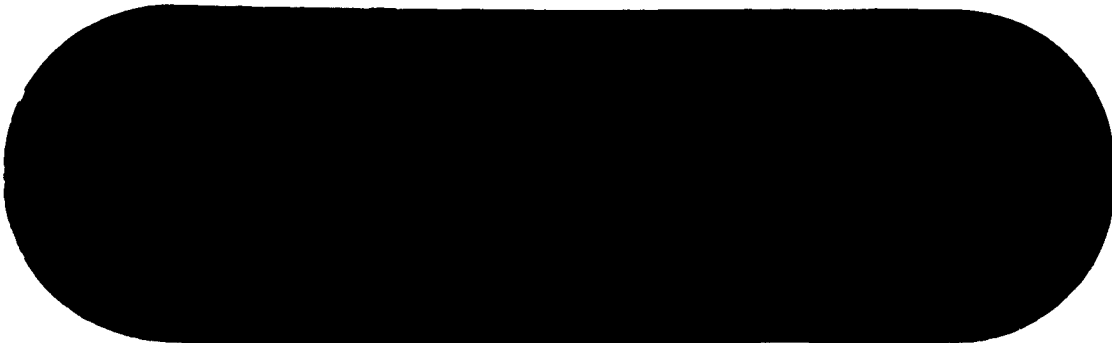


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SATURN V AS-504
LAUNCH VEHICLE
REFERENCE TRAJECTORY
VOLUME I OF II

MAY 15, 1967

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REVISIONS

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ABSTRACT AND LIST OF KEY WORDS

This document defines the Launch Vehicle Reference Trajectory for the Apollo/Saturn V vehicle AS-504. Volume I contains a mission description, mass characteristics data, propulsion systems performance data, a sequence of events, a summary of tracking capability, a detailed description of major vehicle and trajectory characteristics, and a summary of the 120 specific translunar trajectories that comprise the AS-504 Launch Vehicle Reference Trajectory study. Volume II contains the targeting data used in this study and computer-printed trajectory listings defining the boost to parking orbit, coast in parking orbit, expended-stage trajectories, translunar injection boost, translunar and transearth coast, and nominal trajectories for performance analysis.

AS-504

SA-504

Reference Trajectory

Launch Vehicle Trajectory

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PREFACE

The AS-504 Launch Vehicle Reference Trajectory analysis was performed by the following personnel:

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AERO 2 Rev. A	NASA Memorandum R-AERO-DA-4-67, "Target Objectives for AS-504 Reference Trajectory Analysis."	4/17/67	
AERO 5	NASA Trajectory Document 66- FMP-13, "AS-504 and Subsequent Missions Joint Preliminary Reference Constraints."	7/28/66	
AERO 10a.1, 2	NASA Memorandum TMX-53517, "Static Aerodynamic Character- istics of the Apollo-Saturn V Vehicle."	9/16/66	
AERO 10a.1, 2	NASA Memorandum R-AERO-AD -66-14, "Range Safety Aerody- namics for the Apollo-Saturn V Vehicle."	3/28/66	
AERO 12c	NASA Memorandum TMX-53328, "Terrestrial Environment (Climatic) Criteria Guidelines for Use in Space Vehicle De- velopment, 1966 Revision."	5/1/66	
AERO 12d, e,f	NASA-OMSF Memorandum M-DE 8020.008B, "Natural Environment and Physical Standards for the Apollo Program."	4/1/65	
P&VE 26	NASA Memorandum R-P&VE-PTF-66 -M-96, "Variations in S-IVB/V Continuous Vent Thrust."	12/15/66	
P&VE 29	NASA Drawing 20M97012, Rev. A, "Description of Propulsion Con- trol System Saturn S-IVB/V."		2/1/66
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P&VE 74	NASA Memorandum R-P&VE-PPE-66 -M-267, "Updated Propulsion Data - AS-504."	12/28/66	

SECTION 1

INTRODUCTION AND MISSION SUMMARY

1.0 INTRODUCTION

The Apollo/Saturn AS-504 mission is presently scheduled as the first lunar landing mission (LLM). The function of the Saturn V launch vehicle during a lunar landing mission is to inject the Apollo spacecraft onto a circumlunar conic with specified periselenium and free-return earth perigee characteristics.

The primary purpose of the AS-504 Launch Vehicle Reference Trajectory study is to provide sufficient trajectory data for determining typical variations in the mission profile, mission requirements, vehicle operating characteristics, and targeting and guidance presettings for launch during an extended period. To achieve this purpose, launch vehicle injection-boost and spacecraft translunar-coast trajectories were simulated for launch during selected days of February, March, and April, 1968. A group of four launch days were selected for each monthly launch window, and trajectories were simulated for five launch azimuths (72, 81, 90, 99, and 108 degrees) during each launch day. Trajectories were simulated for two injection opportunities for each launch azimuth.

The two volumes of the AS-504 Launch Vehicle Reference Trajectory document contain trajectory and trajectory support data for each of the 120 translunar trajectories simulated, and data for two additional launch vehicle trajectories that are specifically designed for performance analysis studies. Volume I is a summary containing a mission description, the mission objectives and constraints, the vehicle characteristics used in the simulation, a discussion of the simulation techniques used, a detailed description of each major phase of the launch vehicle trajectory, a summary of trajectory characteristics at major event times, and an abbreviated summary of tracking and communications capability. Volume II is divided into six books; Book 1 of 6 contains trajectory data from liftoff through parking orbit, Book 2 of 6 contains spent-stage trajectory data and injection-boost trajectory data for the two performance-analysis trajectories, Books 3, 4, and 5 of 6 contain injection-boost and translunar-coast trajectory data for the 120 translunar trajectories, and Book 6 of 6 contains the targeting and guidance functions and presettings used to prepare these trajectory data.

1.1 MISSION SUMMARY

The phases of a lunar landing mission that include launch vehicle operation are as follows:

- a. Launch and S-IC, S-II, and S-IVB stage boost to earth parking orbit.
- b. "Coast" in earth parking orbit (a continuous, low-thrust level occurs during the stay in parking orbit).
- c. S-IVB stage boost to translunar injection.
- d. Pre-separation coast in the translunar trajectory.
- e. Launch Vehicle/Spacecraft (LV/SC) separation.
- f. Post-separation translunar and transearth coast of the expended S-IVB/IU.

In the AS-504 Launch Vehicle Reference Trajectory study, LV/SC separation and other post-injection operations that perturb the orbit of either the launch vehicle or the spacecraft are not simulated. Therefore, in this study, the translunar and transearth launch vehicle and spacecraft trajectories are identical. The launch vehicle lunar-landing-mission trajectories presented in this document are simulated in the following phases:

- a. S-IC, S-II, and S-IVB stage boost to earth parking orbit.
- b. Earth parking orbit stay.
- c. S-IVB stage boost to translunar injection.
- d. LV/SC translunar coast from injection to periselenium and transearth coast from periselenium to free-return vacuum perigee.

The launch dates selected for these simulated flights are February 1, 2, 3, and 4, March 1, 3, 5, 7, and 31, and April 2, 4, and 6, 1968. The simulated flights are launched from Pad 39A of the Kennedy Space Center along the azimuths previously defined. Two injection opportunities are planned for each launch opportunity. The launch time for each launch opportunity is selected to assure the optimum combination of vehicle injection weights for the two injection opportunities.

1.1 (Continued)

The boost to parking orbit consists of complete burns of the S-IC and S-II stages and a partial burn of the S-IVB stage. The S-IVB stage inserts the vehicle into a circular parking orbit. At insertion, the parking orbit radius equals the mean equatorial radius plus 185.2 KM (100 NMI).

During the vehicle stay in parking orbit, the orbital characteristics and the vehicle injection capability are changed by operation of the continuous H₂ propulsive vents. The thrust level of these vents is low, but the effects of the vents during three revolutions in orbit are an increase in the mean orbital radius of 20 KM and a decrease in vehicle injection capability of approximately 1900 pounds. The reignition time and orbital position of the S-IVB injection boost depend upon the lunar declination and upon the injection window and opportunity to be used. A Pacific injection window is used for these trajectories and results in reignition positions in the Southern Hemisphere over the Indian Ocean and Australia. The first injection opportunity occurs midway through the second revolution in parking orbit, and the second injection opportunity occurs midway through the third revolution.

The S-IVB stage performs the injection boost to the translunar conic. Because of the method of selecting the launch time, the launch vehicle always performs a plane change during the first-opportunity injection boost, and may or may not perform a plane change during the second-opportunity boost. For the trajectories simulated during this study, the direction of first-opportunity plane change causes the translunar conic to have a lower inclination than the parking orbit and an inertial ascending node that is east of that of the parking orbit. If a plane change is performed during the second opportunity injection boost, the resulting translunar conic has a higher inclination than the parking orbit and has an ascending node position that is west of the node of the parking orbit.

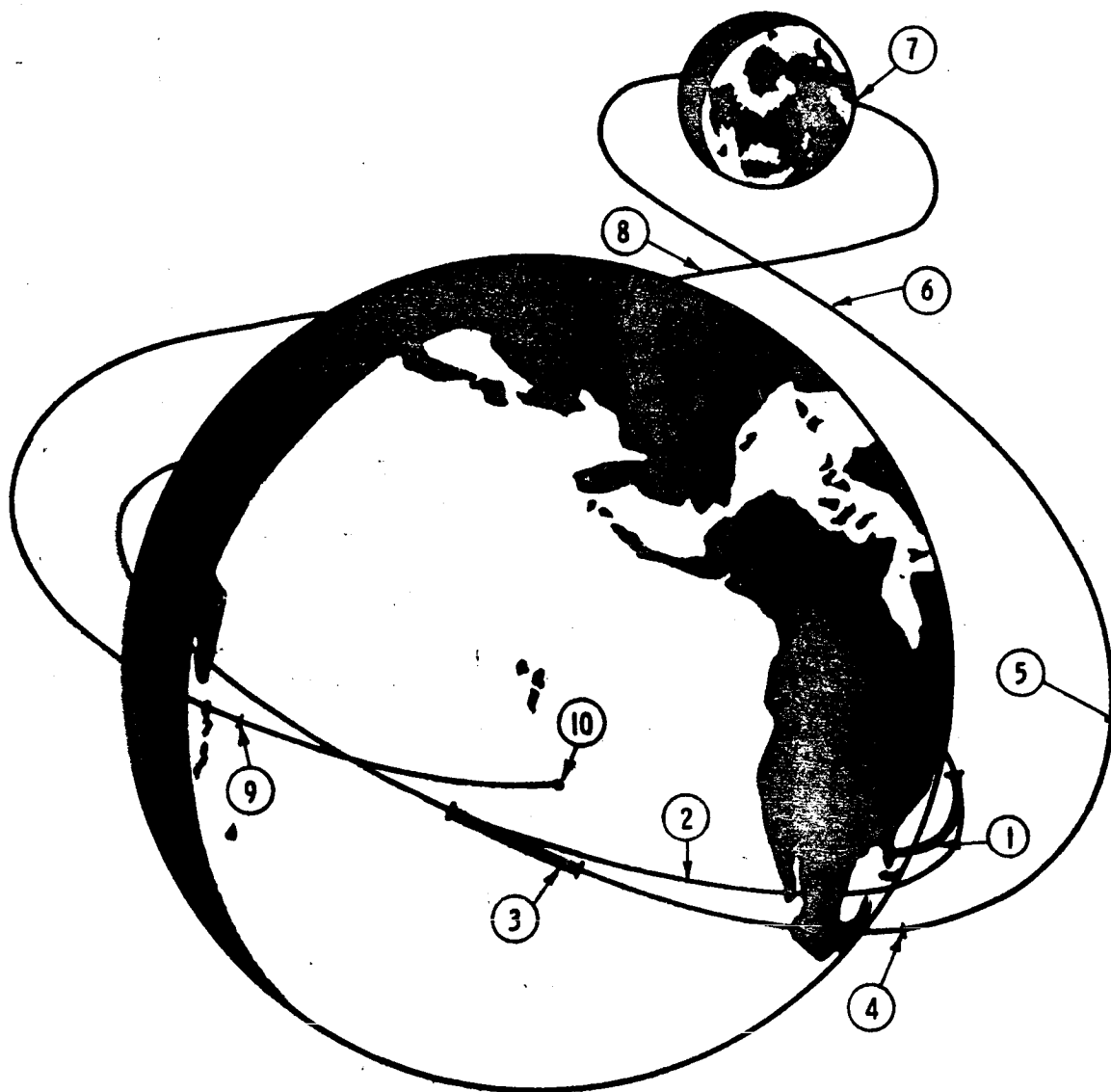
At injection, the launch vehicle and spacecraft are on a free-return translunar conic that passes periselenium near the desired periselenium location and returns to earth. The injection conic normally requires minor velocity adjustments to achieve the desired periselenium and free-return perigee conditions. The velocity adjustments required for these trajectories range from 1 to 11 feet/second for first-opportunity trajectories and from 0 to 7 feet/second for second-opportunity trajectories. These velocity adjustments are evaluated at the vehicle position 4.0 hours after injection (the nominal time for the first spacecraft midcourse correction).

1.1 (Continued)

A mission profile showing the launch vehicle boost and coast trajectory phases during a lunar landing mission is given in Figure 1-1. Ground tracks of the complete launch vehicle trajectories resulting from launch on February 1 along a 72-degree launch azimuth are given in Figures 1-2 and 1-3 for the first and second injection opportunities. The ground tracks of the insertion boosts and injection boosts, and the projections on the earth's surface of the periselenium and free-return perigee positions are summarized in Figure 1-4 for the 10 simulated February 1 trajectories.

Figures 1-5 through 1-8 show the geographic areas that include all of the S-IVB stage liftoff positions after reignition, all of the translunar injection positions, all of the projected periselenium positions on the earth's surface, and all of the free-return perigee positions for the 120 trajectories simulated.

Sequences of events are given in Table 1-I for the first and second injection-opportunity trajectories resulting from launch on February 1 along a 72-degree launch azimuth.



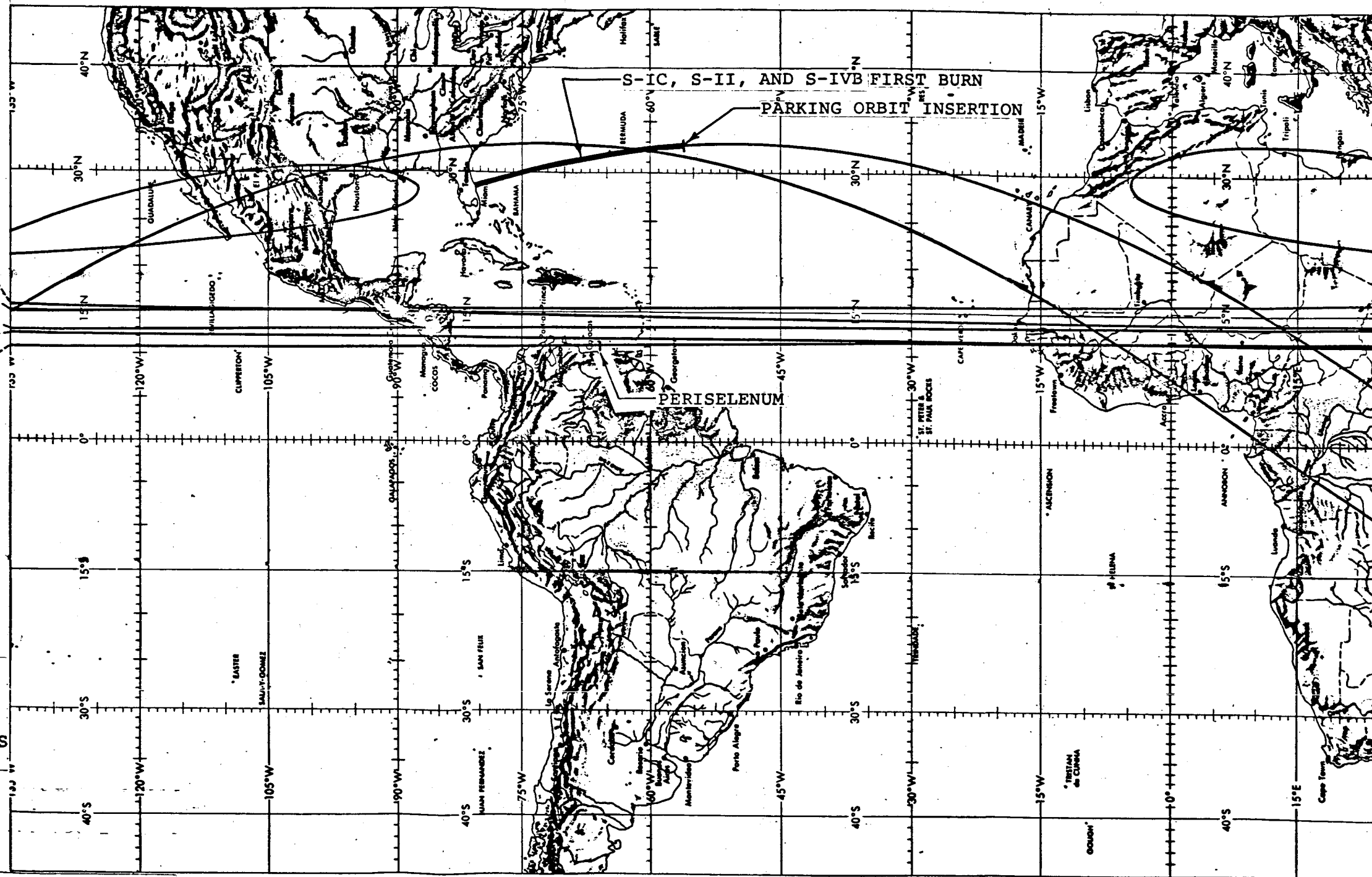
- | | |
|-----------------------------------------------------------|----------------------------------|
| 1. BOOST TO EARTH ORBIT - S-IC, S-II, AND S-IVB OPERATION | 5. LV/SC FINAL SEPARATION |
| 2. COAST IN EARTH ORBIT | 6. TRANSLUNAR COAST |
| 3. S-IVB TRANSLUNAR INJECTION BOOST | 7. LUNAR PASSAGE |
| 4. INITIATE TRANSPOSITION AND DOCKING MANEUVER | 8. FREE-RETURN TRANS-EARTH COAST |
| | 9. EARTH ATMOSPHERE REENTRY |
| | 10. SPLASH |

FIGURE 1-1. LAUNCH VEHICLE TRAJECTORY PROFILE FOR A LUNAR LANDING MISSION

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AA	9 HRS TO 34 HRS
BB	34 HRS TO 58 HRS
CC	58 HRS TO 82 HRS
DD	82 HRS TO 106 HRS
EE	106 HRS TO 130 HRS
F	130 HRS TO VACUUM
	PERIGEE

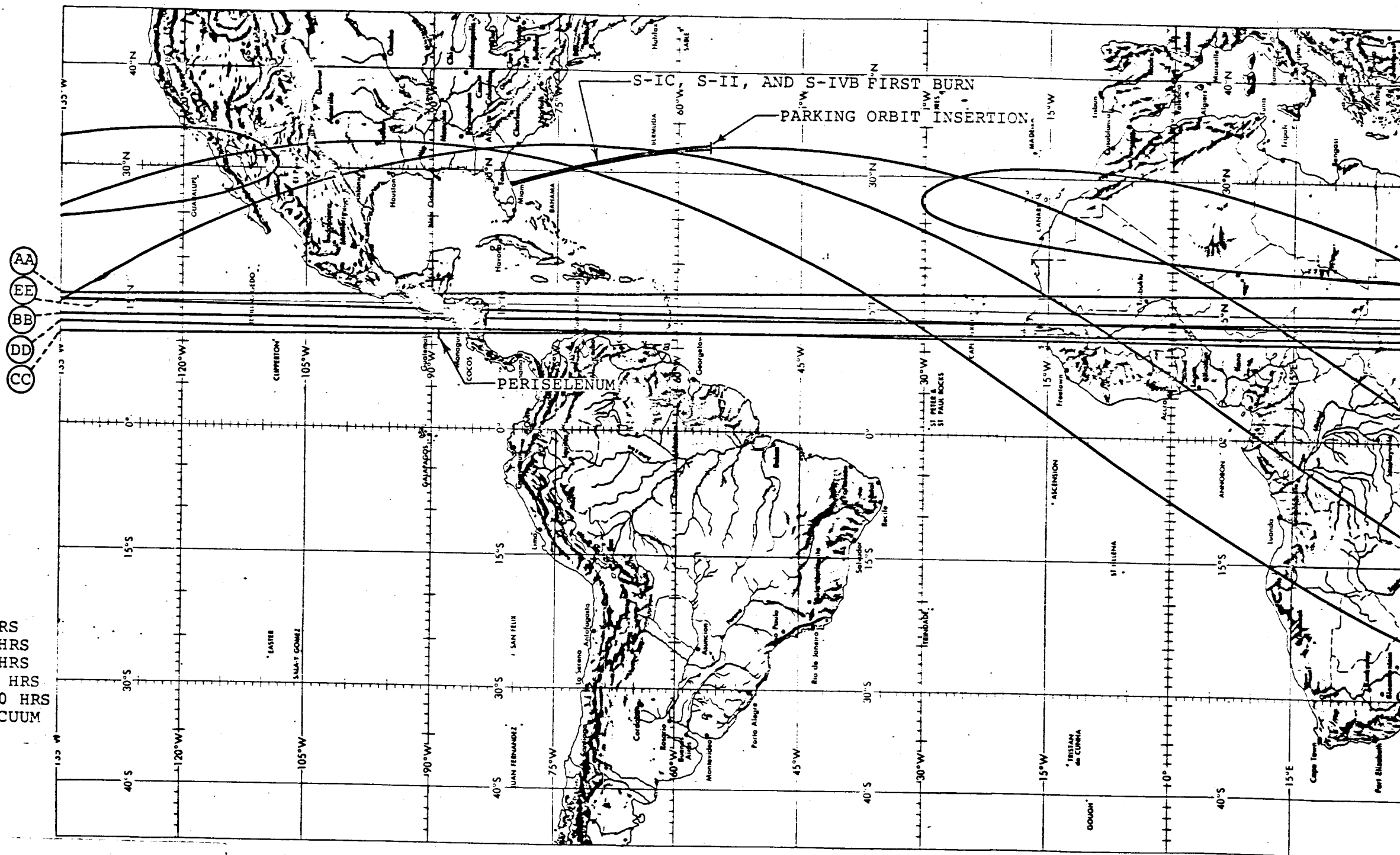
EE
AA
BB
DD
CC



Foldout #1

AA	9 HRS TO 34 HRS
BB	34 HRS TO 58 HRS
CC	58 HRS TO 82 HRS
DD	82 HRS TO 106 HRS
EE	106 HRS TO 130 HRS
F	130 HRS TO VACUUM PERIGEE

Foldout #1



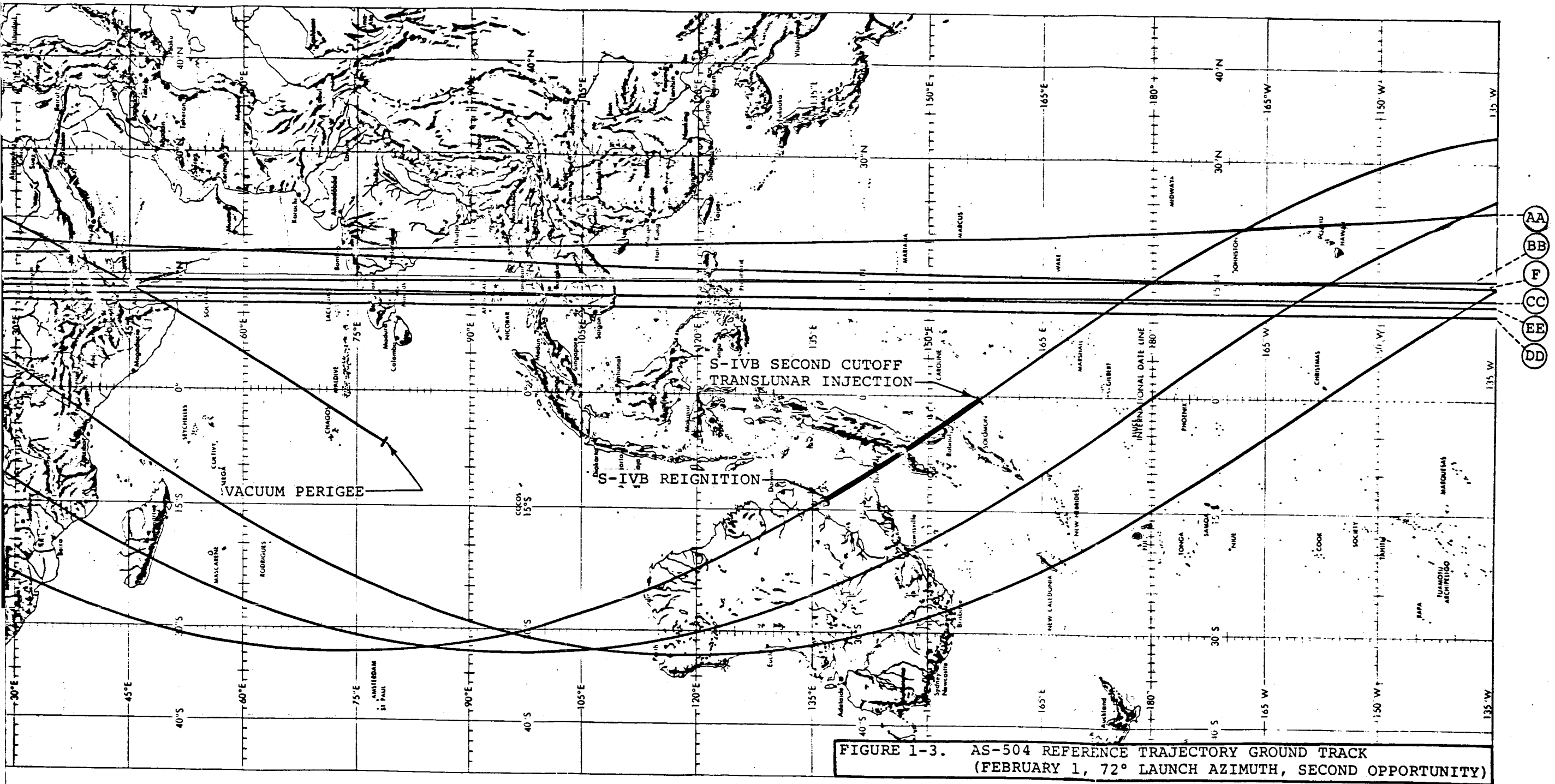
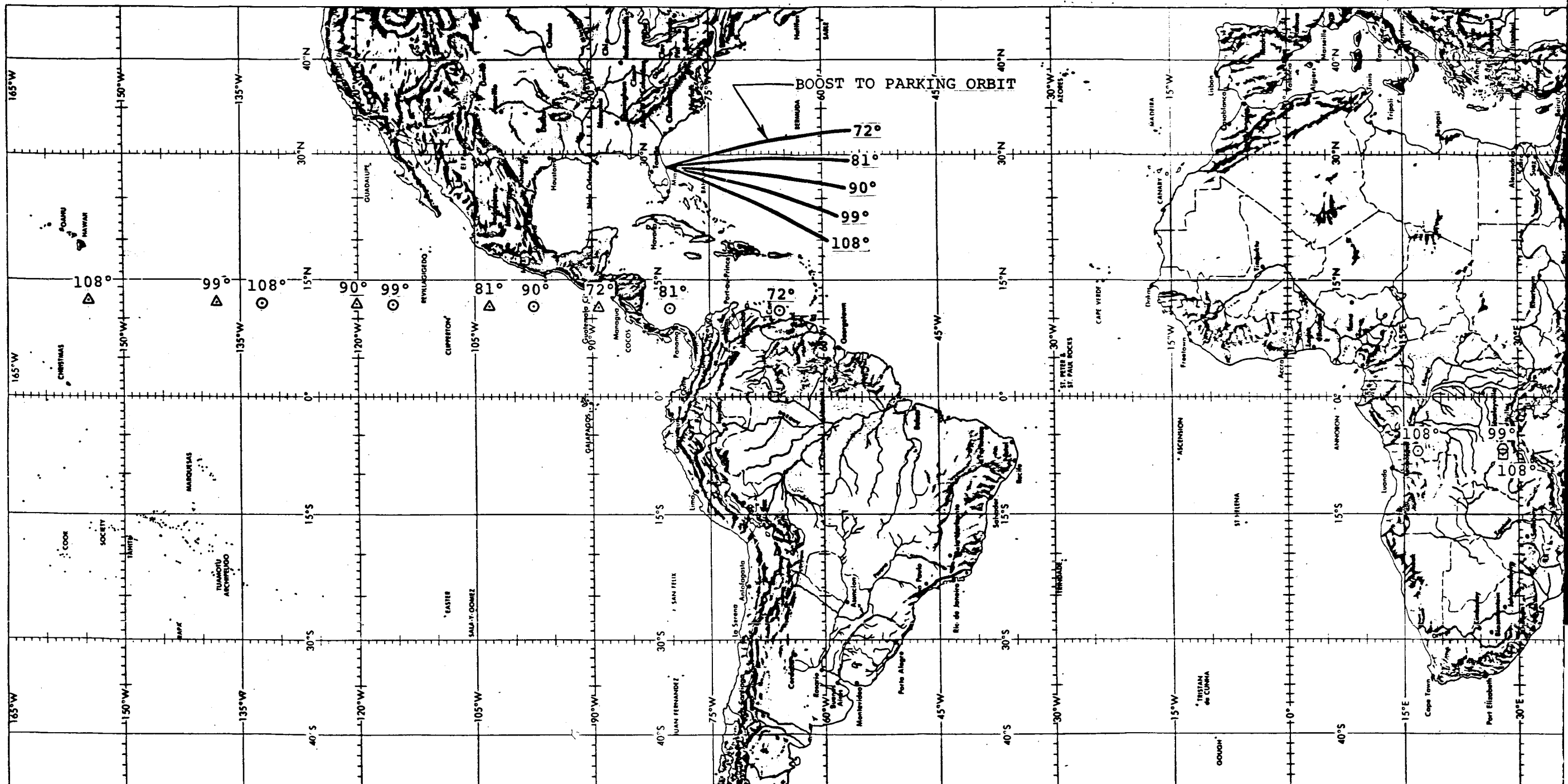


FIGURE 1-3. AS-504 REFERENCE TRAJECTORY GROUND TRACK
(FEBRUARY 1, 72° LAUNCH AZIMUTH, SECOND OPPORTUNITY)

