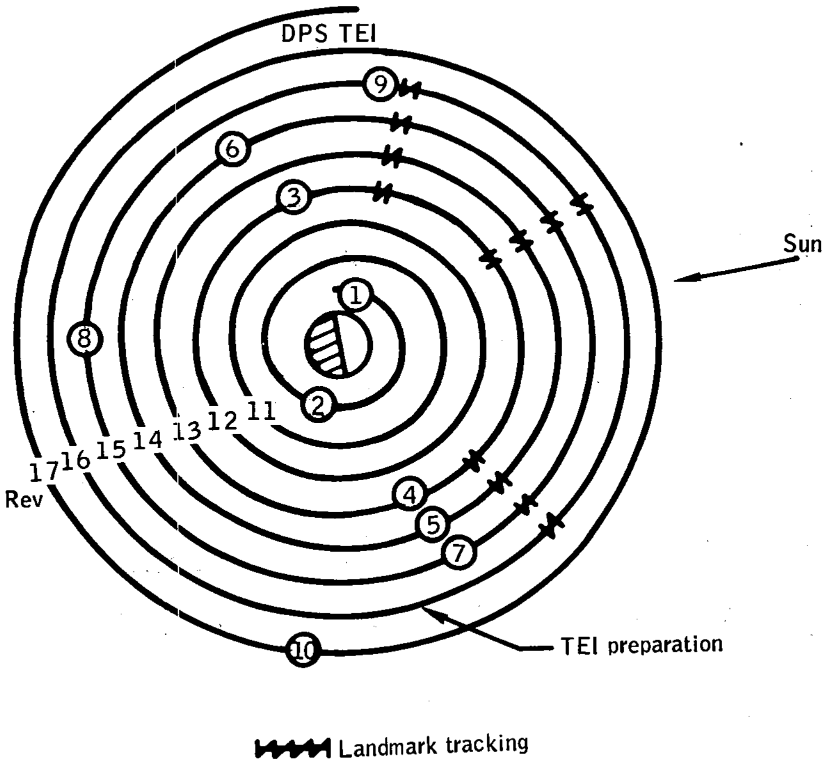
(b) Elevation versus time for perilune of 60-by 8-n. mi. orbit.

Figure 16.- Continued.



(c) Inertial altitude for landmark tracking a perilune of 60-by 8-n. mi. orbit.

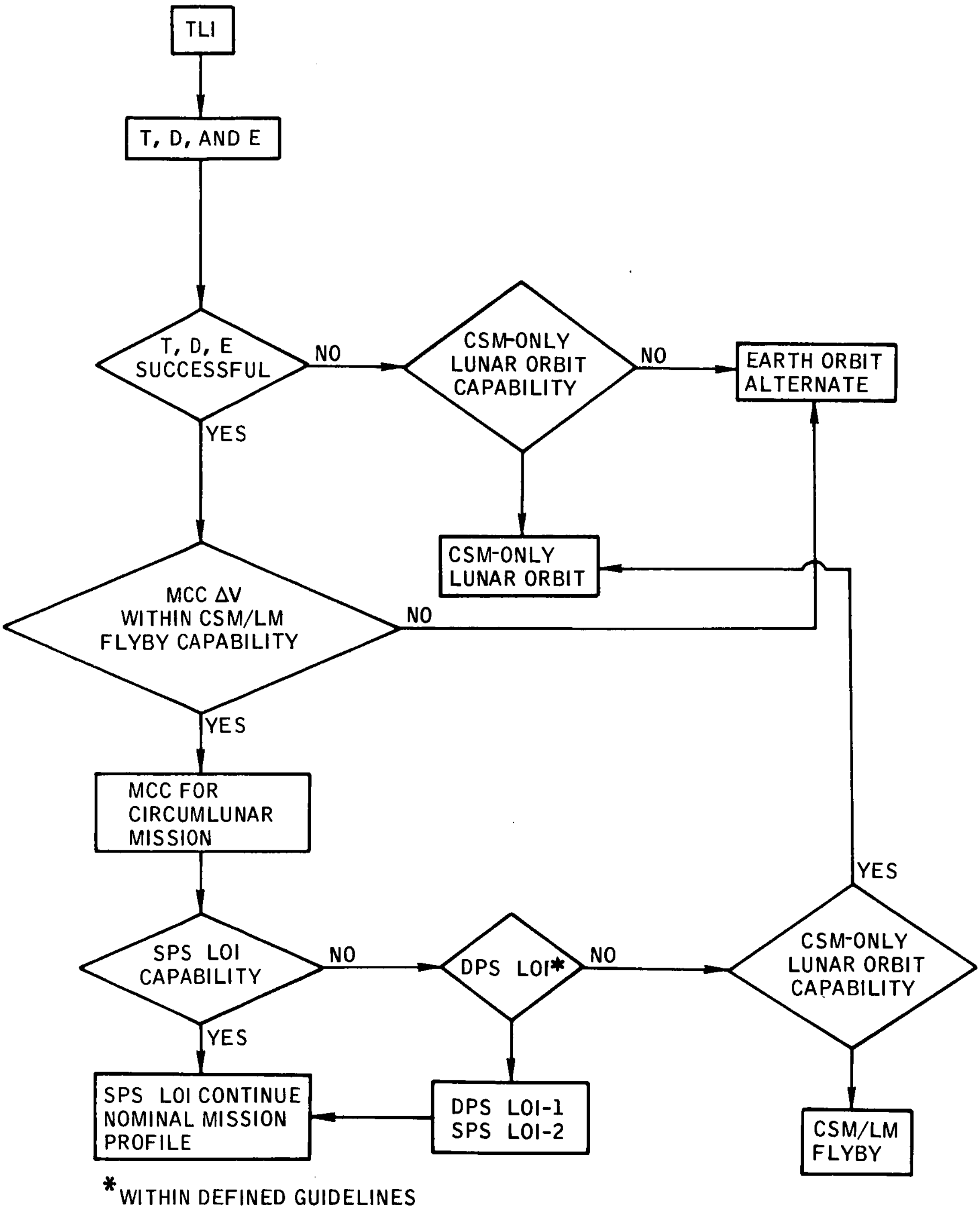
Figure 16.- Concluded.



