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APOLLO 10 (MISSION F) SPACECRAFT OPERATIONAL ALTERNATE MISSION PLANS

VOLUME I

EARTH ORBITAL ALTERNATES

Orbital 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 I - EARTH ORBITAL ALTERNATES

By David D. DeAtkine and Ronny H. Moore
Orbital Mission Analysis Branch

April 10, 1969

MISSION PLANNING AND ANALYSIS DIVISION
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VOLUME I - EARTH ORBITAL ALTERNATES

By David D. DeAtkine and Ronny H. Moore

SUMMARY

The plans proposed in this report define alternate mission sequences that result from the following contingencies which could occur during Apollo 10 (Mission F).

1. A COI maneuver when the S-IVB fails late in its first burn and is followed by CSM separation and an SPS burn to orbit

2. A TLI NO-GO (no S-IVB reignition)

3. Premature or nonnominal TLI termination that results in an ellipse whose energy is such that an SPS midcourse ΔV of greater than approximately 4000 fps is required to achieve a circumlunar mission

4. Failure to eject the LM from the S-IVB in any of the above situations (COI requires the loss of the LM)

The proposed earth orbital alternate missions involve several different procedures. The sequence used is determined by the contingency situation itself and by such constraints as SPS and DPS ΔV capability, availability of the LM (for docked DPS burns, rendezvous, and APS burn to depletion), recovery requirements, radiation constraints, and RCS deorbit capability. Targeting objectives of the orbital maneuvers are presented together with the LM-active rendezvous objectives. Several typical alternate mission time lines have been generated to demonstrate the application of the objectives. The general types of mission plans presented are as follows: long-duration CSM-only missions (similar to Apollo 7), long-duration LM development missions, and long-duration combined operations missions (similar to Apollo 9).

INTRODUCTION

This document presents the operational earth orbital alternate mission plans for Apollo 10 (Mission F) and provides Flight Control with a comprehensive set of alternate missions to integrate into mission rules.

The document is restricted to earth orbital alternate missions which stem from either a nonnominal first or second S-IVB burn (or no S-IVB burn), which assume an operational CSM, and which consider LM availability and nonavailability. The general theme of the alternate mission planning philosophy is to maximize LM evaluation; thus, if possible, priority is given to tests of the LM and of its propulsion systems in Missions F and G duty cycles. Circumlunar and lunar orbital alternate mission plans are to be discussed in Volume II of the document entitled Apollo 10 (Mission F) Spacecraft Operational Alternate Mission Plans. Alternate lunar rendezvous plans are discussed in Volume III. This document supersedes the preliminary plan (ref. 1). The study is restricted to the May launch window; however, the same general techniques are applicable to any monthly window.

ABBREVIATIONS

AGS	abort guidance system
APS	ascent propulsion system
CDH	constant differential height
CM	command module
COI	contingency orbit insertion
CSI	coelliptic sequence initiation
CSM	command and service modules
DOI	descent orbit insertion
DPS	descent propulsion system
DTO	detailed test objective
e.s.t.	eastern standard time

G&N	guidance and navigation
G.m.t.	Greenwich mean time
g.e.t.	ground elapsed time
h_a	apogee altitude above earth
h_p	perigee altitude above earth
Δh	height differential
LM	lunar module
LOI	lunar orbit insertion
MCC	midcourse correction
MSFN	Manned Space Flight Network
PGNCS	primary guidance and navigation control subsystem
RCS	reaction control system
RTACF	Real-Time Auxiliary Computing Facility
RTCC	Real-Time Computer Complex
SM	service module
SPS	service propulsion system
t_b	burn time
TEI	transearth injection
TLI	translunar injection
TPF	terminal phase finalization
TPI	terminal phase initiation
VHF	very high frequency
ΔV	incremental velocity

NOMINAL MISSION DESCRIPTION AND INPUT DATA

Apollo 10 (Mission F) is planned to be a CSM/LM combined operations and lunar orbital mission. The prime objectives are to satisfy a number of DTO's associated with CSM/LM cislunar and lunar operations, and to demonstrate crew/space vehicle/mission support facilities performance during a CSM/LM manned lunar mission. The mission will provide additional data for the lunar gravitational potential and for the MSFN state vector determination capability. A complete list of Apollo 10 (Mission F) test objectives is presented in reference 2.

The AS-505/CSM-106/LM-4 space vehicle is to be launched within a window which opens on May 18, 1969, and which closes May 25, 1969. The nominal Apollo 10 mission description given in reference 3 was designed for a particular launch and injection opportunity; namely, May 18, 72° launch azimuth, $11^{h}48^{m}$ e.s.t., and injection on the first opportunity.

Input data used in the preparation of this document were obtained from the following sources.

Mission F DTO's	Ref. 2
Mission and spacecraft constraints	Refs. 4, 5, 6
Crew time line	Ref. 7
Spacecraft parameters	Refs. 4, 5, 6
Mission rules	Ref. 8

DEFINITIONS, GROUND RULES, AND ASSUMPTIONS

Because the mission and spacecraft constraints documents (refs. 4 and 5) do not contain all necessary ground rules and assumptions for earth orbital alternate mission plans, it is necessary to document the basic guidelines used to plan the alternate missions that are described.

Definitions

Several terms which are used in this report are defined as follows.

1. Alternate mission - A mission with a reduced number of preplanned nominal test objectives to which the crew can revert in situations for which continuation of the nominal mission is not possible but for which crew safety is not in jeopardy

2. Abort - Any situation in which crew safety requires immediate action toward termination of the mission and safe crew return without consideration for further accomplishment of mission objectives

3. Semisynchronous orbit - An elliptic orbit with a 12-hour period which, therefore, has two perigee passes per day; the perigee positions are fixed relative to the earth, 180° apart in longitude

Ground Rules and Assumptions

1. Alternate mission planning will be consistent with current spacecraft, crew, and operational constraints.

2. No additional RTCC processors will be necessary. No additional real-time requirements are currently defined, but if they occur, they will be considered for incorporation in the RTACF.

3. Coverage by MSFN for all SPS and LM maneuvers is desirable. Coverage for all large LM maneuvers is mandatory.

4. LM testing in earth orbit has priority over a CSM-only lunar mission.

5. If return to a low earth orbit with rendezvous is not possible, LM testing in a high ellipse is preferable to LM testing in a low earth orbit.

6. Deorbit from all alternate missions will be planned such that recovery lighting constraints are met whenever possible.