Foldout #2



Foldout #1

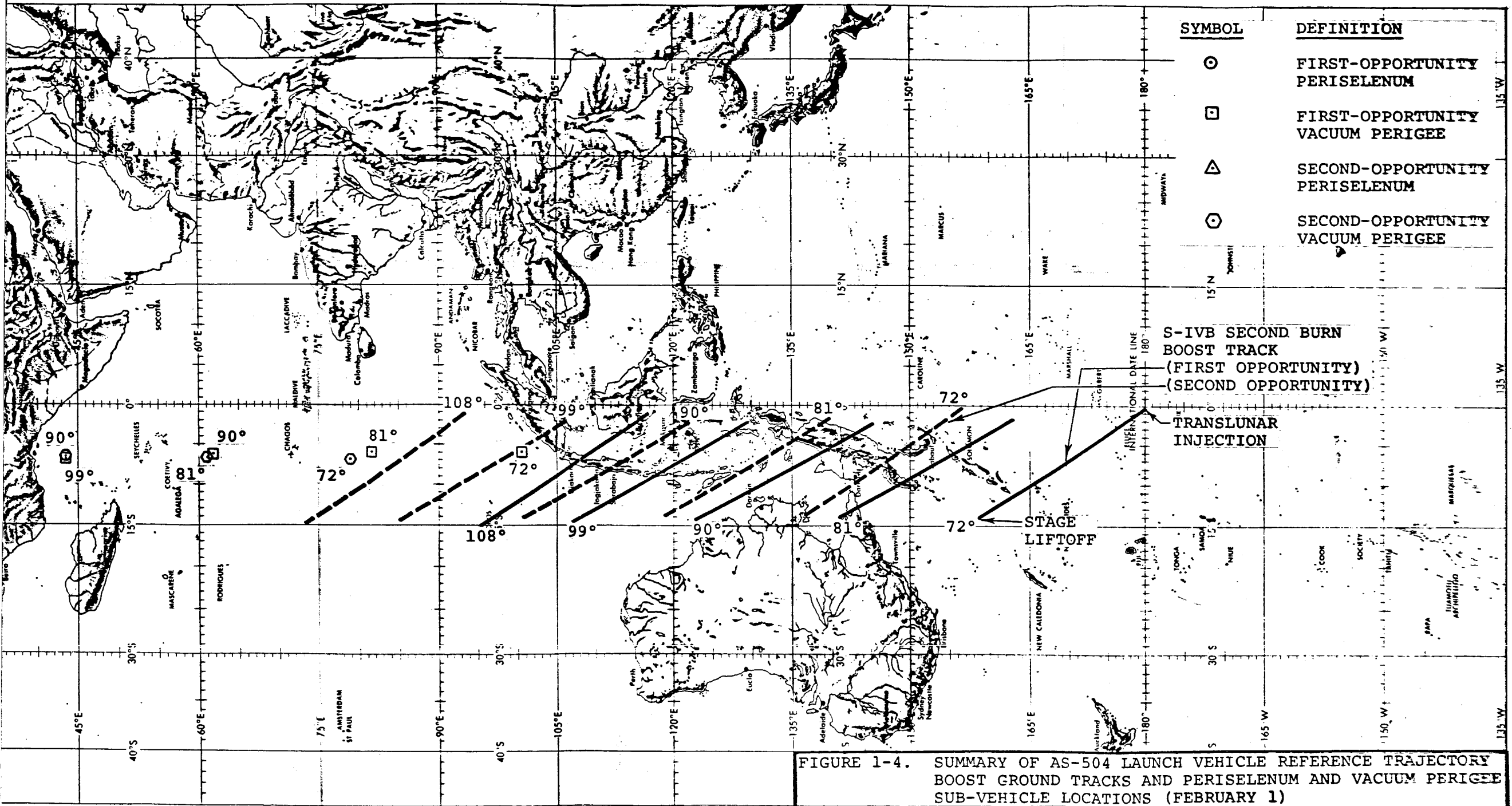


FIGURE 1-4. SUMMARY OF AS-504 LAUNCH VEHICLE REFERENCE TRAJECTORY BOOST GROUND TRACKS AND PERISELENUM AND VACUUM PERIGEE SUB-VEHICLE LOCATIONS (FEBRUARY 1)

Foldout #2

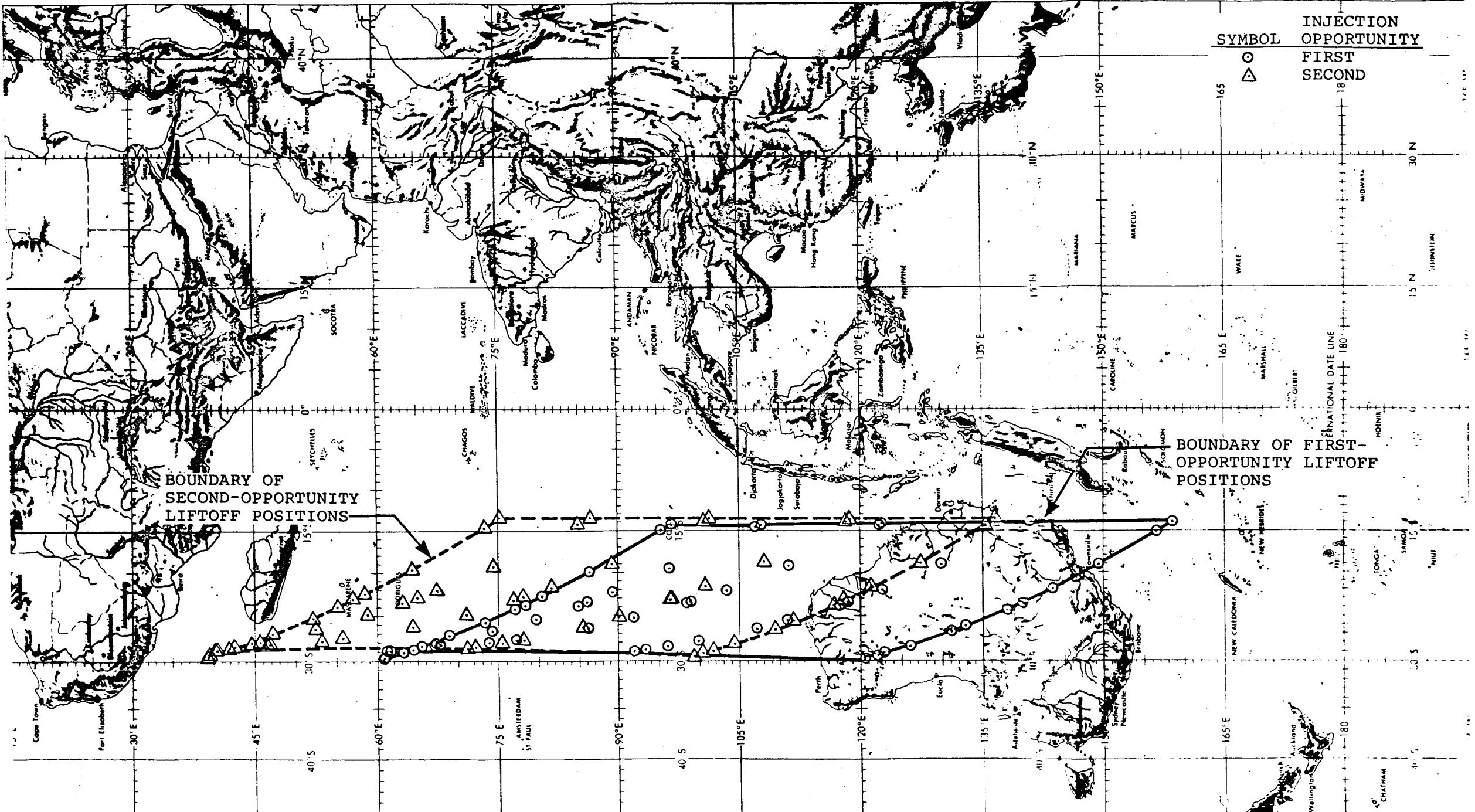


FIGURE 1-5. SUMMARY OF S-IVB LIFTOFF POSITIONS AFTER REIGNITION

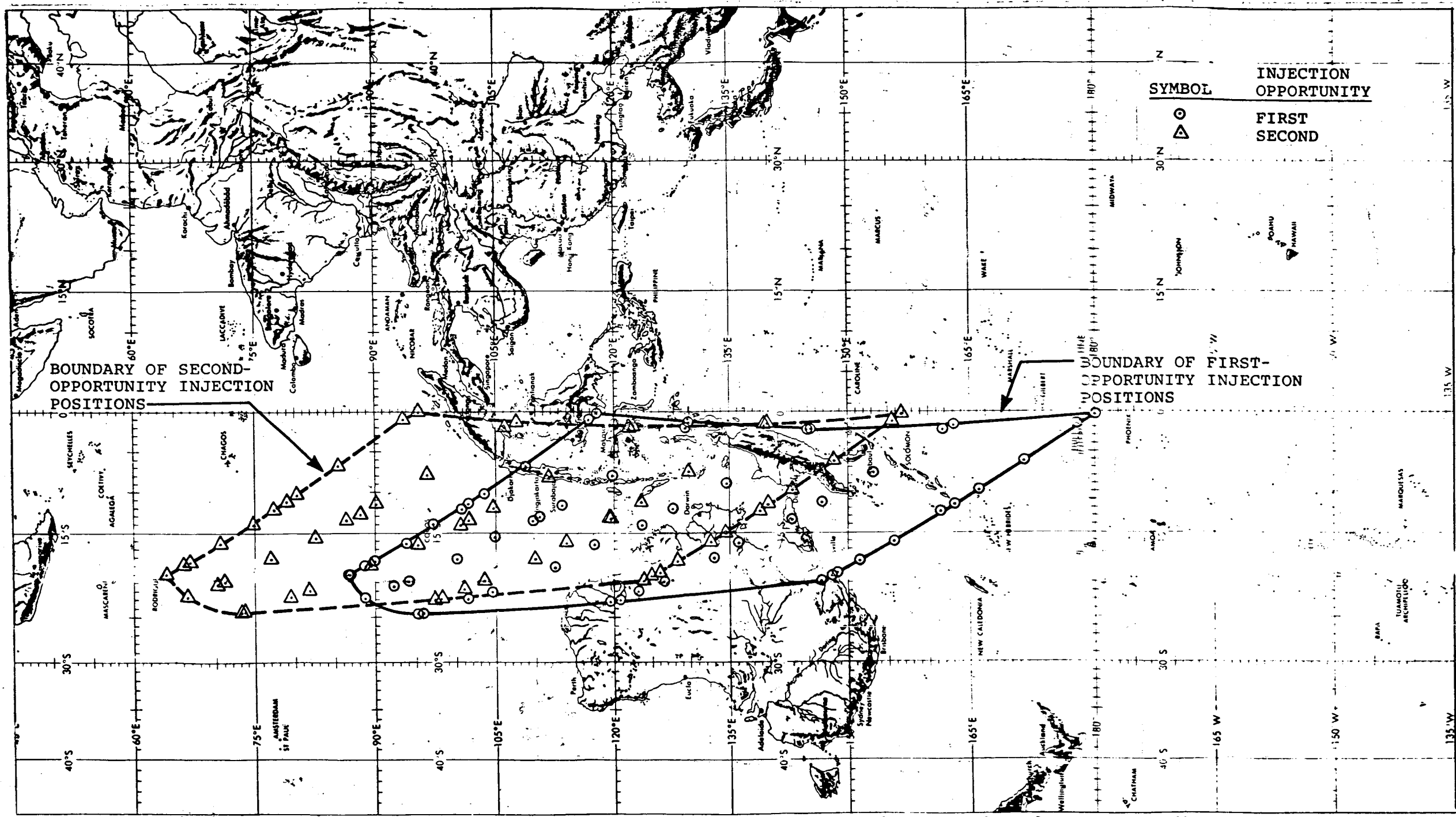
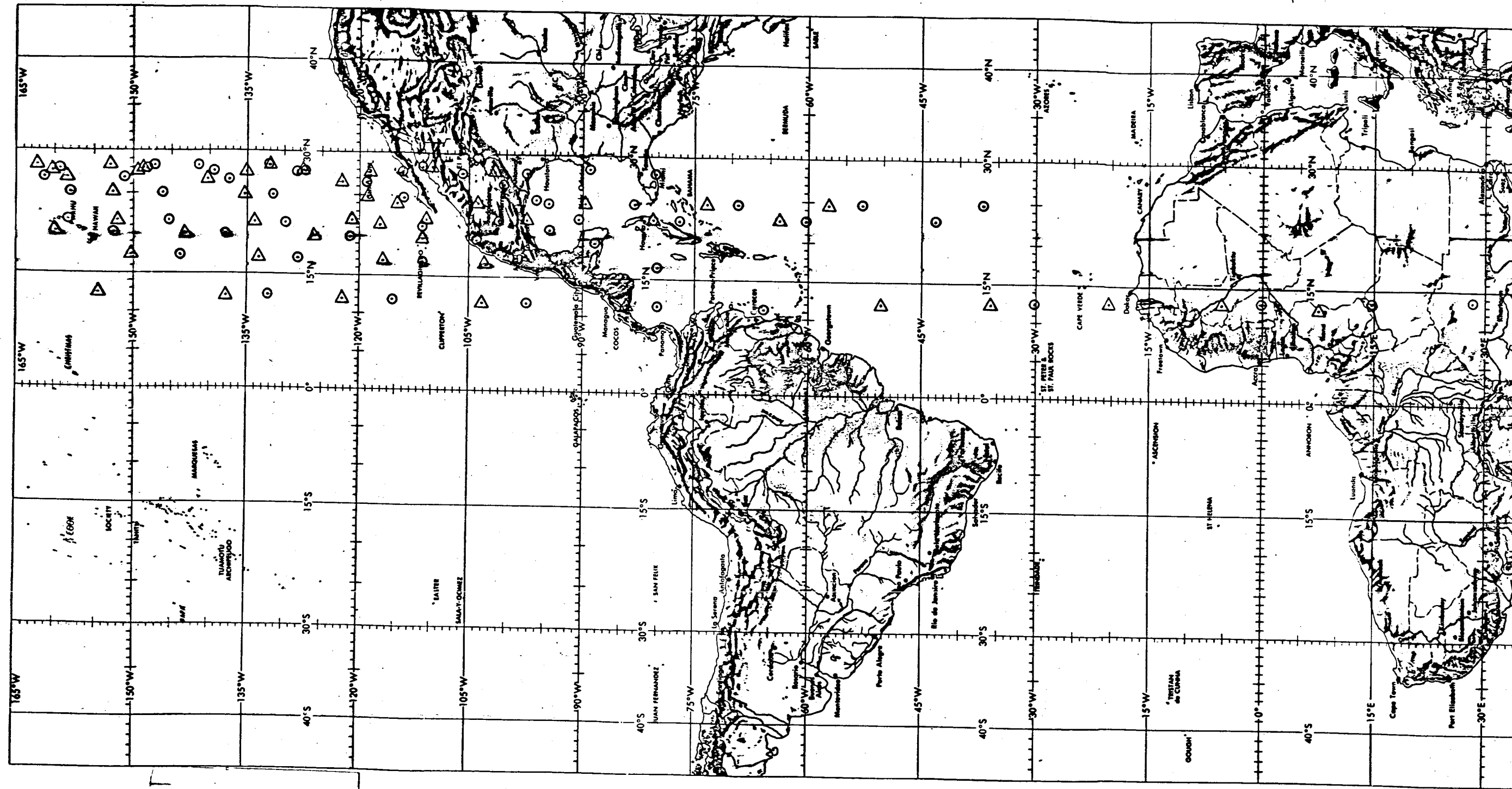


FIGURE 1-6. SUMMARY OF TRANSULAR INJECTION POSITIONS

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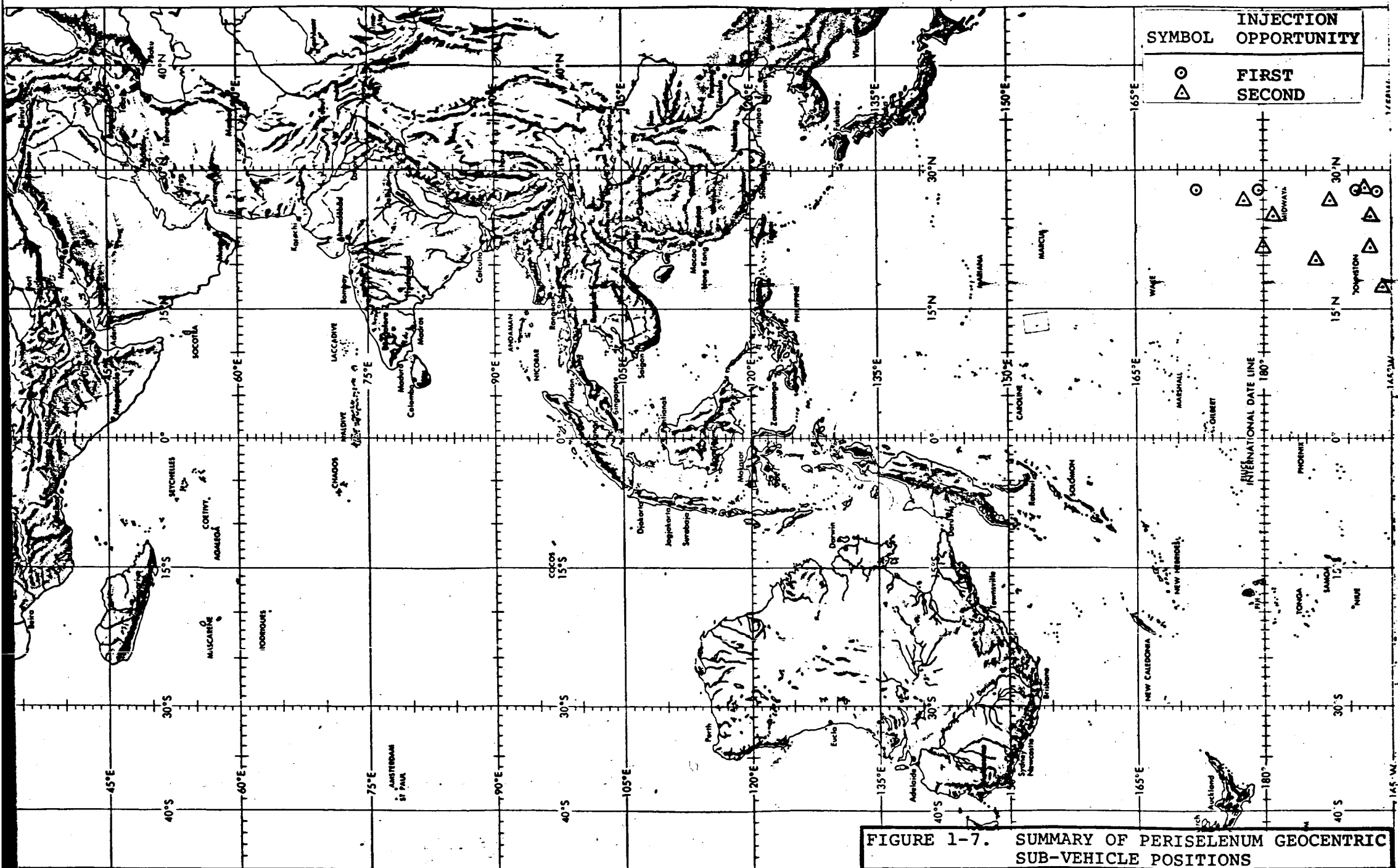
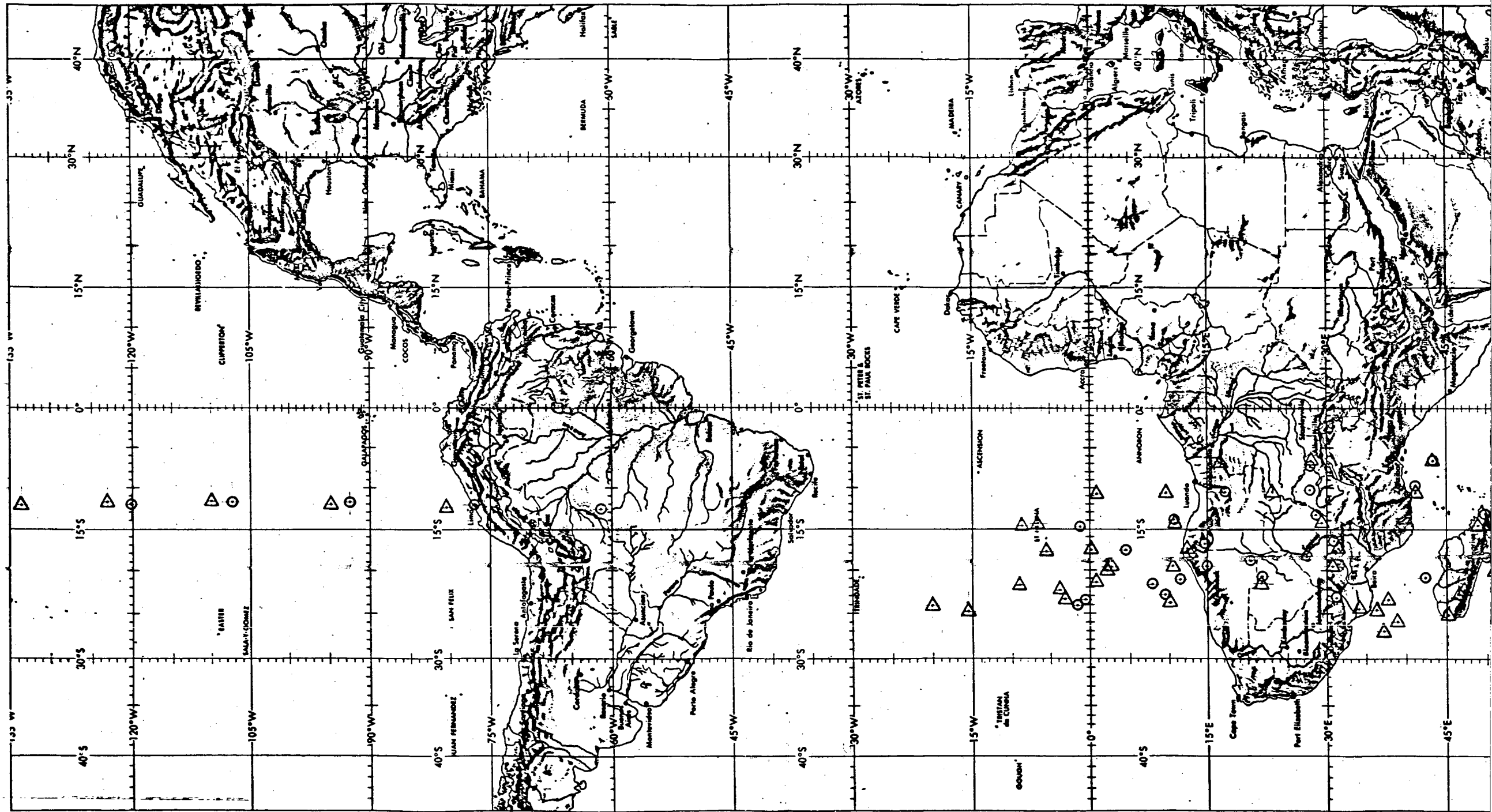


FIGURE 1-7. SUMMARY OF PERISELENUM GEOCENTRIC SUB-VEHICLE POSITIONS

Foldout #2

1-17/18



Foldout #1

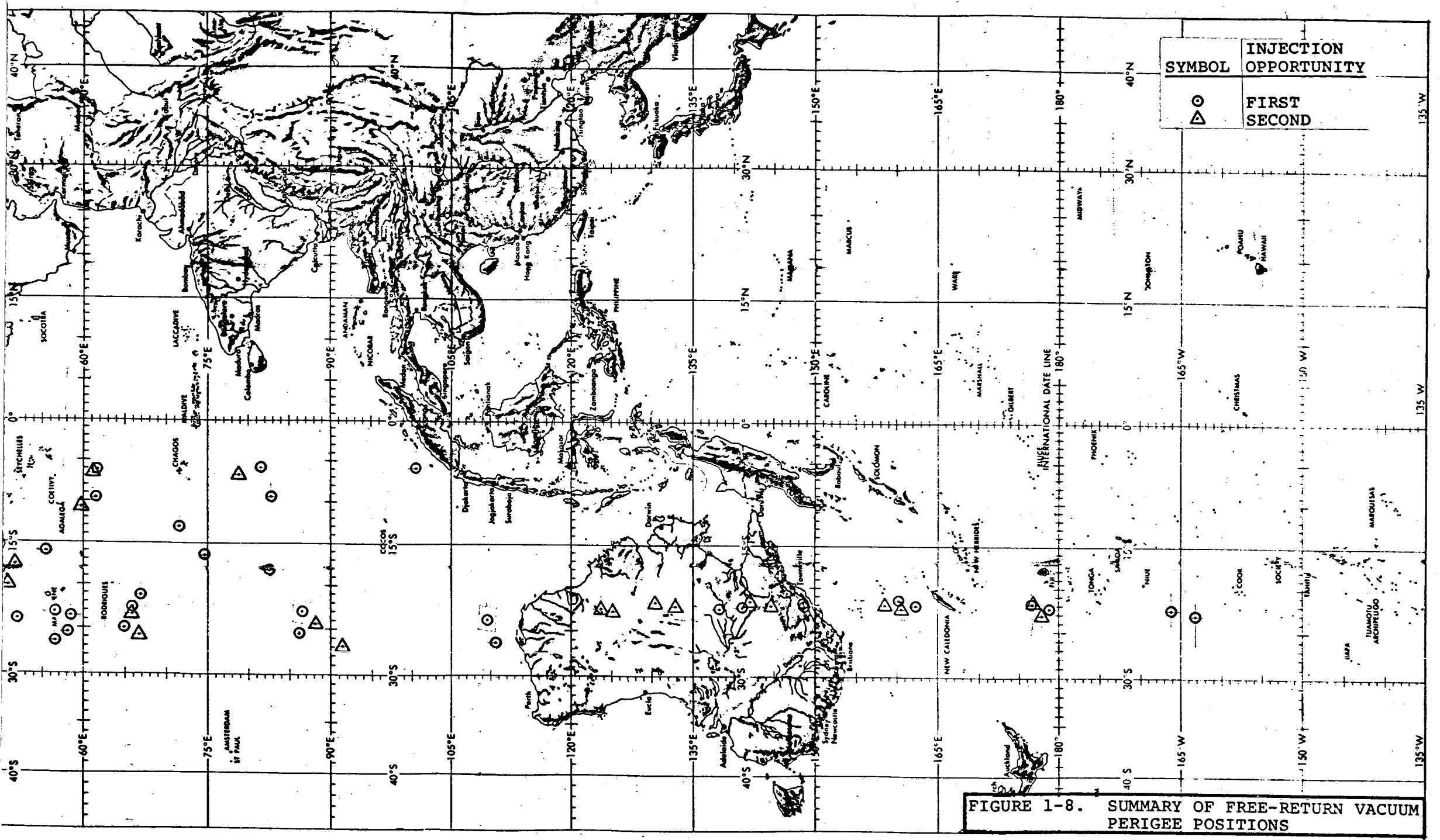


FIGURE 1-8. SUMMARY OF FREE-RETURN VACUUM PERIGEE POSITIONS

Foldout #2

TABLE 1-I. SEQUENCE OF EVENTS FOR 1 FEBRUARY 1968,
72-DEGREES LAUNCH AZIMUTH

EVENT	TIME FROM LAUNCH (SECONDS)	
	FIRST OPPORTUNITY	SECOND OPPORTUNITY
LIFTOFF	0.000	0.000
BEGIN TILT MANEUVER	12.000	12.000
MAXIMUM DYNAMIC PRESSURE	82.250	82.250
S-IC INBOARD ENGINE THRUST TERMINATION	147.329	147.329
TILT ARREST	153.000	153.000
S-IC OUTBOARD ENGINE THRUST TERMINATION AND S-IC/S-II SEPARATION	159.329	159.329
IGNITE S-II STAGE ULLAGE ENGINES	159.459	159.459
S-II STAGE AT 90-PERCENT THRUST	163.759	163.759
UNLOCK PROPELLANT UTILIZATION VALVE	165.859	165.859
JETTISON S-IC/S-II FORWARD INTERSTAGE	189.559	189.559
JETTISON LAUNCH ESCAPE SYSTEM	194.559	194.559
INITIATE ITERATIVE GUIDANCE MODE	200.000	200.000
S-II MIXTURE-RATIO SHIFT	437.627	437.627
S-II THRUST TERMINATION AND S-II/S-IVB SEPARATION	537.424	537.424
IGNITE S-IVB STAGE ULLAGE ENGINES	537.442	537.442

TABLE 1-I. SEQUENCE OF EVENTS FOR 1 FEBRUARY 1968,
72-DEGREES LAUNCH AZIMUTH (Continued)

EVENT	TIME FROM LAUNCH (SECONDS)	
	FIRST OPPORTUNITY	SECOND OPPORTUNITY
S-IVB STAGE AT 90- PERCENT THRUST	543.142	543.142
UNLOCK PROPELLANT UTILIZATION VALVE	545.742	545.742
JETTISON S-IVB ULLAGE ROCKET CASES	549.542	549.542
S-IVB STAGE FIRST THRUST TERMINATION - PARKING ORBIT INSERTION - BEGIN POST- INSERTION APS ULLAGE	658.378	658.378
OPEN CONTINUOUS LH ₂ VENT	717.378	717.378
CUTOFF ULLAGE ENGINES	742.378	742.378
BEGIN MANEUVER TO LANDMARK- SIGHTING ATTITUDE	3358.378	3358.378
VEHICLE IN LANDMARK- SIGHTING ATTITUDE	3598.378	3598.378
BEGIN MANEUVER TO NORMAL ORBITAL ATTITUDE	5818.378	5818.378
VEHICLE IN NORMAL ORBITAL ATTITUDE	6058.378	6058.378
PREIGNITION SEQUENCE INITIATION	9144.000	14456.000
CLOSE CONTINUOUS LH ₂ VENT - IGNITE O ₂ /H ₂ BURNER	9229.000	14541.000
BEGIN APS ULLAGE	9490.000	14802.000
CUTOFF O ₂ /H ₂ BURNER	9491.000	14803.000

TABLE 1-I. SEQUENCE OF EVENTS FOR 1 FEBRUARY 1968,
72-DEGREES LAUNCH AZIMUTH (Continued)

EVENT	TIME FROM LAUNCH (SECONDS)	
	FIRST OPPORTUNITY	SECOND OPPORTUNITY
INITIATE ENGINE START SEQUENCE	9594.000	14906.000
S-IVB STAGE AT 90-PERCENT THRUST - CUTOFF ULLAGE ENGINES	9604.000	14916.000
UNLOCK PROPELLANT UTILIZATION VALVE	9606.600	14918.600
INITIATE ITERATIVE GUIDANCE MODE	9610.000	14922.000
S-IVB MIXTURE-RATIO SHIFT	9646.728	14988.565
S-IVB STAGE SECOND THRUST TERMINATION - TRANSLUNAR INJECTION	9937.232 (02:45:37.232)	15231.592 (04:13:51.592)
PERISELENUM	279046.06 (77:30:46.06)	284796.89 (79:06:36.89)
FREE-RETURN VACUUM PERIGEE	538726.90 (149:38:46.90)	544181.64 (151:09:41.64)

SECTION 2

AS-504 MISSION OBJECTIVES AND CONSTRAINTS

2.0 MISSION OBJECTIVES

The primary and secondary mission objectives for the AS-504 Launch Vehicle Reference Trajectory study were obtained from Reference 1.

2.0.1 Primary Objectives

The primary objectives of the AS-504 mission are:

- a. Demonstrate the capability to perform a lunar landing and return to earth.
- b. Perform selenological inspection, survey, and sampling.

2.0.2 Secondary Objectives

A successful lunar landing mission requires completion of several secondary objectives. Achievement of these secondary objectives does not assure a successful lunar landing mission, but for the first lunar landing mission, completion of each of these secondary objectives represents a significant achievement. The secondary objectives are:

- a. Demonstrate operational launch vehicle capability by injecting a fully loaded Apollo spacecraft onto a specified circumlunar conic.
- b. Demonstrate the adequacy of all spacecraft systems and operational procedures for translunar and transearth flight.
- c. Demonstrate the adequacy of deep-space navigation techniques and of guidance accuracy during translunar and transearth midcourse corrections.
- d. Demonstrate acceptable SPS performance and spacecraft guidance during the lunar orbit insertion boost and the transearth injection boost.
- e. Demonstrate acceptable Lunar Module (LM) systems performance during the descent-to-hover boost.
- f. Demonstrate acceptable LM systems performance during the ascent and rendezvous mode.

