



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MSC INTERNAL NOTE NO. 67-FM-195

December 29, 1967

# APOLLO 5 MISSION (AS-204/LM-1) SPACECRAFT OPERATIONAL TRAJECTORY

## VOLUME I - MISSION DESCRIPTION

By Edwin G. Dupnick

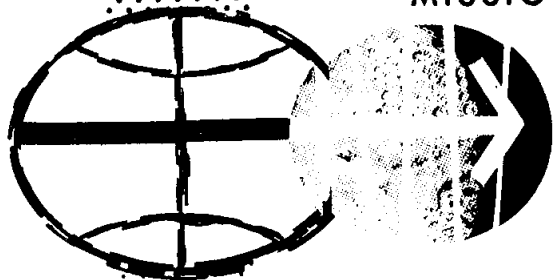
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Veit Hanssen,

Lunar Landing Branch

(This revision supersedes Volume I of MSC Internal Note 67-FM-5 dated April 1, 1967)

MISSION PLANNING AND ANALYSIS DIVISION



MANNED SPACECRAFT CENTER  
HOUSTON, TEXAS

INDEXING DATA

DATE	OPR	#	T	PCM	SUBJECT	SIGNATOR	LOG
12-29-67	100	67-195	1	MP	(276)	DUPNICK	027-67

MSC INTERNAL NOTE NO. 67-FM-195

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PROJECT APOLLO

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By Edwin G. Dupnick and Veit Hanssen  
Lunar Landing Branch

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MISSION PLANNING AND ANALYSIS DIVISION  
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION  
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# APOLLO 5 MISSION (AS-204/IM-1) OPERATIONAL TRAJECTORY

## VOLUME I - MISSION DESCRIPTION

By Edwin G. Dupnick and Veit Hanssen

### 1.0 SUMMARY AND INTRODUCTION

This document revises the spacecraft operational trajectory for the unmanned Apollo 5 mission (AS-204/IM-1). The operational trajectory is intended to satisfy mission objectives within mission rules and constraints (ref. 1, 2, and 3, respectively). It defines the nominal mission profile that has been generated based on the spacecraft data presented in section 3.0 of this report and revision 1 of the launch vehicle operational trajectory (ref. 4).

The revised operational trajectory is similar to the mission profile defined in reference 5. However, this report reflects the revisions and modifications to the mission profile that have been issued since publication of reference 5. The mission profile incorporates the free-flight attitude control and powered-flight guidance-steering logic utilized in the spacecraft onboard program (ref. 6). The data presented for the ascent-to-orbit phase and the orbital coast phase from insertion to IM/S-IVB separation are based on data extracted from reference 4.

This report is presented in four volumes. Volume I summarizes the spacecraft data used in the generation of the mission profile and describes the major mission phases and events, tabular time history of salient spacecraft position, velocity, and weight characteristics, and MSFN coverage data.

Volume II of this report contains the tables of the spacecraft trajectory simulation and reference coordinate system definitions.

Volume III presents detailed tracking time histories of radar data for the land-based MSFN stations and the tracking ships that are currently planned to be available for support during this mission. In addition, AOS/LOS data is provided.

The consumables requirements for the nominal Apollo 5 mission are given in Volume IV.

## 2.0 ABBREVIATIONS

AOS	acquisition of signal
APS	ascent propulsion system
APS-1	first APS burn
APS-2	second APS burn
DAP	digital autopilot
DPS	descent propulsion system
DPS-1	first DPS burn
DPS-2	second DPS burn
ECI	Earth-centered inertial
e.s.t.	eastern standard time
FITH	fire-in-the-hole
FTP	fixed throttle points
GCS	guidance cutoff signal
g.e.t.	ground elapsed time
G.m.t.	Greenwich mean time
IMU	inertial measurement unit
IU	instrumentation unit
LGC	LM guidance computer
LH <sub>2</sub>	liquid hydrogen
LM	lunar module
LOS	loss of signal
LOX	liquid oxygen



MSFN	Manned Space Flight Network
RCS	reaction control system
SLA	spacecraft-IM adapter

### 3.0 SUMMARY OF INPUT DATA

#### 3.1 Saturn IB Launch Vehicle

The Saturn IB launch vehicle which will be used to insert the S-IVB/SLA/IM combination into the initial earth orbit is comprised of the S-IB and S-IVB stages and is illustrated in figure 1. A brief launch vehicle weight statement obtained from reference 4 is presented in table I. The characteristics of the insertion state vector are presented in table II.

#### 3.2 Spacecraft (IM-1)

The Apollo spacecraft which will be inserted into orbit by the AS-204 launch vehicle consists of IM-1, a spacecraft IM adapter, and an aerodynamic shroud. The specifications for these items have been obtained from reference 6. An outboard profile of IM-1, including the spacecraft coordinate system definition and rotation convention, is presented in figure 2. The spacecraft data required to support this operational trajectory revision are presented in the following subsections.

3.2.1 Weight characteristics.- The spacecraft inert structure and propellant weight characteristics were obtained from reference 6. These data are summarized in table III.

3.2.2 Propulsion characteristics.- The propulsion characteristics of the LM RCS were obtained from reference 7. There are four basic uses of the LM RCS: translation, rotation, deadband operation, and moment control. The criteria for LM RCS propellant consumption for these modes are discussed in the following paragraphs.

In the Apollo 5 mission, translation maneuvers require four +X-axis thrusters. The propulsion characteristics of a single RCS thruster are shown in table IV.

For simulation purposes, all orientation maneuvers have been accomplished at a 5-deg/sec rate. However, if the resultant maneuver time is less than 1 second, a maneuver rate of 1 deg/sec was used instead.

For the AS-204/IM-1 mission no control is provided about the spacecraft X-axis. Thus, for all attitude maneuvers dictated by guidance (including prethrust alignment) the axis of rotation is normal to a plane defined by the present spacecraft X-axis and the desired spacecraft X-axis. Thus the X-axis travels through the shortest path to attain a desired attitude. The RCS propellant consumption during unguided attitude orientation maneuvers was taken from reference 8.

During all orbital coasts, the LM is maintained within a specified angular displacement from a desired attitude. The angular displacement may be either the  $\pm 5^\circ$  maximum or the  $\pm 3^\circ$  minimum deadband. The criteria for RCS propellant consumption during deadband operations are given in table V and are also taken from reference 8.

The RCS is also used for moment control during guided descent engine and ascent engine burns. For simulation purposes, one RCS jet was assumed to be thrusting for appropriate lengths of time in a post-grade direction for moment control. The time rate of propellant utilized by the RCS during the DPS-1, DPS-2, and APS-2 burns is given in figures 3, 4, and 5, respectively, and is taken from reference 9.

3.2.2.1 Descent propulsion system: The descent propulsion system characteristics have been obtained from reference 6.

The start sequence for the DPS burn consists of an 8-second RCS ullage maneuver which begins 7.5 seconds before DPS engine-on signal is sent and terminates 0.5 second later. It should be noted that when an engine-on signal is sent, thrust does not begin immediately. However, the term ignition will be applied to the time of engine on, and not thrust initiation. Following DPS ignition at the 10 percent throttle setting (1283-lb thrust), the throttle setting is increased to the FTP 26 seconds after ignition. The DPS buildup and tailoff profiles are given in figures 6 and 7, respectively, and are taken from reference 6. Propellant consumption rate as a function of DPS thrust is presented in figure 8.

3.2.2.2 Ascent propulsion system: The ascent propulsion system characteristics were also obtained from reference 6.

The start sequence for the APS-2 burn consists of a 13-second RCS ullage maneuver which begins 12.5 seconds before APS ignition and terminates 0.5 second later. The thrust buildup and tailoff characteristics are presented in figures 9 and 10, respectively. The APS thrust and propellant flow rate are given in table VI. Plume impingement effects during the FTTH abort test were simulated by applying an impulse of 774 lb/sec to the ascent stage. This datum was obtained from reference 10. The sequence of events concerned with the FTTH maneuver were taken from reference 11.

### 3.3 MSFN Stations

The locations and capabilities of the MSFN stations that are planned to be available for support of Apollo 5 mission were obtained from references 12 and 13. These data are summarized in table VII.

## 4.0 MISSION DESCRIPTION

### 4.1 S-IB/S-IVB IM Launch Phase

Launch of Apollo 5 is planned to occur from launch complex 37B of the Kennedy Space Center. For mission simulations, launch is assumed to occur at 14:00 hours G.m.t. (09:00 hours e.s.t.) on January 16, 1968.

A discrete events summary of this mission phase, based on reference 4, is presented in table VIII.

Insertion into elliptic orbit occurs 608.152 seconds after lift-off. The vehicle state vector at insertion is presented in table II.

It should be noted that the data presented for this mission phase are included for completeness only. The official launch vehicle operational trajectory data are presented in the launch vehicle operational trajectory (ref. 4).

### 4.2 S-IVB/SLA/IM Orbital Coast

At S-IVB GCS the S-IVB auxiliary propulsion system initiates a maneuver to maintain the inertial attitude of the S-IVB/SLA/IM. The launch vehicle time base four ( $t_{b_4}$ ) is established by the IU 0.2 second later. S-IVB LOX venting begins 0.2 second after  $t_{b_4}$  and terminates after 40 seconds;  $LH_2$  venting starts 0.4 second after  $t_{b_4}$  and terminates 1260 seconds later. Six seconds after S-IVB/IM orbit insertion, mission phase 6 is enabled. This phase will be disabled 716 seconds later.

The aerodynamic shroud which covered the IM during the ascent-to-orbit mission phase is jettisoned at 00:10:43.35 g.e.t. The aerodynamic shroud is springloaded so that separation imparts a  $\Delta V$  of 7 fps to the shroud.

Forty-five seconds after shroud jettison, the launch vehicle second stage maneuvers to maintain the spacecraft +X-axis in the local horizontal plane in the direction of motion and the +Z-axis pointing upward along the local vertical. This attitude would place a crew on their backs with heads into the direction of flight in relation to the ground.

Deployment of the SLA occurs at 00:19:58.35 g.e.t. (10 minutes after  $t_{p4}$ ) southwest of the Canary Island tracking station. Mission phase 6 (S-IVB/LM coast) is disabled at 00:22:10.15 g.e.t.

#### 4.3 S-IVB/LM Separation

The S-IVB/LM will begin an inertial attitude-hold to maintain a constant inertial attitude during the separation sequence at 00:50:05.00. Some 27 seconds later mission phase 7, S-IVB/LM separation, is enabled. Four minutes 22 seconds after the S-IVB begins holding inertial attitude, four LM RCS thrusters are ignited to provide +X-axis translation. Five seconds after RCS ignition, the straps holding the LM in the SLA are mechanically severed, and the LM begins withdrawal from the SLA. Five seconds after the restraining straps are severed, RCS thrusting is terminated. Then, following a 5-second coast, the four +X-axis RCS thrusters are reignited for an additional 5-second burn. Mission phase 7 is then disabled at RCS shutdown.

#### 4.4 Orbital Coast to DPS-1

Twenty seconds after completion of separation, mission phase 8 (DPS cold soak) is enabled. This 150-second mission phase orients the spacecraft to an inertial attitude calculated by the LM. The LM maintains this inertial attitude in the maximum deadband mode for the duration of the subsequent two revolution coasts until 03:55:08.50 g.e.t. when mission phase 9, DPS-1 burn, is enabled.

#### 4.5 DPS-1

A 20-second coast is initiated after mission phase enable, during which the time of DPS ignition and initial thrust attitude are automatically calculated by the LM. This attitude maneuver is performed in order to minimize the attitude transients at the DPS-1 initiation. Four +X-axis RCS thrusters are ignited 7.5 seconds prior to the calculated DPS ignition time (about 262 seconds after mission phase enable) to provide ullage settling. RCS thrusting is then terminated 0.5 second

after the DPS engine is commanded on. Unlike the upcoming DPS-2 burn, steering begins when the DPS engine is turned on. The DPS throttle setting is increased to the FTP, 26 seconds after ignition from the initial 10 percent throttle setting. Guidance cutoff occurs approximately 12 seconds after reaching full throttle.

The "Hohmann descent" guidance technique is used to control the spacecraft attitude to achieve the desired velocity following DPS-1 (ref. 14). This guidance technique exhibits the following characteristics:

1. Burnout at a  $0^\circ$  inertial flight-path angle establishing a new line of apsides.
2. Burnout at a velocity such that a desired radius magnitude is achieved after free flight through a central angle of  $180^\circ$ .

Following DPS thrust tailoff, mission phase 9 is disabled at 04:00:16.10 g.e.t. The resulting ellipse is 115 and 179 n. mi. (perigee and apogee altitude).

116 179

#### 4.6 Orbital Coast to DPS-2

Following DPS-1, the IM begins an orbital coast to DPS-2. The spacecraft inertial attitude at the end of DPS-1 is maintained in the maximum deadband mode during this coast of approximately 33 minutes.

#### 4.7 DPS-2/FTTH/APS-1

4.7.1 Second DPS burn.- Mission phase 11 (DPS-2/FTTH/APS-1) is enabled at 04:33:00.3 g.e.t. During the following 25-second coast, the IM is using the engine-on algorithm and powered landing guidance to compute an ignition time and initiate thrust direction. This attitude maneuver is performed in order to minimize the attitude transients at DPS-2 initiation. Approximately 220 seconds after mission phase enable, an 8-second RCS +X-axis translation maneuver is initiated to provide ullage settling which terminates 0.5 second after DPS ignition.

The DPS-2 thrust profile represents the profile expected for lunar landing, which consists of five phases: start sequence, braking, high gate, visibility, and the random throttling sequence. This is provided by the powered landing guidance (ref. 14) which controls thrust vector magnitude and direction. This guidance philosophy utilizes multiple target phases and target parameter sets. These target parameter sets are defined in inertial space by specification of a unit normal to a plane to be achieved at cutoff. This plane forms a  $15.5^\circ$  angle with

respect to the initial orbit plane and the line of intersection is about  $23^{\circ}$  away from the radius at DPS-2 ignition. As noted previously, the spacecraft maintains a constant inertial attitude during the DPS-2 start sequence and guidance-steering is not initiated until the throttle is set to the FTP.

The random throttling sequence, the FTTH abort test and the first APS burn are performed in an attitude-hold mode with the thrust vector normal to the target orbit plane. The random throttling phase has throttle settings lasting 10 seconds each at 10, 50, 30, 40, and 20 percent thrust levels. The throttle position will then be increased to maximum throttle in preparation for the FTTH. The DPS-2 duration is 12 minutes 34 seconds. The majority of the 7000-fps  $\Delta V$  is directed out of the orbit plane in order to optimize ground coverage of APS-2. The orbit resulting from DPS-2 has a predicted perigee altitude of 165 n. mi. and an apogee altitude of 172 n. mi.

4.7.2 FTTH/APS-1.- The FTTH abort test is initiated immediately upon completion of the DPS-2 random throttling with almost simultaneous DPS shutdown, IM staging, and APS ignition. Upon detection of the abort stage sequence initiate signal, the DPS engine is commanded off. A time delay of 0.447 second is used to allow the DPS engine thrust to decay to a level that will allow separation. At this time, physical separation takes place and the descent stage is jettisoned. A 0.21-second coast takes place before the APS is commanded on (ref. 11). For this simulation, 774 lb/sec of impulse were applied to the ascent stage during the abort test to simulate plume impingement effects. The APS engine is commanded off 5 seconds later. Mission phase 11 is disabled 0.3 second later after APS tailoff at 4:49:28.76. At APS burn shutdown, the resulting orbit is 167 by 177 n. mi. Specific events during the DPS-2/FTTH/APS-1 sequence are illustrated in figure 11.

#### 4.8 Orbital Coast to APS-2

Following the APS-1 shutdown, the IM begins an orbital coast to DPS-2. The inertial attitude of the spacecraft at the end of APS-1 is maintained in the maximum deadband mode during this coast of approximately 1 hour 23 minutes.