7. Only water landings are planned.

8. It is assumed to be desirable to stay in orbit after a non-nominal TLI or not TLI for a full-duration mission (approximately 10 days) rather than to abort the mission.

9. In all alternate missions, the nominal mission time line is followed whenever possible.

10. Radiation hazards do not prohibit one pass through perigee in a high ellipse (h_a > 4000 n. mi.) with crewmen in the LM. No radiation hazard exists for crewmen in the CM for these types of orbits.

11. No additional crew training will be required for alternate missions.

12. RCS deorbit capability is maintained for all alternate missions.

13. A high-ellipse phasing maneuver, when required, will occur as near as possible to the nominal MCC-1 time.

14. No shifting of the line of apsides or the line of nodes is attempted in a phasing maneuver for a partial TLI high-ellipse alternate; only a change in orbital period is made.

15. The docked DPS, simulated LOI, and phasing maneuvers will achieve, in combination, a 100- by 400-n. mi. altitude ellipse prior to a rendezvous sequence. When no rendezvous is possible, these burns are used to achieve a semisynchronous orbit.

16. The May 17 launch date has been used in this study. Since the finalization of input data to this document, the opening day of the May launch window has been moved to May 18; however, the techniques described in this document generally are applicable to any day of the May window, with very minor changes in mission event times.

17. The first SPS maneuver after the last docked DPS maneuver will be at least 40 seconds in duration.

ALTERNATE MISSION PLANS

The alternate missions are summarized in the flow chart and in table I as a function of the type and the time of failure.

Alternate Mission 1 (CSM-only Low Earth Orbit)

Alternate mission 1 assumes that the LM cannot be ejected and assumes either an SPS COI or an S-IVB failure to achieve a 25 000 n. mi. apogee TLI burn. The sequence of events is as follows.

1. SPS phasing burn to assure MSFN tracking for simulated LOI at near nominal g.e.t.

2. Simulated LOI that results in a 100- by 400-n. mi. altitude orbit

3. Further MCC's to achieve the desired end of mission ellipse (90- by 240-n. mi. altitude) and to complete SPS lunar mission duty cycle

4. Approximately a 10-day mission; landing in 150° W Pacific recovery area

Alternate Mission 2 (CSM-only Semisynchronous)

The alternate mission 2 plan assumes that the S-IVB fails during the second burn with $h_a \geq 25\ 000$ n. mi., and that the LM cannot be extracted. The sequence of events is as follows.

1. SPS phasing maneuver to assure simulated LOI burn tracking

2. Simulated SPS LOI expended primarily out of plane; in-plane component used to place CSM in a semisynchronous orbit

3. SPS phasing maneuver to place a later perigee over the 165° W Pacific recovery zone

Alternate Mission 3 (CSM/LM Earth Orbit Combined Operations with SPS Deboost)

The alternate mission 3 plan assumes that the TLI maneuver did not occur or that the TLI apogee does not exceed 4000 n. mi. and that the LM was ejected. The maneuver sequence is as follows.

1. If necessary, SPS maneuver to raise apogee for lifetime requirements

2. LOI maneuver to raise (or lower) apogee to 400 n. mi. expending remainder out of plane

3. Simulated DOI (in docked configuration)

4. Simulated powered descent in docked configuration, using profile shown in figure 1

5. SPS maneuver to circularize orbit at 150 n. mi.; maneuver is at least 40 seconds in duration

6. LM-active rendezvous (description in section on rendezvous)

7. Undocked and unmanned APS burn to depletion (AGS controlled); targeted as in Apollo 9

8. Further SPS maneuvers to achieve desired end-of-mission ellipse (90- by 240-n. mi. orbit) and complete lunar mission duty cycle

9. Approximately a 10-day mission with landing planned for the 150° W area

Alternate Mission 4 (CSM/LM Earth Orbit Combined Operations with DPS/SPS Deboost)

The alternate mission 4 plan assumes that the S-IVB fails during the TLI with 4000 n. mi. $< h_a \leq 10\ 000$ n. mi. and that the LM is successfully extracted. In this situation, the DPS and SPS, in combination, are required to return the CSM/LM to a low earth orbit without the CSM rescue capability being sacrificed. The sequence of events is as follows.

1. SPS phasing maneuver to assure MSFN tracking for next powered descent simulation burn

2. DPS DOI in docked configuration

3. DPS simulated powered descent in docked configuration; used to lower apogee to approximately 4000 n. mi. (remainder expended out of plane) while crew is protected from radiation belts encountered at altitudes between 400 to 2000 n. mi. The throttle profile is presented in figure 1.

4. SPS phasing (simulated MCC) maneuver to insure MSFN tracking for LOI

5. SPS LOI which lowers apogee to 400 n. mi.; remainder of ΔV is expended out of plane

6. SPS maneuver to circularize at 150-n. mi. altitude; maneuver at least 40 seconds in duration

7. LM-active rendezvous

8. Undocked and unmanned APS burn to depletion; targeted as in Apollo 9

9. SPS maneuvers to complete lunar mission time line and to achieve nominal end of mission 90- by 240-n. mi. altitude orbit

10. Approximately a 10-day mission with landing in the 150° W Pacific area

Alternate Mission 5 (CSM/LM Semisynchronous Orbit)

The alternate mission 5 plan assumes that the SPS and DPS in combination cannot place the CSM/LM in low earth orbit without the sacrifice of LM rescue capability and that the SPS propellant is not sufficient for a CSM/LM circumlunar mission; that is, the resultant TLI apogee is such that $50\,000 > h_a \geq 10\,000$ n. mi.[a] The sequence of events is as follows.

1. SPS phasing maneuver (to place a later perigee over a MSFN site)

2. SPS LOI, targeted to make orbit semisynchronous, with remainder of ΔV expended out of plane

3. SPS phasing maneuver, if necessary, to adjust the semi-synchronous orbit

4. Docked DPS DOI

5. Docked DPS powered descent simulation

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[a]50 000-n. mi. limit based upon preliminary estimates of ΔV reserve requirement.

6. SPS phasing maneuver to place later perigee over 165° W recovery zone; burn at least 40 seconds in duration

7. SPS maneuver to establish semisynchronous orbit with perigee over recovery zone

8. Approximately a 10-day mission, with direct return from semisynchronous orbit to 165° W recovery zone

A typical mission events summary for each of the alternate missions is given in table II.