2.1 MISSION CONSTRAINTS

The mission constraints for the AS-504 Launch Vehicle Reference Trajectory study were obtained from References 2 and 3, and from coordination with MSFC and MSC.

2.1.1 Trajectory Profile Constraints

The trajectory profile constraints are:

- a. The launch dates are February 1, 2, 3, and 4, March 1, 3, 5, 7, and 31, and April 2, 4, and 6, 1968.
- b. Launch shall occur along an azimuth of not less than 72 degrees and not greater than 108 degrees east of north.
- c. Translunar injection shall occur from the Pacific window at either the first or second possible opportunity after completing one revolution in parking orbit.
- d. At free-return perigee, the direction of vehicle motion shall be co-rotational with the earth.
- e. Launch vehicle targeting will be based upon the desired pericyynthion (periselenium) selenographic latitudes and altitudes defined in Table 2-I, and based upon a desired free-return perigee altitude of 25 ± 12 NMI (based on the Apollo reference equatorial radius).

2.1.2 Launch Vehicle Constraints

The launch vehicle constraints are:

- a. The guidance-command angle rate shall not exceed one degree per second in pitch and yaw (first-stage tilt program and upper-stage guidance program).
- b. The maximum command attitude in the yaw plane shall not exceed 45 degrees.

TABLE 2-I. DESIRED PERICYNTHION ALTITUDES AND SELENOGRAPHIC LATITUDES

Launch Date	Launch Azimuth (Degrees)	Injection Opportunity	Pericynthion Selenographic Latitude (Degrees)	Pericynthion Altitude (NMI)
February 1	72	1	-5.788	83.956
"	81	1	-5.721	83.950
"	90	1	-5.696	83.961
"	99	1	-5.719	83.974
"	108	1	-5.784	83.981
"	72	2	-5.787	83.997
"	81	2	-5.720	83.987
"	90	2	-5.697	83.979
"	99	2	-5.718	83.986
"	108	2	-5.784	83.992
February 2	72	1	-5.486	82.994
"	81	1	-5.373	83.263
"	90	1	-5.315	83.391
"	99	1	-5.333	83.346
"	108	1	-5.409	83.161
"	72	2	-5.459	83.059
"	81	2	-5.346	83.327
"	90	2	-5.291	83.443
"	99	2	-5.306	83.404
"	108	2	-5.386	83.206
February 3	72	1	-1.441	83.944
"	81	1	-1.367	83.947
"	90	1	-1.339	83.944
"	99	1	-1.362	83.944
"	108	1	-1.429	83.951
"	72	2	-1.437	83.972
"	81	2	-1.364	83.966
"	90	2	-1.336	83.948
"	99	2	-1.359	83.955
"	108	2	-1.426	83.967
February 4	72	1	-1.236	83.718
"	81	1	-1.129	83.869
"	90	1	-1.093	83.897
"	99	1	-1.106	83.890
"	108	1	-1.180	83.786
"	72	2	-1.215	83.751
"	81	2	-1.114	83.890
"	90	2	-1.076	83.928
"	99	2	-1.097	83.897
"	108	2	-1.167	83.810

TABLE 2-I. DESIRED PERICYNTHION ALTITUDES AND SELENOGRAPHIC LATITUDES (Continued)

Launch Date	Launch Azimuth (Degrees)	Injection Opportunity	Pericynthion Selenographic Latitude (Degrees)	Pericynthion Altitude (NMI)
March 1	72	1	-3.445	83.884
"	81	1	-3.364	83.942
"	90	1	-3.332	83.962
"	99	1	-3.351	83.959
"	108	1	-3.416	83.931
"	72	2	-3.433	83.977
"	81	2	-3.356	84.018
"	90	2	-3.325	84.022
"	99	2	-3.343	84.019
"	108	2	-3.406	83.976
March 3	72	1	0.105	83.719
"	81	1	0.235	83.960
"	90	1	0.285	84.028
"	99	1	0.261	83.962
"	108	1	0.174	83.805
"	72	2	0.133	83.764
"	81	2	0.253	83.972
"	90	2	0.297	84.029
"	99	2	0.276	83.955
"	108	2	0.193	83.799
March 5	72	1	3.808	84.048
"	81	1	3.833	83.864
"	90	1	3.856	83.827
"	99	1	3.834	83.911
"	108	1	3.807	83.959
"	72	2	3.794	83.911
"	81	2	3.835	83.836
"	90	2	3.864	83.586
"	99	2	3.835	83.917
"	108	2	3.809	83.957
March 7	72	1	2.419	83.694
"	81	1	2.492	83.467
"	90	1	2.556	83.181
"	99	1	2.484	83.504
"	108	1	2.435	83.631
"	72	2	2.414	83.733
"	81	2	2.479	83.548
"	90	2	2.516	83.423
"	99	2	2.489	83.501
"	108	2	2.447	83.576

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TABLE 2-1. DESIRED PERICYNTHION ALTITUDES AND SELENOGRAPHIC LATITUDES (Continued)

Launch Date	Launch Azimuth (Degrees)	Injection Opportunity	Pericynthion Selenographic Latitude (Degrees)	Pericynthion Altitude (NMI)
March 31	72	1	1.832	83.606
"	81	1	1.990	83.912
"	90	1	2.052	84.004
"	99	1	2.018	83.936
"	108	1	1.906	83.712
"	72	2	1.857	83.658
"	81	2	2.008	83.953
"	90	2	2.063	84.005
"	99	2	2.033	83.951
"	108	2	1.929	83.758
April 2	72	1	2.082	83.957
"	81	1	2.126	84.161
"	90	1	2.105	84.200
"	99	1	2.145	84.173
"	108	1	2.132	84.011
"	72	2	2.101	84.009
"	81	2	2.140	84.209
"	90	2	2.116	84.223
"	99	2	2.156	84.164
"	108	2	2.149	84.000
April 4	72	1	3.813	83.676
"	81	1	3.865	83.544
"	90	1	3.893	83.468
"	99	1	3.869	83.526
"	108	1	3.817	83.983
"	72	2	3.815	83.691
"	81	2	3.868	83.544
"	90	2	3.896	83.468
"	99	2	3.872	83.514
"	108	2	3.811	83.899
April 6	72	1	0.329	83.763
"	81	1	0.345	83.647
"	90	1	0.356	83.604
"	99	1	0.345	83.675
"	108	1	0.327	83.734
"	72	2	0.329	83.799
"	81	2	0.344	83.666
"	90	2	0.354	83.611
"	99	2	0.343	83.666
"	108	2	0.329	83.863

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SECTION 3

LAUNCH VEHICLE CHARACTERISTICS

3.0 CONFIGURATION

The Apollo/Saturn V vehicle consists of the Saturn V launch vehicle and the Apollo spacecraft. The Saturn V launch vehicle consists of the S-IC, S-II, and S-IVB booster stages and the Instrument Unit (IU). The Apollo spacecraft consists of the Command Module (CM), Service Module (SM), Lunar Module (LM), Launch Escape System (LES) tower, and Spacecraft LM Adapter (SLA). Of the five major spacecraft components, only the CM, SM, and LM perform lunar operations; the LES tower is jettisoned during S-II stage flight, and the SLA remains attached to the S-IVB/IU during and after final spacecraft separation.

The Apollo/Saturn V configuration at liftoff is shown in Figure 3-1.

3.1 AERODYNAMIC CHARACTERISTICS

The aerodynamic characteristics for the Apollo/Saturn V S-IC stage configuration (Figure 3-1) were obtained from Reference 4, and aerodynamic data for the S-II stage configuration were obtained from Reference 5. The variations of the axial-force coefficient with Mach number for zero angle of attack are shown in Figure 3-2 for these two stages. Figure 3-3 shows the variation of the normal-force-coefficient gradients at zero angle of attack with Mach number for these stages. The longitudinal positions of the aerodynamic center of pressure for near-zero pitch angles of attack are given in Figure 3-4. For this study center-of-pressure data for yaw angles of attack are assumed to be identical to those given for pitch.

During S-IVB stage flight the vehicle is at altitudes that require the use of free-molecular-flow aerodynamic coefficients. At the flight and vehicle-attitude conditions existing during the S-IVB boost and coast phases, only aerodynamic drag is a sufficiently perturbing aerodynamic force to warrant simulation in this study; aerodynamic lift during S-IVB stage flight is not simulated in this study. A constant free-molecular-flow drag coefficient of 2.8024 is used in this study throughout S-IVB stage flight. This value was obtained from Reference 6 and is based upon a reference area of 33.47 square meters. This drag coefficient causes a continuous drag force of approximately 0.2 pound during the stay in parking orbit.

3.2 PROPULSION CHARACTERISTICS

3.2.1 Propulsion Characteristics during Mainstage Operation

The propulsion characteristics used during mainstage operation in preparing the AS-504 L/V Reference Trajectory study are obtained from simple propulsion models that approximate predicted vehicle propulsion performance. These propulsion models consist of equations or numerical step-functions that define thrust, specific impulse, propellant-flowrate mixture ratio, and/or propellant flowrates. The data used to formulate these models were obtained from numerical analyses of the tabular S-IC, S-II, and S-IVB stage propulsion data contained in Reference 7. Simple propulsion models were selected for use in this study instead of detailed tabular data (Reference 7) because the tabular data are too inflexible for use in a mission-profile shaping study; tabular data cannot be easily adjusted to account for the propulsion deviations that result from changes in the mission-profile shape and event times.

3.2.1.1 S-IC Stage Propulsion Model

The S-IC stage propulsion model used in this study consists of the following equations for thrust, LOX flowrate, and RP-1 flowrate:

Thrust per Engine (lbs)

$$F = 1,532,830. + 15,085.(14.696 - P_{\infty}) + 30,060.(a_s - 1.195) - 2823.(a_s - 1.195)^2$$

LOX Flowrate per Engine (lbs/sec)

$$\dot{W}_{LOX} = 4015.0 + 67.408(a_s - 1.195) - 3.465(a_s - 1.195)^2$$

RP-1 Flowrate per Engine (lbs/sec)

$$\dot{W}_{RP-1} = 1751.5 + 11.057(a_s - 1.195) - 0.387(a_s - 1.195)^2$$

where:

P_{∞} = ambient atmospheric pressure (PSIA)

a_s = sensed vehicle longitudinal acceleration (g's)

$$= \frac{\text{Total Thrust} - \text{Drag}}{\text{Weight}}$$

The values of thrust and propellant flowrates obtained using these equations are compared in Figures 3-5 through 3-7 with the S-IC data of Reference 7.

3.2.1.2 S-II and S-IVB Stage Propulsion Models

A step-function propulsion model is used during simulated S-II and S-IVB stage flight. In this type of propulsion model, constant values of thrust, specific impulse, and propellant-flowrate mixture ratio are used during specified periods of stage operation. The specified periods of stage operation and the propulsion characteristics used in this study are summarized in Table 3-I.

The S-II and S-IVB propulsion-model thrust levels are compared with Reference 7 data in Figures 3-8 through 3-10. The thrust history in Figure 3-10 shows a nearly constant thrust level during the S-IVB stage injection boost. This nearly constant thrust level results only if reignition occurs at a time when the ratio of LOX to LH₂ remaining in the tanks (as measured by the tank propellant sensors) equals a "nominal" propellant consumption ratio. This nominal consumption ratio corresponds to the desired thrust level for the injection boost and is 4.948 in this study. For the propellant loading and bias used in this study, a nearly constant thrust level results from reignition after 2.0 revolutions in parking orbit.

The orientations of the target vectors for the desired trans-lunar trajectories cause first-injection-opportunity reignition to occur after approximately 1.5 revolutions in parking orbit and second-opportunity reignition to occur after approximately 2.5 revolutions. During both injection-opportunity boosts the Propellant Utilization (PU) System adjusts the propellant-flow mixture ratio to maximize S-IVB stage performance. These mixture-ratio adjustments result in non-constant thrust levels. The thrust histories provided by the S-IVB stage propulsion model during the first and second-opportunity injection boosts of this study are summarized in Figures 3-11 and 3-12.

The thrust levels shown in Table 3-I for ullage-motor operation and J-2 thrust buildup are determined from the sums of the total ullage-motor impulse and the total J-2 impulse during thrust buildup. The specific impulses for this operating period (Table 3-I) are based upon the weight losses specified in Reference 8 for these events rather than upon the weight losses indicated by Reference 7.

These S-II and S-IVB stage propulsion models do not simulate thrust decay. During simulated S-II stage flight, full thrust is provided after the cutoff signal until all of the allotted S-II thrust-decay propellant is consumed; the thrust is then set equal to zero. During S-IVB stage flight, the cutoff signal is given when the desired terminal conditions

are reached. Thrust-decay velocity biases are not used. Therefore, full thrust is used until the cutoff signal is given, and the thrust is then instantaneously set equal to zero. The S-IVB thrust-decay propellant specified by Reference 8 is assumed to be the last propellant consumed during the burn.

3.2.2 Propulsion Characteristics during Parking Orbit

Thrust during the vehicle stay in parking orbit is of low magnitude and is intended to keep the S-IVB propellant seated against the aft bulkheads. After parking orbit insertion, two 70-pound-thrust APS ullage engines (Reference 9) are operated for 84 seconds to damp out propellant disturbances that may occur at S-IVB cutoff. During APS-ullage operation, the propulsive H_2 vents are opened. These vents provide continuous thrust until after preignition-sequence initiation (t_{B6}). A thrust history from orbit insertion to preignition-sequence initiation is given in Figure 3-13. Thrust data for the propulsive H_2 vents were obtained from Reference 10.

The propulsive H_2 vents remain open for 85 seconds after preignition-sequence initiation. The oxygen-hydrogen burner (helium heater) is ignited as the continuous H_2 vent is closed. The burner, one of two repressurization systems, nominally operates for 262 seconds while repressurizing the LOX and LH_2 tanks for reignition. One second before burner cutoff, the APS ullage engines are turned on. These engines operate until shortly before the J-2 engine reaches its operating thrust level. A thrust history from preignition-sequence initiation to J-2 engine start-sequence initiation is given in Figure 3-14. System sequencing data and O_2/H_2 -burner thrust data during the preignition sequence were obtained from Reference 11.

During operation of the continuous H_2 vents, the H_2 weight flowrate corresponds to a constant vent specific impulse. The specific impulse magnitude is selected so that a loss of 2783 pounds of H_2 and helium occurs during 2.0 revolutions in parking orbit (Reference 8). Constant weight flowrates are used during operation of other thrust systems; these flowrates are selected so that the weight losses specified in Reference 8 occur.

3.2.3 Post-Injection Propulsion Characteristics

Post-injection propulsion characteristics are not available. Vehicle thrust after injection is not simulated.

3.3 FLIGHT SEQUENCE

The flight sequence used in this study is given in Table 3-II.

3.3 (Continued)

This sequence defines the flight events that set the computer time bases. It also identifies the flight events simulated in this study that are commanded by the flight computer at specified time intervals after the computer time bases. Flight events that nominally occur at specified times after the various time bases but are not commanded by the flight computer are also included. The flight sequence shown in Table 3-II is taken from Reference 12 except for sequence data between preignition-sequence initiation (t_{B_0}) and J-2 engine restart initiation. These latter data were obtained from Reference 11.

3.4 WEIGHT AND MASS CHARACTERISTICS

Table 3-III contains a weight summary for the AS-504 vehicle during the first and second injection-opportunity missions for February 1, 72-degrees launch azimuth. The itemized weights shown are identical to those defined in Reference 8 except for the propellant consumed during the two S-IVB burns and the S-IVB H_2 vented during parking orbit. These last weight items are mission-dependent and vary significantly among the simulated trajectories.

The longitudinal location of the center of gravity and the pitch and roll moments of inertia are given in Figures 3-15 through 3-17. These data were obtained from Reference 8. In this study the vehicle center of gravity is assumed to lie on the longitudinal body axis. Yaw moment-of-inertia data are assumed to be the same as for pitch.

3.5 CONTROL GAINS AND FILTERS

During boost flight, control about the vehicle center of mass is provided by an attitude/attitude-rate control system and the gimballed engines. Instantaneous engine-deflection response to control commands is assumed for this study. The nozzle deflection angle, β , in the pitch and yaw planes is commanded by the following equation:

$$\beta = a_0 F_\phi \Delta\theta + a_1 F_\dot{\phi} \dot{\theta}$$

The values, a_0 and a_1 , are attitude and attitude-rate control gains, respectively. The term, $\Delta\theta$, is the difference between the commanded attitude and the actual attitude; $\dot{\theta}$ is the actual vehicle attitude rate. The gains used in this simulation were obtained from Reference 13 and are given in Table 3-IV. F_ϕ and $F_{\dot{\phi}}$ are filters and are used to alter the gains, a_0 and a_1 , at the lower body frequencies to improve vehicle performance.

3.5 (Continued)

The filter values used in this study were taken from Reference 13 and are $F_\phi = F_{\dot{\phi}} = 1.00$ except for the following S-IC stage filters:

S-IC Stage Pitch and Yaw Attitude-Gain Filter

$$F_\phi = \frac{0.4 (S + 0.095)}{S + 0.038}$$

S-IC Stage Roll Attitude-Gain Filter

$$F_\phi = \frac{2.35}{S + 2.35}$$

where S is a Laplace operator.