#### 4.9 APS-2

Following acquisition by the Coastal Sentry Quebec during the fourth revolution, mission phase 13 is enabled at 06:12:23.23 g.e.t. A 20-second coast is then initiated, during which an initial thrust direction is calculated to minimize attitude start transients at the beginning of APS-2. An attitude maneuver is then performed to orient

the LM to this altitude. The RCS +X-axis thrusters are ignited for 13 seconds to provide ullage settling 157.5 seconds after mission phase enable. The APS-2 engine-on command is sent 12.5 seconds after RCS ignition is initiated.

The ascent guidance logic (ref. 14) is used to control the spacecraft attitude during this powered maneuver. The ascent guidance simulates a lunar ascent trajectory by satisfying two requirements:

1. The spacecraft must reach a specific position in space.
2. This spatial position vector must be reached at a specified time.

Spacecraft radius magnitude, velocity vector, and flight-path angle at predicted cutoff are determined by the ascent guidance to confirm that the intercept requirements are achieved. Nine seconds after APS burn initiation, an RCS interconnect test is initiated to determine the operation of RCS using propellants fed from the APS tanks. This test is terminated 342 seconds after APS ignition. It should be noted that only the RCS is used for ascent stage attitude control and stabilization during this burn.

This burn is specifically targeted so that the APS fuel available for impulse will be depleted prior to the time of guidance commanded shutdown, some 60 seconds away. Also, the instantaneous perigee altitude will not drop below 149 n. mi. to provide for alternate mission capabilities in case of premature APS shutdown. As for DPS-2, the majority of the  $\Delta V$  expended during the 438-second APS-2 (about 6800 fps) is directed out of the orbital plane.

#### 4.10 Post-APS-2 RCS Tests

The Apollo 5 mission is essentially complete at this time; however, additional spacecraft tests are scheduled. Only tests that affected the trajectory (namely, RCS tests) were incorporated in this simulation.

All the RCS tests will utilize only two +X-axis thrusters except the fifth test which will use four +X-thrusters. The RCS will also be used to provide attitude control during powered flight (ref. 8).

Following acquisition by the Rose Knot Victor during the sixth revolution, the LM will be oriented so that the thrust axis is in the orbit plane and about  $45^\circ$  above the local horizontal in preparation for the first RCS burn test. This 4-minute 14-second burn is designed to deplete the RCS propellant available for impulse in tankage system B and verify the RCS thrusters under a long-duration burn.

After RCS shutdown, the vehicle then maintains inertial attitude in the minimum deadband mode until acquisition by Texas. The IM will then be commanded to an orientation such that the thrust vector is normal to the orbit plane and in the local horizontal for the second RCS burn test. This 45-second RCS burn is to investigate the effects of helium ingestion into the RCS propellants on RCS thruster and DAP operation.

After RCS shutdown, the vehicle maintains inertial attitude in the minimum deadband until acquisition again by Texas late in the seventh revolution. Another RCS helium ingestion test (third RCS test) will then be performed for 45 seconds in the same inertial attitude as the previous test. The spacecraft will then coast for 180 seconds and the RCS thrusters reignited for 10 seconds. This fourth RCS burn test will investigate RCS thruster operation after maximum soak back from previous thruster operation. This test should be conducted within 180 seconds after previous thruster operation of greater than 15 seconds.

The IM will then coast until acquisition by Hawaii in revolution 8. An erroneous ascent stage weight will then be updated to the IM and four RCS thrusters ignited to deplete tankage system A. This 50-second burn will verify the response of IGC attitude control with an erroneous vehicle weight in IGC memory. It will also determine the RCS usage for attitude control under these conditions.

All RCS tests will utilize only two +X-axis thrusters except the fifth test which will use four +X-thrusters.

This concludes the planned powered-flight maneuver tests for Apollo 5. An additional revolution has been added after the fifth RCS test to provide data for planning any additional spacecraft testing.

Table IX presents a detailed summary according to mission event, ground elapsed time, position, velocity, total spacecraft weight, DPS or AFS and RCS propellant consumed,  $\Delta V$ , and significant orbital parameters. The RCS propellant consumption reflects that used in reference 8. Table X presents a summary of MSFN coverage during the mission for a minimum elevation angle of  $5^\circ$  and a maximum slant range of 750 n. mi. Table XI presents the same data for  $0^\circ$  and 32 000 n. mi. Figure 12 presents the ground tracks for the nominal mission. Table XII presents the computed matrix necessary to transform vectors from the IMU system to the Greenwich ECI system. It also contains the matrix REFSMMAT, which transforms vectors from the IMU system to the spacecraft Besselian ECI system. Table XIII contains the targets generated and utilized by the Lunar Landing Branch to simulate the nominal mission.



TABLE I.- SATURN IB WEIGHT STATEMENT

Spacecraft <sup>a</sup> , lb . . . . .	36 342	
Instrument unit, lb . . . . .	4 600	
S-IVB stage dry, lb . . . . .	23 427	
S-IVB residuals, lb . . . . .	2 450	
Useable reserve propellants (including FPR), lb . . . . .	<u>3 386</u>	
Injection weight, lb. . . . .		70 205
J-2 thrust decay propellants and LOX venting, lb. . . . .	<u>241</u>	
S-IVB cutoff weight, lb . . . . .		70 446
S-IVB propellant consumed, lb . . . . .	224 976	
S-IVB APS propellant consumed, lb . . . . .	6	
Ullage cases, lb. . . . .	<u>215</u>	
S-IVB "90 percent thrust" weight, lb. . . . .		295 643
S-IVB GH2 start tank, lb. . . . .	4	
S-IVB buildup propellant consumed, lb . . . . .	390	
Ullage propellant consumed, lb. . . . .	176	
S-IVB detonation package, lb. . . . .	<u>5</u>	
S-IVB stage weight at separation, lb. . . . .		296 218
S-IVB aft frame hardware, lb. . . . .	31	
S-IB/S-IVB interstage, lb . . . . .	6 654	
S-IB dry weight (including residual and reserves), lb . . . . .	96 160	
S-IVB frost consumed, lb. . . . .	100	
S-IB frost consumed, lb . . . . .	1 000	
S-IB seal purge, fuel additive and lubricants consumed, lb. . . . .	747	
Thrust decay propellants consumed, lb . . . . .	3 796	
S-IB mainstage propellant consumed, lb. . . . .	<u>880 338</u>	
Vehicle lift-off weight, lb . . . . .		1 285 044
<hr/>		
<sup>a</sup> SLA closed with ring, lb . . . . .	3 950	
LM-1, lb . . . . .	31 325	
Nose cap, lb . . . . .	<u>1 067</u>	
Total, lb. . . . .		36 342

TABLE II.- APOLLO 5 INSERTION CHARACTERISTICS

[Orbital Insertion - Guidance Cutoff Signal + 10.2 sec]

Time, sec . . . . .	608.152
Radius, ft. . . . .	21 442 116
Altitude <sup>a</sup> , ft . . . . .	516 394
Inertial velocity, fps. . . . .	25 684.38
Inertial flight-path angle, deg . . . . .	0.008
Inertial azimuth, deg from true north . . . . .	85.913
Geodetic latitude, deg north. . . . .	31.567
Longitude, deg west . . . . .	61.480
Inclination, deg. . . . .	31.614
Perigee altitude <sup>a</sup> , n. mi. . . . .	84.978
Apogee altitude <sup>a</sup> , n. mi. . . . .	119.557
Eccentricity, n.d. . . . .	0.0049
Semimajor axis, ft. . . . .	21 547 145
True anomaly, deg . . . . .	1.60
Period, min . . . . .	88.28

---

<sup>a</sup>Referenced to an earth radius of 3443.9308 n. mi.

TABLE III.- LM-1 MASS PROPERTIES

Item	Component weight, lb	Design weight, lb	Possible variation, lb
Ascent	--	4599	±50
Loaded APA propellants			
Unusable tanked <sup>a</sup>	124		
Minimum usable	5056		
Total		5180	±25
Loaded RCS propellants			
Unusable tanked <sup>b</sup>	74.6		
Minimum usable	539.6		
Total		614.2	±3
Descent Stage	--	3260	±50
Loaded DPS propellants			
Unusable tanked <sup>a</sup>	363		
Minimum usable	17 605		
Total		17 968	±90
Total <sup>c</sup>		31 621.2	±245

<sup>a</sup>Includes system variables, residuals in tanks, engine and valve operation, and contingency.

<sup>b</sup>Includes expulsion efficiency, oxidizer/fuel ratio variation, and loading variation. (from ref. 8).

<sup>c</sup>Prior to S-IVB/LM separation.

TABLE IV.- RCS THRUSTER PROPULSION CHARACTERISTICS

Thrust, lb	Specific impulse, sec	Propellant flow rate, lb/sec
100.0	272.479	0.367

TABLE V.- RCS DEADBAND USAGE

Deadband Mode	Rate, lb/hr
Minimum	4.86
Maximum	0.54

TABLE VI.- APS CHARACTERISTICS

Thrust, lb	Specific impulse, sec	Propellant flow rate, lb/sec
3493.	305.974	11.416

TABLE VII.- LOCATIONS OF APOLLO 5 MSFN STATIONS

Station	Call letters	Geodetic latitude, deg	Longitude, deg	Altitude, ft
Merritt Island (C-band)	MLA	28.4248	-80.6644	39.370
Grand Bahama	GBI	26.6363	-78.2677	39.370
Bermuda (C-band)	BDA	32.3481	-64.6538	59.055
Grand Canary	CYI	27.7632	-15.6348	131.233
Antigua	ANT	17.1440	-16.7928	190.288
Ascension	ASC	- 7.9727	-14.4016	469.159
Pretoria	PRE	-25.9437	28.3584	5334.628
Hawaii	HAW	22.1220	-159.6653	3740.145
Guam	GWM	13.3092	144.7344	416.665
Goldstone	GDS	35.3416	-116.8732	3166.000
White Sands	WHS	32.3582	-106.369	4041.981
Texas	TEX	27.6537	-97.3784	32.808
Tananarive	TAN	-19.0007	47.3150	51.000
Carnarvon	CRO	-24.8974	113.7160	190.288
Pt. Arguello	CAL	34.5829	-120.561	2119.416
Guaymas	GYM	27.9632	-110.720	62.336
Coastal Sentry Quebec	CSQ	-27.0000	96.0000	72.178
Rose Knot Victor	RKV	31.0000	-124.000	65.617
Watertown	WTN	30.0000	-138.000	70.000
Patrick AFB	PAT	28.2265	-80.599	49.212

TABLE VII.- LOCATIONS OF APOLLO 5 MSFN STATIONS - Concluded

Station	Call letters	Geodetic latitude, deg	Longitude, deg	Altitude, ft
Grand Canary	CYI	27.7400	-15.6030	169.850
Redstone	RED	28.0000	-41.0000	32.808
Merritt Island (S-band)	MIL	28.5082	-80.6934	32.808
Bermuda (S-band)	BDA	32.3512	-64.6581	68.897

TABLE VIII.- AS-204/IM-1 LAUNCH VEHICLE OPERATIONAL FLIGHT TRAJECTORY

Event	Flight time, second	Altitude, n. mi.	Velocity, fps	Space-fixed flight-path angle, deg	Azimuth, deg	Geodetic latitude, deg	Longitude, deg
Guidance reference release	-5.0	0.02	1341.63	0.000	90.00	28.53	-80.56
First motion	0.0	0.02	1341.63	0.000	90.00	28.53	-80.56
Maximum dynamic pressure	74.0	6.66	2445.99	+32.146	83.40	28.54	-80.53
Tilt arrest	133.2	28.41	6863.04	+28.715	76.07	28.66	-80.11
Inboard engine cutoff	139.1	31.76	7578.43	+27.846	75.71	28.69	-80.03
Outboard engine cutoff	142.1	33.52	7771.41	+27.394	75.64	28.70	-79.98
S-IB/S-IVB physical separation	143.5	34.33	7774.20	+27.146	75.64	28.71	-79.95
J-2 Engine start command	144.8	35.10	7756.38	+26.898	75.66	28.71	-79.93
Ullage case jettison	155.4	41.02	7789.68	+25.010	75.68	28.76	-79.76
Initiate IGM	159.3	43.07	7831.61	+24.369	75.67	28.78	-79.69
EMR shift sensed by IGM	475.8	95.57	17 990.22	-1.465	81.53	30.73	-69.88
Guidance cutoff signal	598.2	88.12	25 661.01	-0.004	85.71	31.52	-62.24
Orbit insertion	608.2	88.13	25 684.33	0.008	86.13	31.57	-61.48

TABLE IX.- MAJOR MISSION EVENTS

Event	Rev. No.	Time hr:min:sec	LM location			Inertial velocity vector			Total weight lb	Propellant used		$\Delta V$ ft/sec	Apogee/perigee, n.mi.	True Anomaly, deg
			Geodetic Latitude, deg	Longitude, deg	Altitude, n.mi.	Velocity, fps	Flightpath angle, deg	Azimuth, deg		DPS/APS lb	RCS, lb			
S-IVB orb. insertion - maintain cut off inert. att. - cont. venting	1.05	00:10:10.15	31.58	-61.33	88.12	25684.550	.019	86.21	*70488.92			1.18	123/88	1.79
Enable mission phase six (S-IVB/LM coast)		00:10:14.15	31.59	-61.02	88.13	25684.994	.020	86.38	70464.76			1.92		2.08
Terminate S-IVB vox venting	1.06	00:10:38.55	31.69	-59.16	88.17	25687.639	.027	87.40	70317.39			4.92		3.79
Jettison nose cap		00:10:43.35	31.70	-58.80	88.18	25687.578	.028	87.61	69250.38					4.10
Initiate pitch maneuver to align longitudinal axis with local horizontal plane	1.07	00:11:28.35	31.78	-55.36	88.29	25686.842	.037	89.51						7.03
Terminate pitch maneuver - maintain local attitudes	1.08	00:12:04.46	31.77	-52.60	88.40	25686.040	.044	91.04						9.38
Deploy SLA panels	1.17	00:19:58.35	25.84	-18.00	91.60	25658.976	.137	109.11						38.21
Disable mission phase six	1.20	00:22:10.15	22.58	-9.32	93.06	25646.545	.162	112.89						45.32
Terminate S-IVB LH2 venting	1.28	00:30:58.75	5.59	21.48	101.15	25582.010	.246	121.21						73.31
S-IVB/LM begin inertial attitude hold for separation	1.47	00:50:05.00	-29.01	89.21	119.73	25458.194	.097	103.53						164.52
Enable mission phase seven (S-IVB/LM separation)	1.48	00:50:32.49	-29.43	91.16	119.91	25457.139	.086	102.53						166.64
RCS ignition with S-IVB attached	1.52	00:54:27.49	-31.63	108.38	120.61	25453.588	-.006	93.24						183.96
Sever restraining straps - extract LM from SLA	1.53	00:54:32.49	-31.65	108.76	120.61	25454.461	-.008	93.04	69243.04 31606.66		7.34	0.93		184.24
RCS shutdown		00:54:37.49	-31.67	109.13	120.60	25456.381	-.008	92.83	31599.32			2.97		184.41
RCS ignition		00:54:42.49	-31.68	109.50	120.60	25456.417	-.010	92.63			14.68			184.77
RCS shutdown - set dap at maximum deadband - disable mission phase seven		00:54:47.49	-31.70	109.88	120.60	25458.334	-.011	92.42	31588.80		7.34	2.04		184.94
Enable mission phase eight (estab. cold soak att.)		00:55:07.49	-31.74	111.38	120.58	25458.524	-.018	91.59	31582.70		3.18			186.38
Disable mission phase eight - set dap at maximum deadband	1.56	00:57:37.49	-31.47	122.60	120.05	25462.084	-.076	85.38	31582.70		6.10			197.27

\* 17968 lb DPS propellant, 614 lb RCS propellant.