Nominal timeline events

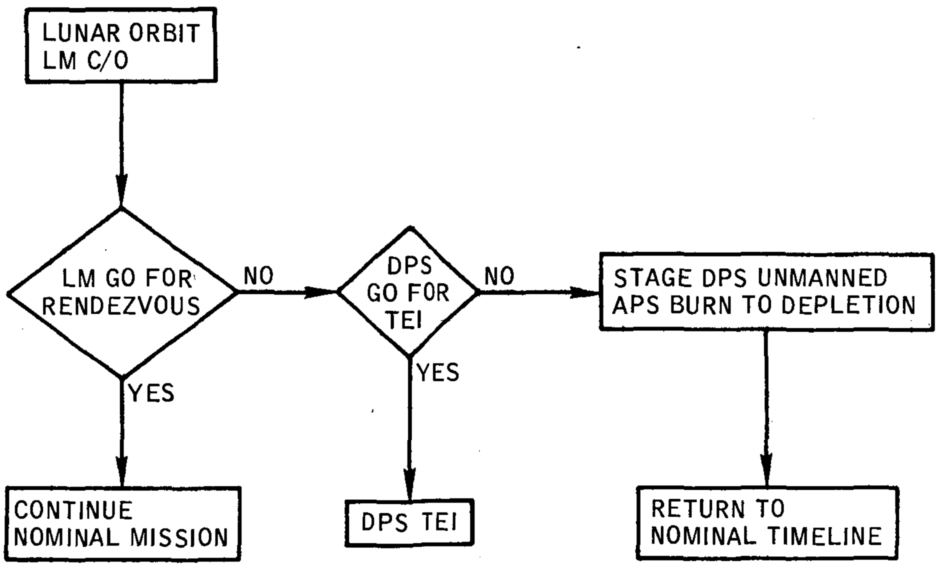
Event	Time, g.e.t.
1 - Awake and eat	94:00
2 - Begin LM checkout	95:00
3 - DOI	99:54
4 - Phasing	101:06
5 - Insertion	103:03
6 - CSI	103:54
7 - CDH	104:52
8 - TPI	105:59
9 - Docking	106:40
10 - APS burn to depletion	109:04

Figure 17 .- DPS TEI on DOI day.



(a) TLI contingency.

Flow chart 1.- Decision logic for lunar alternate missions.



(b) Lunar orbit.

Flow chart 1.- Concluded.

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1. CSM/LM Spacecraft Operational Data Book, Volume I, Part 1 - Constraints and Performance. SNA-8-D-027, May 1, 1968.

2. Lunar Mission Design Section: Preliminary Apollo Mission F Trajectory Data for the May 1969 Launch Window. MSC IN 69-FM-27, February 4, 1969.

3. Zeiler, Kenneth T.: Apollo Mission F ΔV Requirements for a Flyby to Hawaii at LOI - 5 Hrs. MSC memo 69-FM52-46, February 24, 1969.