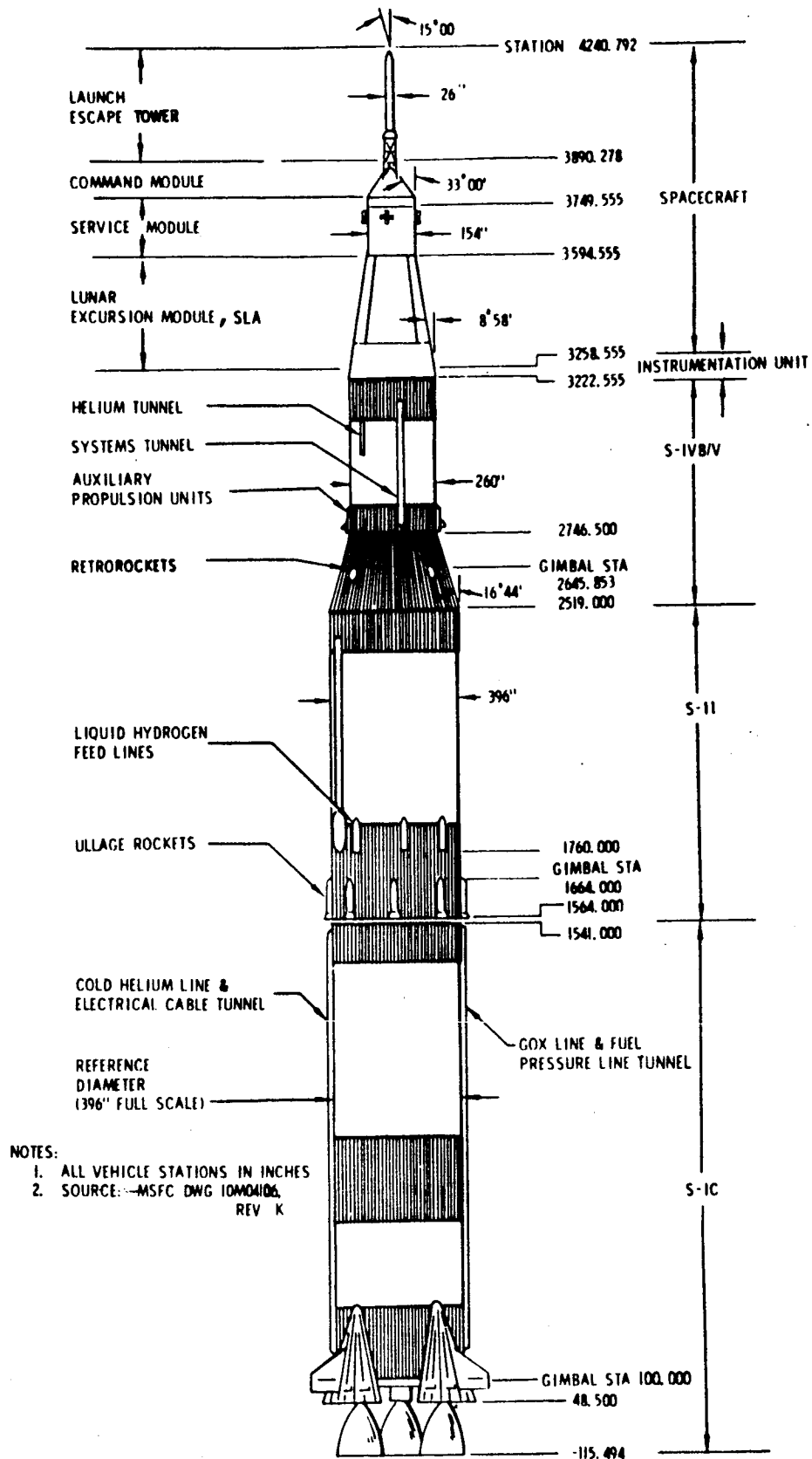


FIGURE 3-1. APOLLO/SATURN V VEHICLE GEOMETRY

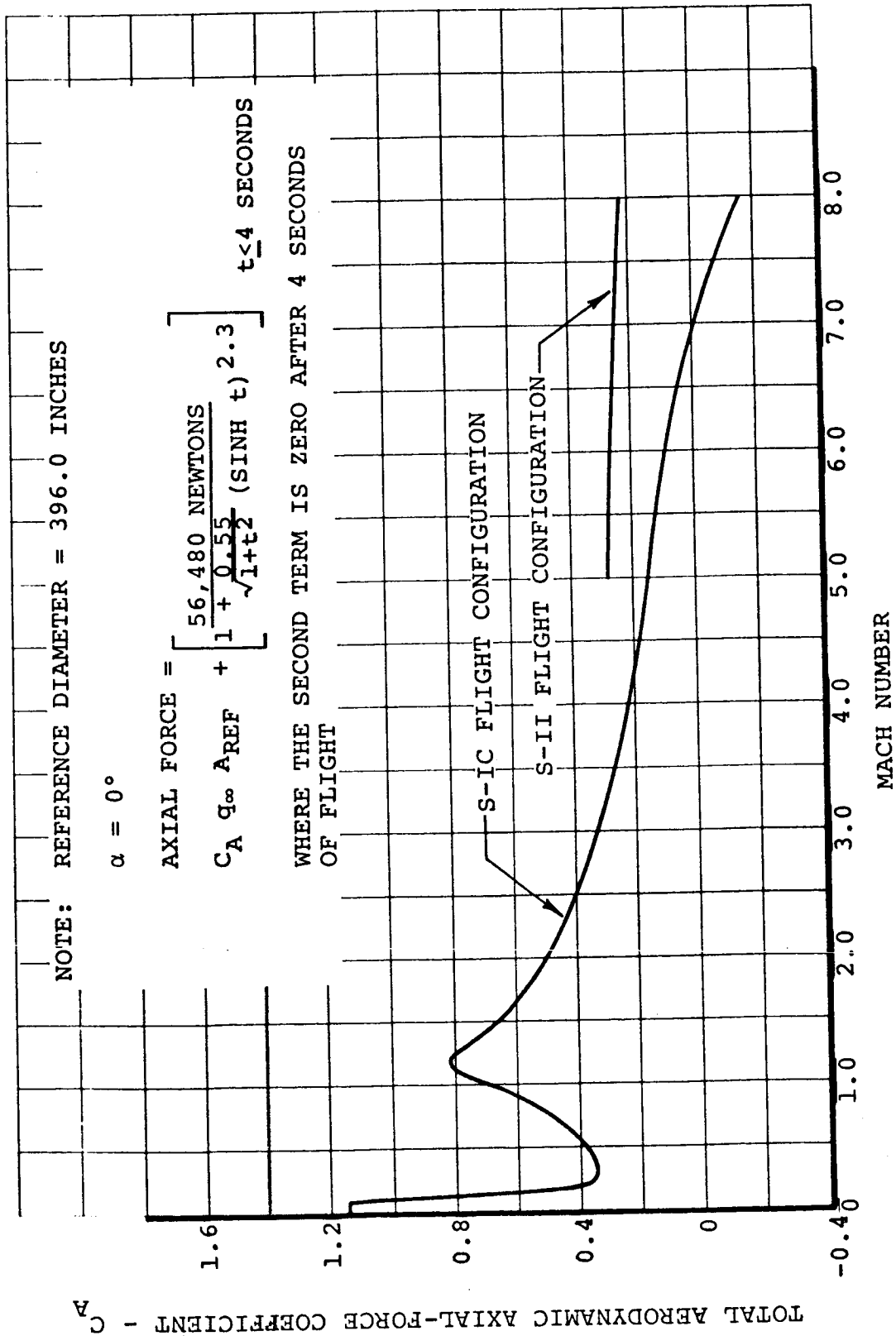


FIGURE 3-2. VARIATION OF APOLLO/SATURN V VEHICLE AXIAL-FORCE COEFFICIENT WITH MACH NUMBER

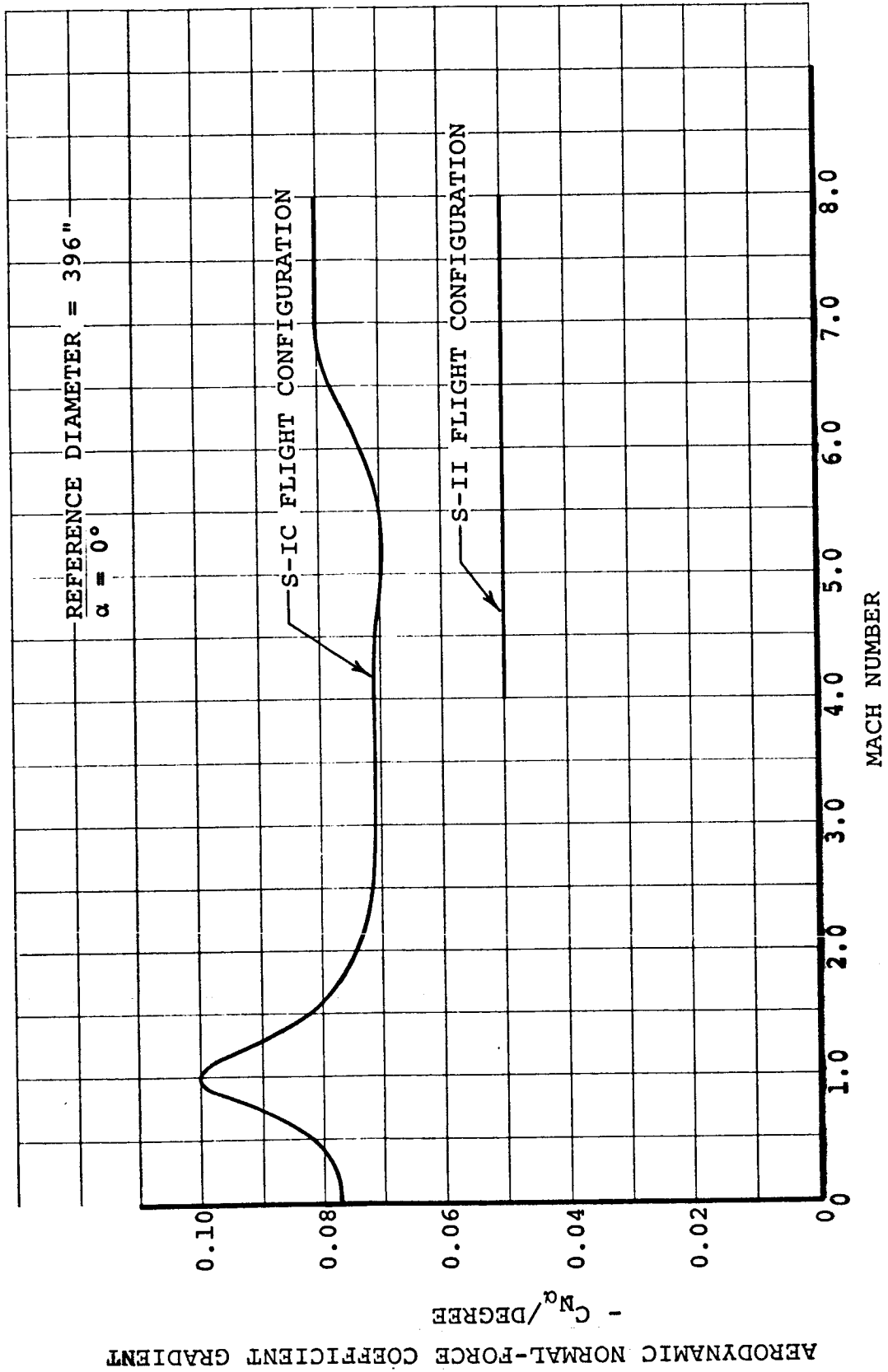


FIGURE 3-3. VARIATION OF APOLLO/SATURN V VEHICLE NORMAL-FORCE COEFFICIENT GRADIENT WITH MACH NUMBER

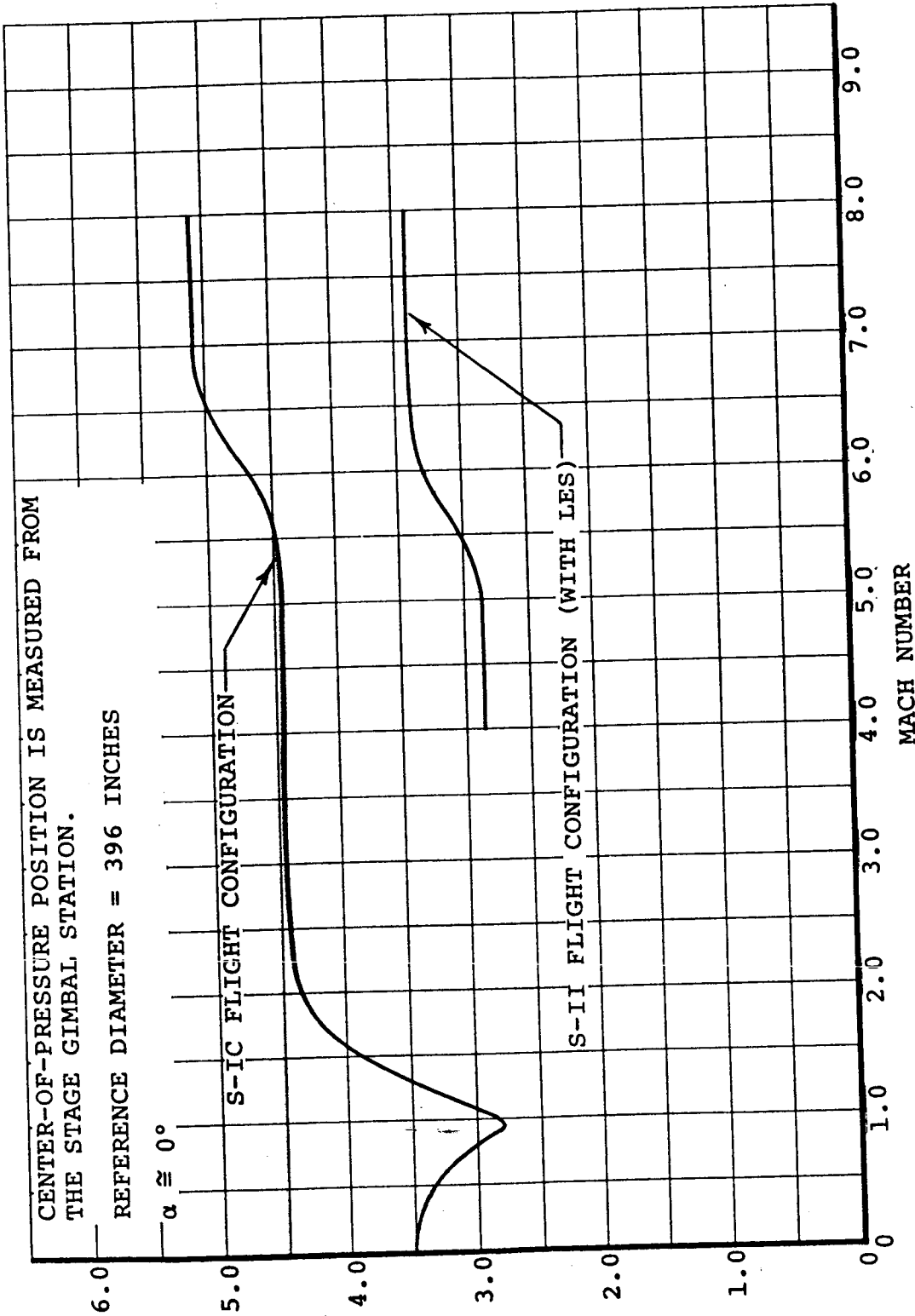


FIGURE 3-4. VARIATION OF APOLLO/SATURN V VEHICLE PITCH CENTER OF PRESSURE WITH MACH NUMBER

AERODYNAMIC PITCH CENTER OF PRESSURE IN CALIBERS - X_{CP}

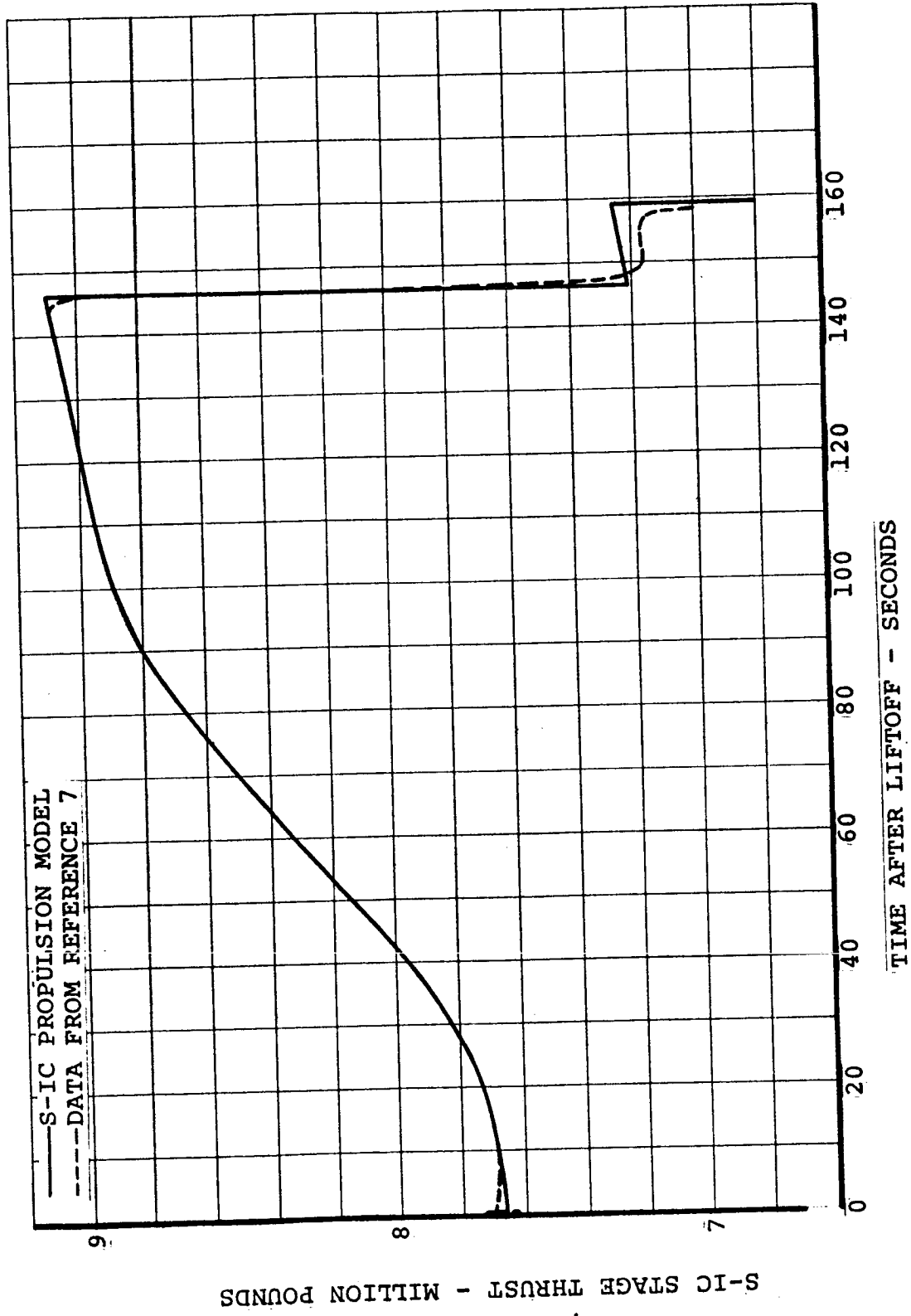


FIGURE 3-5. S-IC STAGE THRUST HISTORY

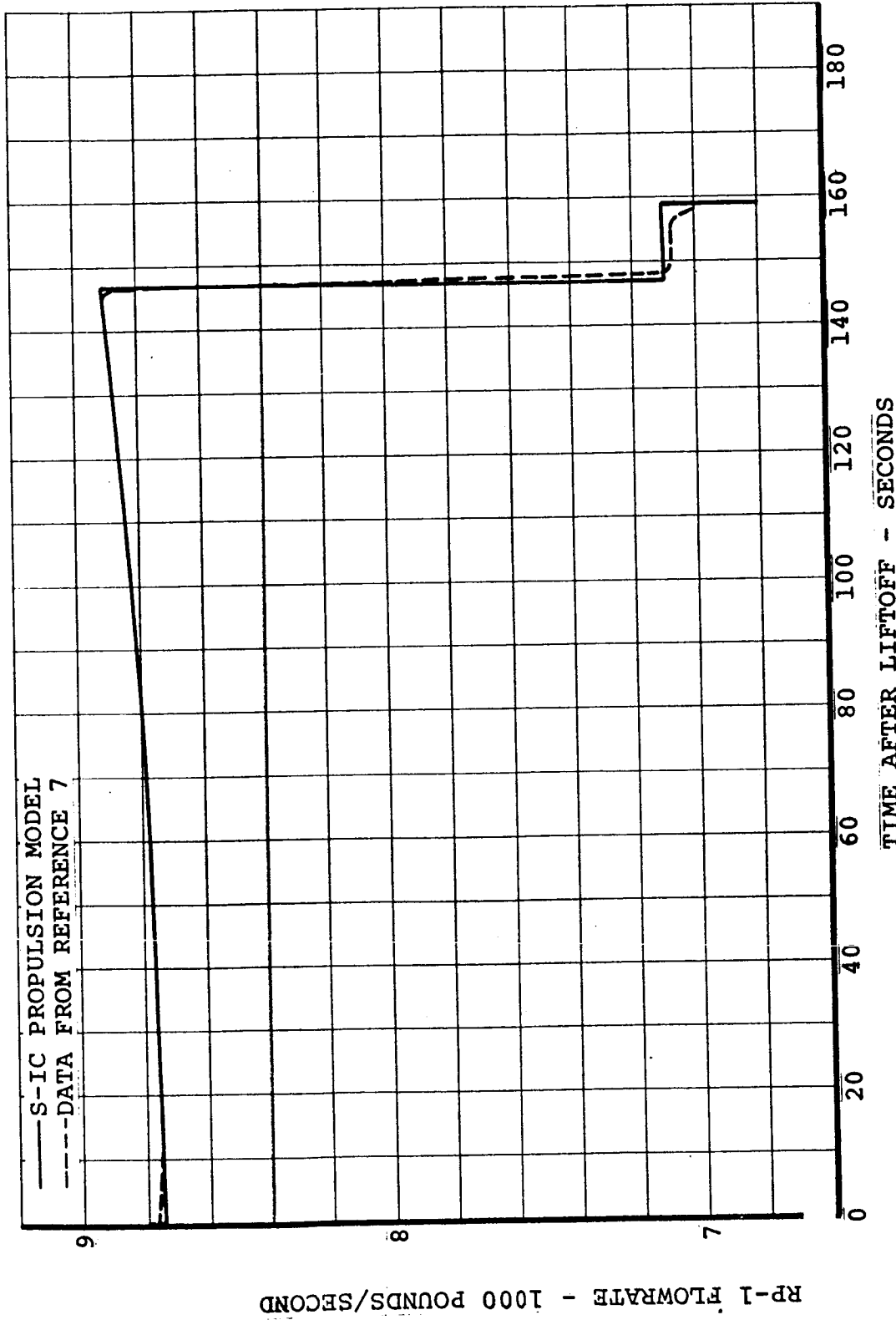


FIGURE 3-6 S-IC TOTAL, RP-1 FLOWRATE

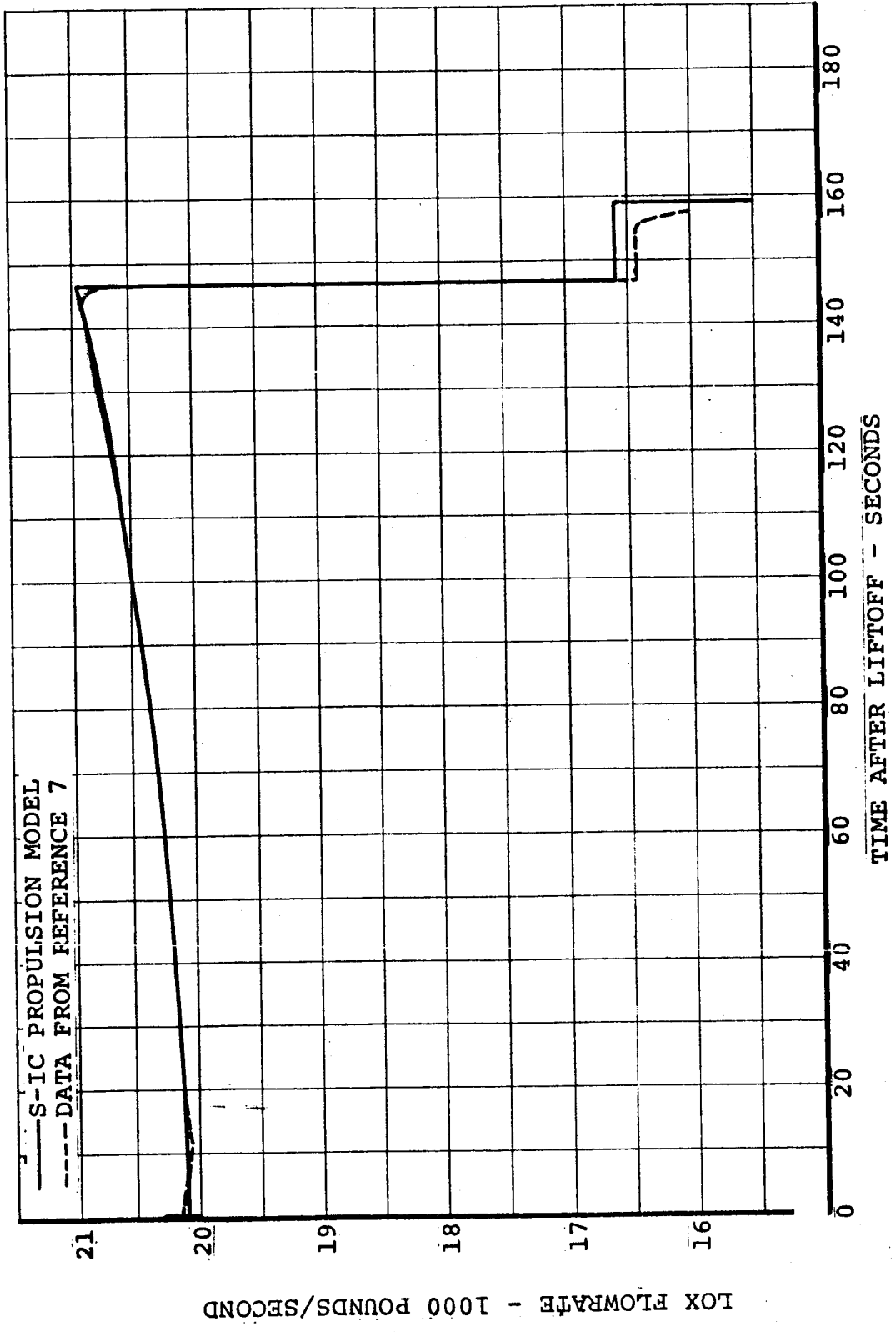


FIGURE 3-7. S-IC TOTAL LOX FLOWRATE

TABLE 3-I. S-II AND S-IVB STAGE PROPULSION CHARACTERISTICS

FROM	TO	PERIOD (SECONDS)	THRUST (POUNDS)	SPECIFIC IMPULSE (SECONDS)	FLOWRATE MIXTURE RATIO (LÖX/LH ₂)
<u>S-II STAGE</u>					
ULLAGE ENGINE IGNITION	THE NOMINAL TIME OF 90-PERCENT THRUST	4.3	274,320.	269.432	2.281
90-PERCENT THRUST	PU SYSTEM ACTIVATION	2.1	1,024,121.	423.960	4.876
PU SYSTEM ACTIVATION	FINAL MIXTURE- RATIO SHIFT (MR)	272.	1,163,649.	425.143	5.543
FINAL MR SHIFT	THRUST TERMINATION	100.	953,695.	428.715	4.690
<u>S-IVB FIRST BURN</u>					
ULLAGE ENGINE IGNITION	THE NOMINAL TIME OF 90-PERCENT THRUST	5.7	27,114.7	276.978	2.760
90-PERCENT THRUST	PU SYSTEM ACTIVATION	2.6	206,996.	427.633	4.964
PU SYSTEM ACTIVATION	THRUST TERMINATION	VARIABLE (109.4 TO 112.6)	233,347.	425.280	5.480

TABLE 3-I. S-II AND S-IVB STAGE PROPULSION CHARACTERISTICS (Continued)

FROM	TO	PERIOD (SECONDS)	THRUST (POUNDS)	SPECIFIC IMPULSE (SECONDS)	FLOWRATE MIXTURE RATIO (L _O X/LH ₂)
<u>S-IVB SECOND BURN</u>					
J-2 START SEQUENCE INITIATION	THE NOMINAL TIME OF 90-PERCENT THRUST	10.0	18,251.	*	Not Used in this simula- tion.
90-PERCENT THRUST	PU SYSTEM ACTIVATION	2.6	207,303.	427.663	4.985
PU SYSTEM ACTIVATION	FINAL MR SHIFT	VARIABLE (40. to 70.)	177,749.4 or 233,347.	431.138 or 425.280	4.346 or 5.480
FINAL MR SHIFT	THRUST TERMINATION	VARIABLE (243. to 290.)**	206,047.2	427.572	4.948

* The specific impulse used in this study is artificial and causes the loss of all the weights (designated in Reference 8) that are lost during this period.

** This period is inversely proportional to the thrust level and burn period of the previous thrust period.

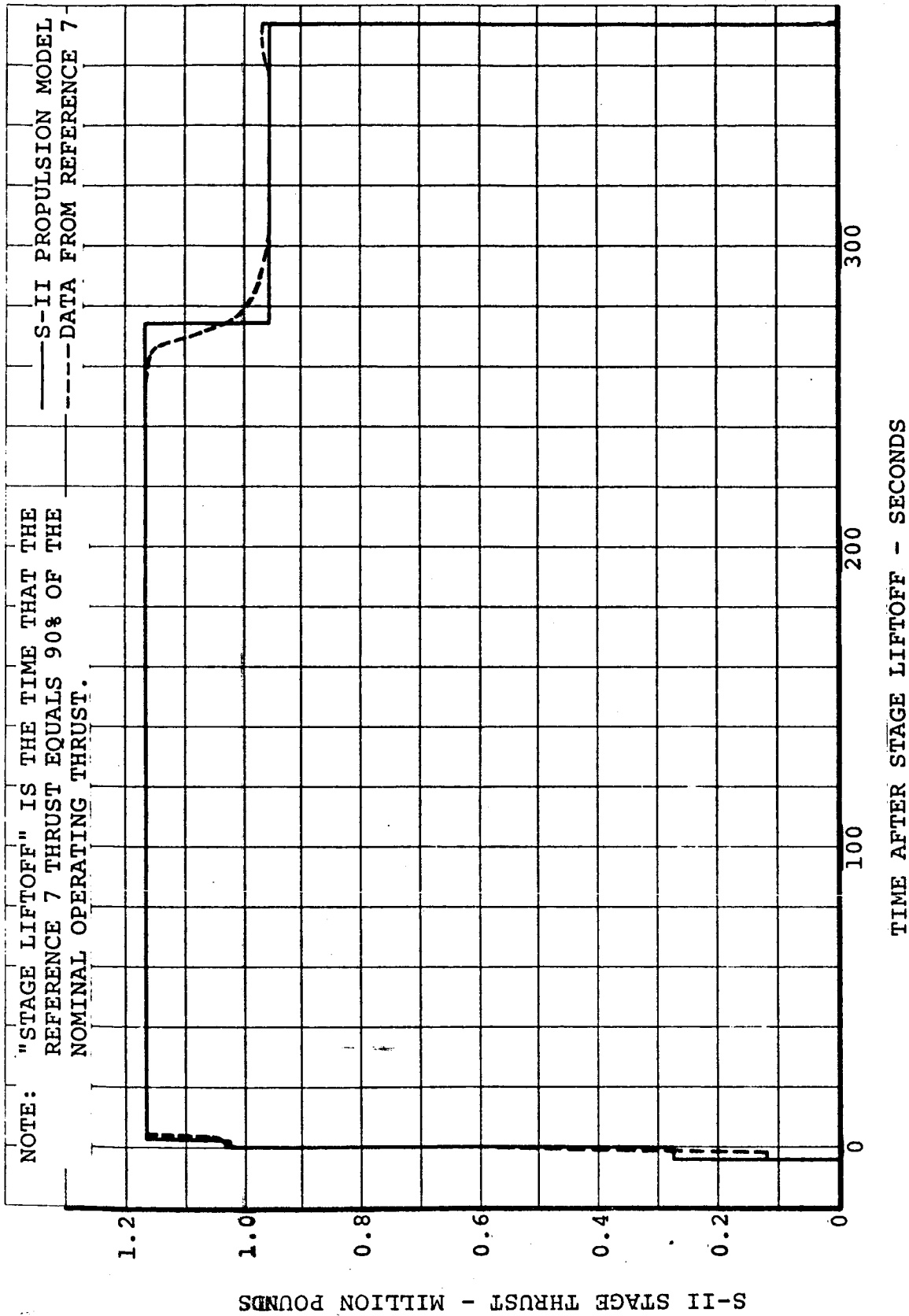


FIGURE 3-8. S-II STAGE THRUST HISTORY

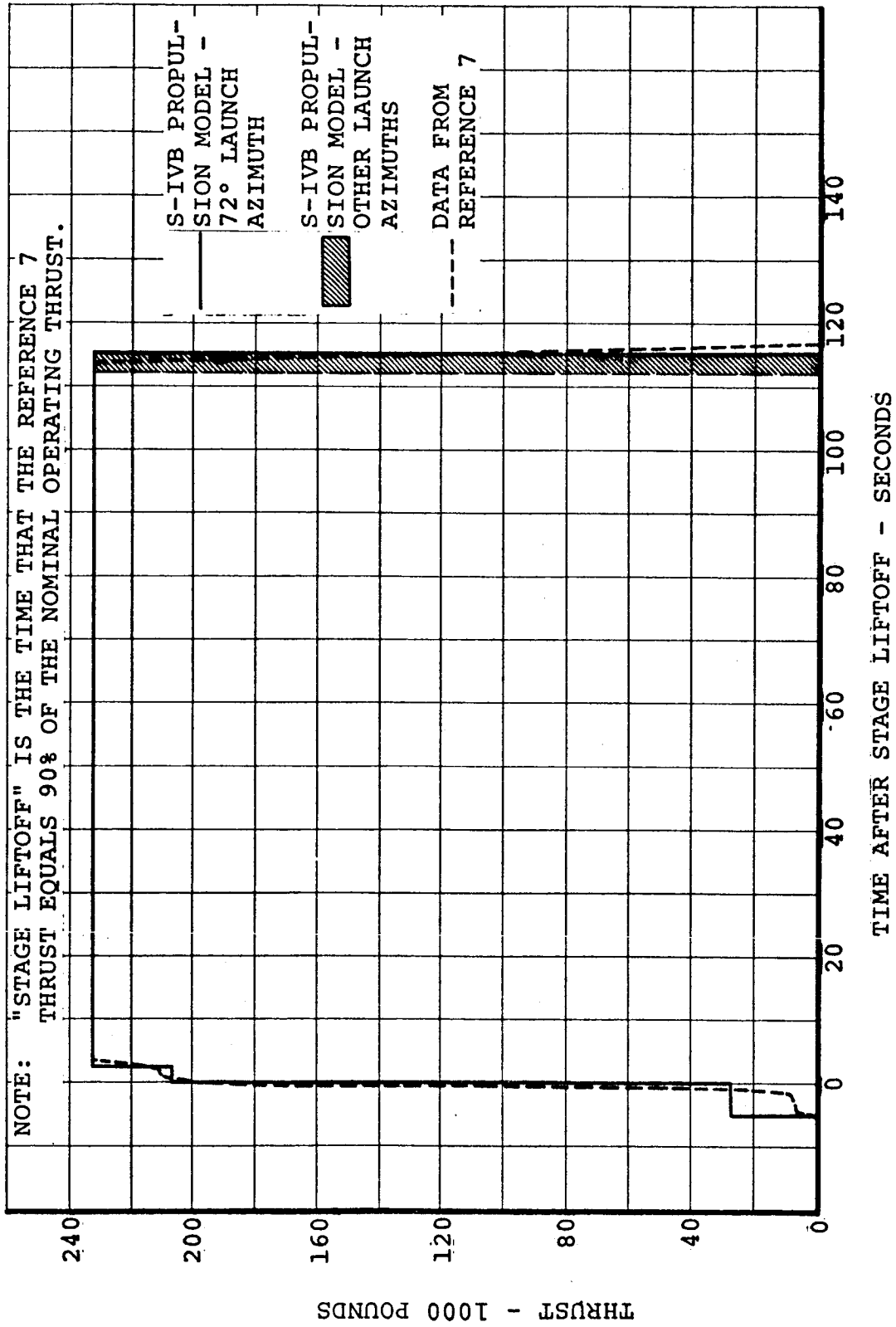
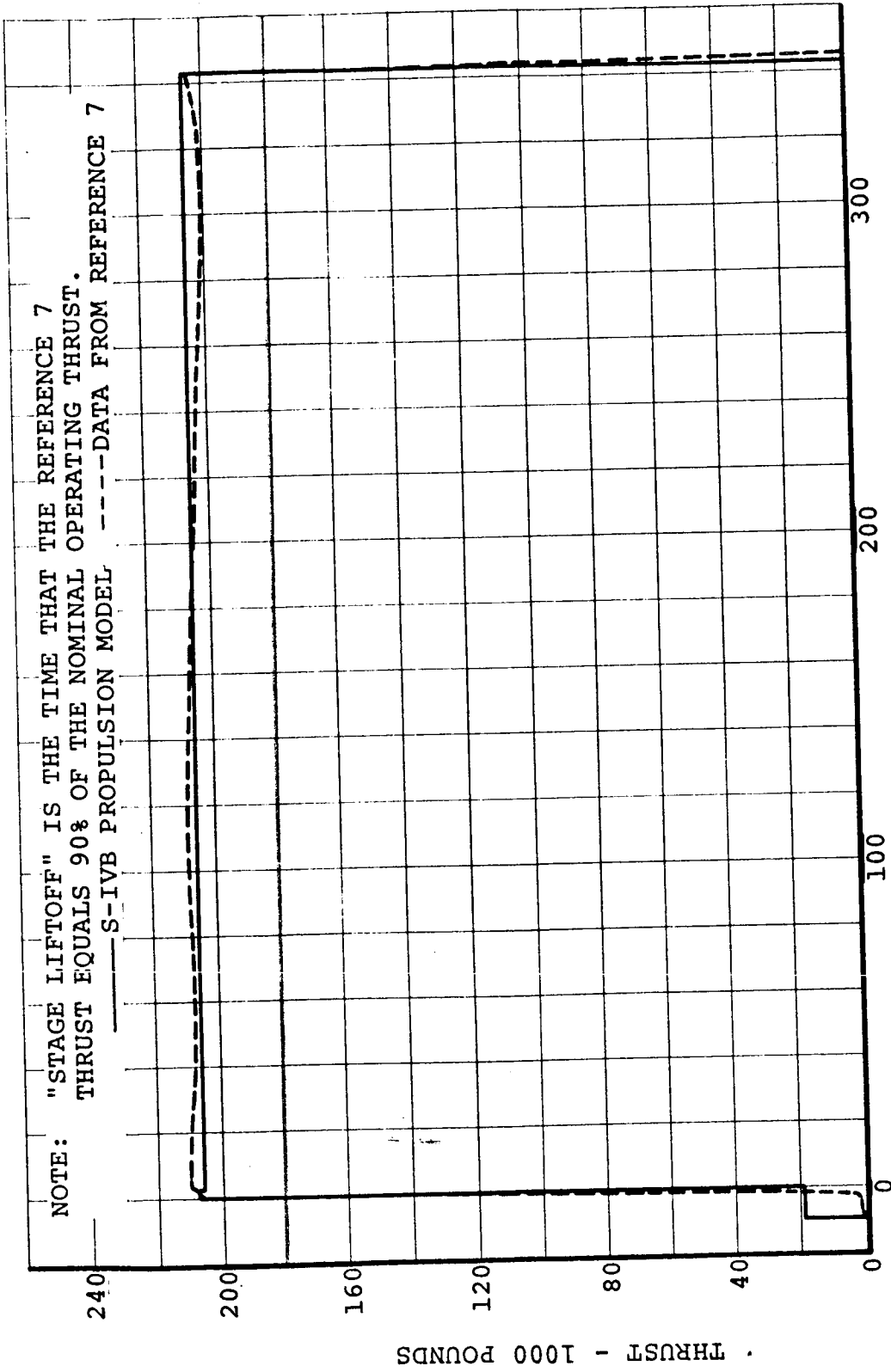