TABLE IX.-MAJOR MISSION EVENTS - Continued

Event	Rev. No.	Time hr:min:sec	LM location			Inertial velocity vector			Total weight, lb	Propellant used		ΔV ft/sec	Apogee/perigee, n.mi.	True Anomaly, deg
			Geodetic Latitude, deg	Longitude, deg	Altitude, n.mi.	Velocity, fps	Flightpath angle, deg	Azimuth, deg		DPS/APS lb	RCS, lb			
Enable mission phase nine, (first DPS burn)	3.45	03:55:08.50	-31.02	82.32	119.24	25466.198	-.093	82.72	31574.68		1.60			200.48
RCS ignition	3.51	03:59:30.00	-26.96	101.99	116.41	25483.941	-.183	72.56	31574.68		6.42		120/95	222.61
First DPS ignition - execute guidance commands - begin thrust built up		03:59:37.50	-26.81	102.50	116.31	25487.387	-.182	72.32	31563.67					225.23
RCS shutdown		03:59:38.00	-26.80	102.54	116.30	25487.617	-.182	72.30	31562.94		11.74	3.26		225.42
Terminate thrust built up		03:59:40.20	-26.75	102.69	116.27	25488.967	-.181	72.23	31558.14	4.79		1.43		226.51
Guidance commanded shutdown - begin DPS tail off	3.52	04:00:15.50	-25.99	105.08	115.88	25628.825	-.050	71.12	31069.45	485.03	2.67	152.86		0.07
Disable mission phase nine - set <del>dep</del> to maximum deadband		04:00:16.10	-25.98	105.12	115.88	25630.637	-.044	71.10	31065.51	4.64		1.11	179/116	0.31
Enable mission phase eleven (second DPS/fith/first APS burn)	3.84	04:33:00.30	30.64	-138.35	164.15	25290.918	.371	81.18	31059.21		0.30			127.85
RCS ignition	3.88	04:36:40.70	31.77	-122.31	169.27	25253.884	.264	89.99	31048.20		6.30		174/119	143.08
Second DPS ignition	3.89	04:36:48.20	31.77	-121.76	169.41	25252.960	.261	90.29	31047.47					143.57
RCS shutdown		04:36:48.70	31.77	-121.72	169.42	25252.900	.260	90.31	31042.67		11.74	3.32		143.60
Terminate thrust built up		04:36:50.90	31.77	-121.56	169.46	25252.641	.259	90.39	30938.96	8.44		1.46		143.75
Begin preprogrammed random throttling - set throttle to 10 percent	4.03	04:48:30.74	27.32	- 71.47	167.73	25358.025	-.076	101.12	15065.81	15948.35	28.50	6998.89	180/166	329.50
Set throttle to 50 percent		04:48:40.74	27.19	- 70.78	167.67	25357.674	-.071	101.40	15020.78	15991.91	1.47	7027.17		329.48
Set throttle to 30 percent		04:48:50.84	27.06	- 70.10	167.62	25355.460	-.050	101.47	15017.91	16167.50	0.73	7140.14		327.73
Set throttle to 40 percent		04:49:00.74	26.93	- 69.41	167.56	25354.306	-.038	101.64	14738.27	16272.95	0.76	7208.71		326.92
Set throttle to 20 percent		04:49:10.74	26.79	- 68.73	167.51	25352.839	-.022	101.71	14597.79	16413.49		7300.30		325.73
Set throttle to maximum		04:49:20.74	26.65	- 68.04	167.47	25352.157	-.013	101.99	14527.04	16484.18		7346.44		352.47
Initiate fire in the hole - abort test	4.04	04:49:22.74	26.63	- 67.91	167.46	25351.555	-.006	101.95	14461.78	16549.44		7390.19		324.93
Jettison descent stage		04:49:23.19	26.62	- 67.88	167.45	25351.498	-.005	101.97	14457.19	16554.01		7393.22		324.90
First APS ignition - begin thrust built up		04:49:23.46	26.62	- 67.86	167.45	25351.498	-.005	101.97	* 10288.46					324.91
Terminate APS thrust built up		04:49:23.86	26.61	- 67.83	167.45	25350.241	-.000	101.97	10286.42	1.45	0.59	2.37		325.94

\* 5180 lb APS propellant

TABLE IX.- MAJOR MISSION EVENTS - Concluded

Event	Rev. No.	Time hr:min:sec	LM location			Inertial velocity vector			Total weight, lb	Propellant used		ΔV ft/sec	Apogee/perigee, n.mi.	True Anomaly, deg
			Geodetic Latitude, deg	Longitude, deg	Altitude, n.mi.	Velocity, fps	Flightpath angle, deg	Azimuth, deg		DPS/APS lb	RCS, lb			
Command APS shutdown - begin thrust tailoff		04:49:28.46	26.55	- 67.52	167.43	25351.042	.006	102.01	10232.59	52.15	1.68	51.92		333.98
Terminate APS tailoff - disable phase eleven - set dap to maximum deadband		04:49:28.76	26.54	- 67.50	167.43	25351.065	.006	102.01	10231.51	0.97	2.90	1.03	177/167	334.21
Enable mission phase thirteen (second APS burn)	4.88	06:12:23.23	28.69	-123.04	168.56	25355.774	.023	85.76	10228.61		1.20			317.82
RCS ignition	4.91	06:15:00.70	28.94	-111.82	168.33	25353.353	.017	91.91	10227.41				177/167	321.81
Second APS ignition - begin thrust build up - command guidance execution	4.92	06:15:13.23	28.91	-110.92	168.31	25353.353	.017	91.91						320.74
Terminate APS built up		06:15:13.63	28.91	-110.90	168.31	25353.219	.017	91.92		1.40				320.56
RCS shutdown		06:15:13.73	28.91	-110.89	168.31	25353.213	.017	91.92	10204.42		19.09	15.98		320.37
APS shutdown on APS fuel depletion - set dap to maximum deadband	5.00	06:22:31.17	27.36	- 80.04	170.01	25803.00	-.147	92.41	5191.42	5000.03	15.47	6723.65	456/170	356.42
Orient for first RCS test	6.40	08:52:24.58	-23.96	87.53	425.52	23987.172	-.655	77.12	5166.42		25.00		450/175	200.06
First RCS burn test - deplete system B	6.46	08:52:44.016	-23.68	88.66	424.51	23992.824	-.697	76.63	5165.62		0.80			201.23
RCS shutdown - set dap to minimum deadband	6.50	08:56:58.81	-18.77	104.21	411.61	24265.618	-.497	70.80	4977.80		185.32	320.50	440/308	213.03
Orient for second RCS test	6.98	09:46:20.40	18.09	- 86.39	313.97	25059.061	.458	110.11	4970.80		7.00		447/302	31.46
Second RCS burn test	6.98	09:46:39.99	17.64	- 85.27	314.59	25054.534	.477	110.51	4970.00		0.80			32.60
RCS shutdown - set dap to minimum deadband	6.99	09:47:23.859	16.62	- 82.78	316.07	25053.581	.525	111.22	4937.00		33.00	57.00	453/302	33.90
Third RCS burn test	7.94	11:27:39.00	13.46	-100.65	320.57	25025.394	.624	113.11	4915.60		21.40		453/302	40.72
RCS shutdown - set dap to minimum deadband	7.95	11:28:23.96	12.30	- 98.21	322.52	25021.084	.674	113.64	4882.60		33.00	59.06	459/303	2.01
Fourth RCS burn test	7.97	11:31:23.96	7.46	- 88.67	331.44	24955.668	.837	115.71	4882.45		0.15		459/304	2.51
RCS shutdown - set dap to minimum deadband	7.97	11:31:33.70	7.19	- 88.16	331.97	24953.718	.847	115.76	4875.30		7.15	12.85	460/303	2.78
Orient for fifth RCS test	8.72	12:52:11.00	26.96	-175.95	308.01	25106.192	-.331	91.38	4857.44		17.86		458/302	349.22
Fifth RCS burn test	8.72	12:52:18.10	26.92	-175.48	307.92	25107.286	-.323	91.61	4857.04		0.40			349.65
RCS shutdown - set dap to minimum deadband	8.73	12:52:58.59	26.72	-172.80	307.44	25131.819	-.271	92.67	4797.60		59.44	107.98	470/303	353.25

TABLE X.- RADAR ACQUISITION DATA FOR A MINIMUM ELEVATION OF 5° AND A MAXIMUM SLANT RANGE OF 750 N. MI.

STATION NAME	REV NO.	ACQUISITION				LOSS				ELAPSED TIME		MAX ELEV DEGREES	ACQ RANGE N. MI.	MIN RANGE N. MI.
		D	H	M	S	D	H	M	S	M	S			
BDA C RTVC	1	0	0	10	6	0	0	11	41	1	35	25.9	538.	192.
BDA S RTVC	1	0	0	10	6	0	0	11	41	1	35	25.8	538.	192.
RED C,S RTVC	1	0	0	12	35	0	0	16	53	4	17	24.9	520.	200.
CYI C RTVC	1	0	0	18	6	0	0	22	33	4	26	29.0	533.	182.
CYI S RTVC	1	0	0	18	7	0	0	22	33	4	26	29.2	531.	181.
TAN C R V	1	0	0	38	0	0	0	42	3	4	2	12.2	606.	415.
CSQ S TVC	1	0	0	48	52	0	0	54	11	5	18	29.6	663.	232.
CRO C RTVC	1	0	0	53	27	0	0	57	47	4	20	12.6	659.	436.
RKV C TVC	1	0	1	28	55	0	1	30	41	1	46	6.1	550.	515.
GYM S RTVC	1	0	1	29	59	0	1	34	33	4	33	51.3	496.	116.
WHS C R	1	0	1	31	30	0	1	35	33	4	3	17.4	524.	272.
TEX S RTVC	1	0	1	32	57	0	1	37	24	4	26	31.6	546.	167.
MLA C R	2	0	1	36	50	0	1	41	7	4	16	22.7	521.	219.
PAT C R	2	0	1	36	52	0	1	41	7	4	14	21.4	529.	231.
MIL S RTVC	2	0	1	36	50	0	1	41	7	4	17	23.3	521.	215.
GBI C RTVC	2	0	1	37	38	0	1	41	25	3	46	13.6	548.	326.
BDA C RTVC	2	0	1	40	12	0	1	44	47	4	34	46.7	528.	124.
BDA S RTVC	2	0	1	40	12	0	1	44	47	4	34	46.6	527.	124.
RED C,S RTVC	2	0	1	45	34	0	1	50	9	4	35	36.9	539.	152.
TAN C R V	2	0	2	10	29	0	2	15	38	5	9	26.4	607.	245.
CSQ S TVC	2	0	2	22	23	0	2	27	26	5	3	20.4	636.	310.
CRC C RTVC	2	0	2	26	38	0	2	31	38	4	59	20.3	660.	307.
HAW C RTVC	2	0	2	52	26	0	2	56	1	3	34	11.7	553.	371.
NTN C,S R	2	0	2	57	37	0	3	1	36	3	59	16.2	549.	288.
RKV C TVC	2	0	3	9	23	0	3	4	53	4	29	39.0	496.	141.
CAL C R V	2	0	3	1	36	0	3	5	31	3	54	15.5	543.	296.
GDS S RTVC	2	0	3	2	26	0	3	6	17	3	51	14.8	509.	305.
GYM S RTVC	2	0	3	3	17	0	3	7	34	4	16	22.8	545.	219.
WHS C R	2	0	3	4	12	0	3	8	47	4	34	56.2	527.	108.
TEX S RTVC	2	0	3	6	25	0	3	10	31	4	5	17.7	510.	267.
MLA C R	3	0	3	9	58	0	3	14	31	4	32	39.4	551.	142.
FAT C R	3	0	3	10	0	0	3	14	32	4	31	36.8	509.	149.
MIL S RTVC	3	0	3	9	58	0	3	14	30	4	32	40.6	547.	138.
GBI C RTVC	3	0	3	10	41	0	3	15	3	4	21	24.4	543.	210.
EDA C RTVC	3	0	3	13	35	0	3	17	13	3	38	12.2	545.	357.
BDA S RTVC	3	0	3	13	35	0	3	17	13	3	38	12.2	545.	357.
ANT C RTVC	3	0	3	16	6	0	3	18	40	2	33	7.5	563.	475.
ASC C R V	3	0	3	29	15	0	3	33	15	4	0	12.6	591.	390.
PRE C R	3	0	3	40	0	0	3	45	26	5	25	50.9	634.	149.
TAN C R V	3	0	3	45	55	0	3	47	9	1	13	5.4	657.	645.
CSC S TVC	3	0	3	55	32	0	4	0	59	5	27	50.9	653.	150.
CRC C RTVC	3	0	4	5	2	0	4	5	2	5	20	43.7	649.	165.
HAW C RTVC	3	0	4	24	37	0	4	30	30	5	52	36.6	710.	248.
NTN C,S R	3	0	4	29	53	0	4	36	13	6	19	75.5	750.	169.
RKV C TVC	3	0	4	33	7	0	4	39	26	6	19	74.1	748.	175.
CAL C R V	3	0	4	34	1	0	4	40	7	6	6	42.9	744.	242.