TARGETING OF ORBITAL MANEUVERS

In-plane and out-of-plane targeting for orbital maneuvers was indicated in the preceding mission descriptions. While the docked DPS maneuver and the LOI maneuver are being performed, appreciable out-of-plane ΔV may be available. The resultant ΔV may be used to advance or retard the line of nodes, a procedure which may be used to shift the groundtrack not only to cover the rendezvous sequence better but also to optimize deorbit maneuver tracking. To insure maximum tracking during the rendezvous sequence, the TPI maneuver will be planned to occur during a revolution which has a descending node of approximately 40° W longitude. The time of occurrence of such a revolution (and, therefore, the location of TPI and all other maneuver points) may be influenced by a nodal shift. If no problem exists in tracking, the node may be advanced with one maneuver and retarded with another, with a resultant minimal shift in the line of nodes. The most desirable situation for deorbit occurs when two successive opportunities for the intended recovery zone are available. It is highly desirable to have land-based tracking for the first opportunity. Out-of-plane thrusting in the previously discussed maneuvers may be used to provide both situations.

LM-ACTIVE RENDEZVOUS FOR ALTERNATES 3 AND 4

The objective of the LM-active rendezvous (alternates 3 and 4) is to simulate as closely as possible in earth orbit the nominal G mission lunar rendezvous from the CDH maneuver through the terminal phase. The situation is simulated by matching the vehicle-to-vehicle line-of-sight elevation angles (which yield a standard terminal phase) from CDH through TPF. To design a comparable earth orbital simulation, the lunar rendezvous profile described in reference 3 was used as a guide. At the same time, however, consideration of flight crew training and ground support workloads dictated that the rendezvous be kept as simple as possible and yet achieve the conditions previously described. The result of the considerations is a profile which resembles the C mission rendezvous profile, for which the Apollo 10 (Mission F) prime crew has trained.

To assure a safe perigee for all rendezvous maneuvers and still retain SM/CM RCS hybrid deorbit capability, a 150-n. mi. altitude circular orbit was chosen as the base orbit for the rendezvous. The rendezvous sequence is begun by an SM RCS 5-fps radial separation maneuver. The burn is directed radially upward, and the LM moves below and in front of the CSM in an equiperiod orbit. Approximately 45 minutes or one-half orbit later, the LM performs a DPS phasing maneuver which provides the desired Δh and phase angle at the CDH point slightly over an orbit later. This burn places the LM in a 198- by 139-n. mi. altitude orbit and is somewhat comparable to the phasing burn in the nominal Apollo 10 (Mission F) sequence of events. The CSI maneuver is computed on board; however, because the phasing maneuver provided the proper CDH offset, the CSI maneuver nominally will be zero. If the maneuver is performed, it would occur half an orbital period (approximately 45 min) before CDH near apogee. The maneuver CDH is a near-horizontal, retrograde burn with the DPS which places the LM in a 139-n. mi. circular orbit. This burn yields a constant Δh of approximately 11 n. mi. below the CSM. A maximum separation range of 170 n. mi. is achieved; this distance is considered sufficient for rendezvous radar and VHF ranging tests. The separation range results in the time between CDH and TPI being approximately 110 minutes. However, the time can be changed to achieve MSFN coverage for CDH. The time between CDH and TPI is sufficient to allow another CSI CDH sequence to adjust the coelliptic approach. If it is required, the final CSI-2 would occur 25 minutes after CDH-1 and the accompanying CDH-2 would occur 45 minutes later, which would leave approximately 40 minutes between CDH-2 and TPI. The DPS will be staged some time (probably 30 min) prior to TPI. The maneuver TPI is based on lighting conditions such that sunrise occurs at a range of approximately 2.5 n. mi. For earth orbit profiles, TPI is executed 25 minutes prior to daylight and on a LM-to-CSM elevation angle of 26.6°. The CSM travel angle from TPI to theoretical TPF is 130°.

Coverage by MSFN is desirable for all maneuvers; however, for all launch opportunities, this coverage may not be possible. Coverage of the phasing and CDH burn and adequate tracking between CDH and TPI were assumed mandatory and will be provided by initiation of the rendezvous sequence during the proper revolution over the United States. In most cases, adequate tracking will exist between the other rendezvous maneuvers.

A detailed sequence of events for a typical alternate 3 earth rendezvous is shown in table III. A typical earth rendezvous relative motion and its bar chart are shown in figures 2 and 3, respectively. The CSM rescue procedures are essentially limited to mirror-image maneuvers for CDH and TPI.

Two other possibilities exist in situations for which the planned earth orbit rendezvous cannot be completed because of one or more inoperative propulsive systems or because of inoperative G&N systems. The possibilities are as follows.

1. An all-APS rendezvous may be scheduled if the DPS fails. The half-loaded APS has enough ΔV capability to perform both the DPS phasing and the CDH-1 maneuvers. The rendezvous lasts approximately 4.5 hours, which is within the time limit of the APS power supply. The remaining ΔV will be sufficient to perform a long APS burn to depletion. The only difference from the planned rendezvous is the burn durations that result from use of the APS. The relative motion is the same as figure 2.

2. If both the DPS and APS fail or if the PGNCS or AGS guidance systems are inoperative, capability still exists to perform a large football rendezvous. The normal minifootball is first performed with a 5-fps radially-downward maneuver by the SM RCS that places the CSM and LM in equiperiod orbits. Just prior to the quarter-orbit point, the descent stage is jettisoned, and approximately 45 minutes after the minifootball separation, the LM RCS is used to place the LM on a large relative motion football with a 51.9-second, 80-fps ΔV maneuver (APS interconnect assumed open), performed radially upward. The maneuver results in a maximum separation range of 45.5 n. mi., which is sufficient to perform rendezvous radar and VHF ranging checks. The LM performs TPI ($\Delta V \approx 24$ fps) approximately 70 minutes after the RCS phasing maneuver at the normal 26.6° elevation angle. From that point on, the terminal phase is a nominal approach. Relative motion for this RCS-only rendezvous is shown in figure 4. The rendezvous, if performed, would be planned such that normal terminal phase lighting is achieved; TPI would occur 25 minutes before daylight.

CONCLUDING REMARKS

The data presented and procedures described in this document represent the operational earth orbital alternate mission plans for the Apollo 10 (Mission F) lunar orbital mission. The purpose of the document has been to define, primarily qualitatively rather than quantitatively, the alternate mission procedures. Because of the large amount of data that would be necessary to cover completely the launch window and corresponding alternate mission situations, the data presented are meant merely to be representative of the range of maneuvers which could be used. The RTCC and RTACF procedures and processors will be used to compute the maneuvers in real time, and real-time maneuver targeting rather than preflight generated data will be relied upon for the alternate missions.