FIGURE 3-9. S-IVB FIRST-BURN THRUST HISTORY



TIME AFTER STAGE LIFTOFF - SECONDS

FIGURE 3-10. S-IVB SECOND-BURN THRUST HISTORY AFTER 2.0 REVOLUTIONS IN PARKING ORBIT

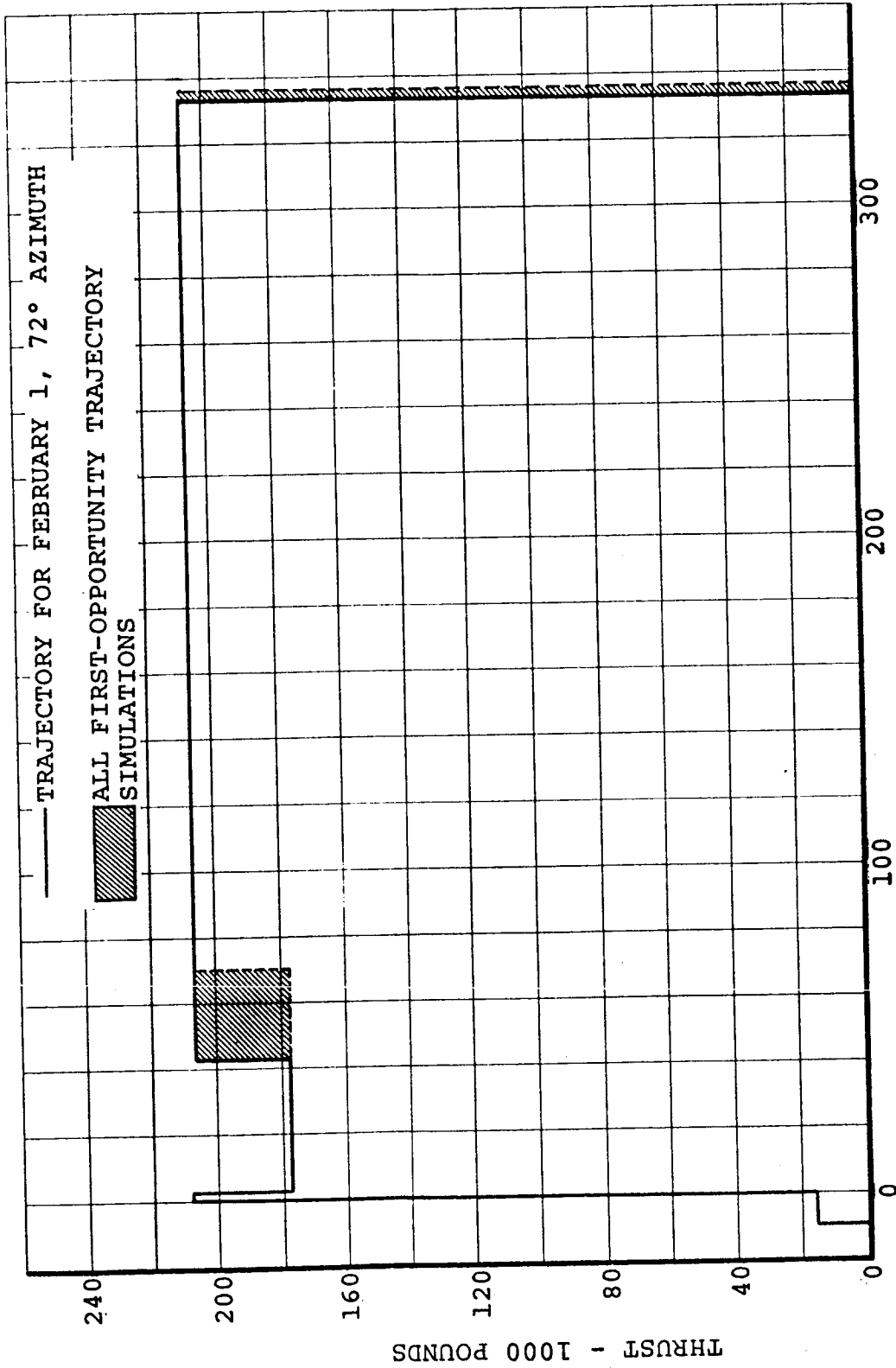
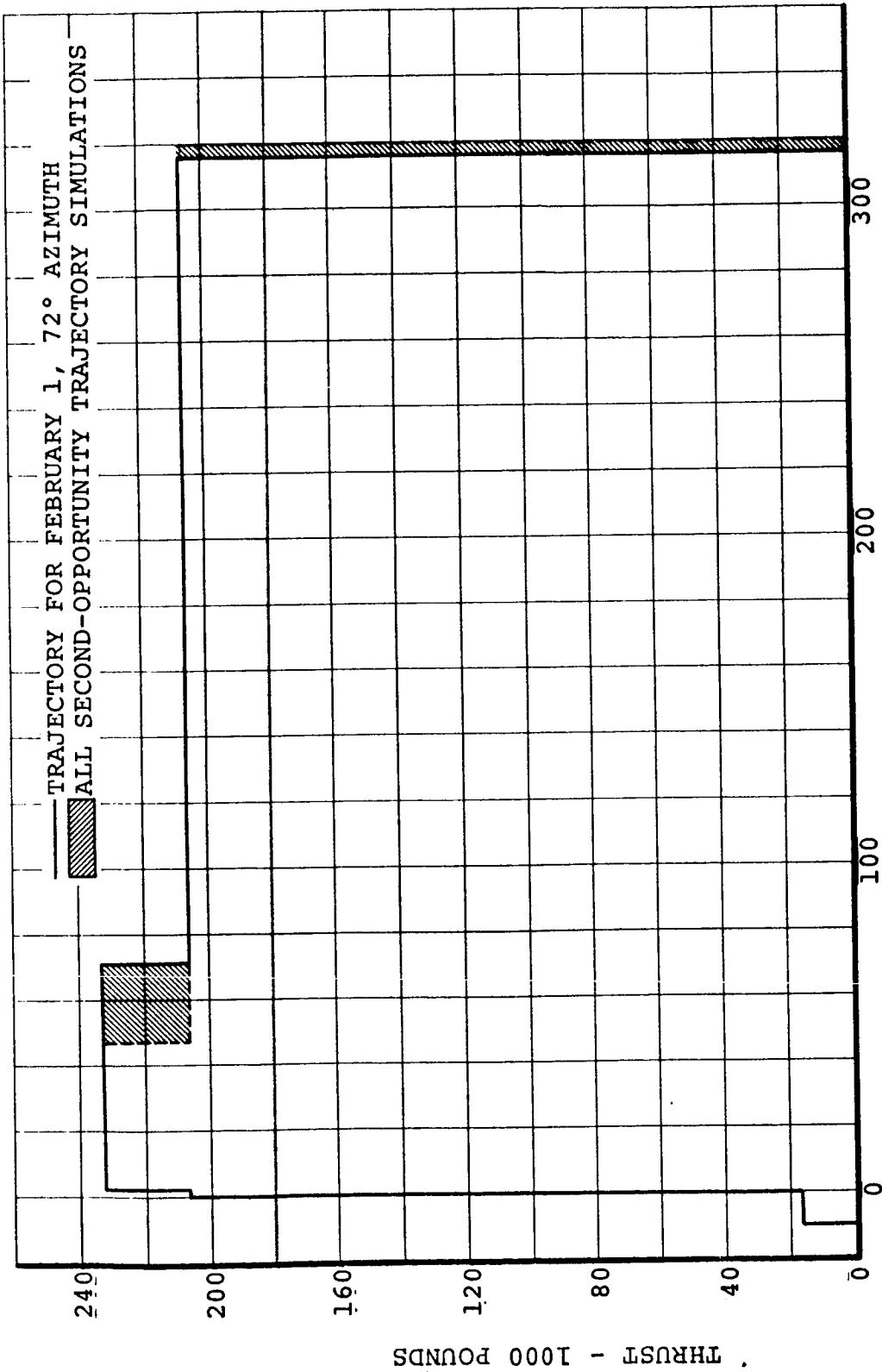
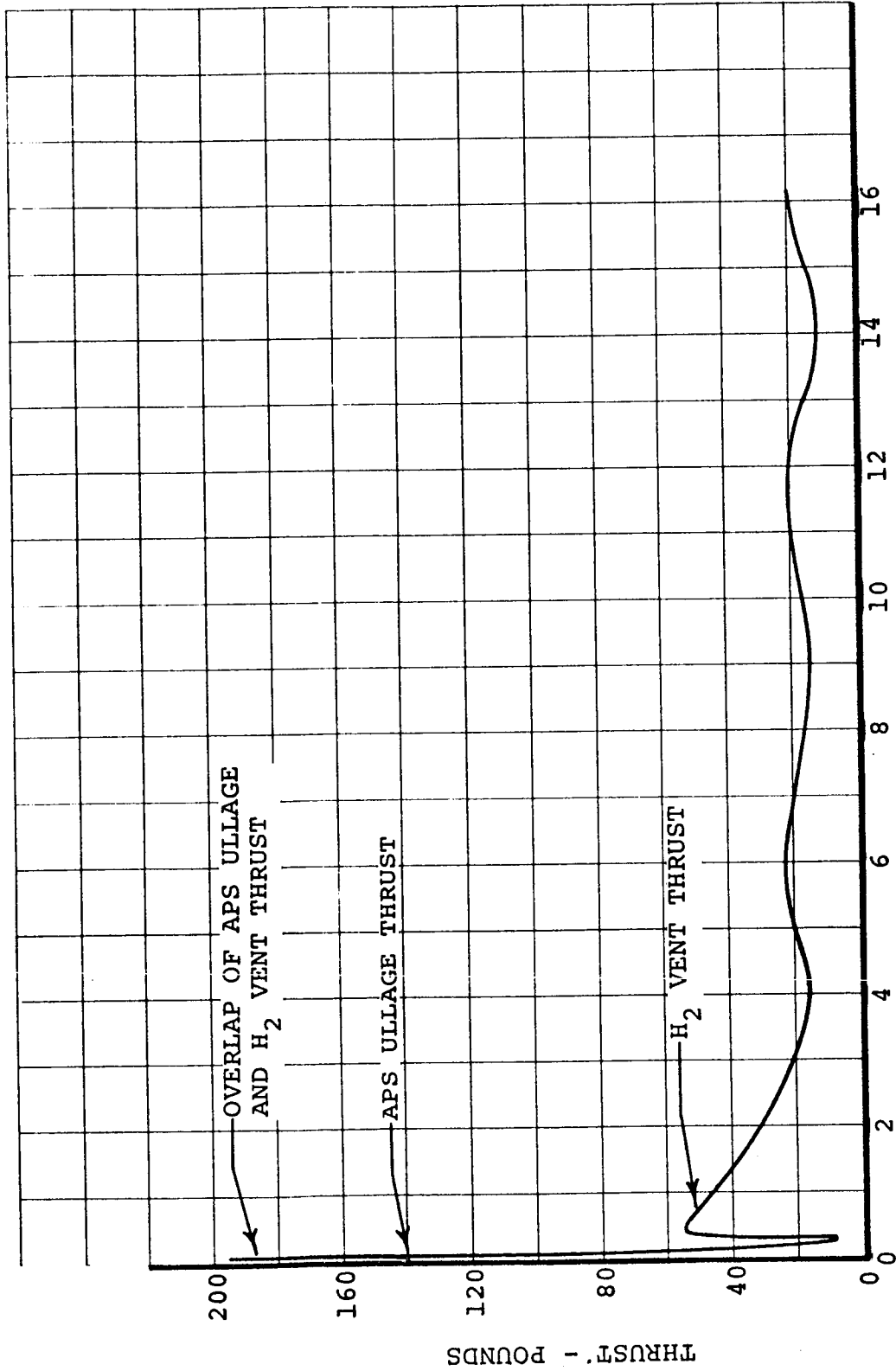


FIGURE 3-11. S-IVB SECOND-BURN THRUST HISTORY FOR FIRST-OPPORTUNITY INJECTION SIMULATIONS



TIME AFTER STAGE LIFTOFF - SECONDS

FIGURE 3-12. S-IVB SECOND-BURN THRUST HISTORY FOR SECOND-OPPORTUNITY INJECTION SIMULATIONS



TIME FROM PARKING ORBIT INSERTION - 1000 SECONDS

FIGURE 3-13. THRUST DURING PARKING ORBIT

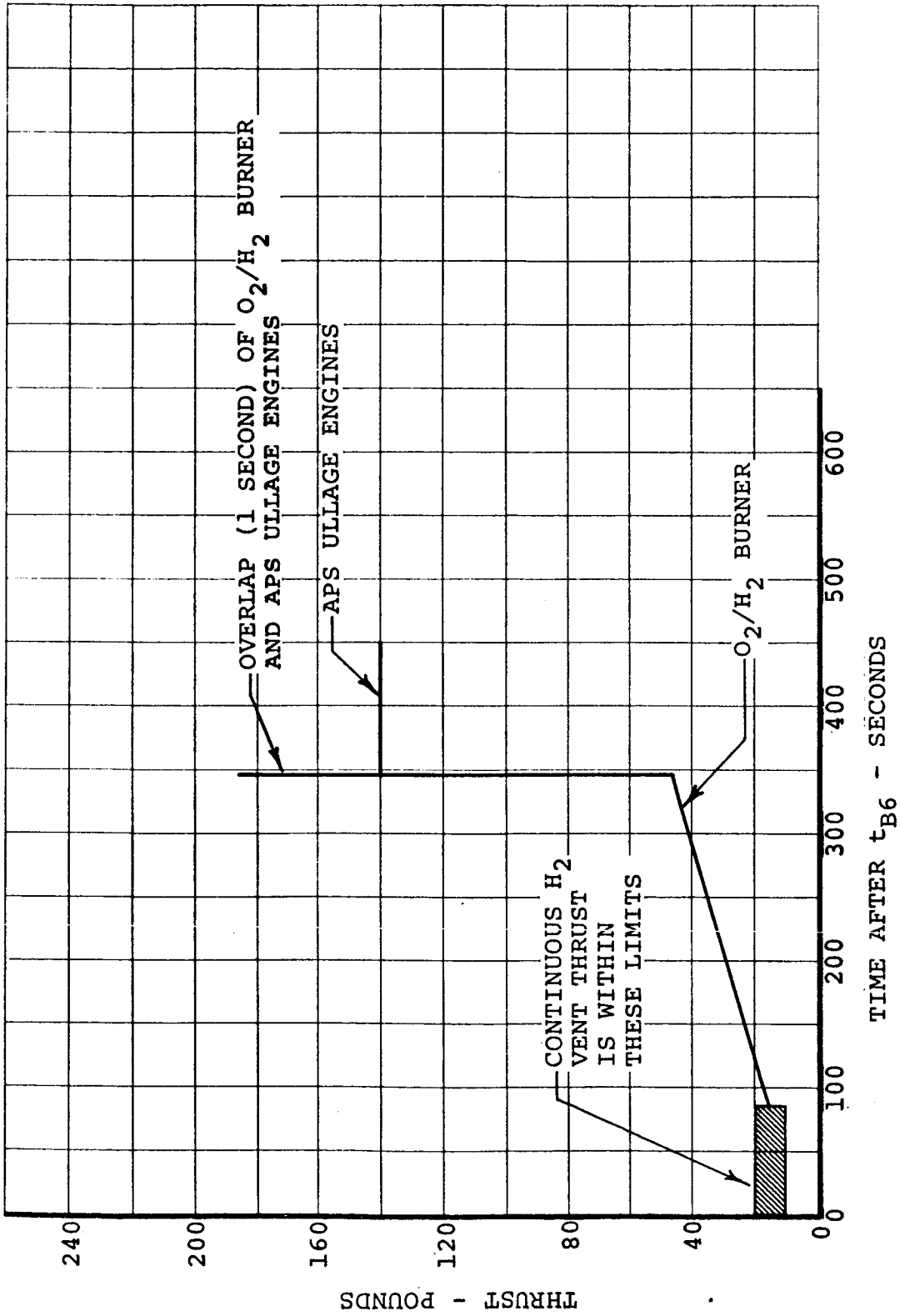


FIGURE 3-14. THRUST DURING THE PREIGNITION SEQUENCE

TABLE 3-II. FLIGHT SEQUENCE*

EVENT	TIME BASE	PROGRAM TIME (SECONDS)	REMARKS
LIFTOFF	1	0.0	SETS COMPUTER TIME BASE
SIGNAL TO CUTOFF INBOARD ENGINE	2	0.0	RESETS COMPUTER TIME BASE - SIGNAL IS INITI- ATED BY PROPELLANT SENSORS
SIMULATED INBOARD-ENGINE THRUST TERMINATION	2	0.27	
SIGNAL TO CUTOFF OUTBOARD ENGINES	3	0.0	RESETS COMPUTER TIME BASE - SIGNAL IS INITI- TIATED BY PROPELLANT SENSORS
SIMULATED S-IC OUTBOARD-ENGINE THRUST TERMINATION AND SIMULATED S-IC/S-II SEPARATION	3	0.27	
SIGNAL TO TRIGGER S-II ULLAGE ROCKET MOTORS	3	0.4	
NOMINAL TIME OF J-2 ENGINES AT 90 PERCENT THRUST	3	4.7	NOT A COMMANDED EVENT
SIGNAL TO ACTIVATE PROPELLANT UTILIZATION SYSTEM	3	6.8	
SIGNAL TO TRIGGER S-IC/S-II INTERSTAGE SEPARATION DEVICES	3	30.5	

*INCLUDES ONLY THE FLIGHT SEQUENCE EVENTS AND SIMULATION TIMES USED IN THIS STUDY.

TABLE 3-II. FLIGHT SEQUENCE (Continued)

EVENT	TIME BASE	PROGRAM TIME (SECONDS)	REMARKS
SIMULATED SEPARATION OF LAUNCH ESCAPE SYSTEM TOWER	3	35.5	NOT A COMMANDED EVENT
SIMULATED TIME OF ITERATIVE GUIDANCE MODE INITIATION	3	40.941	OCCURS AT AN INTEGER VALUE OF FLIGHT TIME APPROXIMATELY 5 SECONDS AFTER LES JETTISON
SIGNAL TO CUTOFF J-2 ENGINES	4	0.0	RESETS COMPUTER TIME BASE - SIGNAL IS INI- TIATED BY PROPELLANT SENSORS
SIMULATED J-2 ENGINE THRUST TERMINATION AND SIMULATED S-II/S-IVB SEPARATION	4	0.182	
SIGNAL TO TRIGGER S-IVB ULLAGE ROCKET MOTORS	4	0.2	
NOMINAL TIME OF J-2 ENGINE AT 90 PERCENT THRUST	4	5.9	NOT A COMMANDED EVENT
SIGNAL TO ACTIVATE PROPELLANT UTILIZATION SYSTEM	4	8.5	
SIGNAL TO JETTISON S-IVB ULLAGE ROCKET CASES	4	12.3	
SIGNAL TO CUTOFF J-2 ENGINE	5	0.0	RESETS COMPUTER TIME BASE - SIGNAL IS INITI- ATED BY FLIGHT COMPUTER

TABLE 3-II. FLIGHT SEQUENCE (Continued)

EVENT	TIME BASE	PROGRAM TIME (SECONDS)	REMARKS
SIMULATED THRUST TERMINATION - ORBIT INSERTION	5	0.0	
SIGNAL TO TURN ON 70-POUND ULLAGE ENGINES	5	0.0	PROGRAM TIME HAS BEEN CHANGED FROM 0.3 SECOND (REFERENCE 12) TO IMPROVE SIMULATION ACCURACY.
SIGNAL TO OPEN LH ₂ VENT VALVE FOR CONTINUOUS VENTING	5	59.0	PROGRAM TIME HAS BEEN CHANGED FROM 59.2 SECONDS (REFERENCE 12) TO IMPROVE SIMULATION ACCURACY.
SIGNAL TO SHUTOFF 70-POUND ULLAGE ENGINES	5	84.0	
SIGNAL TO BEGIN RESTART PREPARA- TIONS (PREIGNITION SEQUENCE INITIATION)	6	0.0	RESETS COMPUTER TIME BASE - SIGNAL IS INITIATED BY FLIGHT COMPUTER
SIGNAL TO CLOSE LH ₂ PROPULSIVE VENT VALVE - SIGNAL TO IGNITE O ₂ /H ₂ BURNER	6	85.0	
SIGNAL TO TURN ON 70-POUND ULLAGE ENGINES	6	346.0	
SIGNAL TO CUTOFF O ₂ /H ₂ BURNER	6	347.0	
SIGNAL TO INITIATE ENGINE START SEQUENCE	6	450.0	

TABLE 3-II. FLIGHT SEQUENCE (Continued)

EVENT	TIME BASE	PROGRAM TIME (SECONDS)	REMARKS
SIGNAL TO SHUTOFF 70-POUND ULLAGE ENGINES	6	460.0	CHANGED FROM NOMINAL TIME OF 460.2 SECONDS TO IM-PROVE SIMULATION ACCURACY
SIMULATED TIME OF J-2 ENGINE AT 90-PERCENT THRUST	6	460.0	CHANGED FROM NOMINAL TIME OF 460.4 SECONDS TO IM-PROVE SIMULATION ACCURACY
SIGNAL TO ACTIVATE PROPELLANT UTILIZATION SYSTEM	6	462.6	THE SIMULATED SIGNAL IS GIVEN 2.6 SECONDS AFTER THE SIMULATED TIME OF 90-PERCENT THRUST RATHER THAN 13.0 SECONDS AFTER ENGINE START SEQUENCE INITIATION (REFERENCE 12)
SIGNAL TO CUTOFF J-2 ENGINE	7	0.0	RESETS COMPUTER TIME BASE - SIGNAL IS INITIATED BY FLIGHT COMPUTER
SIMULATED J-2 THRUST TERMINATION - TRANSLUNAR INJECTION	7	0.0	

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TABLE 3-III. AS-504 LAUNCH VEHICLE WEIGHT CHARACTERISTICS
FOR LAUNCH ON 1 FEBRUARY 1968, 72-DEGREES
LAUNCH AZIMUTH

	FIRST OPPORTUNITY		SECOND OPPORTUNITY	
	EVENT WEIGHTS (POUNDS)	WEIGHT LOSSES (POUNDS)	EVENT WEIGHTS (POUNDS)	WEIGHT LOSSES (POUNDS)
AT LIFTOFF	6,401,386		6,401,386	
S-IC MAIN-STAGE PROPELLANT		4,577,722		4,577,722
S-IC FROST		650		650
S-II FROST		450		450
S-IVB FROST		300		300
N ₂ PURGE		37		37
INBOARD-ENGINE THRUST DECAY PROPELLANT		1652		1652
OUTBOARD-ENGINE THRUST DECAY PROPELLANT		6398		6398
AT S-IC BURNOUT	1,814,177		1,814,177	
S-II INSULATION PURGE GAS		120		120
S-IC INBOARD-ENGINE EXPENDED PROPELLANT		408		408
S-IC STAGE AT SEPARATION		352,542		352,542
S-IC/S-II INTERSTAGE (SMALL)		1600		1600

TABLE 3-III. AS-504 LAUNCH VEHICLE WEIGHT CHARACTERISTICS
FOR LAUNCH ON 1 FEBRUARY 1968, 72-DEGREES
LAUNCH AZIMUTH (Continued)

	FIRST OPPORTUNITY		SECOND OPPORTUNITY	
	EVENT WEIGHTS (POUNDS)	WEIGHT LOSSES (POUNDS)	EVENT WEIGHTS (POUNDS)	WEIGHT LOSSES (POUNDS)
S-II START TANK		25		25
AFTER S-IC/S-II SEPARATION	1,459,482		1,459,482	
S-II ULLAGE ROCKET PROPELLANT		2720		2720
S-II THRUST BUILDUP PROPELLANT		1659		1659
AT S-II 90% THRUST	1,455,103		1,455,103	
S-II PROPELLANT CONSUMED TO P.U. UNLOCK		5072		5072
S-IC/S-II INTERSTAGE (LARGE)		9900		9900
LAUNCH ESCAPE SYSTEM		8650		8650
S-II PROPELLANT CONSUMED AT MR = 5.543		743,851		743,851
S-II PROPELLANT CONSUMED AT MR = 4.690		221,599		221,599

TABLE 3-III. AS-504 LAUNCH VEHICLE WEIGHT CHARACTERISTICS
FOR LAUNCH ON 1 FEBRUARY 1968, 72-DEGREES
LAUNCH AZIMUTH (Continued)

	FIRST OPPORTUNITY		SECOND OPPORTUNITY	
	EVENT WEIGHTS (POUNDS)	WEIGHT LOSSES (POUNDS)	EVENT WEIGHTS (POUNDS)	WEIGHT LOSSES (POUNDS)
S-II THRUST DECAY PRO- PELLANT		404		404
AT S-II BURN- OUT	465,627		465,627	
S-II STAGE AT SEPARA- TION		94,468		94,468
S-II/S-IVB INTERSTAGE		7559		7559
AFT FRAME		48		48
S-IVB DETO- NATION PACK- AGE		5		5
FUEL LEAD LOSS		3		3
H ₂ IN START TANK		4		4
AFTER S-II/S-IVB SEPARATION	363,540		363,540	
S-IVB ULLAGE ROCKET PRO- PELLANT		122		122
S-IVB THRUST BUILDUP PROPELLANT		436		436
AT S-IVB 90° THRUST	362,982		362,982	

TABLE 3-III. AS-504 LAUNCH VEHICLE WEIGHT CHARACTERISTICS
FOR LAUNCH ON 1 FEBRUARY 1968, 72-DEGREES
LAUNCH AZIMUTH (Continued)

	FIRST OPPORTUNITY		SECOND OPPORTUNITY	
	EVENT WEIGHTS (POUNDS)	WEIGHT LOSSES (POUNDS)	EVENT WEIGHTS (POUNDS)	WEIGHT LOSSES (POUNDS)
S-IVB PROPELLANT CONSUMED TO P.U. UNLOCK		1259		1259
ULLAGE ROCKET CASES		127		127
S-IVB MAIN-STAGE PROPELLANT		61,699		61,699
APS POWER ROLL PROPELLANT		17		17
S-IVB THRUST DECAY PROPELLANT		103		103
AT PARKING ORBIT INSERTION	299,777		299,777	
PROPELLANT BELOW ENGINE VALVE		39		39
APS PROPELLANT LOSSES IN ORBIT		420		420
LOX/HYDROGEN BURNER PROPELLANT		16		16
OXIDIZER VENTED IN ORBIT		265		265
H ₂ + He VENTED IN ORBIT		2413		3426

TABLE 3-III. AS-504 LAUNCH VEHICLE WEIGHT CHARACTERISTICS
FOR LAUNCH ON 1 FEBRUARY 1968, 72-DEGREES
LAUNCH AZIMUTH (Continued)

	FIRST OPPORTUNITY		SECOND OPPORTUNITY	
	EVENT WEIGHT (POUNDS)	WEIGHT LOSSES (POUNDS)	EVENT WEIGHTS (POUNDS)	WEIGHT LOSSES (POUNDS)
START TANK		2		2
FUEL LEAD LOSS		30		30
S-IVB H ₂ IN START TANK		4		4
S-IVB THRUST BUILDUP PROPELLANT		483		483
J-2 AT 90% THRUST AFTER REIGNITION	296,105		295,092	
S-IVB MAIN- STAGE PRO- PELLANT CON- SUMED TO IN- JECTION		157,217		156,204
FLIGHT GEOME- TRY RESERVE (FGR) PRO- PELLANT CON- SUMED TO IN- JECTION *		494		474
FLIGHT PER- FORMANCE RESERVE PRO- PELLANT CON- SUMED TO IN- JECTION		0		0
S-IVB THRUST DECAY PRO- PELLANT		87		87

* SEE SECTION 9 FOR A DESCRIPTION OF THE METHOD USED TO DEFINE FGR PROPELLANT CONSUMED.

TABLE 3-III. AS-504 LAUNCH VEHICLE WEIGHT CHARACTERISTICS
FOR LAUNCH ON 1 FEBRUARY 1968, 72-DEGREES
LAUNCH AZIMUTH (Continued)

	FIRST OPPORTUNITY		SECOND OPPORTUNITY	
	EVENT WEIGHTS (POUNDS)	WEIGHT LOSSES (POUNDS)	EVENT WEIGHTS (POUNDS)	WEIGHT LOSSES (POUNDS)
AT J-2 SECOND CUTOFF	138,307		138,327	
APS POWER ROLL PROPELLANT LOSSES DURING INJECTION BOOST		32		32
PROPELLANT BELOW EN- GINE VALVE		39		39
USABLE PROPEL- LANT NOT NEEDED FOR MISSION (IN- CLUDING RESERVES)		8607		8627
APS POWER ROLL PROPELLANT LOSSES DURING TRANS- LUNAR COAST		32		32
S-IVB STAGE AT SEPARATION (EMPTY, WET)		27,447		27,447
INSTRUMENT UNIT		4150		4150
SPACECRAFT AND SLA		98,000		98,000

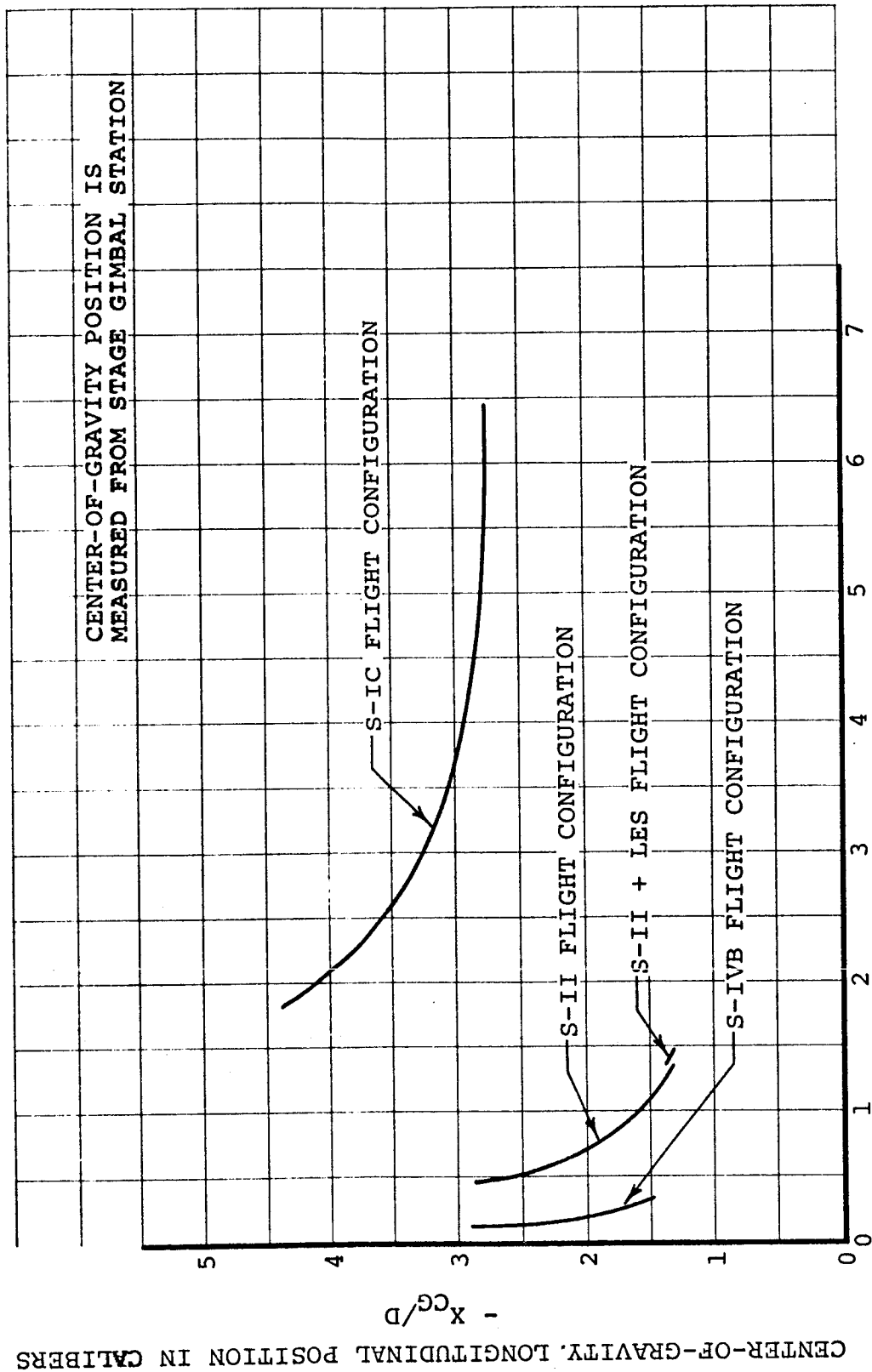


FIGURE 3-15. VARIATION OF AS-504 VEHICLE CENTER-OF-GRAVITY LONGITUDINAL POSITION WITH WEIGHT

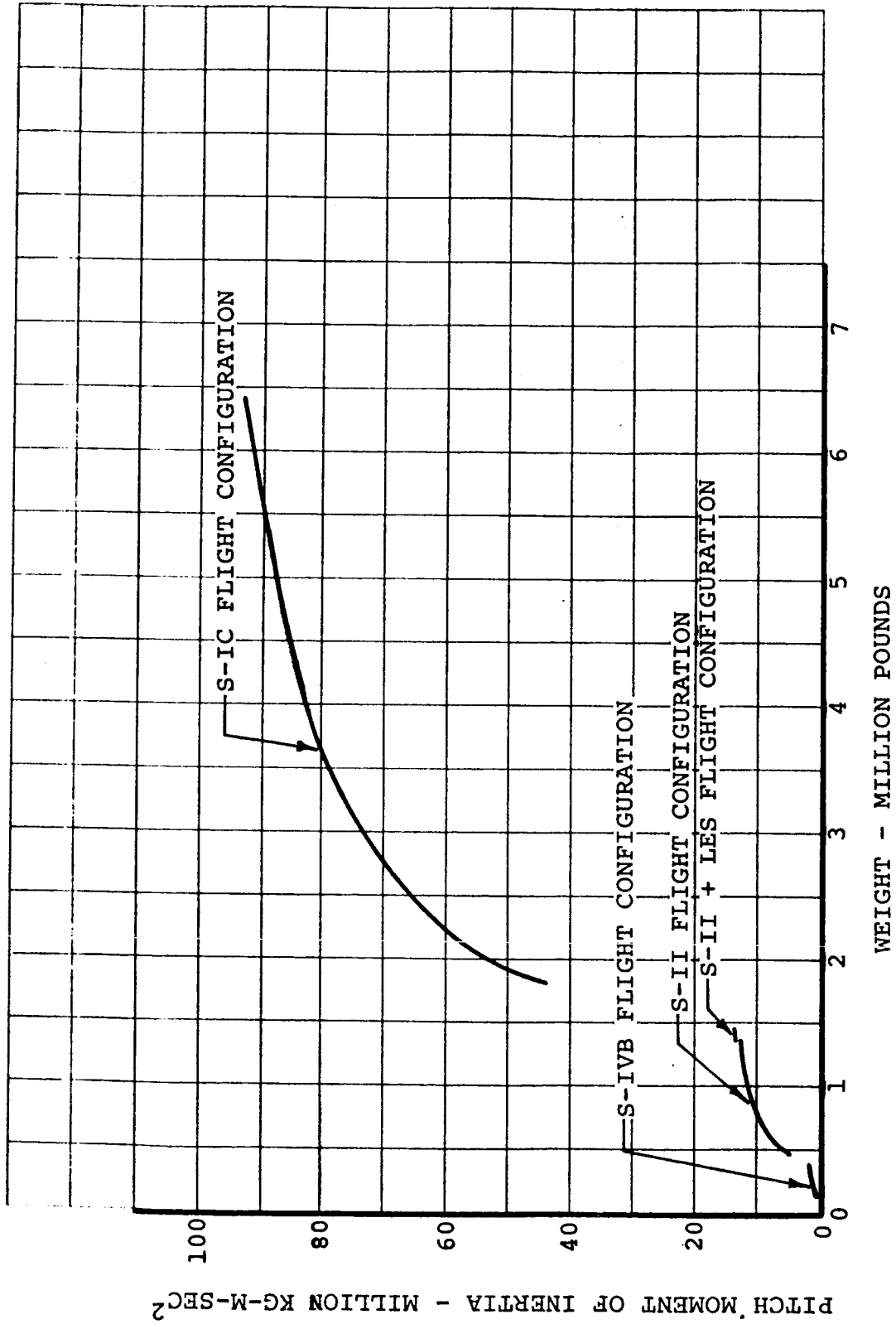


FIGURE 3-16. VARIATION OF AS-504 VEHICLE PITCH MOMENT OF INERTIA WITH WEIGHT

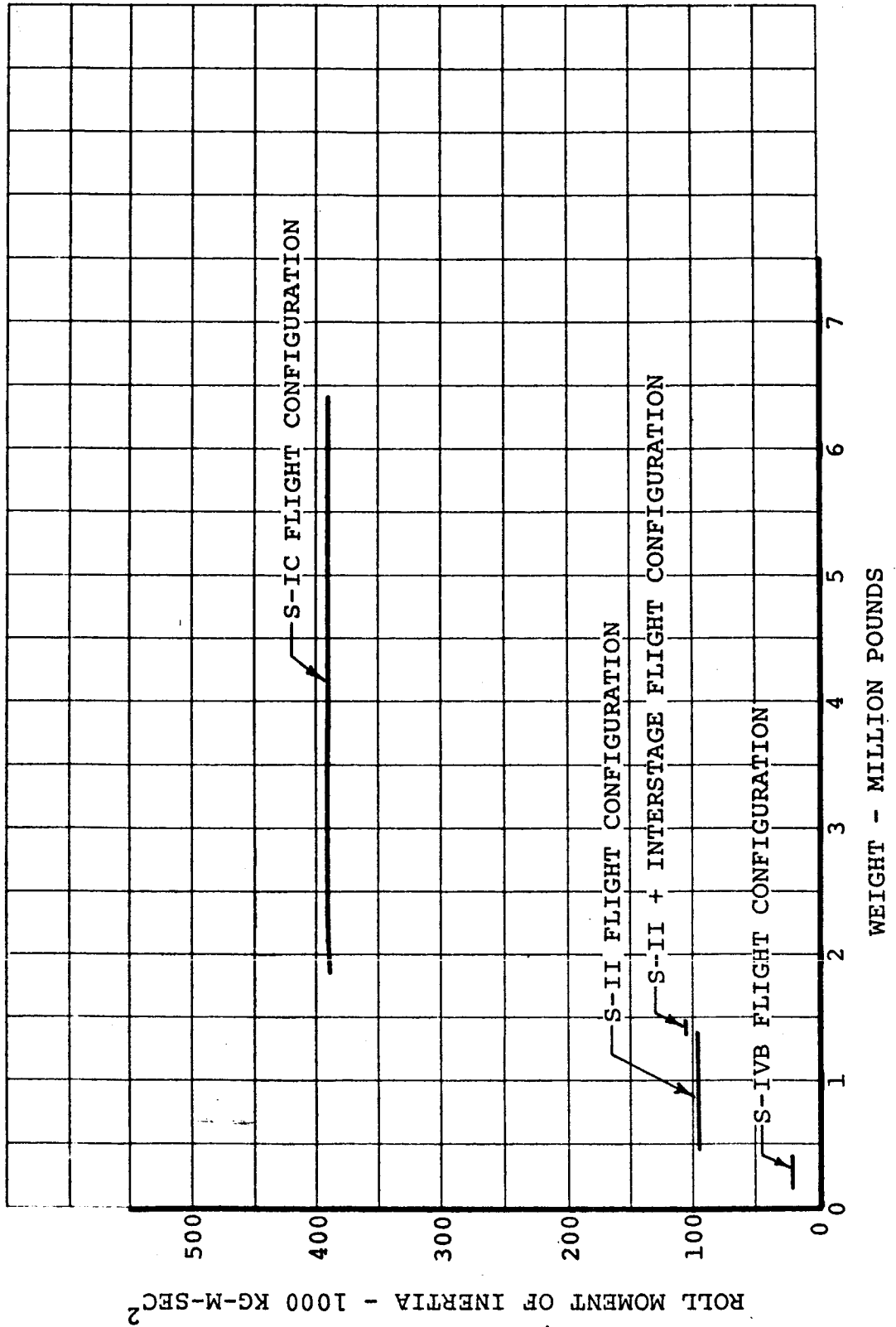


FIGURE 3-17. VARIATION OF AS-504 VEHICLE ROLL MOMENT OF INERTIA WITH WEIGHT

TABLE 3-IV. ATTITUDE AND ATTITUDE-RATE CONTROL GAINS

STAGE	STAGE FLIGHT TIME		PITCH AND YAW ATTITUDE CONTROL GAINS		PITCH AND YAW ATTITUDE-RATE CONTROL GAINS		ROLL ATTITUDE CONTROL GAINS		ROLL ATTITUDE-RATE CONTROL GAINS	
	FROM	TO	ATTITUDE	CONTROL GAINS	ATTITUDE	CONTROL GAINS	ATTITUDE	CONTROL GAINS	ATTITUDE	CONTROL GAINS
S-IC	0	100	0.82		0.657		0.245		0.15	
	100	160	0.45		0.438		0.245		0.15	
S-II	0	60	1.12		1.89		0.25		0.20	
	60	190	0.65		1.10		0.25		0.20	
	190	400	0.44		0.74		0.25		0.20	
S-IVB	0	600	0.81		0.97		Not simulated		Not simulated	