TABLE X.- RADAR ACQUISITION DATA FOR A MINIMUM ELEVATION OF 5° AND A MAXIMUM SLANT RANGE OF 750 N. MI. - Continued

STATION NAME	REV. NO.	ACQUISITION				LOSS				ELAPSED TIME		MAX ELEV DEGREES	ACQ RANGE N. MI.	MIN RANGE N. MI.
		U	H	M	S	D.	H	M	S	M	S			
GDS S RTVC	3	0	4	37	51	0	4	40	53	5	3	35.3	744.	282.
CYM S RTVC	3	0	4	37	23	0	4	42	22	5	59	37.3	748.	272.
WHS C R	3	0	4	37	8	0	4	43	26	6	18	66.4	748.	187.
TFX S RTVC	3	0	4	39	24	0	4	45	30	0	5	42.9	749.	245.
MLA C R	4	0	4	43	10	0	4	49	34	6	23	82.3	747.	170.
PAT C R	4	0	4	43	12	0	4	49	15	6	3	78.5	744.	172.
MIL S RTVC	4	0	4	43	10	0	4	49	17	6	6	84.0	749.	170.
GBI C RTVC	4	0	4	43	49	0	4	49	56	6	6	56.0	748.	201.
EDA C RTVC	4	0	4	47	2	0	4	52	15	5	13	20.5	747.	417.
BDA S RTVC	4	0	4	47	2	0	4	51	54	4	51	23.5	747.	417.
ANT C RTVC	4	0	4	47	4	0	4	53	54	4	49	15.3	746.	506.
REB C,S RTVC	4	0	4	53	4	0	4	57	15	4	10	12.2	718.	577.
ASC C R V	4	0	5	4	23	0	5	7	14	2	50	9.1	731.	659.
PRE C R	4	0	5	15	3	0	5	20	16	5	12	19.7	727.	424.
TAN C R V	4	0	5	18	45	0	5	24	14	5	29	20.9	736.	407.
CSQ S TVC	4	0	5	31	21	0	5	36	25	6	4	80.1	722.	169.
CRG C RTVC	4	0	5	34	41	0	5	40	55	6	15	59.1	728.	193.
HAW C RTVC	4	0	6	0	20	0	6	6	35	6	15	58.3	744.	196.
WTN C,S R	4	0	6	5	45	0	6	11	47	6	1	38.6	715.	261.
RKV C TVC	4	0	6	9	1	0	6	15	13	6	11	48.0	744.	223.
CAL C R V	4	0	6	10	20	0	6	15	44	5	23	22.7	749.	390.
GDS S RTVC	4	0	6	11	2	0	6	16	27	5	24	20.0	744.	426.
GYM S RTVC	4	0	6	12	3	0	6	18	21	6	17	70.5	749.	178.
WHS C R	4	0	6	13	6	0	6	19	8	6	1	35.4	747.	278.
TEX S RTVC	4	0	6	15	13	0	6	21	29	6	16	76.6	750.	173.
MLA C R	5	0	6	19	4	0	6	25	13	6	8	68.9	750.	182.
FAT C R	5	0	6	19	7	0	6	23	33	4	26	72.6	746.	178.
MIL S RTVC	5	0	6	19	5	0	6	23	55	4	50	07.4	748.	183.
GBI C RTVC	5	0	6	19	42	0	6	25	52	6	10	75.4	745.	175.
EDA C RTVC	5	0	6	23	24	0	6	28	13	4	49	20.2	702.	432.
BDA S RTVC	5	0	6	23	22	0	6	27	43	4	21	20.2	702.	432.
ANT C RTVC	5	0	6	24	57	0	6	29	32	4	35	15.7	736.	518.
RED C,S RTVC	5	0	6	28	34	0	6	33	34	4	59	17.3	730.	521.
PRF C R	5	0	6	53	9	0	6	55	41	2	31	26.0	748.	712.
TAN C R V	5	0	6	22	12	0	7	1	41	39	29	61.6	747.	442.
CSQ S TVC	5	0	7	9	8	0	7	14	24	5	16	86.5	747.	433.
CRG C RTVC	5	0	7	14	8	0	7	20	22	6	14	77.5	739.	431.
HAW C RTVC	5	0	7	41	52	0	7	47	36	5	44	36.6	719.	356.
WTN C,S R	5	0	7	46	25	0	7	53	2	6	37	25.9	740.	395.
RKV C TVC	5	0	7	50	36	0	7	56	24	5	48	31.4	739.	322.
CAL C R V	5	0	7	51	57	0	7	56	30	4	32	16.9	741.	496.
GDS S RTVC	5	0	7	52	57	0	7	57	31	4	34	15.2	732.	526.
GYM S RTVC	5	0	7	53	25	0	7	59	24	5	59	76.0	697.	176.
WHS C R	5	0	7	54	35	0	8	0	13	5	37	26.8	736.	348.
TFX S RTVC	5	0	7	56	39	0	8	2	18	5	39	71.4	698.	179.
MLA C R	6	0	8	0	37	0	8	6	14	5	36	32.2	703.	312.
PAT C R	6	0	8	0	43	0	8	5	45	5	2	33.5	695.	303.
MIL S RTVC	6	0	8	0	42	0	8	5	48	5	5	31.7	707.	316.
GBI C RTVC	6	0	8	0	27	0	8	6	55	6	27	42.3	741.	257.

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TABLE X.- RADAR ACQUISITION DATA FOR A MINIMUM ELEVATION OF 5° AND A MAXIMUM SLANT RANGE OF 750 N. MI. - Concluded

STATION NAME	REV NU.	ACQUISITION				LOSS				ELAPSED TIME		MAX ELEV DEGREES	ACQ RANGE N. MI.	MIN RANGE N. MI.
		D	H	M	S	D	H	M	S	M	S			
ANT C RTVC	6	0	8	5	39	0	8	11	55	6	16	72.2	741.	207.
ASC C R V	6	0	8	20	11	0	8	26	20	6	9	69.8	710.	327.
PRE C R	6	0	8	33	9	0	8	39	22	6	12	70.1	745.	426.
TAN C R V	6	0	8	23	55	0	8	43	2	19	6	36.2	746.	657.
CSQ S TVC	6	0	8	51	48	0	8	56	51	5	2	49.5	747.	528.
CRD C RTVC	6	0	8	57	50	0	9	0	23	2	32	30.3	747.	707.
GWM S RTVC	6	0	9	11	31	0	9	12	43	1	11	24.4	742.	738.
HAW C RTVC	6	0	9	23	52	0	9	30	2	6	10	61.1	737.	361.
WTN C S R	6	0	9	23	52	0	9	35	15	6	22	61.1	749.	351.
CAL C R V	6	0	9	34	32	0	9	37	48	3	16	28.2	736.	578.
RKV C TVC	6	0	9	33	12	0	9	38	39	5	26	49.3	716.	395.
GDS S RTVC	6	0	9	35	52	0	9	39	22	3	29	24.1	725.	642.
WHS C R	6	0	9	37	13	0	9	42	22	5	9	28.3	744.	578.
GYM S RTVC	6	0	9	35	56	0	9	41	48	5	51	60.0	693.	351.
TEX S RTVC	6	0	9	39	32	0	9	45	22	5	49	39.5	735.	462.
GBI C RTVC	6	0	9	47	5	0	9	47	41	0	35	19.6	750.	749.
ANT C RTVC	7	0	9	50	49	0	9	54	1	3	11	24.5	739.	675.
ASC C R V	7	0	10	6	29	0	10	9	21	2	52	29.0	743.	696.
PRE C R	7	0	10	18	8	0	10	24	1	5	53	78.2	714.	429.
TAN C R V	7	0	10	24	29	0	10	28	21	3	52	37.9	736.	638.
GWM S RTVC	7	0	10	53	29	0	10	59	40	6	11	78.6	736.	355.
WTN C S R	7	0	10	45	52	0	11	18	16	32	24	46.0	699.	413.
RKV C TVC	7	0	11	18	9	0	11	19	5	0	56	26.7	741.	603.
GYM S RTVC	7	0	11	21	49	0	11	25	1	3	11	23.4	736.	665.
FRE C R	8	0	12	2	58	0	12	8	51	5	53	86.3	724.	432.
TAN C R V	8	0	12	4	55	0	12	14	31	9	36	72.7	727.	444.
GWM S RTVC	8	0	12	39	40	0	12	42	50	3	10	24.1	748.	684.
HAW C RTVC	8	0	12	53	23	0	12	59	35	6	11	59.7	729.	353.
WTN C S R	8	0	13	0	3	0	13	1	54	1	51	20.3	743.	725.
PRE C R	9	0	13	48	42	0	13	53	15	4	32	43.8	734.	595.
TAN C R V	9	0	13	54	23	0	13	58	35	4	12	38.8	750.	623.
HAW C RTVC	9	0	14	38	23	0	14	43	55	5	32	47.1	696.	418.
ASC C R V	11	0	17	10	2	0	17	13	55	3	52	38.0	738.	640.
GWM S RTVC	11	0	17	55	3	0	18	0	15	5	11	38.3	706.	478.

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TABLE XI.- RADAR ACQUISITION DATA FOR A MINIMUM ELEVATION OF 0° AND A MAXIMUM SLANT RANGE OF 32 000 N. MI.

STATION NAME	REV NO.	ACQUISITION				LOSS				ELAPSED TIME		MAX ELEV DEGREES	LOSS RANGE N. MI.	MIN RANGE N. MI.
		D	H	M	S	D	H	M	S	M	S			
EDA C RTVC	1	0	0	10	11	0	0	12	44	2	33	25.9	786.	192.
EDA S RTVC	1	0	0	10	11	0	0	12	44	2	33	25.8	786.	192.
RED C,S RTVC	1	0	0	11	31	0	0	17	58	6	26	24.9	794.	200.
CYI C RTVC	1	0	0	17	3	0	0	23	39	6	36	29.0	816.	182.
CYI S RTVC	1	0	0	17	3	0	0	23	40	6	36	29.2	816.	181.
TAN C R V	1	0	0	36	41	0	0	43	22	5	40	12.3	899.	415.
CSQ S TVC	1	0	0	47	43	0	0	55	18	7	35	29.6	916.	232.
CRD C RTVC	1	0	0	52	9	0	0	59	5	6	55	12.6	911.	436.
WTN C,S R	1	0	1	25	11	0	1	27	29	1	17	.1	812.	801.
RKV C TVC	1	0	1	27	9	0	1	32	24	5	15	6.1	800.	513.
CAL C R V	1	0	1	28	45	0	1	32	55	4	11	3.0	802.	637.
GDS S RTVC	1	0	1	29	25	0	1	33	53	4	28	3.6	801.	608.
GYM S RTVC	1	0	1	28	55	0	1	35	35	6	40	51.1	793.	116.
WHS C R	1	0	1	30	20	0	1	36	41	6	21	17.4	796.	271.
TEX S RTVC	1	0	1	31	53	0	1	38	27	6	34	32.3	792.	165.
MLA C R	2	0	1	35	45	0	1	42	13	6	27	22.6	795.	220.
FAT C R	2	0	1	35	47	0	1	42	13	6	26	21.3	795.	232.
MIL S RTVC	2	0	1	35	44	0	1	42	13	6	28	23.2	795.	216.
GBI C RTVC	2	0	1	36	27	0	1	42	36	6	8	13.4	795.	328.
EDA C RTVC	2	0	1	39	9	0	1	45	51	6	41	46.7	806.	124.
BDA S RTVC	2	0	1	39	9	0	1	45	51	6	41	46.6	806.	124.
RED C,S RTVC	2	0	1	44	31	0	1	51	15	6	44	36.1	821.	155.
CYI C RTVC	2	0	1	51	14	0	1	55	1	3	47	2.2	836.	697.
CYI S RTVC	2	0	1	51	15	0	1	55	2	3	47	2.2	836.	697.
PRE C R	2	0	2	7	17	0	2	12	26	5	9	4.4	903.	663.
TAN C R V	2	0	2	9	21	0	2	16	46	7	24	26.5	907.	245.
CSQ S TVC	2	0	2	21	13	0	2	28	36	7	22	20.1	909.	313.
CRD C RTVC	2	0	2	25	28	0	2	32	47	7	19	20.3	898.	307.
HAW C RTVC	2	0	2	51	8	0	2	57	15	6	6	11.7	800.	371.
WTN C,S R	2	0	2	55	25	0	3	2	45	6	19	16.2	795.	289.
RKV C TVC	2	0	2	59	19	0	3	5	56	6	37	39.0	794.	141.
CAL C R V	2	0	3	0	25	0	3	6	41	6	16	15.5	797.	296.
GDS S RTVC	2	0	3	1	14	0	3	7	28	6	14	14.8	797.	305.
GYM S RTVC	2	0	3	2	11	0	3	8	39	6	27	22.7	793.	220.
WHS C R	2	0	3	3	9	0	3	9	53	6	40	59.5	797.	105.
TEX S RTVC	2	0	3	5	18	0	3	11	39	6	20	18.0	796.	265.
MLA C R	3	0	3	8	56	0	3	15	36	6	40	39.9	807.	140.
PAT C R	3	0	3	8	57	0	3	15	37	6	39	37.0	807.	149.
MIL S RTVC	3	0	3	8	55	0	3	15	35	6	40	41.2	808.	137.
GBI C RTVC	3	0	3	9	37	0	3	16	10	6	32	23.9	808.	213.
BDA C RTVC	3	0	3	12	21	0	3	18	30	6	8	12.1	819.	359.
BDA S RTVC	3	0	3	12	21	0	3	18	30	6	8	12.1	819.	359.
ANT C RTVC	3	0	3	14	38	0	3	20	12	5	33	7.5	817.	476.
RED C,S RTVC	3	0	3	18	27	0	3	22	56	4	28	3.5	834.	635.
ASC C R V	3	0	3	23	6	0	3	34	33	6	32	12.5	874.	392.
PRE C R	3	0	3	38	54	0	3	46	32	7	37	50.9	912.	149.

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TABLE XI.- RADAR ACQUISITION DATA FOR A MINIMUM ELEVATION OF 0° AND A MAXIMUM SLANT RANGE OF 32 000 N. MI. - Continued

STATION NAME	REV NU.	ACQUISITION				LOSS				ELAPSED TIME		MAX ELEV DEGREES	LOSS RANGE N. MI.	MIN RANGE N. MI.
		D	H	M	S	D	H	M	S	M	S			
TAN C R V	3	0	3	43	47	0	3	49	19	5	32	5.4	910.	645.
CSC S TVC	3	0	3	54	26	0	4	2	5	7	39	50.9	903.	150.
CRO C RTVC	3	0	3	58	35	0	4	6	10	7	35	43.2	910.	166.
FAW C RTVC	3	0	4	23	14	0	4	32	1	8	47	35.5	1068.	254.
WTN C,S R	3	0	4	28	31	0	4	37	46	9	14	75.0	1097.	170.
RKV C TVC	3	0	4	31	40	0	4	41	2	9	21	74.0	1104.	176.
CAL C R V	3	0	4	32	18	0	4	41	48	9	30	43.1	1106.	242.
GDS S RTVC	3	0	4	33	19	0	4	42	36	9	17	35.4	1104.	282.
GYM S RTVC	3	0	4	34	49	0	4	43	57	9	7	37.4	1095.	273.
WHS C R	3	0	4	35	36	0	4	45	2	9	26	66.5	1095.	187.
TEX S RTVC	4	0	4	37	51	0	4	47	3	9	11	43.1	1089.	245.
MLA C R	4	0	4	41	34	0	4	50	59	9	24	82.5	1087.	170.
PAT C R	4	0	4	41	36	0	4	51	0	9	23	78.6	1087.	172.
MIL S RTVC	4	0	4	41	34	0	4	50	58	9	24	84.1	1087.	170.
GBI C RTVC	4	0	4	42	15	0	4	51	35	9	19	56.1	1086.	201.
BDA C RTVC	4	0	4	45	18	0	4	54	7	8	49	20.2	1090.	421.
BDA S RTVC	4	0	4	45	18	0	4	54	7	8	49	20.2	1090.	421.
ANT C RTVC	4	0	4	47	17	0	4	55	38	8	21	15.3	1082.	506.
RED C,S RTVC	4	0	4	51	16	0	4	59	17	8	1	12.2	1088.	576.
ASC C R V	4	0	5	2	7	0	5	9	35	7	28	9.0	1083.	668.
PRE C R	4	0	5	13	21	0	5	22	5	8	44	19.7	1093.	431.
TAN C R V	4	0	5	17	5	0	5	25	55	8	50	21.5	1092.	407.
CSG S TVC	4	0	5	28	50	0	5	38	17	9	26	78.7	1099.	174.
CRO C RTVC	4	0	5	33	7	0	5	42	31	9	23	52.9	1098.	211.
HAW C RTVC	4	0	5	58	45	0	6	8	5	9	19	58.5	1088.	196.
WTN C,S R	4	0	6	4	22	0	6	13	35	9	12	34.6	1090.	283.
RKV C TVC	4	0	6	7	33	0	6	16	51	9	17	46.7	1091.	227.
CAL C R V	4	0	6	8	36	0	6	17	30	8	54	22.5	1094.	392.
GDS S RTVC	4	0	6	9	29	0	6	18	18	8	49	19.9	1096.	427.
GYM S RTVC	4	0	6	10	35	0	6	19	57	9	22	70.9	1095.	177.
WHS C R	4	0	6	11	32	0	6	20	55	9	23	35.3	1099.	279.
TEX S RTVC	5	0	6	13	44	0	6	23	17	9	33	76.6	1095.	174.
MLA C R	5	0	6	17	37	0	6	27	22	9	45	69.6	1112.	181.
PAT C R	5	0	6	17	38	0	6	27	23	9	44	73.2	1112.	178.
MIL S RTVC	5	0	6	17	36	0	6	27	22	9	46	68.0	1112.	183.
GBI C RTVC	5	0	6	18	14	0	6	28	32	10	17	75.4	1124.	176.
BDA C RTVC	5	0	6	21	27	0	6	31	14	9	46	19.9	1162.	436.
BDA S RTVC	5	0	6	21	27	0	6	31	14	9	46	19.9	1162.	436.
ANT C RTVC	5	0	6	23	18	0	6	32	34	9	16	15.2	1177.	528.
RED C,S RTVC	5	0	6	27	23	0	6	36	41	9	18	17.6	1260.	514.
CYI C RTVC	5	0	6	35	9	0	6	40	43	5	34	3.2	1351.	1074.
CYI S RTVC	5	0	6	35	9	0	6	40	43	5	34	3.2	1351.	1074.
ASC C R V	5	0	6	38	1	0	6	47	25	9	24	10.1	1504.	897.
PRE C R	5	0	6	48	41	0	7	2	41	14	0	25.6	1778.	731.
TAN C R V	5	0	6	51	29	0	7	7	54	16	25	63.3	1815.	452.
CSG S TVC	5	0	7	4	9	0	7	21	20	17	11	80.0	1768.	460.
CRC C RTVC	5	0	7	9	21	0	7	25	29	16	8	79.3	1713.	451.
GWM S RTVC	5	0	7	26	45	0	7	34	27	7	42	3.1	1528.	1439.
FAW C RTVC	5	0	7	39	57	0	7	50	40	10	42	36.0	1173.	370.