FLOWCHART FOR F MISSION EARTH ORBITAL ALTERNATE

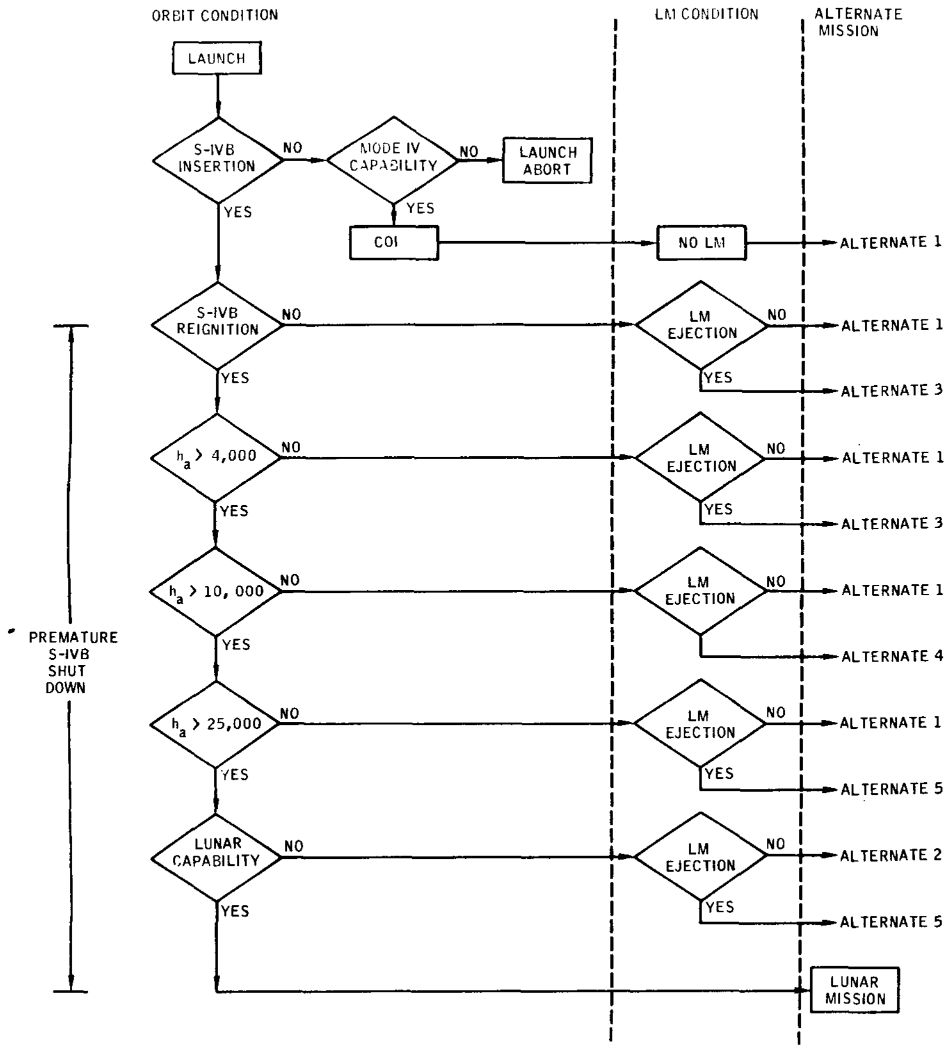


TABLE I.- ALTERNATE MISSION SUMMARY

Alternate mission type

Alternate 1
- No LM
- Return to low earth orbit, if partial TLI occurred
- Continue low earth orbital mission with CSM operations
- ~10-day mission, deorbit into Pacific (150°W)

Alternate 2
- No LM
- Apogee too high to return to low earth orbit
- Go to semisynchronous orbit, perform CSM operations
- ~10-day mission; deorbit from SS orbit; land at 165°W recovery area

Alternate 3
- LM extracted
- Return to low earth orbit with SPS LOI burn
- Perform docked DPS burns, LM rendezvous, APS burn to depletion, CSM operations
- ~ 10-day mission; deorbit into Pacific (150°W)

Alternate 4
- LM extracted
- Return to low earth orbit using DPS SPS burns
- Perform LM rendezvous, APS burn to depletion; CSM operations
- ~10-day mission; deorbit into Pacific (150°W)

Alternate 5
- LM extracted
- Apogee too high to return to low earth orbit
- Go to semisynchronous orbit, perform DPS SPS docked burns
- APS burn to depletion; no rendezvous
- Deorbit from SS orbit; land at 165°W recovery area

TABLE II.- TYPICAL F ALTERNATE MISSION EVENTS

(a) Alternate 1

Mission event	Time of initiation hr:min:sec, g.e.t.	ΔV, fps	t_b, sec	h_a/h_p, n. mi.	Engine	Position of initiation		
						Latitude, deg	Longitude, deg	Altitude, n. mi.
Insertion[a]	00:11:22	--	--	103/101	S-IVB	32.7	-54.3	103
Apogee adjust maneuver	05:58:41.4	55.2	5.3	130/102	SPS	29.5	-165.0	102
LOI simulation	72:30:30.4	3699.7	298.6	402/102	SPS	32.0	-78.1	102
Circularization	74:16:12.4	837.1	53.7	150/150	SPS	13.5	-54.7	150
Deorbit shaping	144:36:53.0	516	30.9	240/91	SPS	16.5	-59.3	150
Deorbit	238:58:42.0	323.4	18.3	235/-2	SPS	-16.5	122.1	192
Touchdown	239:27:13	--	--	--	--	32.2	-150.0	0

[a] In this case, insertion was performed fully by the S-IVB; insertion could be performed by SPS (COI).

TABLE II.- TYPICAL F ALTERNATE MISSION EVENTS - Continued

(b) Alternate 2

Mission events	Time of initiation hr:min:sec, g.e.t.	ΔV, fps	t_b, sec	h_a/h_p, n. mi.	Engine	Position of initiation		
						Latitude, deg	Longitude, deg	Altitude, n. mi.
TLI[a]	02:31:36	--	--	29 606/97	S-IVB	-27.1	128.6	102
First phasing maneuver	19:40:01	79.4	7.4	31 259/95	SPS	-27.6	-130.6	95
LOI simulation	75:01:45	3699.7	288.6	21 729/92	SPS	-27.3	118.4	92
Second phasing maneuver	98:59:20	88.2	5.7	20 705/92	SPS	-27.2	118.3	92
Final semisynchr-onization	189:44:38	89.9	5.7	21 750/92	SPS	-26.7	-165.8	92
Deorbit	231:48:00	47.6	3.0	21 750/20	SPS	26.8	105.1	21 750
Touchdown	237:59:30	--	--	--	--	-26.8	-165.0	0

[a]Premature cutoff.