SECTION 4

SIMULATION TECHNIQUES AND MODELS

4.0 SIMULATION TECHNIQUES

The trajectories simulated during the AS-504 Launch Vehicle Reference Trajectory study are generated using two computer programs: the Boeing BHA 0035 program and the Apollo Reference Mission Program (ARMP). The BHA 0035 program is used to simulate the launch vehicle boost phases and the parking orbit coast phase. The ARMP is used to simulate the translunar and transearth coast phases.

The BHA 0035 program simulates launch vehicle boost flight in six degrees of freedom (vehicle rotation and translation) using two-body equations of motion. Launch vehicle coast flight is simulated in three degrees of freedom (translation only). Flight control about the vehicle center of mass during boost flight is provided by an attitude/attitude-rate control system, and vehicle response to the commanded engine deflections is simulated. A perfect flight navigation system is assumed for this study. The vehicle guidance equations used in this study are those defined in Reference 14, with the following major exceptions: steering misalignment correction equations (Reference 15) are employed by the Iterative Guidance Mode during S-II and S-IVB stage flight, and the S-IVB cutoff times at parking orbit insertion and translunar injection are determined using high-speed-cutoff-loop equations (Reference 16).

The ARMP program simulates vehicle flight in three degrees of freedom (translation). The translunar and transearth coast phases of the trajectories prepared during this study are simulated using four-body equations of motion (the gravitational accelerations of the Earth, Moon, and Sun on the vehicle are integrated to determine the space trajectory). The space coast phases of these trajectories are initiated at the translunar injection conditions determined by the BHA 0035 program, and are terminated at the radius of closest approach to the earth after circumlunar flight. The ARMP program is also used to perform midcourse correction isolations for the final trajectories and to prepare the IGM injection-targeting data required for the BHA 0035 simulations. This latter use requires combined operation of the space coast capability and an S-IVB stage injection-boost simulation capability. The injection-boost simulation capability uses point-mass, two-body (earth/vehicle) equations of motion and IGM or Calculus of Variations to provide thrust-orientation commands.

4.1 SIMULATION MODELS

The Earth and Moon physical and gravitational models were obtained from Reference 17. Earth climatic data were obtained from Reference 18. Moon and Sun ephemeris data were obtained from an unreferenced magnetic tape generated by the Manned Spacecraft Center and transmitted to the Marshall Space Flight Center for use in intercenter trajectory analyses.

SECTION 5

MISSION ANALYSIS AND DESCRIPTION

5.0 GENERAL

The AS-504 Launch Vehicle Reference Trajectory is designed to comply with the mission objectives and constraints defined in Section 2. Paragraphs 5.1 through 5.5 describe the Launch Vehicle Reference Trajectory phases in detail.

5.1 LAUNCH

The simulated trajectories are launched from Complex 39, Pad A, of the Kennedy Space Center. Trajectories are simulated for launch azimuths of 72, 81, 90, 99 and 108 degrees during each launch day considered. The launch days considered in this study are: February 1, 2, 3, 4; March 1, 3, 5, 7 and 31; and April 2, 4, and 6. The Pacific-injection-window launch schedules determined in this study for each launch day are tabulated in Table 5-I and shown in Figures 5-1 through 5-3.

5.2 BOOST TO EARTH PARKING ORBIT

The boost to earth parking orbit consists of complete burns of the S-IC and S-II stages and a partial burn of the S-IVB stage. The S-IVB stage inserts the vehicle into a circular parking orbit. The major flight event times prior to parking orbit insertion are neither launch azimuth nor launch date dependent.

The vehicle rises vertically for 450 feet to clear the tower and then begins a tilt and roll maneuver to attain the flight attitude and proper orientation for the selected flight azimuth. The tilt maneuver lasts for approximately 23 seconds. From the end of this maneuver to a flight time of 153 seconds the vehicle flies a nearly zero-lift (gravity-turn) trajectory. At 153 seconds the commanded pitch attitude is inertialized (tilt arrest) to dampen out pitch rates prior to S-IC/S-II separation. The commanded pitch attitude remains constant from 153 seconds after liftoff until Iterative Guidance Mode (IGM) initiation during S-II stage flight. In this simulation, commanded pitch commands during S-IC and pre-IGM S-II flight are provided from a table of pitch attitude as a function of flight time; during actual flight these commands are provided by multi-segment polynomials. The commanded yaw gimbal angle is zero during this flight phase and the commanded roll gimbal angle is zero after the initial roll maneuver.

5.2 (Continued)

The simulated maximum dynamic pressure occurs during the flight period from 82.00 to 82.25 seconds for the five launch azimuths. The maximum calculated dynamic pressures vary from 700.2 to 700.4 PSF.

The S-IC engine cutoff sequences are initiated by LOX or RP-1 propellant sensors. The standpipe in the center LOX suction line has been extended for the AS-504 vehicle and the LOX upper-level sensor has been relocated to permit earlier inboard engine cutoff. The time used in this simulation between inboard-engine thrust termination and outboard-engine thrust termination is 12.0 seconds. Inboard-engine thrust termination occurs at a flight time of 147.329 seconds and outboard-engine thrust termination occurs at 159.329 seconds.

In this simulation S-IC/S-II separation occurs at outboard-engine thrust termination. Other simulated events during S-IC/S-II staging occur at the sequence times prescribed in Reference 12. The Reference 12 S-IC/S-II staging sequence is referenced to time base 3, the time of the S-IC outboard-engine cutoff signal. In this simulation this signal occurs 0.27 second prior to outboard-engine thrust termination (the S-IC stage outboard-engine thrust-decay propellant is consumed at full thrust in this simulation, and consumption requires 0.27 second). The following events and event times (referenced to time base 3) during early S-II stage flight are specifically included in this simulation: S-II ullage rocket ignition (0.4 second), J-2 at 90 percent of the operating thrust level (4.7 seconds), Propellant Utilization (PU) System activation (6.8 seconds), S-IC/S-II forward interstage separation (30.5 seconds), and Launch Escape System (LES) tower jettison (35.5 seconds). Some of these simulated event times are nominal times and do not correspond to a signal from the flight computer.

The S-II stage propulsion model used in this simulation provides thrust in four constant-thrust-level segments. (See Section 3.) The first segment is applied from the time of ullage rocket ignition to the time that the J-2 engine nominally reaches 90 percent of its operating thrust level (this time is also called "Stage Liftoff"). The total impulse value provided by the model during this segment equals the total ullage-rocket and J-2-thrust-buildup impulse predicted in Reference 7. The other segments are applied from the nominal time of 90-percent thrust to PU System activation, from PU System activation until the mixture-ratio shift, and from the mixture-ratio shift until thrust termination. The simulated mixture-ratio shift occurs when the LOX/LH₂ ratio of the propellant remaining in the S-II tanks

5.2 (Continued)

equals the desired propellant flowrate ratio for the final thrust segment. The flowrate mixture-ratio shift and the corresponding change in the thrust level occur instantaneously at a flight time of 437.627 seconds in this simulation.

In this simulation the guidance mode switches from the open-loop mode used during S-IC and early S-II stage flight to the Iterative Guidance Mode at a flight time of 200 seconds. This switch time is approximately 5 seconds after the nominal LES jettison time. Steering commands are provided by the IGM during boost flight from this time until translunar injection.

The S-II engine cutoff sequence is initiated by propellant sensors in either the LOX or LH₂ tank. A depletion signal from any two of the five sensors in either propellant tank initiates the cutoff sequence simultaneously for all five J-2 engines, and also causes the flight computer to reset its time base (time base 4). In this simulation the S-II cutoff signal (time base 4) occurs 0.182 second prior to thrust termination (the S-II stage thrust-decay propellant is consumed at full thrust in this simulation, and consumption requires 0.182 second).

In this simulation S-II/S-IVB separation occurs at S-II thrust termination. Other simulated events during S-II/S-IVB staging occur at the sequence times prescribed in Reference 12. The following events and event times (referenced to time base 4) during early S-IVB stage flight are specifically included in this simulation: S-IVB ullage-rocket ignition (0.2 second), J-2 at 90 percent of the operating thrust level (5.9 seconds), PU System activation (8.5 seconds), and S-IVB ullage-rocket-case jettison (12.3 seconds). The simulated time that the J-2 engine reaches 90 percent of the operating thrust level is a nominal time and does not correspond to a signal from the flight computer.

The S-IVB stage propulsion model used in this simulation is similar to the S-II stage model. During the S-IVB first burn this model provides thrust in three constant-thrust-level segments. These segments are applied from S-IVB ullage-rocket ignition to the time that the J-2 engine nominally reaches 90 percent of the operating thrust level, from 90-percent thrust to PU System activation, and from PU System activation to thrust termination. At PU System activation the PU valve moves to a full-open position causing the maximum LOX/LH₂ flowrate mixture ratio and the maximum engine thrust. The PU valve remains fully open throughout the boost to parking orbit. The flowrate mixture ratio used in this simulation for this flight phase is 5.480.

5.2 (Continued)

In this simulation the S-IVB cutoff sequence is initiated by the flight computer at the flight time that the computer predicts the vehicle will achieve orbital velocity, and S-IVB thrust termination occurs instantaneously when the cutoff command is given. At the time of the S-IVB J-2 cutoff command, the computer also resets its time base (time base 5). Therefore, in this simulation J-2 thrust termination at orbital insertion and time base 5 occur simultaneously. The J-2 thrust-decay propellant is considered to be the last propellant consumed prior to thrust termination.

At S-IVB first cutoff the vehicle is in a nearly circular parking orbit with an altitude of 185.2 KM (100 NMI) referenced to the mean equatorial radius. Parking orbit insertion time varies with launch azimuth. Table 5-II summarizes the parking orbit insertion conditions for the five launch azimuths considered. Figures 5-4 and 5-5 show altitude as functions of range from Cape Kennedy and flight time. Figures 5-6 through 5-8 show inertial velocity, inertial flight-path angle, and angle of attack as functions of flight time during the boost to parking orbit.

Figures 5-9 through 5-11 show aerodynamic dynamic pressure, aerodynamic axial force, and aerodynamic heating indicator as functions of flight time during S-IC and early S-II stage flight. The effects of these parameters on the trajectory profile are negligible after 190 seconds of flight. Figure 5-12 shows the commanded and actual pitch-attitude profiles during S-IC and pre-IGM S-II stage flight. Figure 5-13 summarizes the weight at parking orbit insertion as a function of launch azimuth.

5.3 COAST IN EARTH PARKING ORBIT

Earth-parking-orbit insertion occurs at the first S-IVB thrust termination, and in this simulation, parking orbit insertion is coincident with time base 5. The following post-insertion events and event times (referenced to time base 5) are specifically included in this simulation: start 70-pound-thrust APS ullage engines (0.0 second), open LH₂ vent valve for continuous propulsive venting (59.0 seconds), cutoff 70-pound-thrust APS ullage engines (84.0 seconds). The event times shown are based on the Reference 12 sequence, but the first two event times are slightly modified to improve simulation accuracy.

Three revolutions of parking orbit are simulated for each of the five azimuths, but the actual stay time in parking orbit is a function of the Earth-Moon geometry, the injection window (Atlantic or Pacific), the launch azimuth,

5.3 (Continued)

and the desired injection opportunity. For the specific lunar missions being considered, the longest stay time in orbit is approximately 2.6 revolutions. During the orbital stay the propulsive H₂ vent provides continuous low-magnitude thrust to keep the S-IVB propellant seated against the aft bulkheads. The net effect of this thrust on the orbit altitude is a mean increase of approximately 14 KM during 2.6 revolutions.

The normal vehicle attitude during the stay in parking orbit is defined as having Position I pointed toward the center of the earth (astronauts' heads are down), the vehicle longitudinal axis in the inertial orbital plane and perpendicular to the radius vector, and the nose ahead. A maneuver to the appropriate attitude for landmark sighting is performed between 45 minutes and 1.5 hours after insertion in accordance with the attitude timeline requirements specified in Reference 19. The maneuver to the sighting attitude consists of a 180-degree roll maneuver followed by a pitch maneuver that places the vehicle longitudinal body axis 20 degrees below the local horizon. This attitude, referenced to the local horizon, is maintained until the return maneuver to the normal coast attitude.

Altitude and inertial velocity during three revolutions in parking orbit are given in Figures 5-14 and 5-15. These figures contain profiles for the specific launch azimuths of 72, 90, and 108 degrees and show the variation in orbital characteristics that can result from boost flight to identical orbital target values of radius, inertial velocity, and inertial flight-path angle. The vehicle roll attitude and pitch angle of attack during parking orbit are shown in Figure 5-16.

5.4 PREIGNITION SEQUENCE AND TRANSLUNAR INJECTION BOOST

The translunar injection boost is part of an ordered flight sequence that begins at preignition-sequence initiation. The flight computer signals the beginning of the preignition sequence when it determines that the vehicle position satisfies a predesignated geometrical relationship with the target vector. (See Section 11 for a complete explanation of the preignition-sequence-initiation/target-vector geometry.) At the time of this signal the computer resets its time base (time base 6) and begins to issue the signals that lead to reignition. The following events and event times (referenced to time base 6) during the preignition sequence and the early part of the S-IVB stage second burn are specifically included in this simulation: close continuous H₂ propulsive vent (85.0 seconds), ignite O₂/H₂ burner (85.0 seconds),

5.4 (Continued)

turn on 70-pound-thrust APS ullage engines (346.0 seconds), cutoff O_2/H_2 burner (347.0 seconds), initiate engine start sequence (450.0 seconds), the time that the J-2 engine nominally reaches 90 percent of the operating thrust level (460.0 seconds), and PU System activation (462.6 seconds). Sequence times from time base 6 (t_{B6}) to $t_{B6} + 450.0$ seconds were taken from Reference 11. The time between J-2 start-sequence initiation and 90-percent thrust is based on the Reference 12 data, but is slightly changed to improve simulation accuracy. The time between 90-percent thrust and PU System activation is taken from Reference 12.

During the preignition sequence, thrust from the continuous H_2 vent keeps the propellant seated until O_2/H_2 burner ignition. The vent is then closed to enable the burner to pressurize both the LOX and LH_2 propellant tanks. The burner is a pressure-fed system and the nominal burner thrust magnitude continues to increase as the pressure in the propellant tanks increases. The burner is part of a dual repressurization system; if the burner fails to operate properly, ambient helium is provided from bottles to complete tank repressurization. The APS ullage engines are turned on one second prior to burner cutoff, and operate throughout J-2 thrust buildup.

The S-IVB stage propulsion model used during simulation of the translunar injection boost provides thrust in four constant-thrust-level segments. These segments are applied from J-2 start-sequence initiation to 90-percent thrust, from 90-percent thrust to PU System activation, from PU System activation until the mixture-ratio shift, and from the mixture-ratio shift to thrust termination. The total impulse provided by the model from start-sequence initiation to 90-percent thrust equals the sum of the APS-ullage and J-2-thrust-buildup impulses for this period.

At PU System activation, the LOX/ LH_2 ratio of the propellant in the tanks is used by the PU System to determine the valve setting that optimizes propellant consumption. In this simulation, the PU valve moves to one of three settings at PU System activation: if the LOX/ LH_2 ratio is 4.948, the valve maintains a flowrate mixture ratio of 4.948 for the remainder of the J-2 burn; if the propellant ratio is LH_2 rich (LOX/ LH_2 < 4.948), the valve causes a flowrate mixture ratio of 4.346 to consume the excess hydrogen; if the propellant ratio is LOX rich (LOX/ LH_2 > 4.948), the valve causes a flowrate mixture ratio of 5.480 to consume the excess LOX. The amount of H_2 vented during the stay in parking orbit is proportional to the coast time. The

5.4 (Continued)

propellant bias and the LH₂ vent schedule used in this simulation cause the nominal propellant ratio to be 4.948 after 2.0 revolutions in parking orbit. For the first-injection-opportunity trajectories simulated in this study, reignition occurs after approximately 1.5 revolutions in parking orbit, and the propellant ratios at PU System activation are all LH₂ rich (LOX/LH₂ < 4.948). For the second-opportunity trajectories studied, reignition occurs after 2.5 revolutions and therefore the vehicle is LOX rich at reignition. Consequently, the PU valve causes either a high or low flowrate mixture ratio in all of the trajectories simulated in this study, and causes a corresponding change in J-2 thrust.

In this simulation the high or low flowrate mixture ratio is maintained until the ratio of the propellant in the tanks equals 4.948. The flowrate mixture ratio is then instantaneously changed to 4.948, and J-2 thrust changes accordingly.

Two types of guidance are used in this simulation between preignition-sequence initiation and translunar injection. From preignition-sequence initiation to 3.4 seconds after PU System activation a restart guidance mode is employed. The vehicle is commanded to maintain a given attitude relative to the local horizon and the inertial orbit plane. IGM initiation occurs 3.4 seconds after PU System activation, and the IGM steers the vehicle to the desired translunar injection conditions.

The translunar injection conditions are defined by a hyper-surface (a translunar-orbit conic rotated about the target vector). (See Section 11.) The IGM steers the vehicle onto the orbit "surface" and into a flight plane that contains the target vector. Because the parking orbit plane precesses in inertial space during flight, and because the target vector rotates in a similar manner to the Earth-Moon vector, only a set of unusual geometrical circumstances can cause the target vector to be in the parking-orbit plane during both the first and second injection opportunities. Therefore, for the vehicle to inject onto a translunar conic in a flight plane that contains the target vector, the vehicle must execute a plane-change maneuver during either the first or the second injection opportunity, or during both. The amount of plane change to be executed during either opportunity is determined by a technique that maximizes vehicle performance. (See Section 11.) During a lunar-landing-mission profile based on two injection opportunities, the plane change during first opportunity causes the inclination of the translunar conic to be lower than that of the parking orbit. A plane change during the second opportunity causes the inclination of the translunar conic to be greater than that of

5.4 (Continued)

the parking orbit.

In this simulation the S-IVB cutoff sequence is initiated by the flight computer at the flight time that the computer predicts the vehicle will achieve injection velocity, and S-IVB thrust termination occurs instantaneously when the cutoff command is given. The J-2 thrust-decay propellant is considered to be the last propellant consumed prior to thrust termination.

Tables 5-III through 5-XXVI summarize flight conditions at S-IVB liftoff following reignition (the nominal time of 90-percent thrust) for the 120 trajectories simulated in this study. Tables 5-XXVII through 5-L summarize the translunar injection conditions for these 120 trajectories. Graphical summaries of the S-IVB liftoff time, altitude, inertial velocity, inertial flight-path angle, inertial pitch angle of attack, commanded yaw gimbal angle, plane-change angle, and injection weight are given in Figures 5-17 through 5-31. Except for the weight summary, separate figures are shown for first and second-opportunity data.

5.5 TRANSLUNAR AND TRANSEARTH COAST

At translunar injection the vehicle is in a trajectory that passes behind the moon and returns to earth without any additional major thrusting. In this study, post-injection forces that perturb the trajectory of either the launch vehicle or the spacecraft (such as LOX blowdown, LM extraction thrusting, etc.) are not simulated. Therefore, in this study, the launch vehicle and spacecraft follow identical trajectory paths after injection.

Summaries of the trajectory altitude, inertial (geocentric) velocity, inertial (geocentric) flight-path angle, and true anomaly are given in Figures 5-32 through 5-35 for the first four hours of coast. After four hours the launch vehicle batteries will probably be depleted and the S-IVB/IU will be a "dead" system.

Figures 5-36 and 5-37 show the projections of the February 1, 72-degrees-launch-azimuth, first-opportunity trajectory on geocentric ephemeral planes. Figure 5-36 shows the trajectory projection on the ephemeral equatorial plane (X,Y plane) and Figure 5-37 shows the projection on the ephemeral X,Z plane. The ephemeral X,Y plane is the mean earth equatorial plane of the beginning of the nearest Besselian year. The ephemeral Z axis is the earth spin axis corresponding to the mean equatorial plane. The ephemeral X axis points toward the mean vernal equinox of the beginning of the nearest

5.5 (Continued)

Besselian year. Figures 5-36 and 5-37 also show the moon positions at vehicle arrival for the 12 launch days considered, and the variation of the solar vector orientation during the three-month launch period.

Tables 5-LI through 5-LXXIV summarize the periselenium conditions for the 120 simulated trajectories, and Tables 5-LXXV through 5-XCVIII summarize the corresponding free-return vacuum perigee conditions.

A midcourse correction evaluation was performed for each simulated trajectory to determine the accuracy of each injected orbit. The velocity increment required to return the spacecraft to an orbit that satisfies the periselenium and free-return-vacuum-perigee targeting conditions was determined for each trajectory at the vehicle position 4 hours after injection. The resulting midcourse correction velocity requirements for the 120 simulated trajectories are summarized in Tables 5-XCIX and 5-C.

5.6 SUMMARY, S-IC AND S-II-STAGE TRAJECTORY DATA

Expended-stage trajectories are initiated at S-IC/S-II first-plane separation and at S-II/S-IVB separation. In this simulation separation occurs at the flight time of stage thrust termination; S-IC thrust termination and separation occur at a flight time of 159.329 seconds and S-II thrust termination and separation occur at a flight time of 537.424 seconds. During expended-stage flight, only aerodynamic and gravitational accelerations are simulated; retro-rocket deceleration at separation causes only minor perturbations in the descent trajectory and impact area, and is not included in this simulation. During descent the expended stages are assumed to tumble.

Details on expended stage trajectories are reported in Volume II, Book 2, Section 8.0.

TABLE 5-I. LAUNCH SCHEDULE FOR THE AS-504 LAUNCH VEHICLE REFERENCE TRAJECTORY STUDY

LAUNCH DATE	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FEBRUARY 1	10:37:28.61	11:53:48.91	13:12:16.36	14:20:37.93	15:12:31.68
FEBRUARY 2	11:59:30.44	13:22:16.46	14:43:22.84	15:48:23.77	16:33:26.33
FEBRUARY 3	13:24:15.02	14:56:11.37	16:21:29.22	17:21:36.04	17:57:13.17
FEBRUARY 4	14:46:34.95	16:29:25.30	18:00:38.21	18:53:13.25	19:17:31.13
MARCH 1	11:03:06.38	12:31:11.76	13:54:40.21	14:56:57.06	15:36:29.02
MARCH 3	13:48:49.61	15:41:23.50	17:18:47.47	18:03:27.10	18:18:00.02
MARCH 5	15:52:10.25	17:53:59.57	19:41:28.49	20:08:33.33	20:14:13.21
MARCH 7	16:40:39.70	18:14:20.36	19:37:07.30	20:31:04.02	21:01:10.00
MARCH 31	12:49:26.54	14:51:30.75	16:41:41.28	17:10:41.58	17:16:13.13
APRIL 2	14:25:16.55	16:18:40.14	17:55:04.68	18:33:31.52	18:46:12.29
APRIL 4	15:00:46.84	16:28:25.90	17:48:21.86	18:45:41.84	19:21:22.42
APRIL 6	15:13:04.35	16:26:11.23	17:40:19.19	18:44:53.96	19:34:56.94