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TABLE XI.-- RADAR ACQUISITION DATA FOR A MINIMUM ELEVATION OF 0° AND A MAXIMUM SLANT RANGE OF 32 000 N. MI. - Continued

STATION NAME	REV NO.	ACQUISITION				LOSS				ELAPSED TIME		MAX ELEV DEGREES	LOSS RANGE N. MI.	MIN RANGE N. MI.
		D	H	M	S	D	H	M	S	M	S			
WTN C,S R	5	0	7	46	34	0	7	55	58	9	23	26.1	1110.	401.
RKV C TVC	5	0	7	49	24	0	7	58	46	9	21	29.0	1098.	350.
GDS S RTVC	5	0	7	51	58	0	8	0	5	8	7	14.8	1099.	535.
CAL C R V	5	0	7	50	43	0	7	59	54	9	11	17.0	1099.	499.
WHS C R	5	0	7	53	28	0	8	2	45	9	16	25.2	1108.	367.
GYM S RTVC	5	0	7	52	10	0	8	2	33	10	23	55.2	1105.	207.
TFX S RTVC	6	0	7	55	59	0	8	5	21	9	21	74.4	1130.	176.
MLA C R	6	0	7	59	58	0	8	9	20	9	21	31.9	1190.	314.
FAT C R	6	0	7	59	59	0	8	9	20	9	21	33.3	1190.	304.
MIL S RTVC	6	0	7	59	58	0	8	9	19	9	21	31.3	1190.	318.
GBI C RTVC	6	0	8	0	7	0	8	9	52	9	44	39.8	1202.	266.
BDA C RTVC	6	0	8	4	1	0	8	11	25	7	24	7.9	1230.	764.
BDA S RTVC	6	0	8	4	1	0	8	11	25	7	24	7.9	1230.	764.
ANT C RTVC	6	0	8	5	13	0	8	15	19	10	5	61.4	1312.	224.
RED C,S RTVC	6	0	8	10	7	0	8	16	40	6	32	3.3	1347.	1065.
ASC C R V	6	0	8	18	3	0	8	31	26	13	23	67.0	1666.	337.
PRE C R	6	0	8	29	55	0	8	45	26	15	30	64.4	1821.	456.
TAN C R V	6	0	8	34	36	0	8	50	36	16	0	37.3	1817.	669.
CSQ S TVC	6	0	8	46	47	0	9	3	50	17	3	51.5	1739.	544.
CRD C RTVC	6	0	8	52	4	0	9	7	53	15	49	31.7	1700.	719.
GWM S RTVC	6	0	9	6	33	0	9	19	57	13	23	23.9	1560.	756.
HAW C RTVC	6	0	9	21	22	0	9	34	39	13	17	58.6	1443.	353.
WTN C,S R	6	0	9	27	52	0	9	40	4	12	11	59.8	1441.	335.
CAL C R V	6	0	9	32	0	0	9	44	0	12	0	26.8	1455.	564.
RKV C TVC	6	0	9	30	45	0	9	43	54	13	8	43.5	1454.	403.
GDS S RTVC	6	0	9	33	14	0	9	45	11	11	56	22.4	1462.	635.
GYM S RTVC	6	0	9	34	35	0	9	46	32	11	57	59.2	1466.	332.
WHS C R	6	0	9	35	51	0	9	46	59	11	8	26.0	1470.	577.
TFX S RTVC	7	0	9	37	25	0	9	49	43	12	18	36.4	1490.	459.
MLA C R	7	0	9	42	31	0	9	53	34	11	2	16.9	1529.	773.
EDA C RTVC	7	0	9	47	28	0	9	53	38	6	10	2.2	1530.	1359.
PAT C R	7	0	9	42	31	0	9	53	35	11	3	17.3	1529.	764.
MIL S RTVC	7	0	9	42	31	0	9	53	33	11	2	16.8	1529.	777.
BDA S RTVC	7	0	9	47	28	0	9	53	38	6	10	2.2	1530.	1359.
GBI C RTVC	7	0	9	42	41	0	9	54	48	12	7	18.7	1543.	733.
ANT C RTVC	7	0	9	47	1	0	10	0	12	13	10	23.3	1602.	671.
ASC C R V	7	0	10	1	42	0	10	16	52	15	9	30.0	1774.	695.
PRE C R	7	0	10	14	12	0	10	30	21	16	9	69.9	1817.	471.
TAN C R V	7	0	10	19	34	0	10	35	38	16	3	38.5	1797.	667.
CSQ S TVC	7	0	10	32	49	0	10	46	21	13	31	19.0	1715.	976.
CRD C RTVC	7	0	10	38	21	0	10	50	3	11	41	8.1	1670.	1317.
GWM S RTVC	7	0	10	50	17	0	11	4	49	14	32	72.5	1498.	363.
HAW C RTVC	7	0	11	6	20	0	11	19	28	13	8	37.4	1440.	453.
WTN C,S R	7	0	11	11	40	0	11	24	49	13	8	41.1	1467.	419.
GDS S RTVC	7	0	11	18	5	0	11	27	34	9	28	11.0	1489.	932.
CAL C R V	7	0	11	16	49	0	11	27	28	10	38	14.0	1488.	833.
RKV C TVC	7	0	11	15	33	0	11	27	29	11	55	25.5	1487.	587.
WHS C R	7	0	11	20	46	0	11	30	0	9	14	10.3	1510.	970.
GYM S RTVC	7	0	11	19	25	0	11	30	25	11	0	21.7	1511.	660.



TABLE XI.- RADAR ACQUISITION DATA FOR A MINIMUM ELEVATION OF 0° AND A MAXIMUM SLANT RANGE OF 32 000 N. MI. - Concluded

STATION NAME	REV NO.	ACQUISITION				LOSS				ELAPSED TIME		MAX ELEV	LOSS RANGE	MIN RANGE
		D	H	M	S	D	H	M	S	M	S	DEGREES	N. MI.	N. MI.
TEX S RTVC	7	0	11	22	21	0	11	33	40	11	18	12.2	1549.	923.
MLA C R	8	0	11	28	30	0	11	34	59	6	29	2.0	1565.	1394.
PAT C R	8	0	11	28	27	0	11	35	1	6	33	2.2	1565.	1385.
WIL S RTVC	8	0	11	28	29	0	11	34	58	6	28	2.0	1565.	1397.
GBI C RTVC	8	0	11	29	0	0	11	36	17	7	16	2.6	1580.	1370.
ANT C RTVC	8	0	11	34	50	0	11	41	49	6	58	3.9	1644.	1373.
ASC C R V	8	0	11	48	21	0	12	1	40	13	19	13.7	1820.	1138.
FRE C R	8	0	11	59	1	0	12	16	14	17	13	83.5	1802.	463.
TAN C R V	8	0	12	4	26	0	12	21	36	17	10	72.7	1758.	471.
CSC S TVC	8	0	12	20	32	0	12	27	0	6	27	1.8	1704.	1633.
GWM S RTVC	8	0	12	36	22	0	12	48	30	12	7	23.1	1463.	686.
HAW C RTVC	8	0	12	51	11	0	13	4	26	13	14	51.7	1476.	361.
GDS S RTVC	8	0	13	5	24	0	13	8	27	3	3	.6	1519.	1449.
CAL C R V	8	0	13	3	3	0	13	8	39	5	35	2.7	1518.	1327.
WTN C,S R	8	0	12	56	33	0	13	8	28	11	54	19.4	1516.	709.
RKV C TVC	8	0	13	0	35	0	13	11	0	10	25	8.4	1547.	1054.
GYM S RTVC	8	0	13	4	37	0	13	13	42	9	5	5.3	1579.	1225.
ASC C R V	9	0	13	35	2	0	13	47	16	12	14	11.0	1853.	1305.
FRE C R	9	0	13	44	22	0	14	0	30	16	7	44.4	1777.	621.
TAN C R V	9	0	13	49	50	0	14	5	50	15	59	40.5	1716.	634.
GWM S RTVC	9	0	14	23	7	0	14	33	45	10	38	12.0	1437.	912.
HAW C RTVC	9	0	14	36	28	0	14	49	42	13	13	46.0	1542.	400.
WTN C,S R	9	0	14	43	10	0	14	51	3	7	53	4.0	1561.	1273.
ASC C R V	10	0	15	20	28	0	15	35	5	14	36	16.6	1810.	1114.
PRE C R	10	0	15	29	55	0	15	44	19	14	23	15.4	1719.	1105.
TAN C R V	10	0	15	36	37	0	15	48	30	11	53	9.5	1666.	1257.
GWM S RTVC	10	0	16	8	33	0	16	19	15	10	42	14.2	1453.	825.
HAW C RTVC	10	0	16	21	53	0	16	32	36	10	43	11.9	1590.	969.
ASC C R V	11	0	17	5	43	0	17	21	45	16	1	37.8	1733.	671.
GWM S RTVC	11	0	17	53	42	0	18	5	51	12	9	35.7	1521.	475.

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TABLE XII.- MATRICES USED IN THE OPERATIONAL TRAJECTORY  
FOR VECTOR CONVERSION

REFSMAT <sup>a</sup>		
-.65568236	-.39013053	+0.64643547
+.37964854	-.91041273	-.16436435
+.65264664	+.13764747	+.74505405

TI2SM <sup>b</sup>		
-.083009347	+.75843959	+.64643547
-.98587430	+.032189984	-.16436435
-.14546918	-.65094789	+.74505405

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$${}^a[\bar{X}]_{\text{IMU}} = [\text{REFSMAT}] [\bar{X}]_{\text{BES}}$$

$${}^b[\bar{X}]_{\text{IMU}} = [\text{TI2SM}] [\bar{X}]_{\text{ECI}}$$

IMU = Inertial measurement unit system (stable member, or inertial platform)

BES = Reference computation system for spacecraft. An earth-centered inertial system with the X-axis in the direction of the vernal equinox at the beginning of the Besselian year nearest the launch date

ECI = Reference computation system for trajectory simulation. An earth centered inertial system with the X-axis in the Greenwich meridian at midnight before launch. (Launch is assumed to be on January 16, 1968, 14:00 hr GMT)

TABLE XIII.- APOLLO 5 SPACECRAFT TARGETS AND EVENT TIMES  
USED IN THE OPERATIONAL TRAJECTORY

Mission phase 9 enable	
time, hr:min:sec, g.e.t. . . . . .	3:55:08.50
$R_{PP}$ , ft . . . . .	22 000 000
Mission phase 11 enable	
time, hr:min:sec, g.e.t. . . . . .	4:33:00.30
$CPT_6$ $E_{CI}$	
X, n.d. . . . . .	+0.48278786
Y, n.d. . . . . .	+0.06931671
Z, n.d. . . . . .	+0.87298972
Mission phase 13 enable	
time, hr:min:sec, g.e.t. . . . . .	6:12:23.3
TGONOM, sec . . . . .	515.6
RDOTD, fps. . . . .	-90.371376
YDOTD, fps. . . . .	24 891.905
ZDOTD, fps. . . . .	7747.6129
$\bar{R}_{CSM}$ $E_{CI}$	
X, ft . . . . .	22 571 889
Y, ft . . . . .	-4 848 133
Z, ft . . . . .	-5 894 065
$R_{CO}$ , ft . . . . .	21 938 132
$T_{INT}$ , sec, g.e.t. . . . . .	24 880

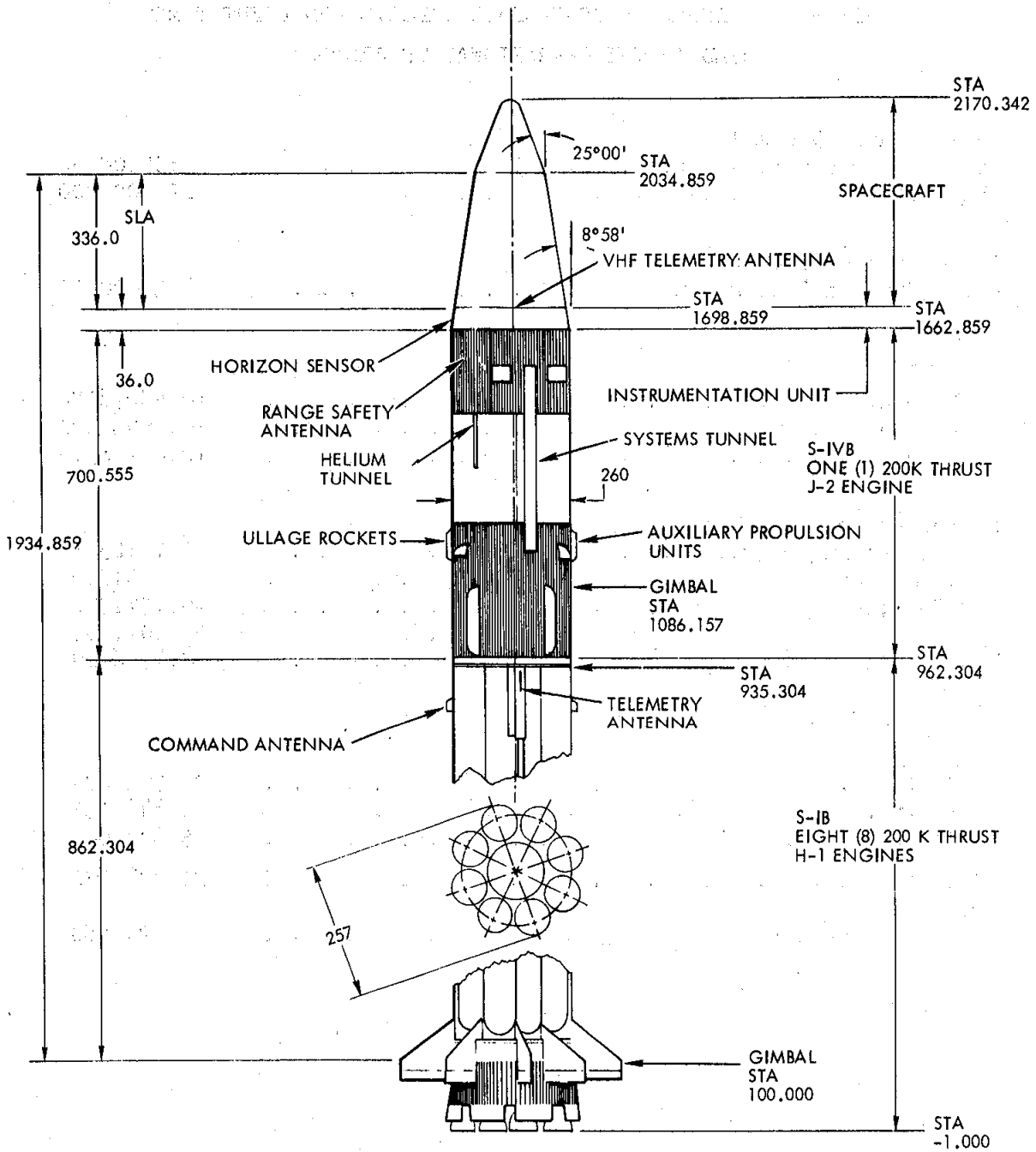


Figure 1.- S-IB launch vehicle.