TABLE II.- TYPICAL F ALTERNATE MISSION EVENTS - Continued

(c) Alternate 3

Mission event	Time of initiation, hr:min:sec, g.e.t.	ΔV, fps	t_b, sec	h_a/h_p, n. mi.	Engine	Position of initiation		
						Latitude, deg	Longitude, deg	Altitude, n. mi.
Insertion	00:11:22	--	--	103/102	S-IVB	32.7	-54.3	103
Apogee adjust maneuver	05:58:41	55.2	7.9	130/102	SPS	29.5	-164.9	102
LOI simulation	72:30:30	3699.7	440.5	402/102	SPS	31.9	-78.1	102
DOI simulation	96:30:30	33.8	15 at 10% 12.5 at 40%	403/102	DPS	-29.2	43.9	337
PD simulation	97:32:21	2019.0	[a]437.0	400/102	DPS	29.7	-90.1	102
Circularization	100:28:11	833.9	63.4	150/150	SPS	27.4	170.3	150
Separation	118:00:49	5.0	12.5	151/150	+X RCS	-20.8	165.8	150
Phasing	118:45:27	178.1	26 at 10% 7.2 at FTP	198/139	DPS	21.3	-26.6	151
CSI	119:43:32	[b]0	0	198/139	+X RCS	4.1	177.3	198
CDH	120:28:44	103.1	26 at 10% 6.8 at 40%	139/138	DPS	-3	-7.3	139
TPI	122:18:15	24.1	15.3	152/138	+X RCS	-31.5	46.5	139
TPF	122:49:40	32.9	42.2	150/149	-Z RCS	17.4	160.6	150

[a]See figure 1 for throttle profile.

[b]Nominally zero.

TABLE II.- TYPICAL F ALTERNATE MISSION EVENTS - Continued

(c) Alternate 3 - Concluded

Mission event	Time of initiation, hr:min:sec, g.e.t.	ΔV, fps	t_b, sec	h_a/h_p, n. mi.	Engine	Position of initiation		
						Latitude, deg	Longitude, deg	Altitude, n. mi.
APS burn to depletion	126:08:11	3721.2	228.2	3443/150	APS	29.0	-164.0	150
Deorbit shaping maneuver	146:34:57	519.9	23.8	242/91	SPS	-6.2	115.2	149
Deorbit	238:30:15	323.3	14.1	235/-2	SPS	149.3	5.1	192
Touchdown	239:01:12	--	--	--	--	32.2	-150.0	0

TABLE II.- TYPICAL F ALTERNATE MISSION EVENTS - Continued

(d) Alternate 4

Mission event	Time of initiation, hr:min:sec, g.e.t.	ΔV, fps	t_b, sec	h_a/h_p, n. mi.	Engine	Position of initiation		
						Latitude, deg	Longitude, deg	Altitude, n. mi.
TLI[a]	02:31:36	--	--	8927/99	S-IVB	-27.1	128.6	102
First phasing maneuver	07:28:13	35.3	5.0	8805/99	SPS	-27.5	54.3	99
DOI simulation	50:27:00	23.3	15 at 10% 12.5 at 40%	8807/101	DPS	6.0	-8.[illegible]	5417
PD simulation	51:27:09	2019.0	[b]437.0	4099/100	DPS	-26.7	113.8	100
Second phasing maneuver	54:19:35.7	426.8	51.8	3467/99	SPS	-26.5	70.8	99
LOI simulation	75:22:50	3316.1	335.6	400/99	SPS	-25.5	115.3	99
Circularization	99:29:59	837.1	68.6	150/150	SPS	20.4	-61.5	150
Separation	119:36:23	5.0	12.5	151/150	+X RCS (CSM)	-23.6	160.2	150
Phasing	120:21:23	178.1	26 at 10% 7.2 at FTP	198/139	DPS	23.6	-32.2	151
CSI	121:19:24	[c]0	0	198/139	+X RCS	-24.3	200.6	198
CDH	122:04:24	103.1	26 at 10% 6.8 at 40%	139/138	DPS	-0.8	-12.0	139

[a]Premature cutoff.

[b]See figure 1 for throttle profile.

[c]Nominally zero.

TABLE II.- TYPICAL F ALTERNATE MISSION EVENTS - Continued

(d) Alternate 4 - Concluded

Mission event	Time of initiation, hr:min:sec, g.e.t.	ΔV, fps	t_b, sec	h_a/h_p, n. mi.	Engine	Position of initiation		
						Latitude, deg	Longitude, deg	Altitude, n. mi.
TPI	123:54:51	23.9	15.3	152/139	+X RCS	-31.5	40.5	139
TPF	124:25:31	32.9	42.2	150/150	-Z RCS	15.0	156.2	150
APS burn to depletion	127:49:59	3721.2	228.2	3443/150	APS	29.8	-163.9	150
Deorbit shaping	142:23:14	523.3	24.1	241/91	SPS	6.0	-134.3	150
Deorbit	235:13:22	323.4	18.3	235/-2	SPS	-32.2	123.1	192
Touchdown	235:42:12	--	--	--	--	6.0	-150.0	0

TABLE II.- TYPICAL F ALTERNATE MISSION EVENTS - Concluded

(e) Alternate 5

Mission event	Time of initiation, hr:min:sec, g.e.t.	ΔV, fps	t_b, sec	h_a/h_p, n. mi.	Engine	Position of initiation		
						Latitude, deg	Longitude deg	Altitude, n. mi.
TLI[a]	02:31:36	--	--	29 606/97	S-IVB	-27.1	128.6	102
First phasing maneuver	19:46:01	79.4	11.3	31 259/95	SPS	-27.5	-130.6	97
LOI simulation	75:01:45	3699.7	439.4	21 729/92	SPS	-27.3	118.5	92
DOI simulation	98:01:45	33.9	15 at 10% 12.5 at 40%	21 731/92	DPS	10.0	4.1	9 313
PD simulation	98:59:20	2019.0	[b]437.0	21 750/92	DPS	-27.2	118.3	92
APS burn to depletion	104:58:43	3902.6	228.2	21 750/13 897	APS	26.8	-152.1	21 750
Second phasing maneuver	122:58:28	796.0	40.0	20 705/92	SPS	-27.1	117.7	92
Final semisynchronization	213:43:44	89.9	4.3	21 750/92	SPS	-26.6	-166.5	92
Deorbit	213:48:00	47.6	2.4	21 750/20	SPS	26.8	105.2	21 750
Touchdown	237:59:30	--	--	--	--	-26.8	-165.0	0

[a]Premature cutoff.