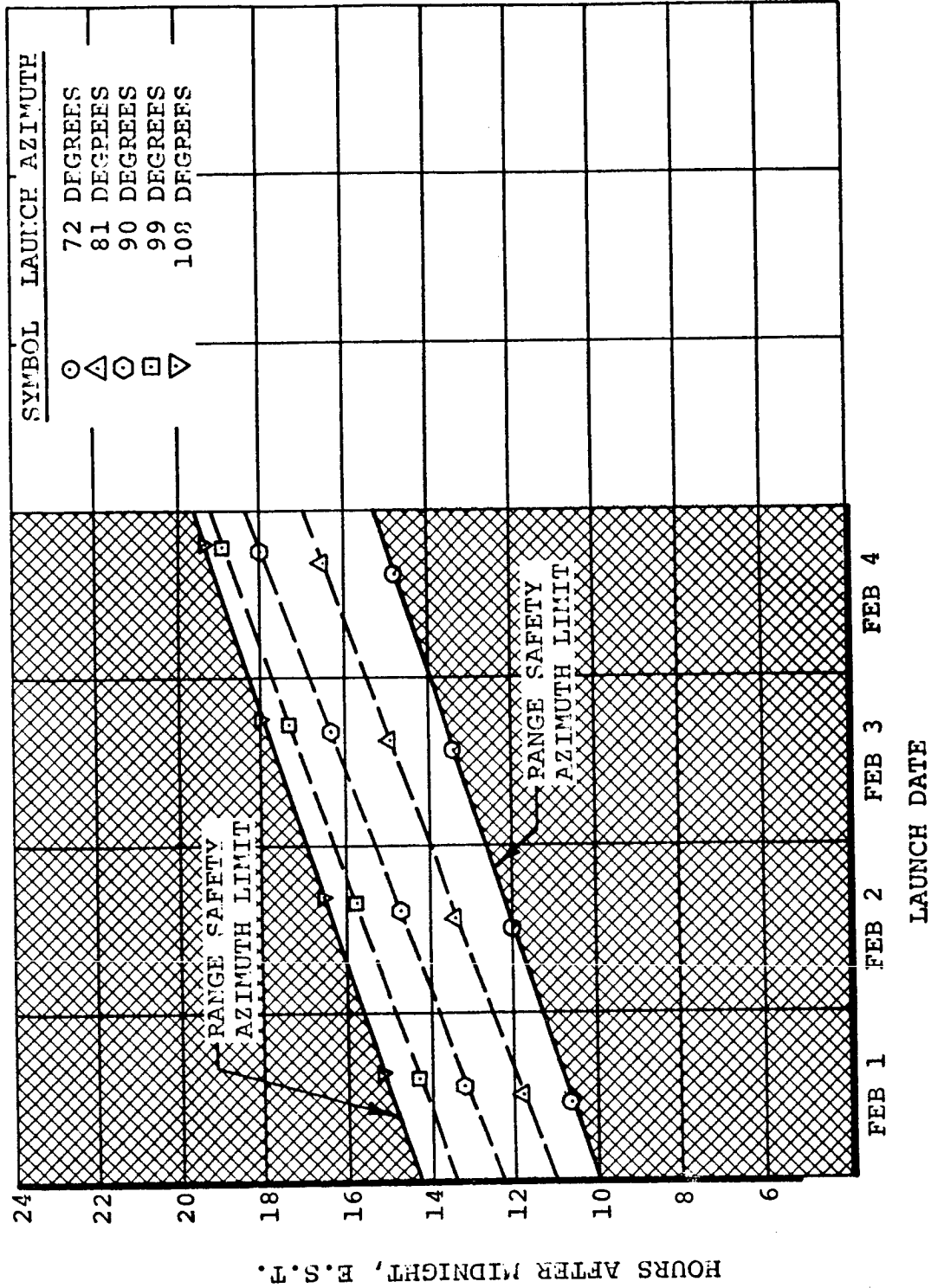


FIGURE 5-1. PACIFIC-INJECTION LAUNCH WINDOW FOR FEBRUARY 1 THROUGH 4, 1968

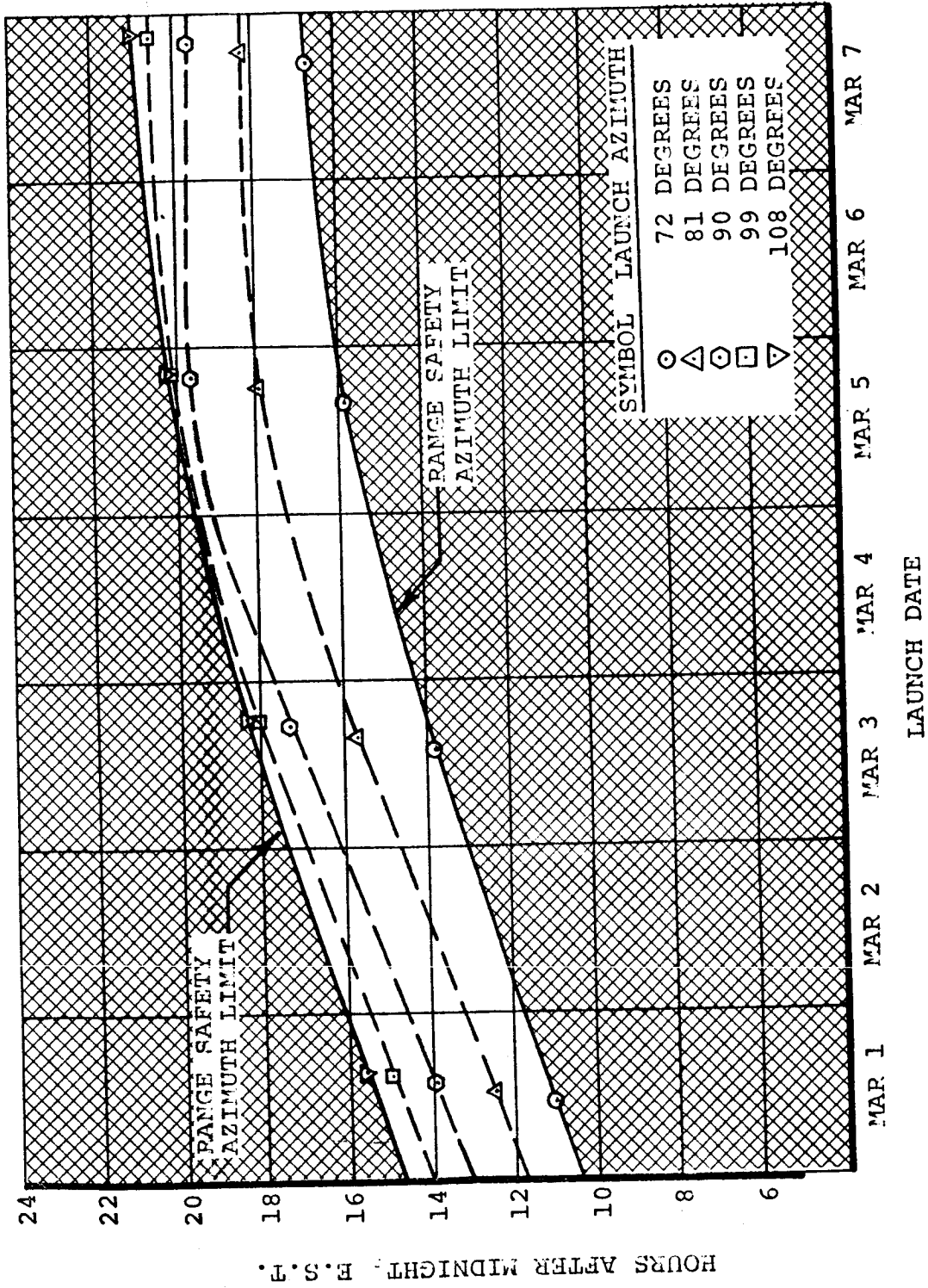


FIGURE 5-2. PACIFIC-INJECTION LAUNCH WINDOW FOR MARCH 1 THROUGH 7, 1968

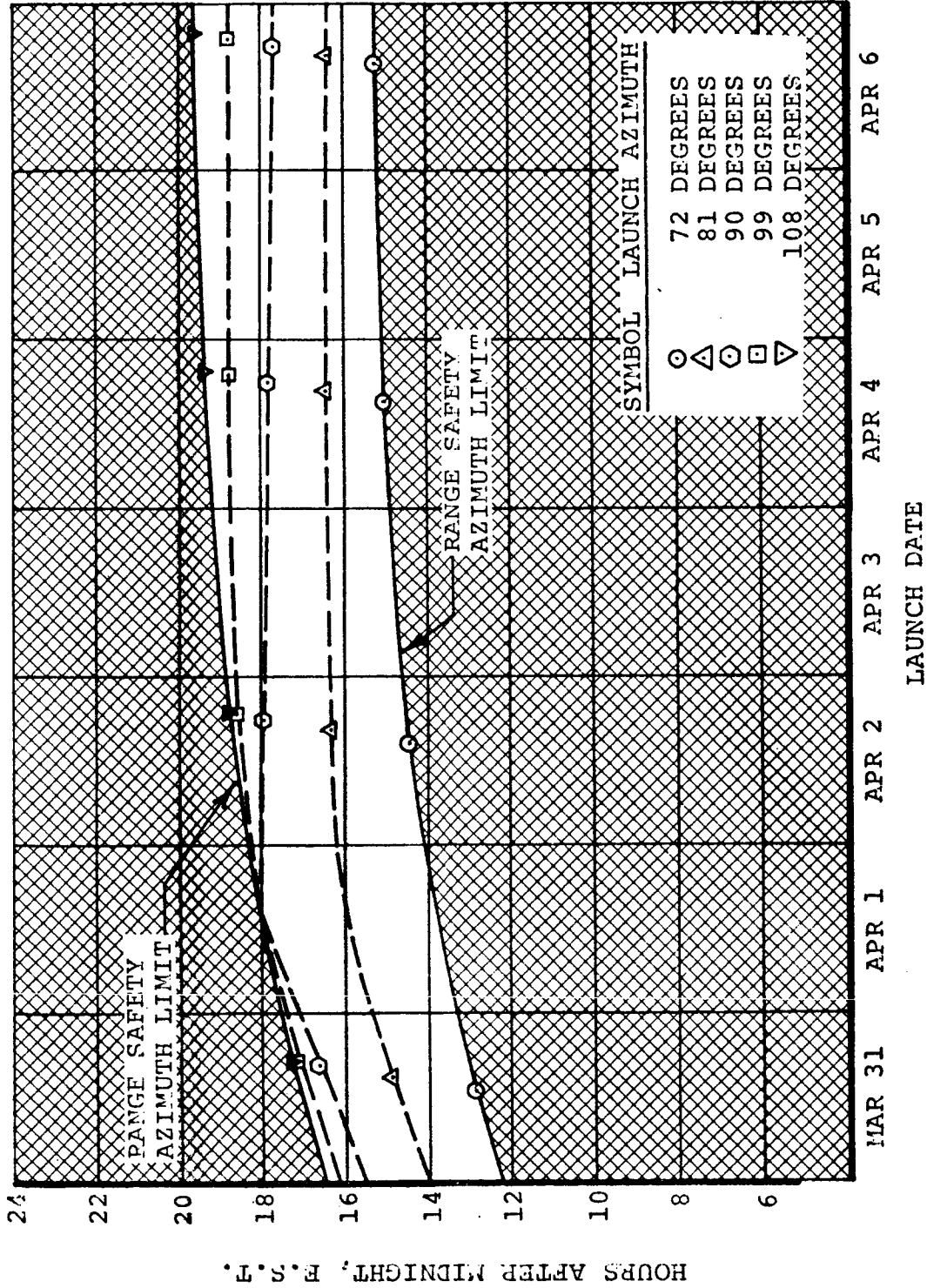


FIGURE 5-3. PACIFIC-INJECTION LAUNCH WINDOW FOR MARCH 31 THROUGH APRIL 6, 1968

TABLE 5-II. EARTH PARKING ORBIT INSERTION CONDITIONS

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	658.378	656.031	655.175	655.832	657.981
GEOCENTRIC LATITUDE (DEGREES N)	32.413	29.131	25.901	22.750	19.701
GEODETTIC LATITUDE (DEGREES N)	32.582	29.290	26.048	22.884	19.820
LONGITUDE (DEGREES E)	-56.198	-56.360	-56.940	-57.898	-59.211
ALTITUDE ABOVE THE GEOID (KILOMETERS)	191.364	190.285	189.295	188.410	187.640
RADIUS (KILOMETERS)	6563.365	6563.365	6563.365	6563.365	6563.364
INERTIAL VELOCITY (M/SEC)	7794.955	7794.955	7794.955	7794.955	7794.955
INERTIAL FLIGHT- PATH ANGLE (DEGREES)	0.000	0.000	0.000	0.000	0.000

TABLE 5-II. EARTH PARKING ORBIT INSERTION CONDITIONS (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL HEADING (DEGREES)	86.756	94.588	102.233	109.753	117.201
INCLINATION (DEGREES)	32.5575	29.4586	28.4633	29.7803	33.1387
WEIGHT (POUNDS)	299777.	301065.	301534.	301174.	299995.
INERTIAL LONGITUDINAL INCREMENT FROM PAD A TO THE DESCENDING NODE (DEGREES)	123.1935	107.6241	90.0050	72.5673	57.4039