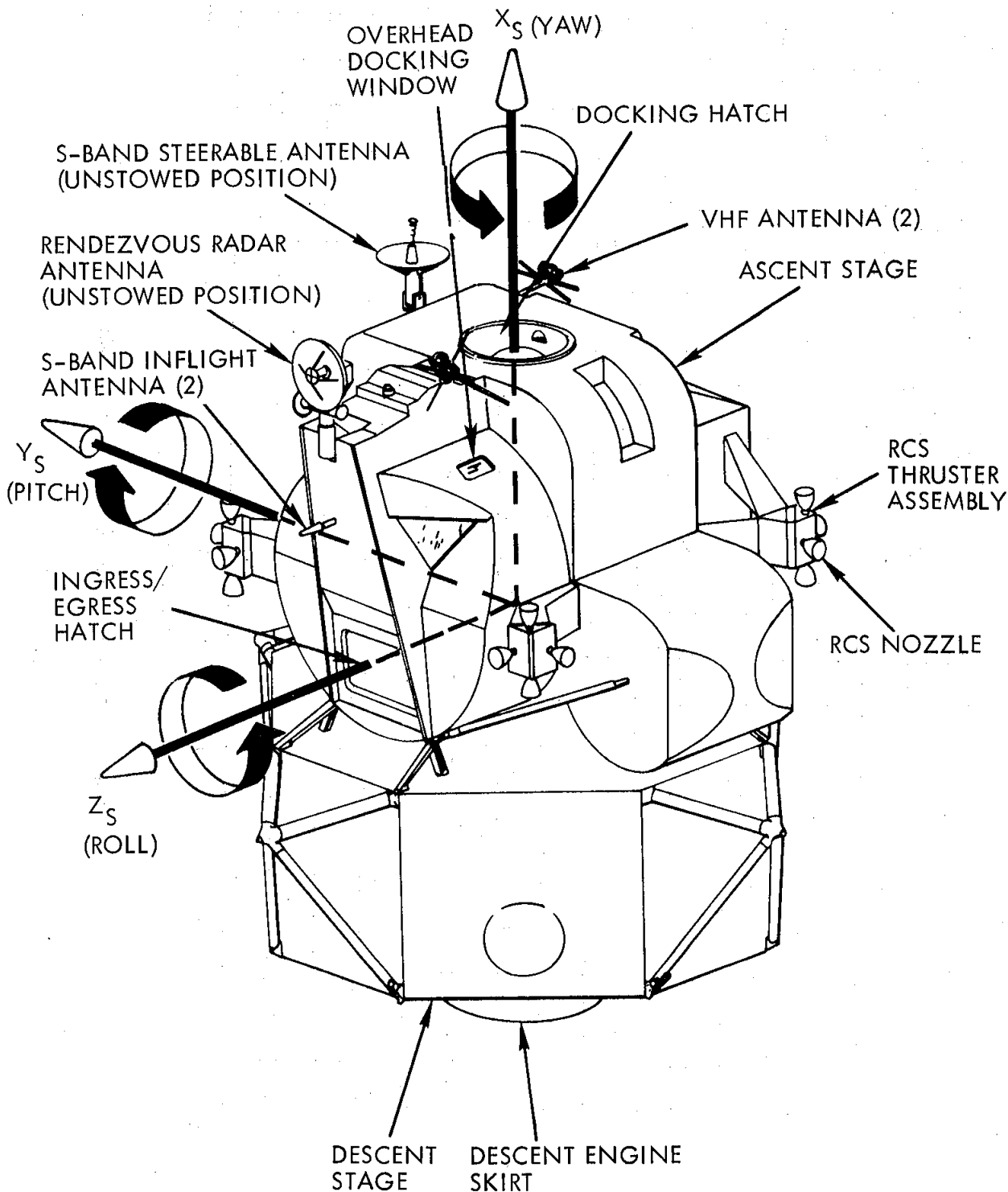


Figure 2 LM-1 flight configuration and body axis system

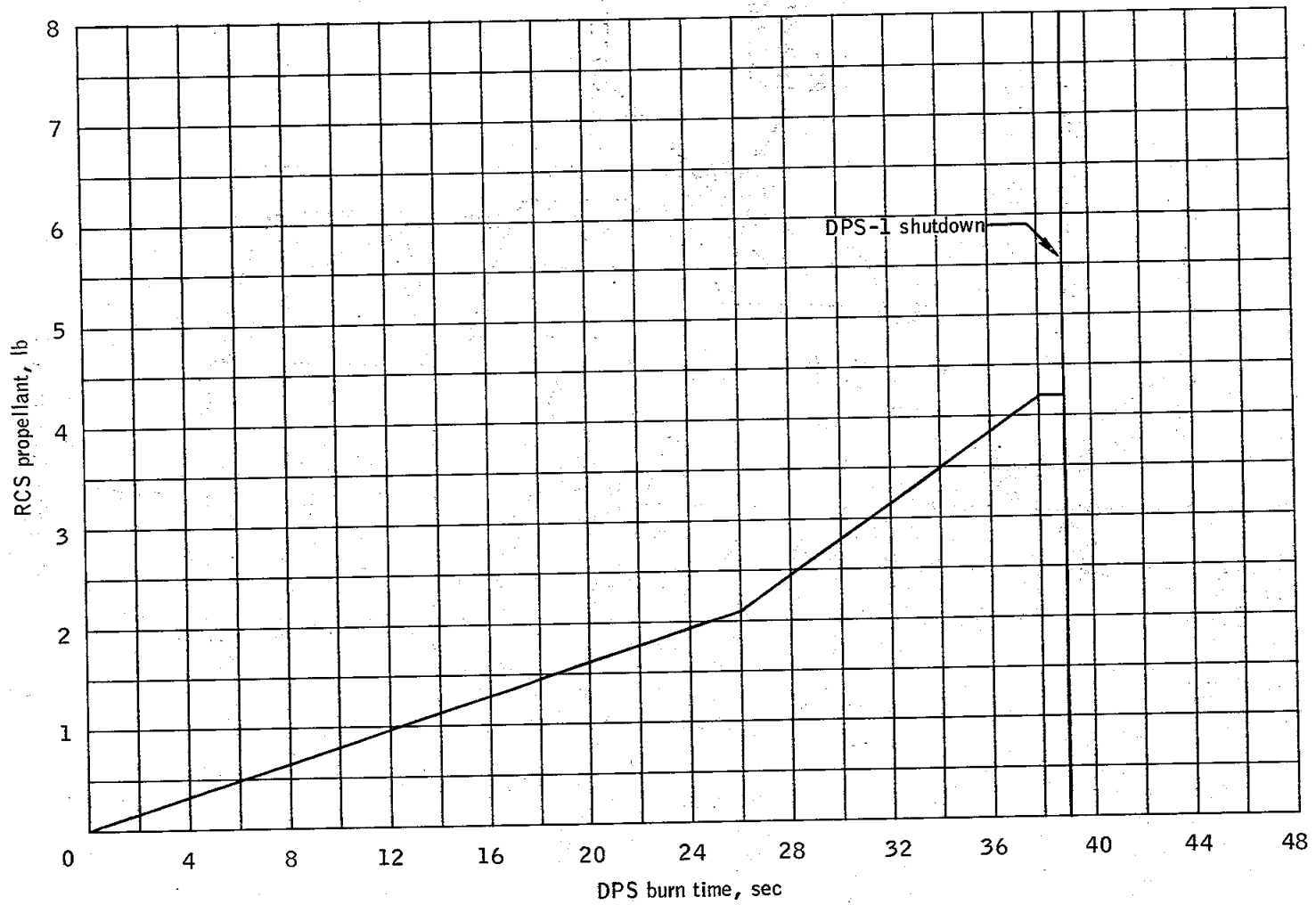


Figure 3.- RCS propellant usage during the DPS-1 burn.

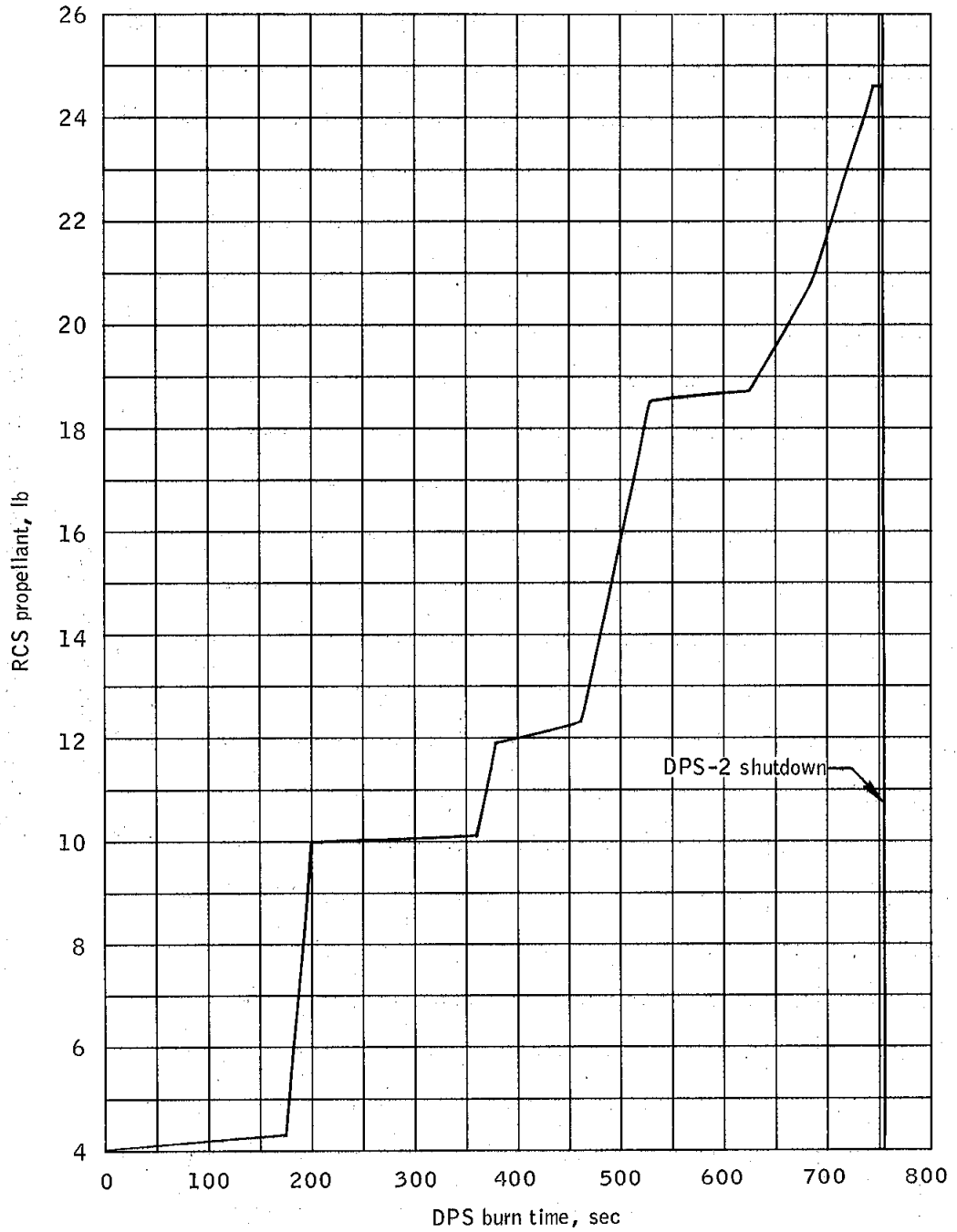


Figure 4.- RCS propellant usage during the DPS-2 burn.

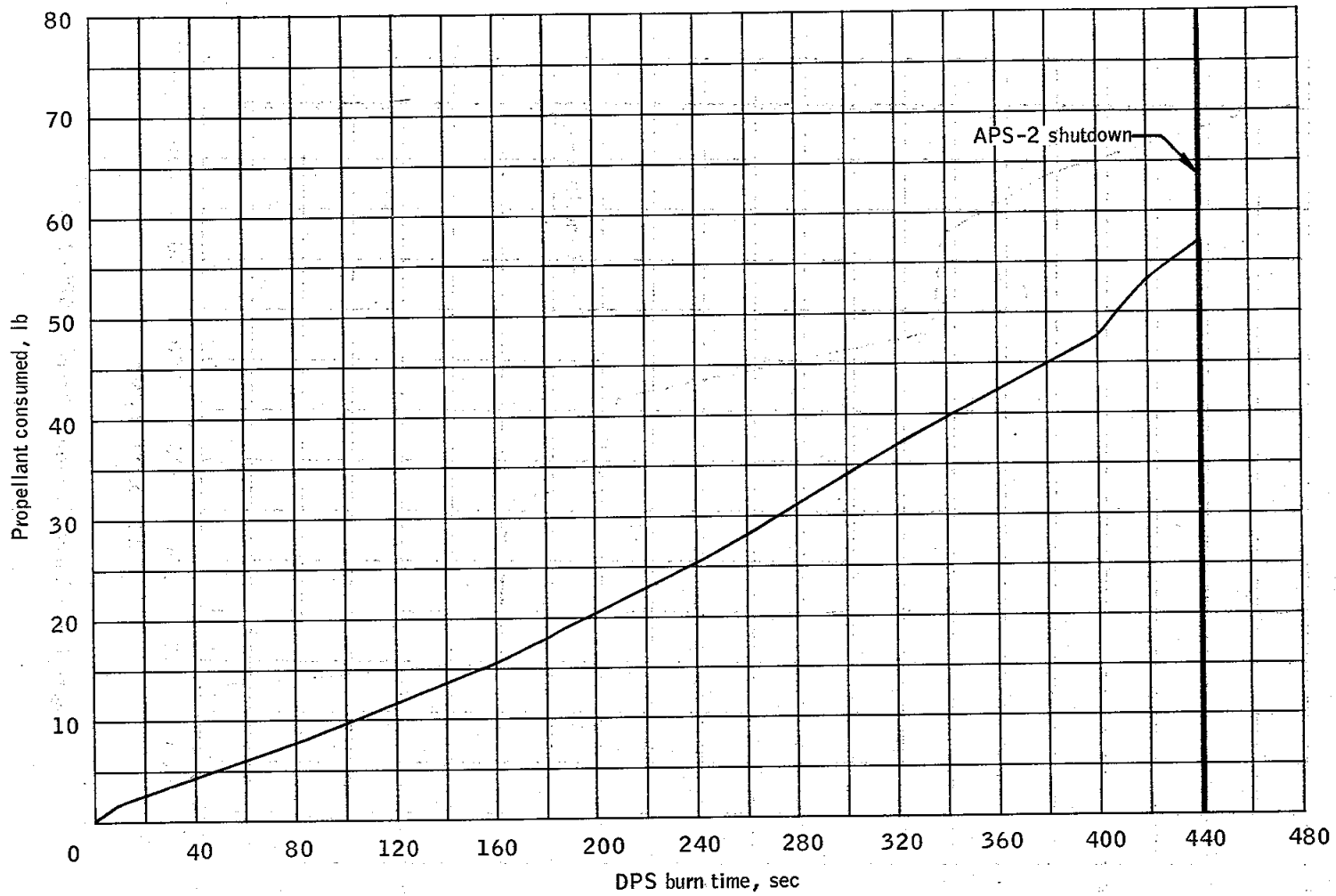


Figure 5.- Propellant consumed by the RCS during the APS-2 burn.