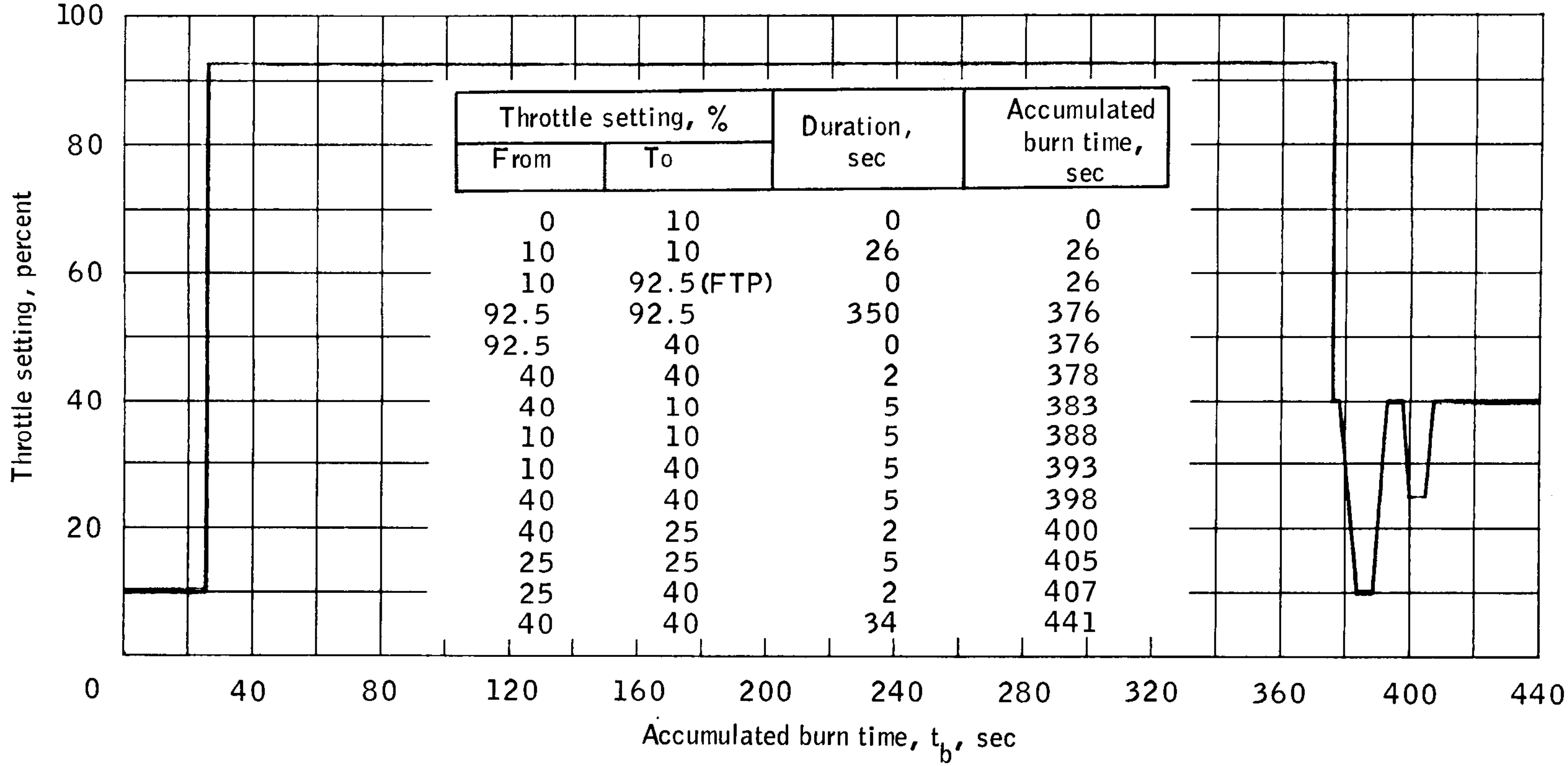
[b]See figure 1 for throttle profile.

TABLE III.- MANEUVER SUMMARY FOR TYPICAL F MISSION ALTERNATE 3 EARTH ORBIT RENDEZVOUS

Maneuver	Time, hr:min:sec, g.e.t.	Time since previous maneuver, min:sec	ΔV, fps	Δt, sec	Thrust direction[a], deg	Propulsion system	Resultant h_a/h_p, n. mi.
Minifootball (CSM)	118:00:49	--	5.0	12.5	-89.6	-X RCS (four-jet)	151/150
Phasing	118:45:27	44:38	178.1	26 at 10% 7.2 at FTP	-70.9	DPS	198/139
CSI	119:43:32	58:05	0	[b]0	--	+X RCS (four-jet)	198/139
CDH	120:28:44	45:12	103.1	26 at 10% 6.8 at 40%	175.7	DPS	139/138
TPI	122:18:15	109:31	23.9	15.3	25.2	+X RCS (four-jet)	152/138
TPF	122:49:40	31:25	32.9	42.2	28.5	-Z RCS (two-jet)	150/149

[a]Pitch measured counter clockwise from direction of motion.

[b]Nominally zero.



Throttle setting, %		Duration, sec	Accumulated burn time, sec
From	To		
0	10	0	0
10	10	26	26
10	92.5 (FTP)	0	26
92.5	92.5	350	376
92.5	40	0	376
40	40	2	378
40	10	5	383
10	10	5	388
10	40	5	393
40	40	5	398
40	25	2	400
25	25	5	405
25	40	2	407
40	40	34	441

Figure 1.- DPS throttle profile for F mission earth orbital alternate.