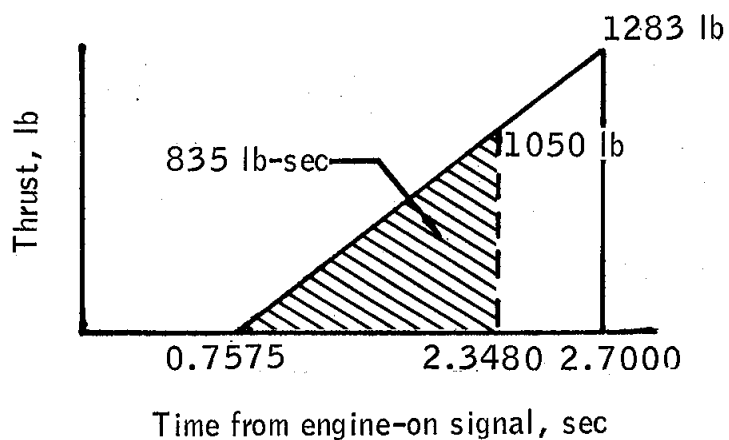


Figure 6.- DPS engine thrust-buildup profile.

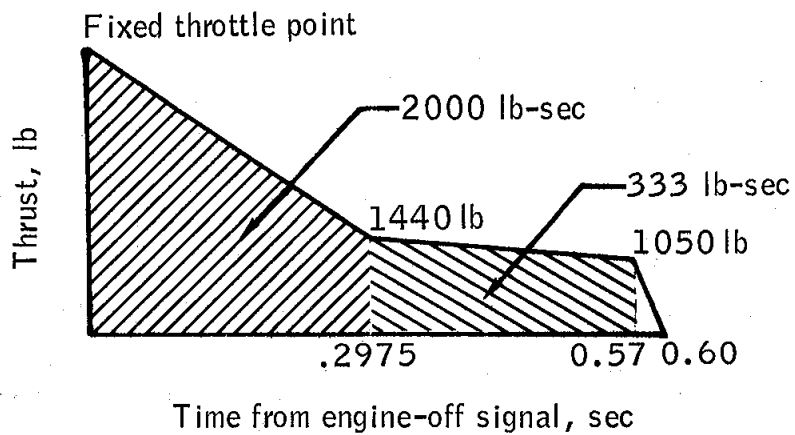


Figure 7.- DPS engine thrust-tailoff profile.

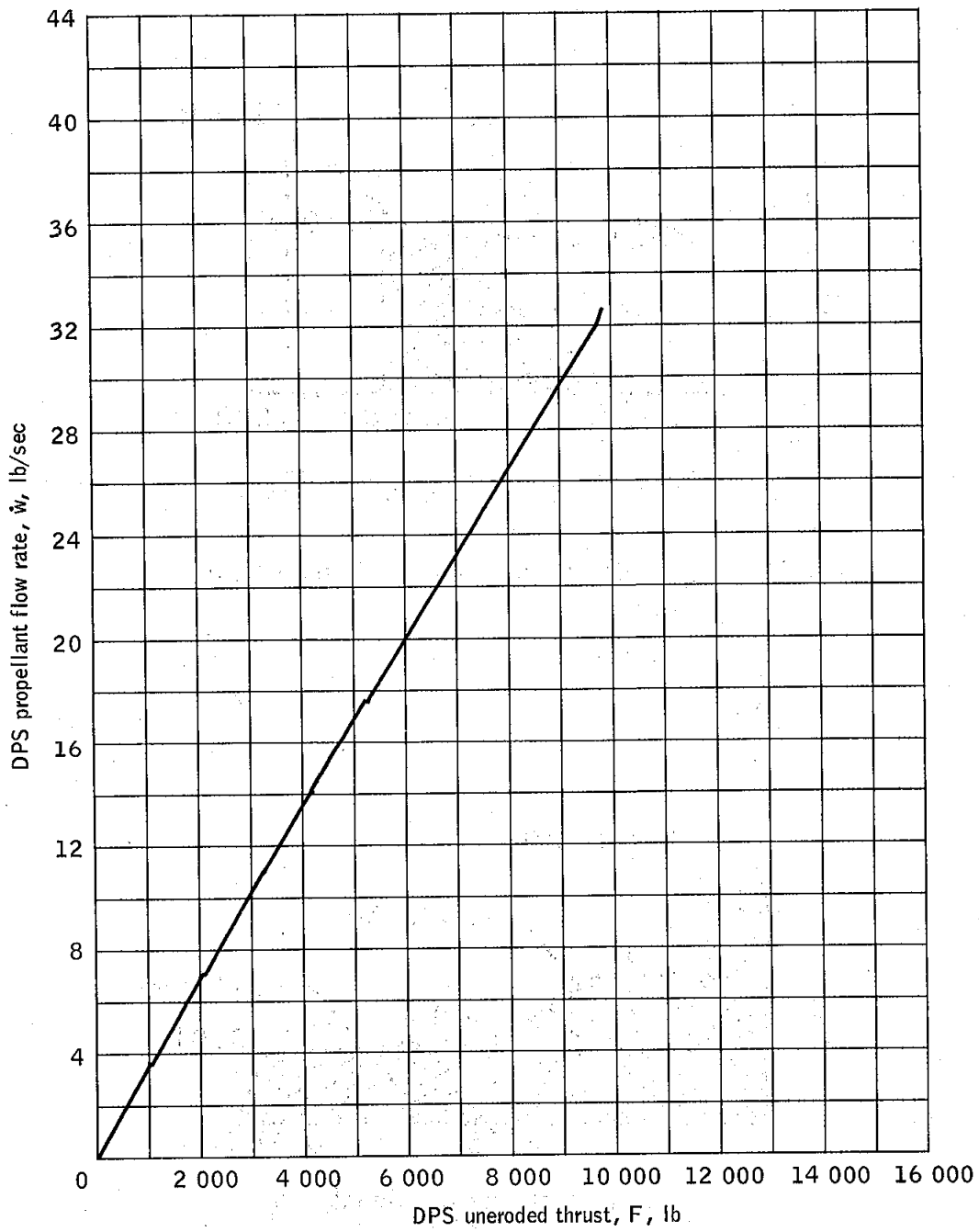


Figure 8.- Uneroded thrust versus propellant flow rate for the LM-1 DPS engine no. 1026.

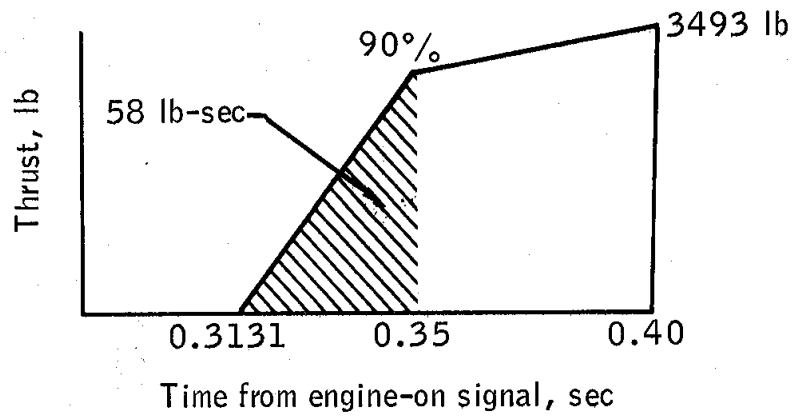


Figure 9.- APS engine thrust-buildup profile.

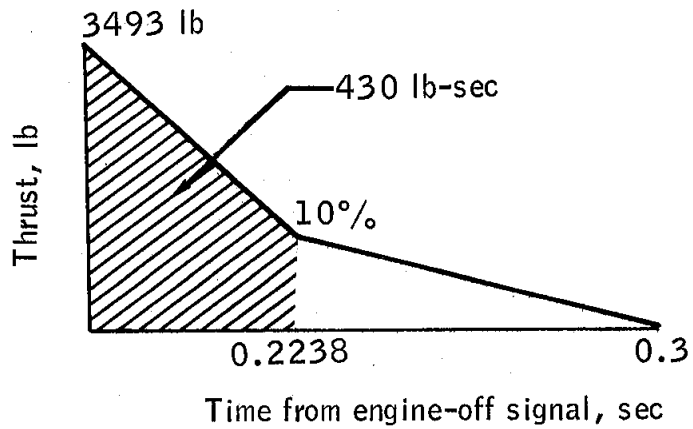
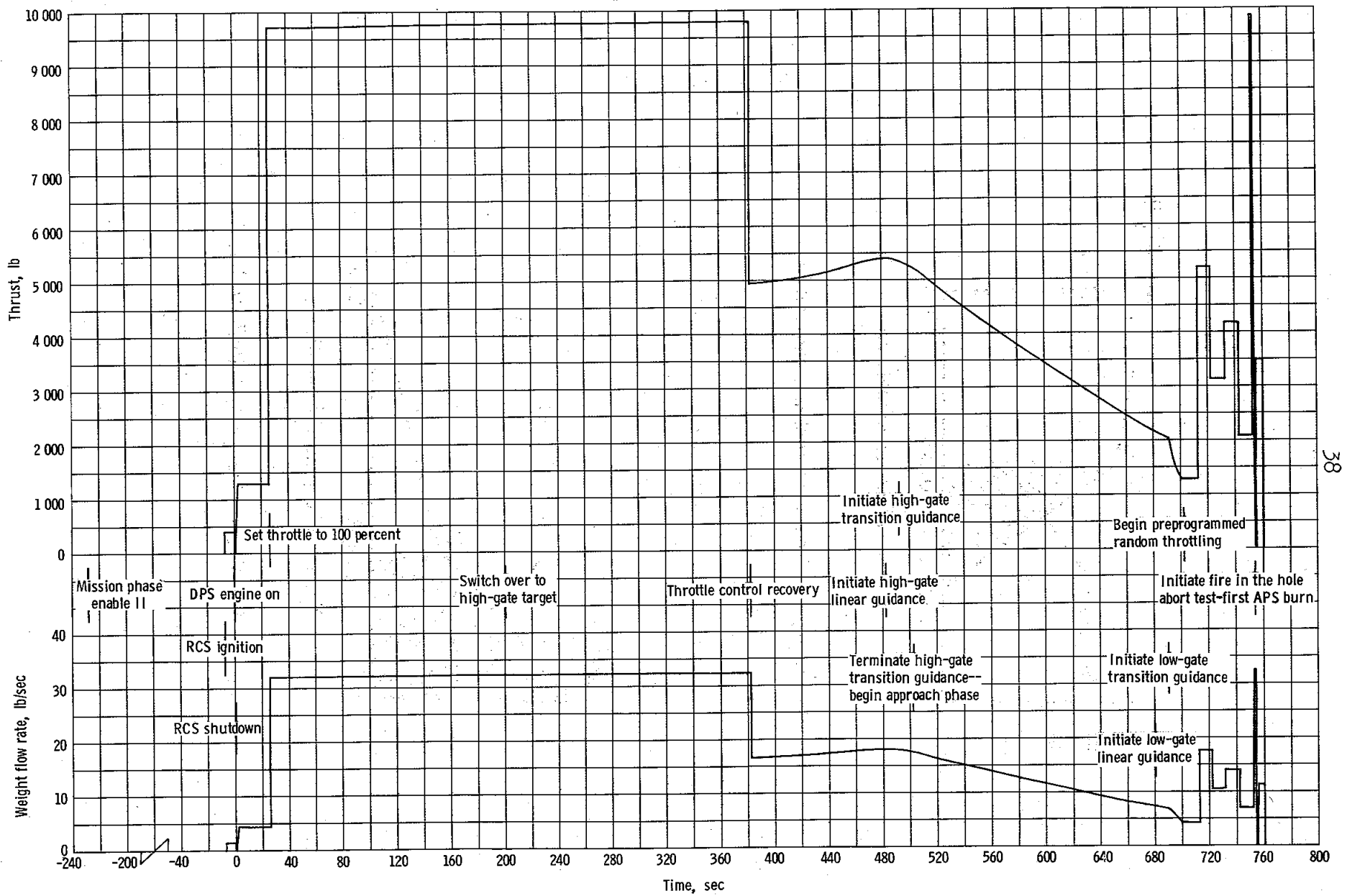


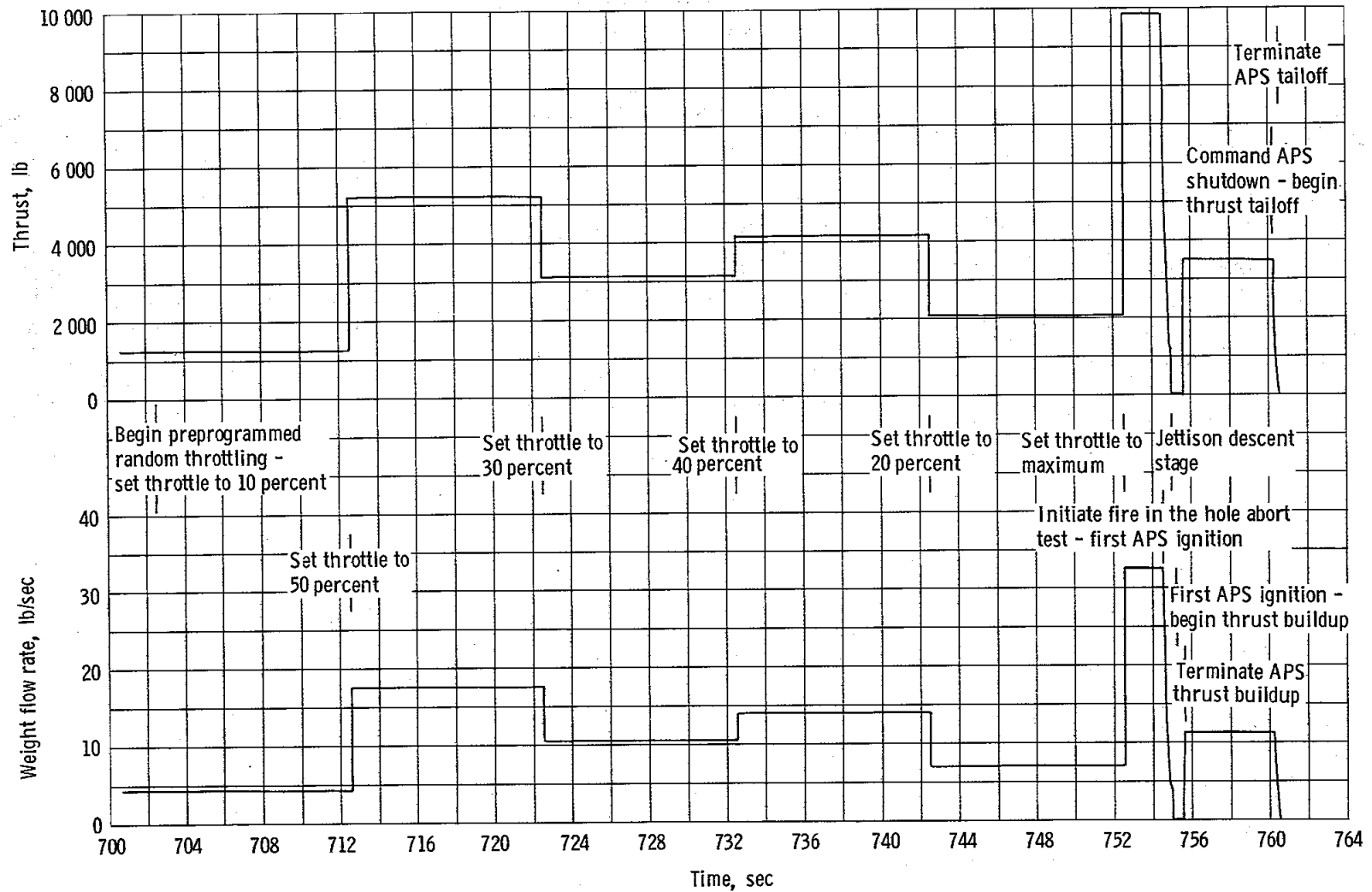
Figure 10.- APS engine thrust-tailoff profile.



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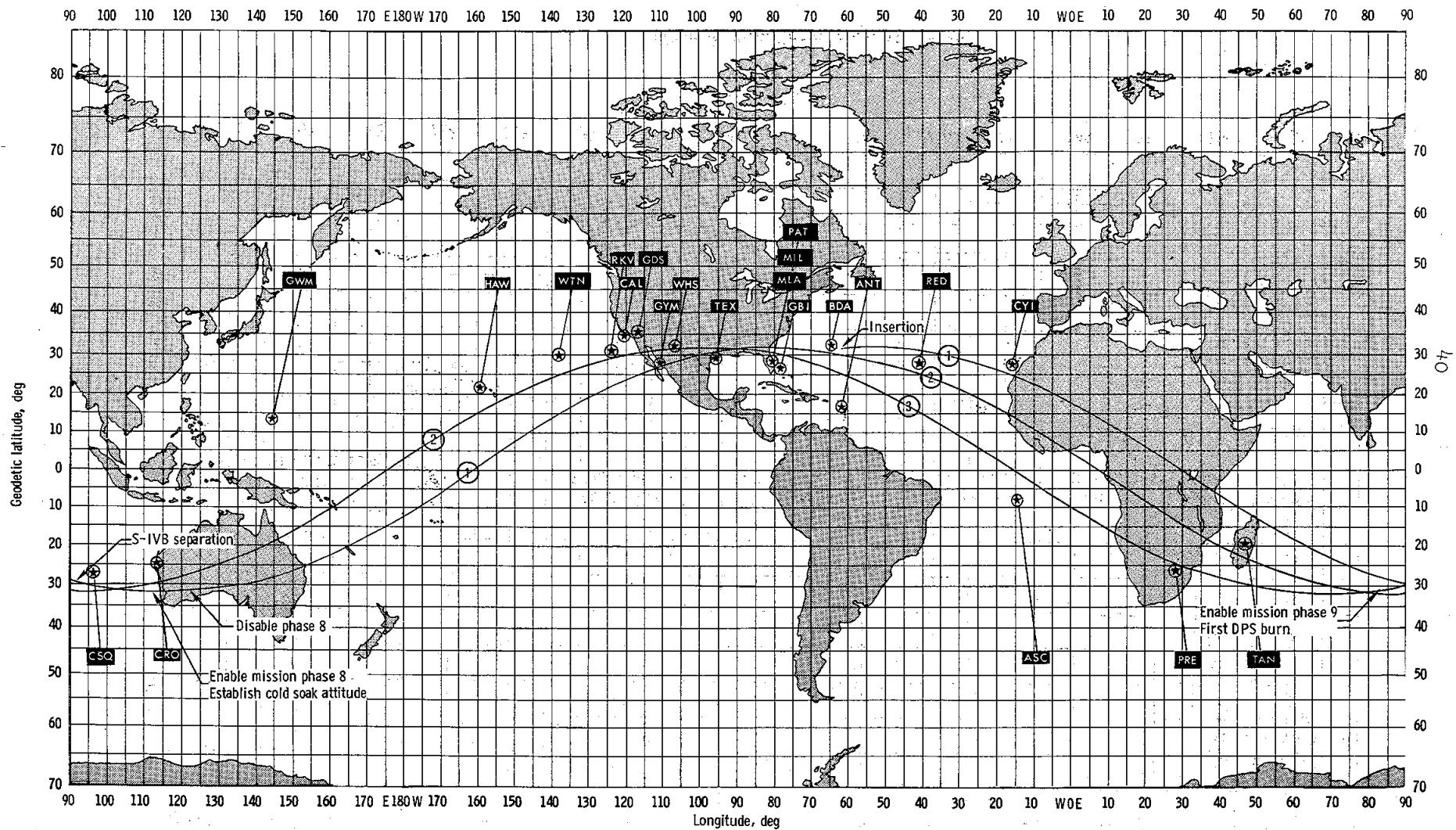
(a) Mission phase enable II through APS tailoff.

Figure 11.- DPS 2 / FITH / APS I time history.



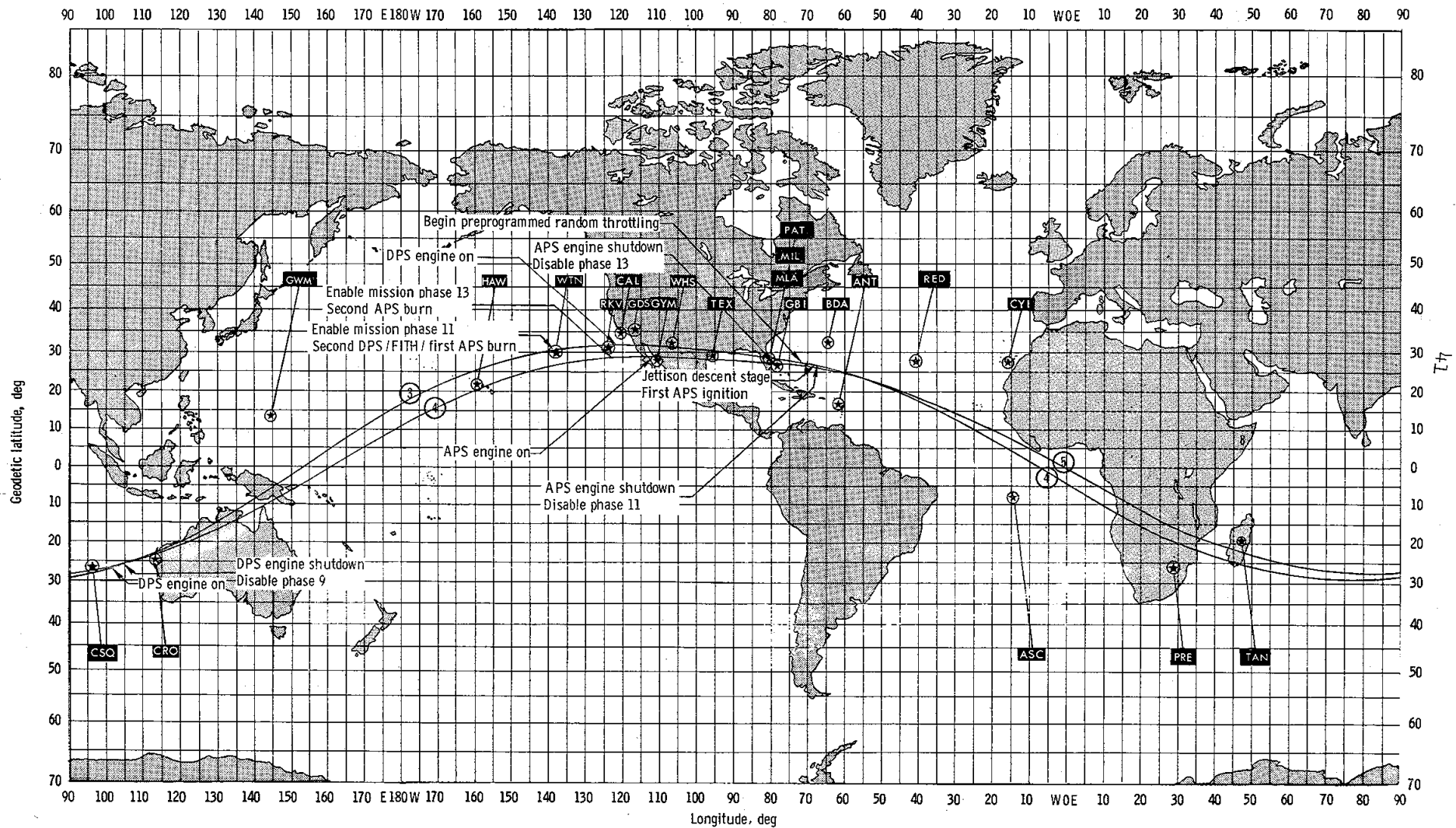
(b) Random throttling through APS tailoff.

Figure 11. - Concluded.



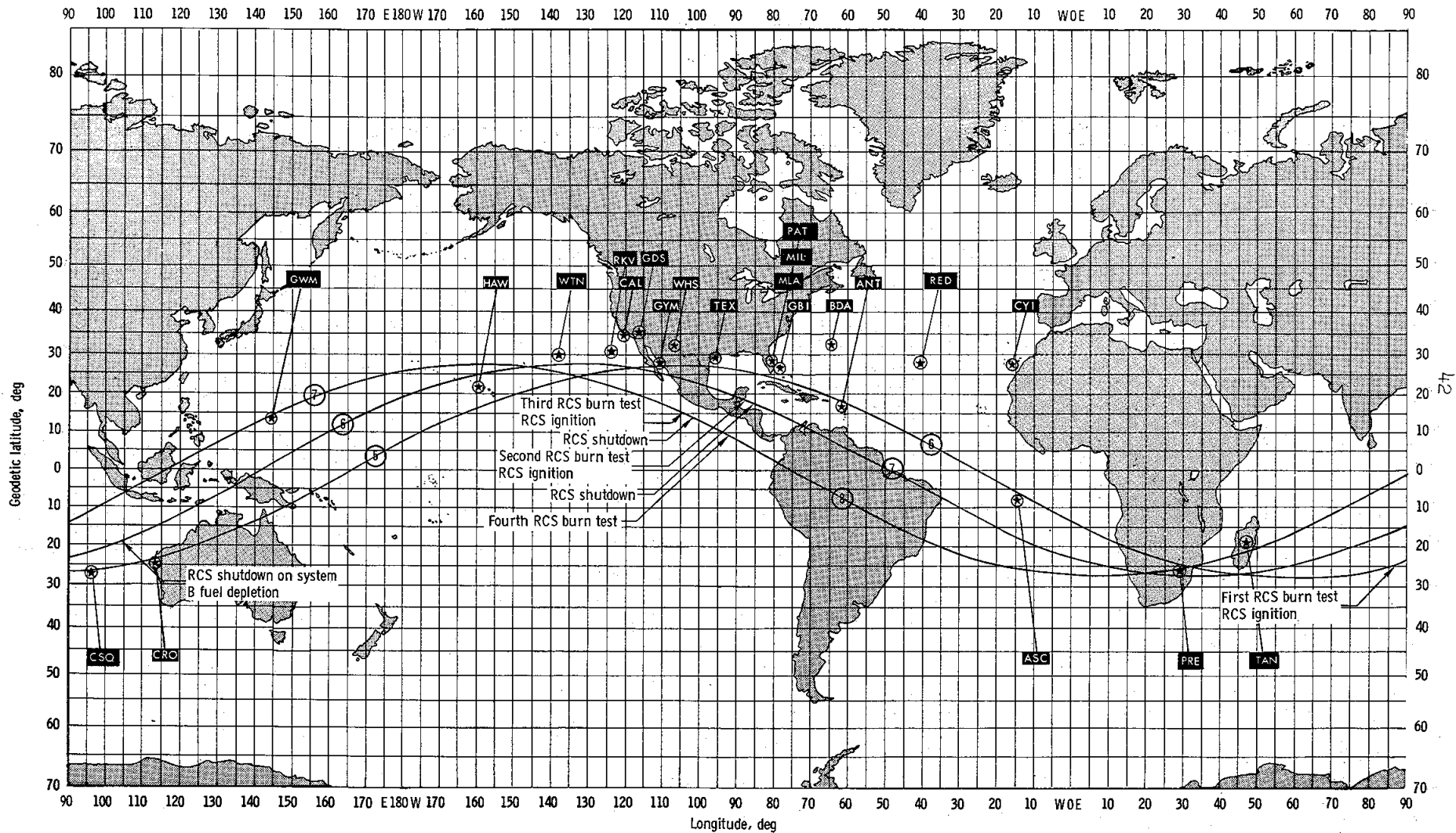
(a) Revolutions 1, 2, and 3.

Figure 12. - Groundtracks and major mission events.



(b) Revolutions 3, 4, and 5.

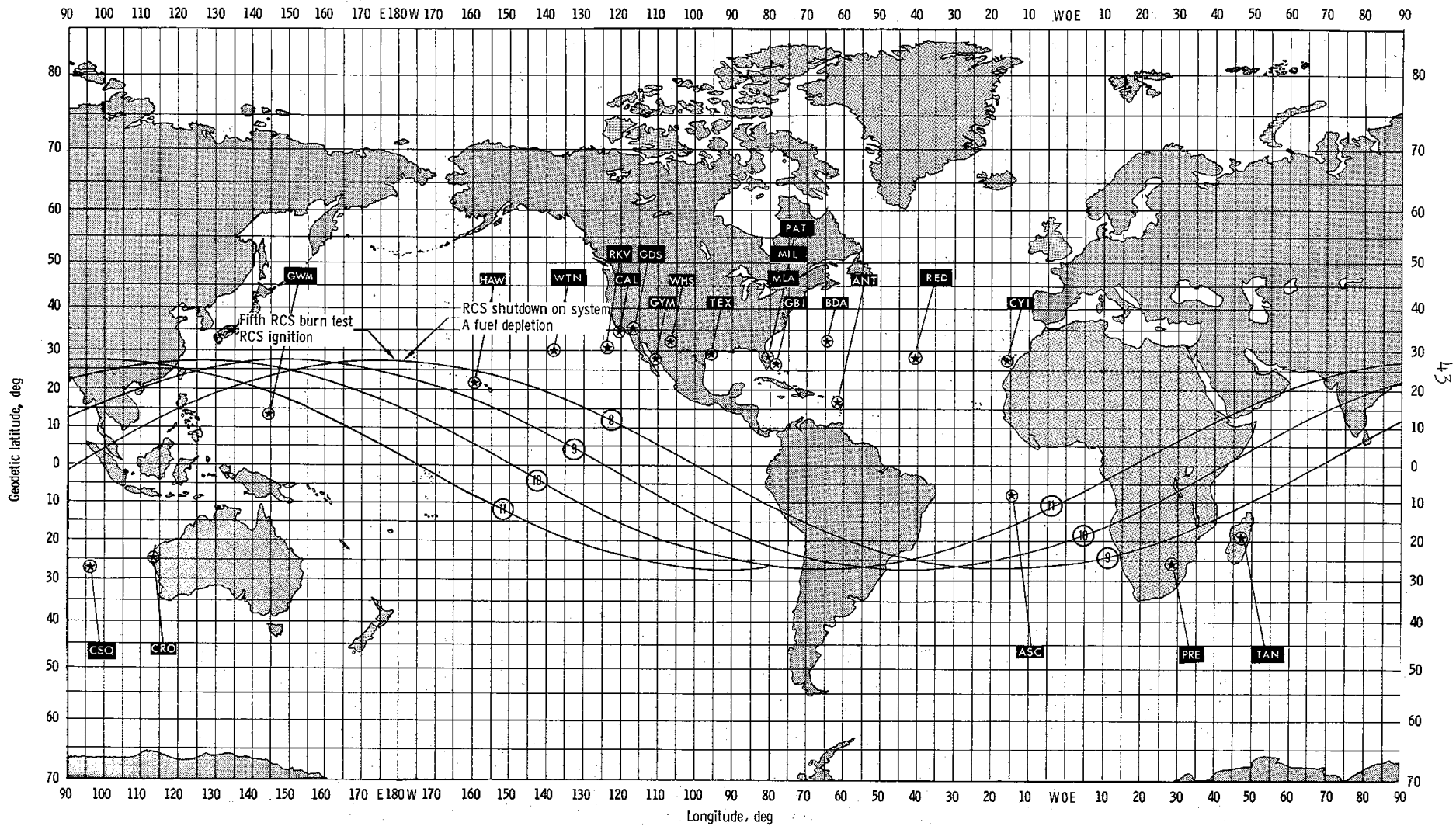
Figure 12. - Continued.



(c) Revolutions 5, 6, 7, and 8.

Figure 12. - Continued.





(d) Revolutions 8, 9, 10, and 11.

Figure 12. - Concluded.

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