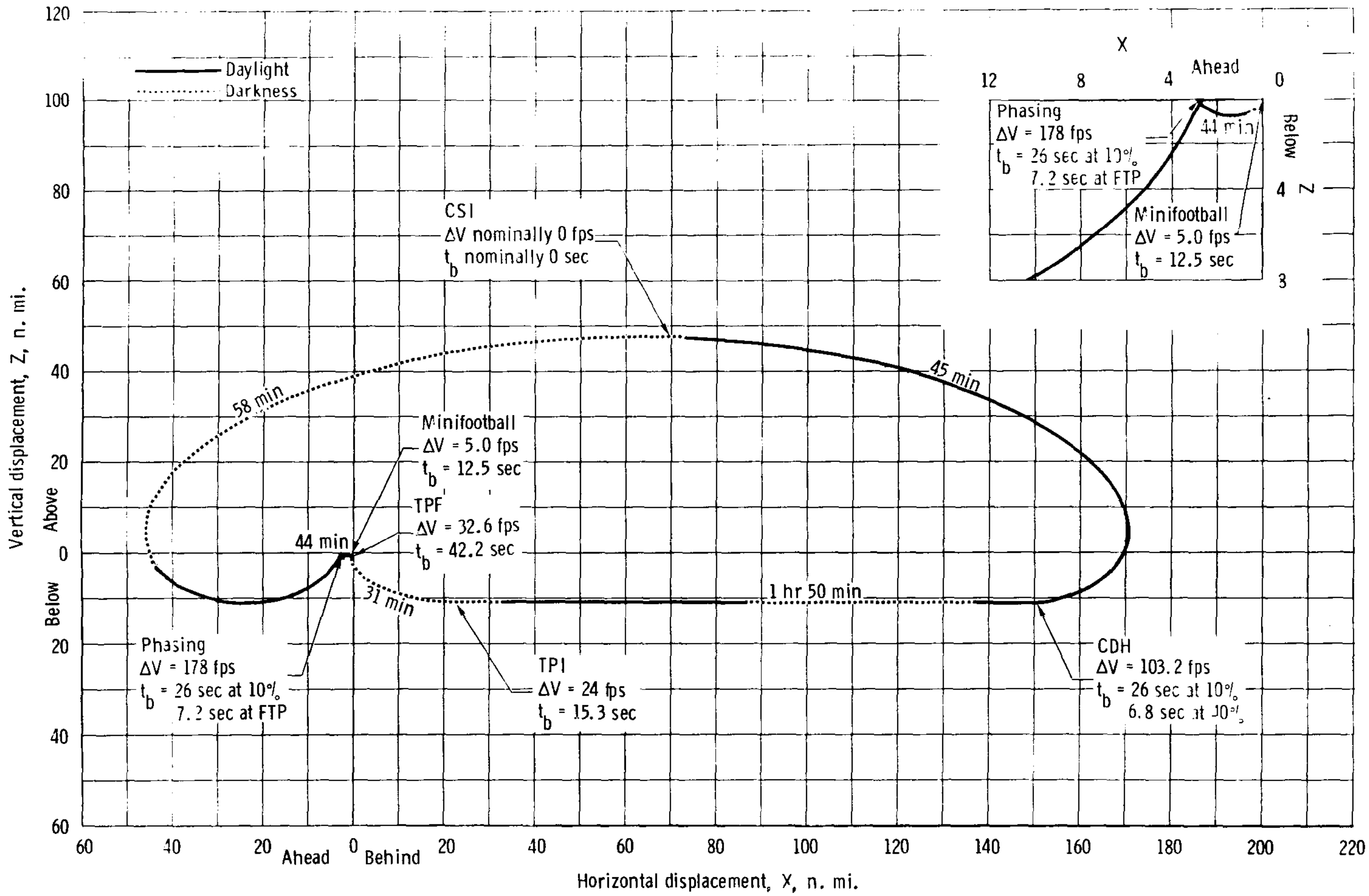


Figure 2.- Relative motion for F mission earth orbital alternate rendezvous.

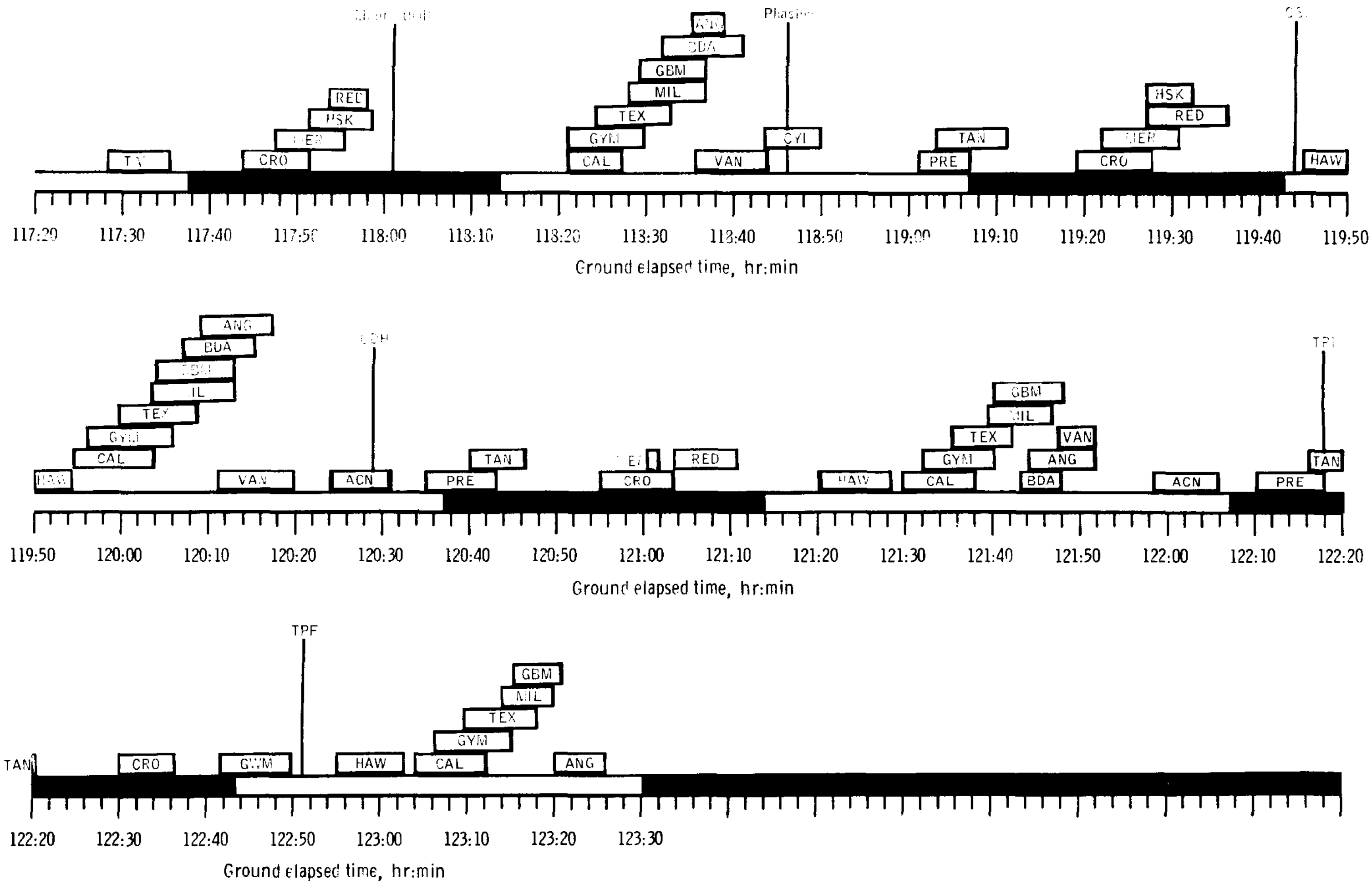


Figure 3. - Tracking summary and events for F mission earth orbit rendezvous.

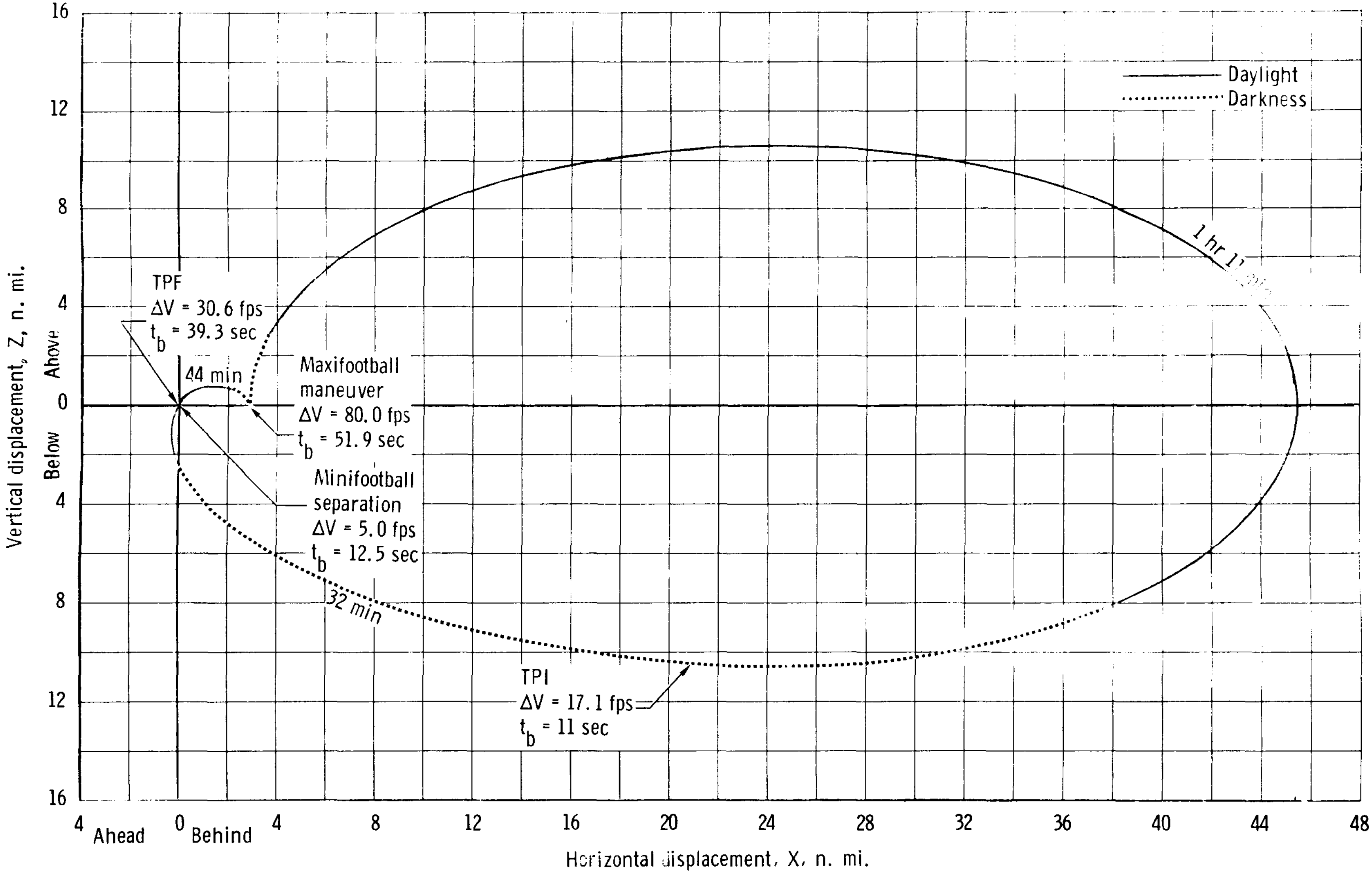


Figure 4.- Relative motion for F mission earth orbital reduced rendezvous.

REFERENCES

1. Orbital Mission Analysis Branch: Preliminary Alternate Mission Plan for Apollo Mission F, Volume I - Earth Orbit. MSC IN 69-FM-25, February 3, 1969.

2. Mission Requirements SA-505/CSM-106/LM-4 F Type Mission - Lunar Orbit. SPD9-R-037, February 11, 1969.

3. Orbital Mission Analysis Branch; Lunar Mission Analysis Branch; and Landing Analysis Branch: Spacecraft Operational Trajectory for Apollo Mission F, Volume I - Operational Mission Profile Launched May 18, 1969. MSC IN 69-FM-65, March 26, 1969.

4. Spacecraft Operational Data Book, Volume I - CSM Data Book. SNA-8-D-027(I), revised as of March 18, 1969.

5. Spacecraft Operational Data Book, Volume II - LM Data Book. SNA-8-D-027(II), revised as of March 7, 1969.

6. Spacecraft Operational Data Book, Volume III - Mass Properties. SNA-8-D-027(III), revised as of March 10, 1969.

7. Flight Crew Support Division: Reference Mission F Flight Plan (AS-505/CSM-106/LM-4). November 22, 1968.

8. Flight Control Division: Preliminary Flight Mission Rules Apollo 10 (AS-505/CSM-106/LM-4). FC021, February 24, 1969.