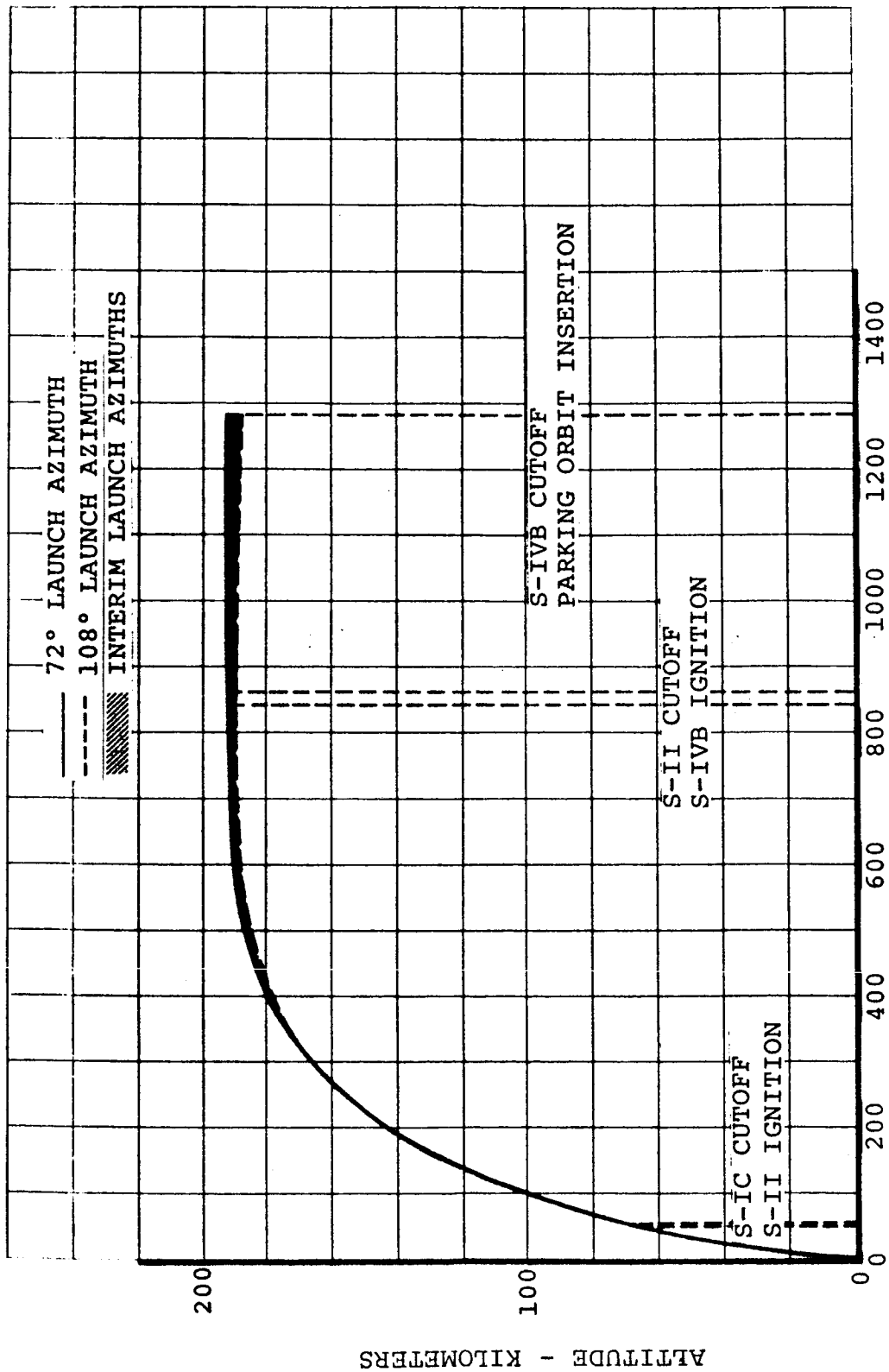


FIGURE 5-4. ALTITUDE-RANGE PROFILE DURING BOOST TO PARKING ORBIT

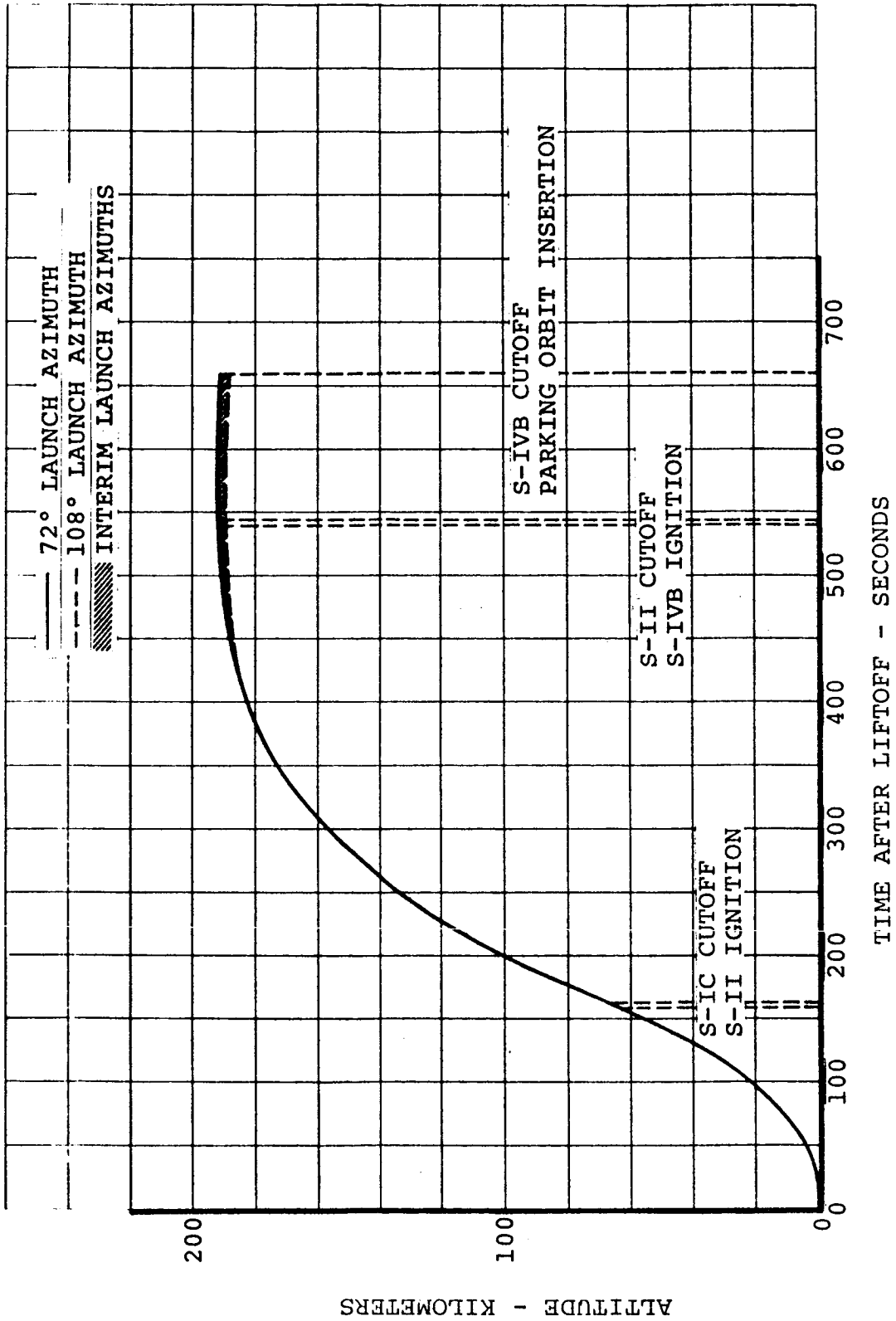


FIGURE 5-5. ALTITUDE DURING BOOST TO PARKING ORBIT

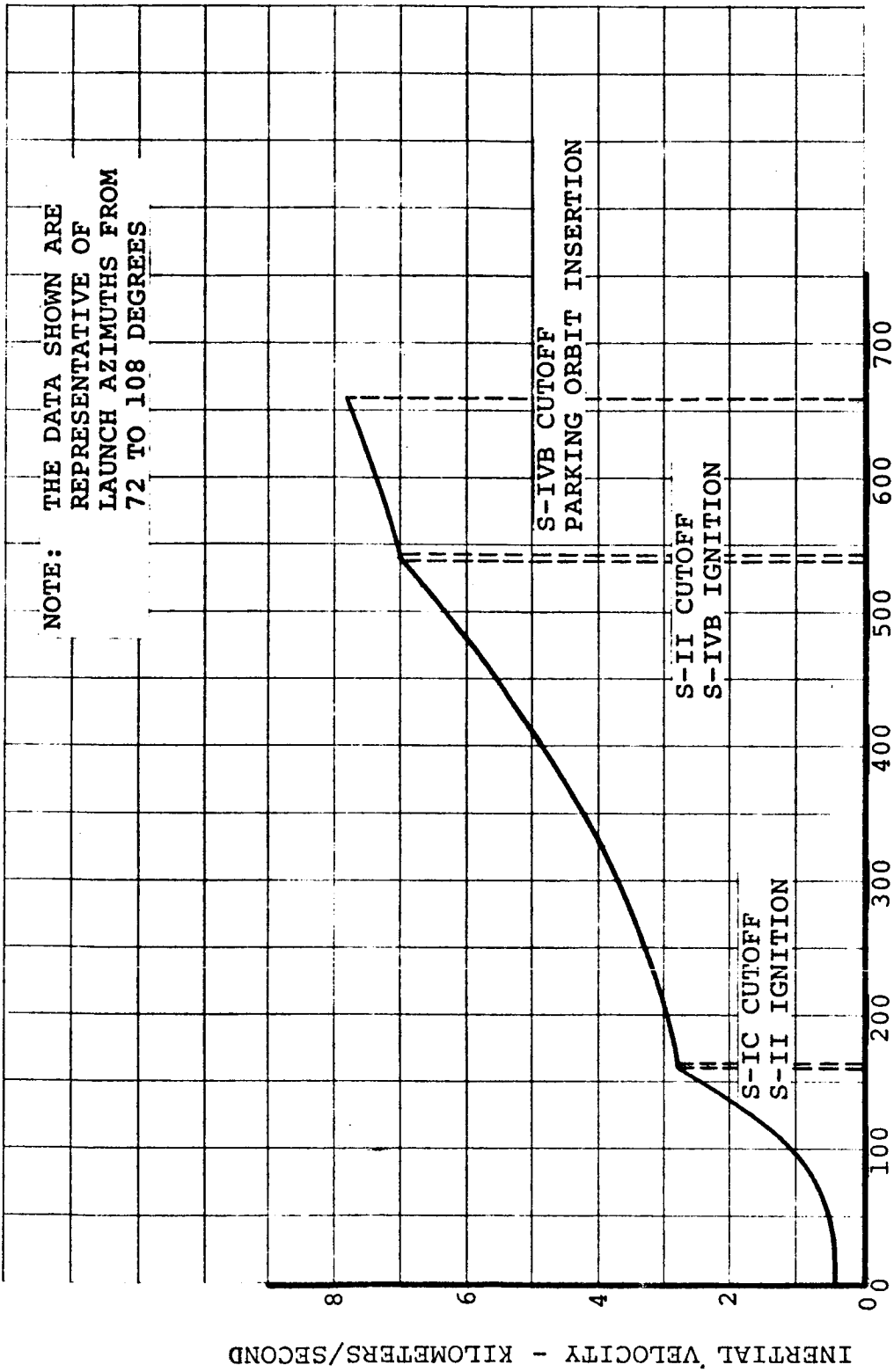


FIGURE 5-6. INERTIAL VELOCITY DURING BOOST TO PARKING ORBIT

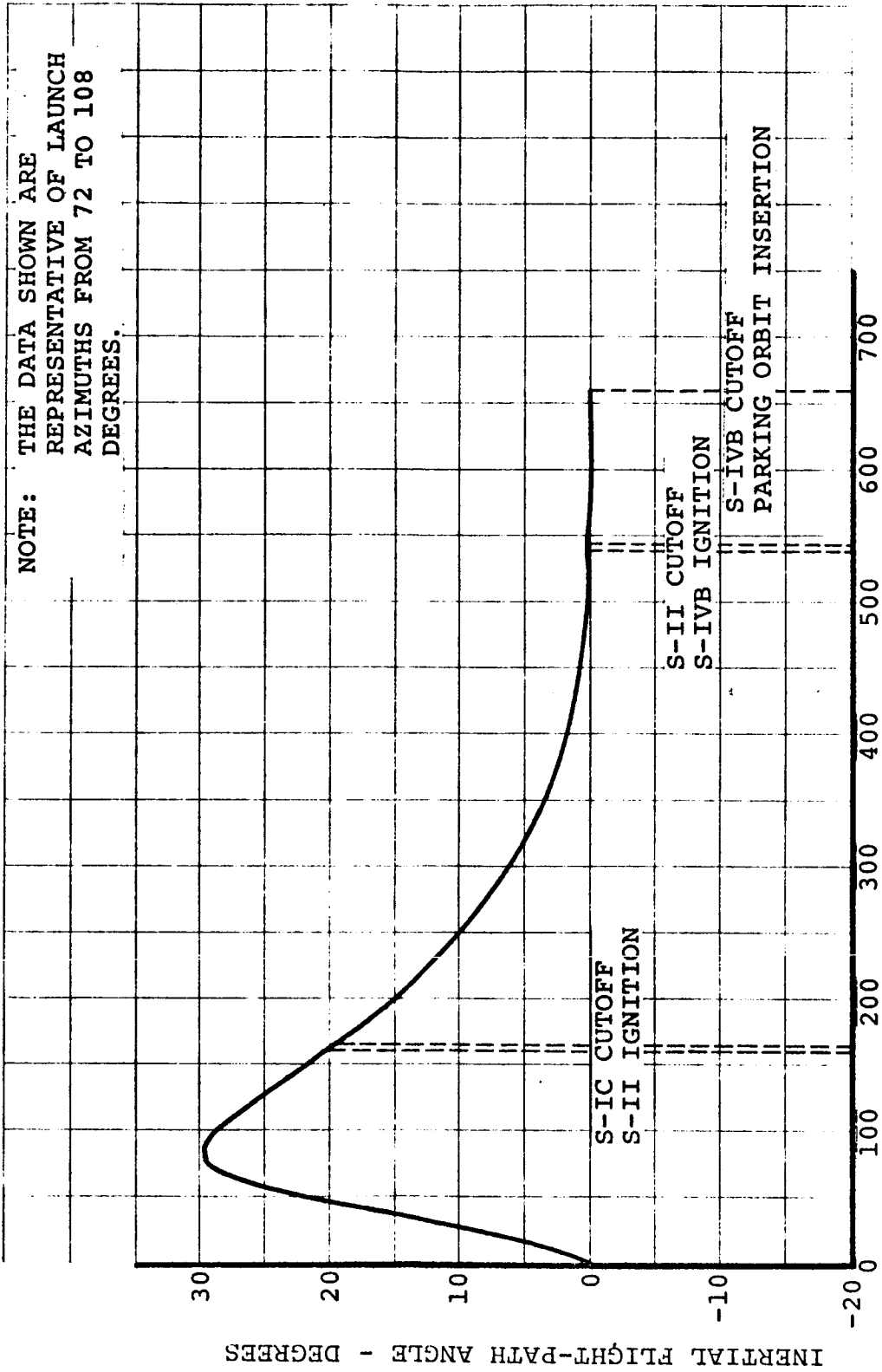


FIGURE 5-7. INERTIAL FLIGHT-PATH ANGLE DURING BOOST TO PARKING ORBIT

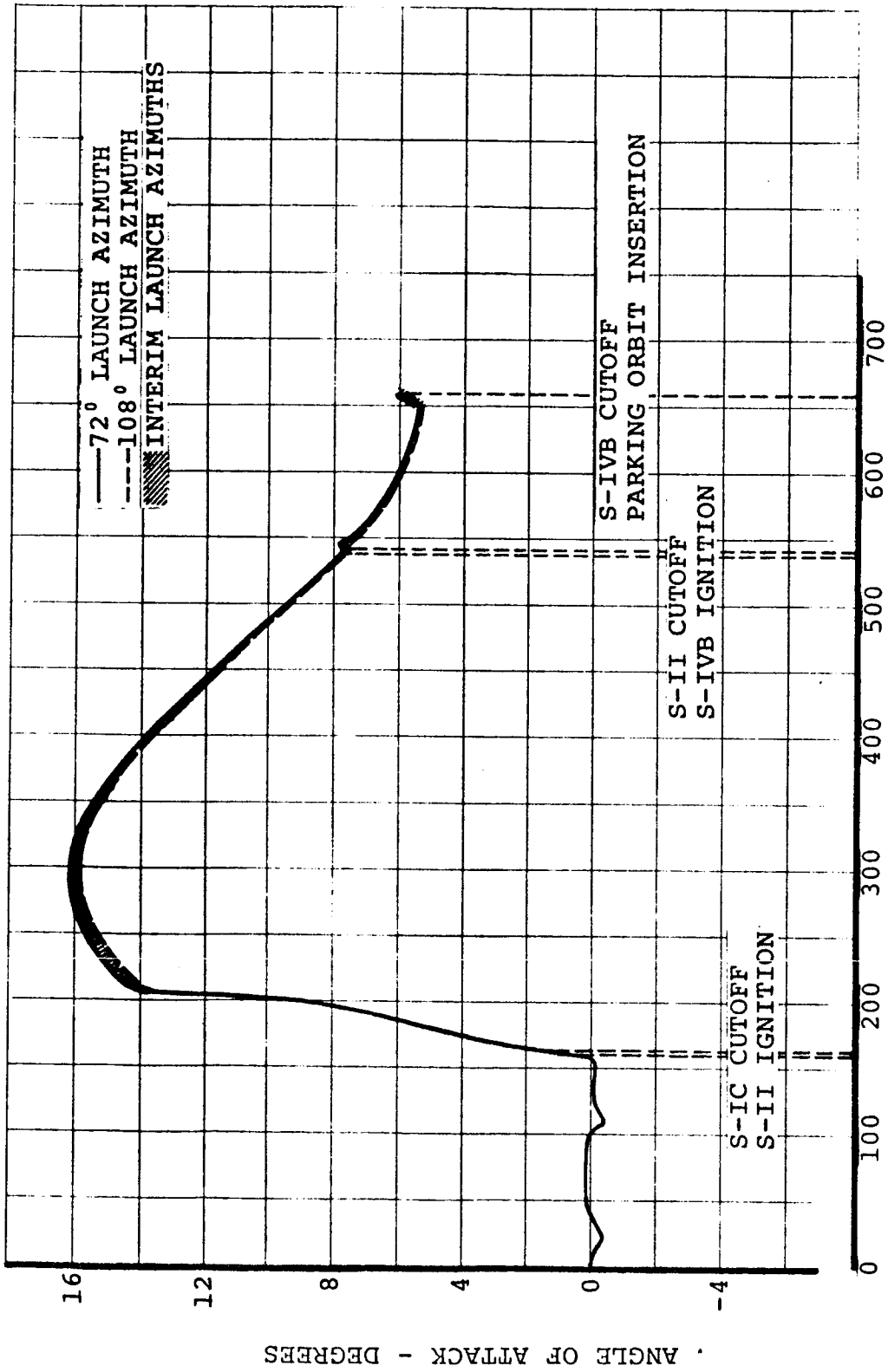


FIGURE 5-8. ANGLE OF ATTACK DURING BOOST TO PARKING ORBIT

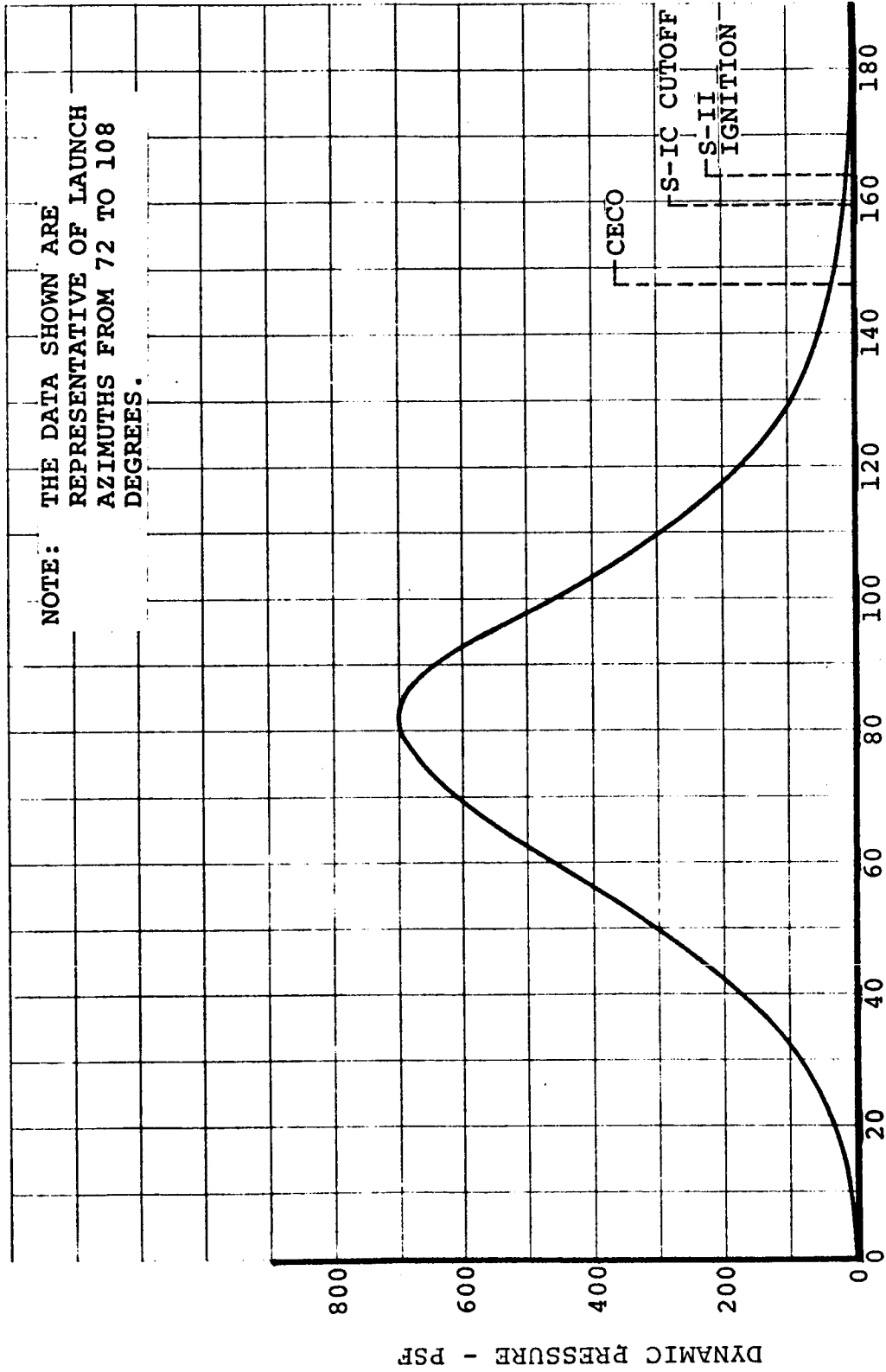


FIGURE 5-9. AERODYNAMIC DYNAMIC PRESSURE DURING S-IC AND EARLY S-II STAGE FLIGHT

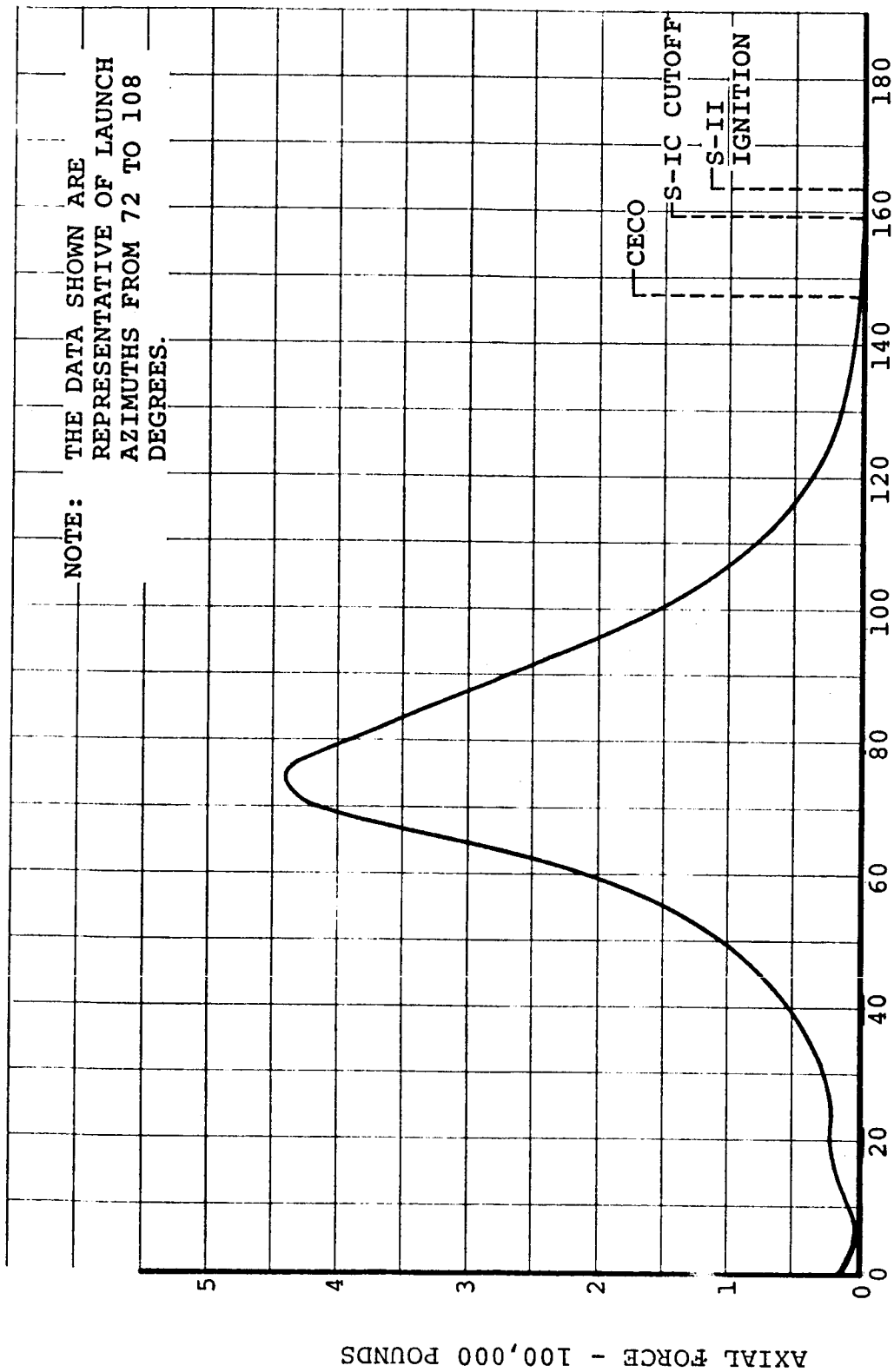


FIGURE 5-10. AERODYNAMIC AXIAL FORCE DURING S-IC AND EARLY S-II STAGE FLIGHT

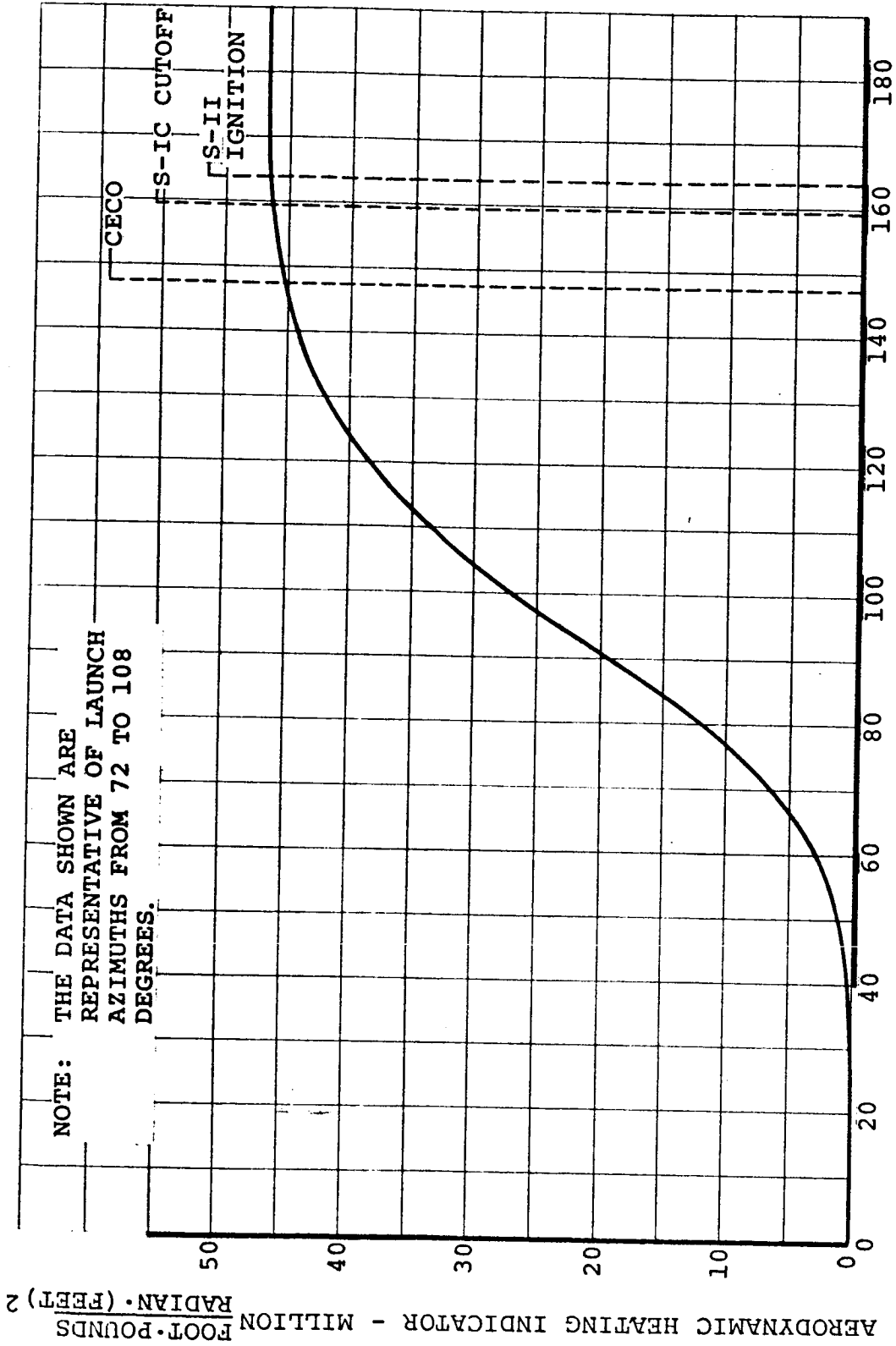


FIGURE 5-11. AERODYNAMIC HEATING INDICATOR DURING S-IC AND EARLY S-II STAGE FLIGHT

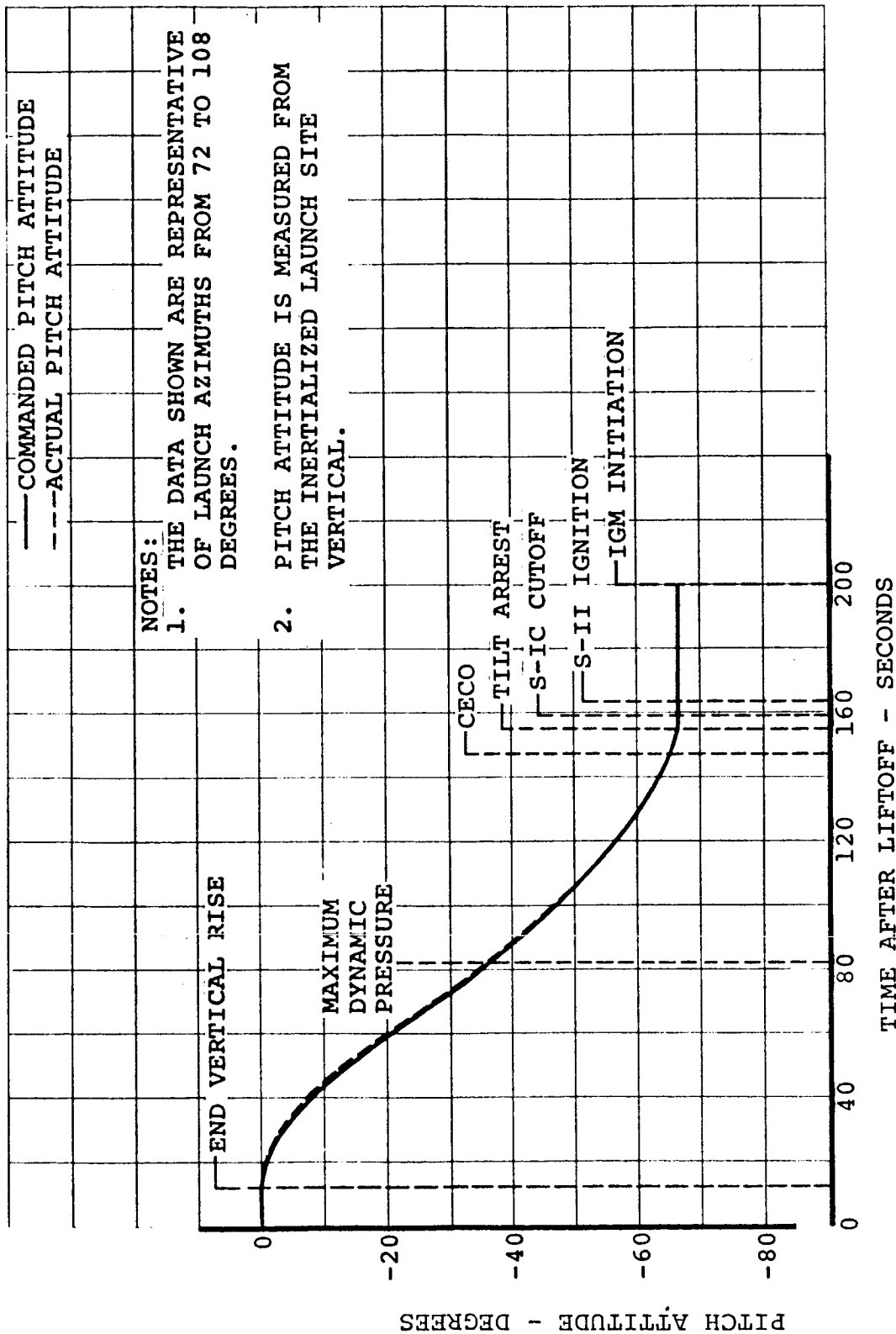


FIGURE 5-12. COMANDED AND ACTUAL PITCH-ATTITUDE PROFILE DURING S-IC AND S-II OPEN LOOP-GUIDANCE

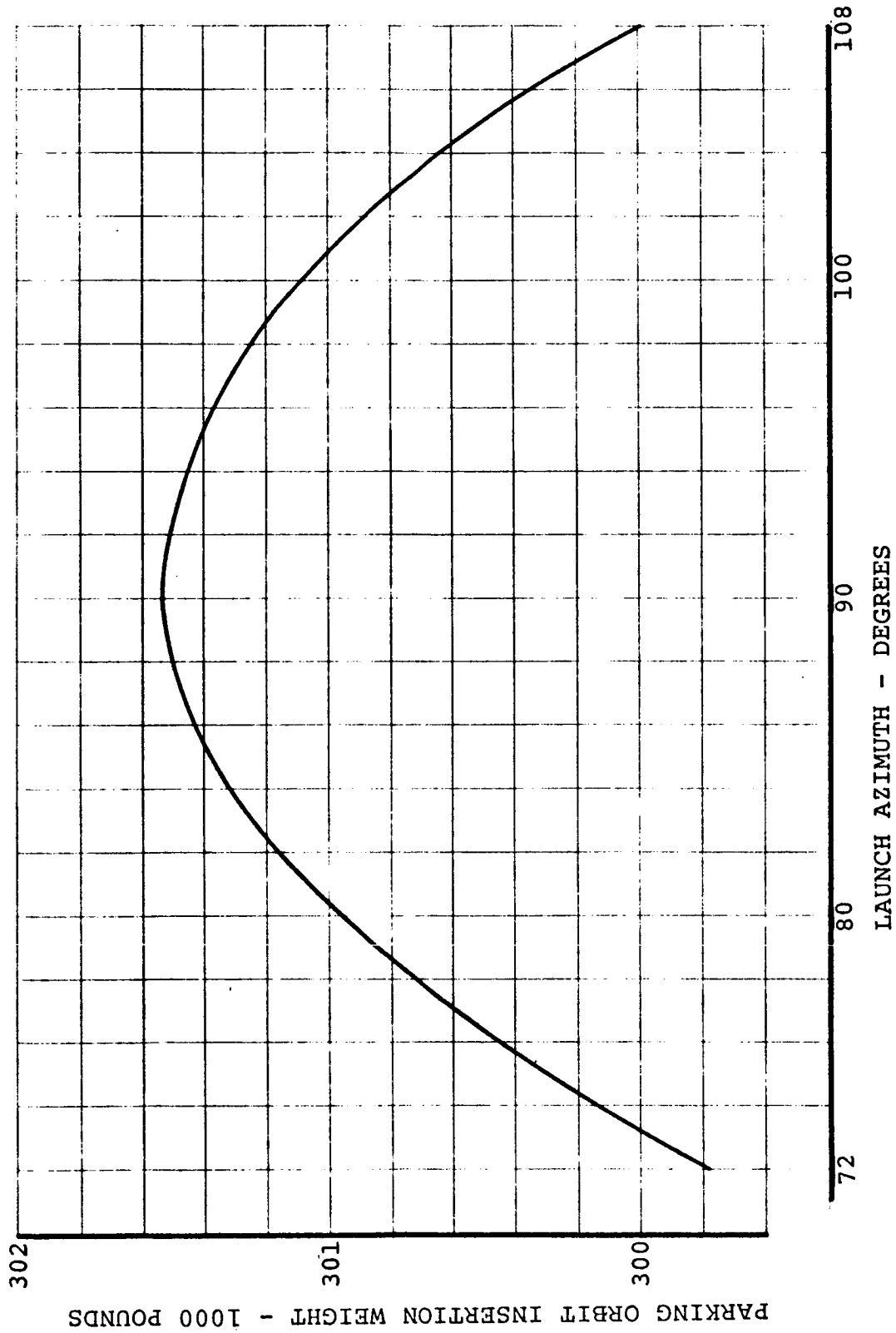


FIGURE 5-13. PARKING ORBIT INSERTION WEIGHT VERSUS LAUNCH AZIMUTH

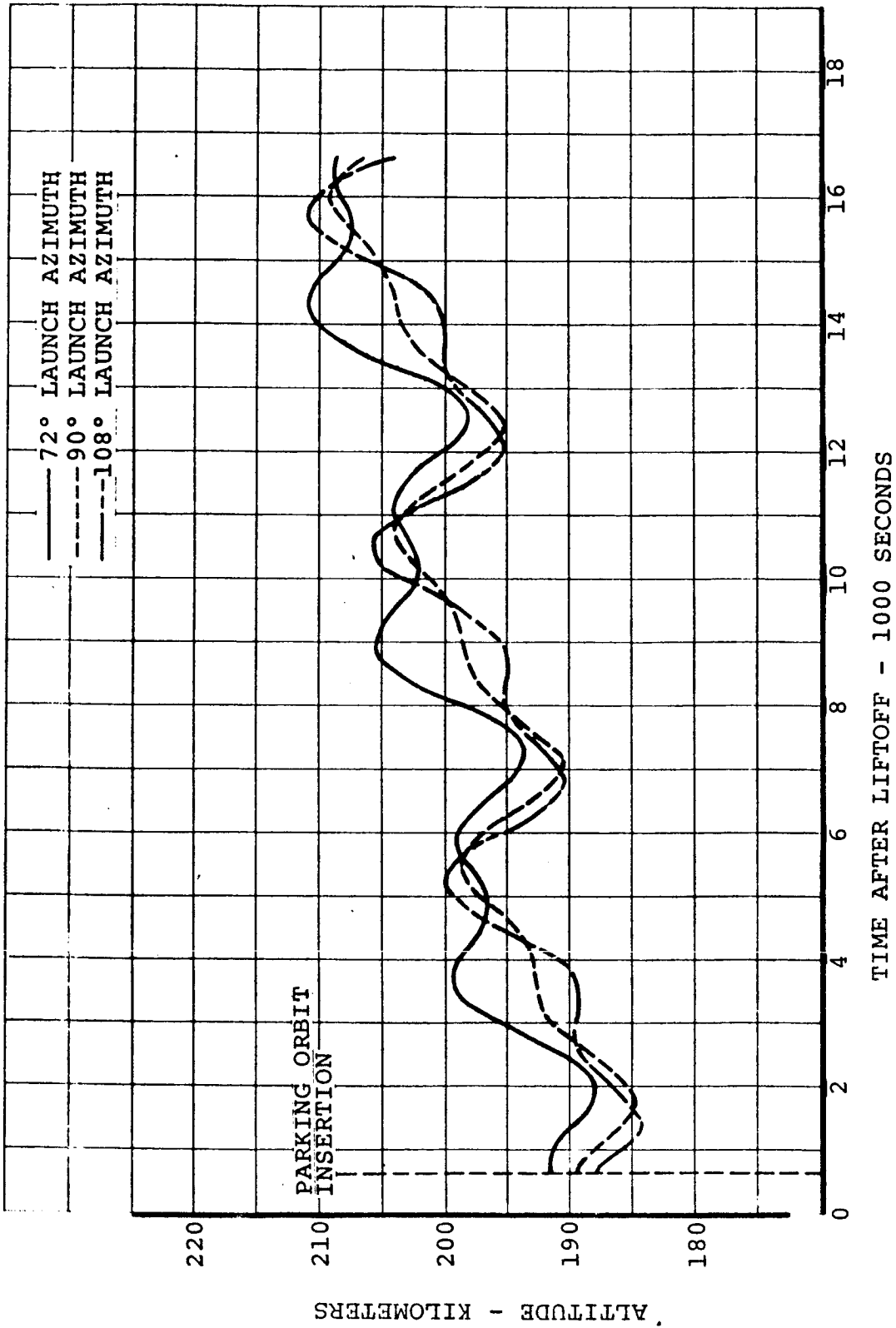
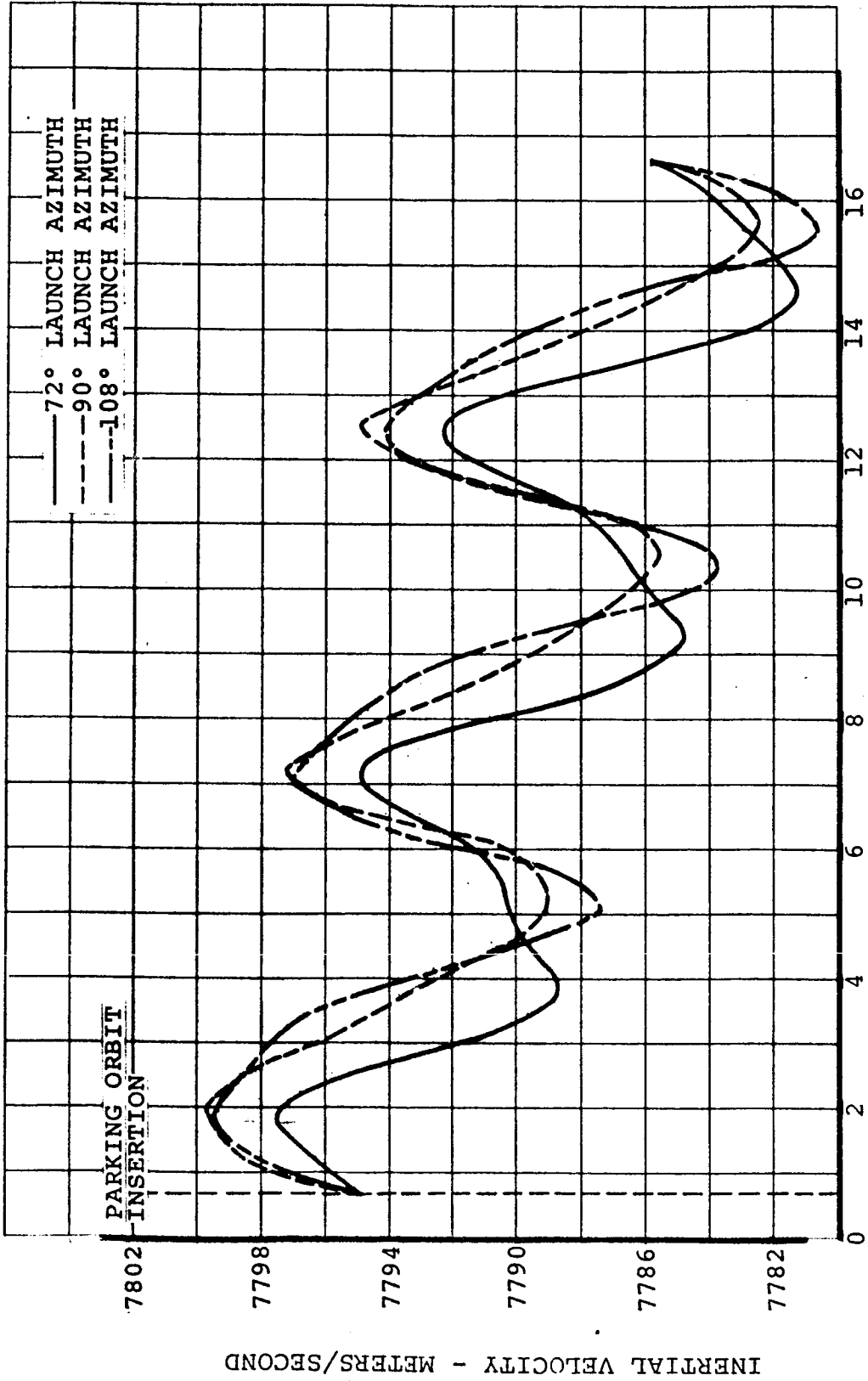


FIGURE 5-14. ALTITUDE DURING PARKING ORBIT



TIME AFTER LIFTOFF - 1000 SECONDS

FIGURE 5-15. INERTIAL VELOCITY DURING PARKING ORBIT

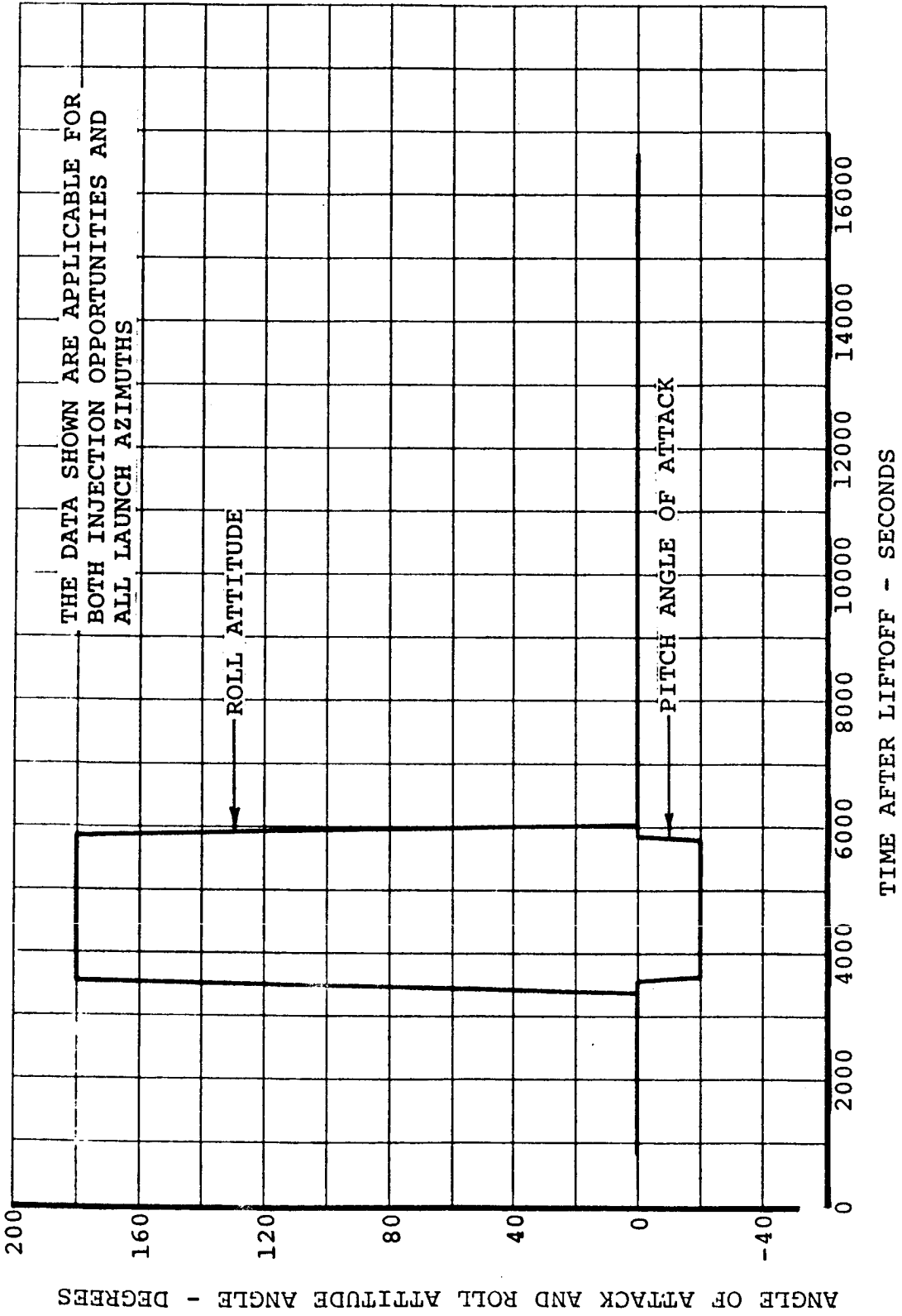


FIGURE 5-16. PITCH ANGLE OF ATTACK AND ROLL ATTITUDE ANGLE DURING PARKING ORBIT

TABLE 5-III TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 1 FEBRUARY 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9604.	9360.	9108.	8892.	8734.
GEOCENTRIC LATITUDE (DEGREES N)	-13.997	-14.049	-14.235	-14.563	-14.997
GEODETTIC LATITUDE (DEGREES N)	-14.085	-14.137	-14.324	-14.654	-15.090
LONGITUDE (DEGREES E)	158.692	140.836	122.693	107.087	95.389
ALTITUDE ABOVE THE GEOID (KILOMETERS)	203.325	201.156	198.626	196.384	194.967
RADIUS (KILOMETERS)	6580.233	6578.056	6575.492	6573.191	6571.694
INERTIAL VELOCITY (METERS/SECOND)	7791.88	7793.66	7795.96	7798.06	7799.33
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.010	0.028	0.041	0.048	0.051
INERTIAL HEADING (DEGREES)	60.266	63.807	65.065	63.718	60.090
WEIGHT (POUNDS)	296105.	297436.	297951.	297631.	296480.

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TABLE 5-IV TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 1 FEBRUARY 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14916.	14670.	14417.	14199.	14040.
GEOCENTRIC LATITUDE (DEGREES N)	-13.681	-13.749	-13.925	-14.272	-14.705
GEODEIC LATITUDE (DEGREES N)	-13.767	-13.836	-14.013	-14.361	-14.797
LONGITUDE (DEGREES E)	136.603	118.798	100.712	85.043	73.283
ALTITUDE ABOVE THE GEOID (KILOMETERS)	208.769	206.579	203.998	201.692	200.230
RADIUS (KILOMETERS)	6585.733	6583.530	6580.919	6578.552	6577.011
INERTIAL VELOCITY (METERS/SECOND)	7788.40	7790.21	7792.58	7794.77	7796.11
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.010	0.028	0.043	0.050	0.054
INERTIAL HEADING (DEGREES)	60.130	63.656	64.898	63.567	59.956
WEIGHT (POUNDS)	295092.	296418.	296927.	296602.	295449.

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TABLE 5-V TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 2 FEBRUARY 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9444.	9180.	8918.	8715.	8579.
GEOCENTRIC LATITUDE (DEGREES N)	-19.153	-19.136	-19.323	-19.584	-20.025
GEODETTIC LATITUDE (DEGREES N)	-19.269	-19.252	-19.440	-19.702	-20.146
LONGITUDE (DEGREES E)	149.400	130.000	111.101	96.393	86.328
ALTITUDE ABOVE THE GEOID (KILOMETERS)	204.038	201.382	198.509	196.217	194.931
RADIUS (KILOMETERS)	6579.892	6577.240	6574.323	6571.970	6570.578
INERTIAL VELOCITY (METERS/SECOND)	7791.62	7793.95	7796.66	7798.83	7799.97
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.017	0.034	0.045	0.049	0.050
INERTIAL HEADING (DEGREES)	63.125	67.139	68.667	67.098	63.029
WEIGHT (POUNDS)	296132.	297468.	297986.	297665.	296511.

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TABLE 5-VI TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 2 FEBRUARY 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14756.	14491.	14229.	14023.
GEOCENTRIC LATITUDE (DEGREES N)	-18.859	-18.839	-18.999	-19.295
GEODEIC LATITUDE (DEGREES N)	-18.973	-18.953	-19.114	-19.412
LONGITUDE (DEGREES E)	127.355	108.072	89.298	74.459
ALTITUDE ABOVE THE GEOID (KILOMETERS)	209.485	206.779	203.829	201.457
RADIUS (KILOMETERS)	6585.407	6582.705	6579.718	6577.277
INERTIAL VELOCITY (METERS/SECOND)	7788.14	7790.54	7793.34	7795.61
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.017	0.035	0.047	0.052
INERTIAL HEADING (DEGREES)	62.925	66.898	68.381	66.858
WEIGHT (POUNDS)	295115.	296445.	296958.	296633.

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TABLE 5-VII
 TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING
 REIGNITION FOR 3 FEBRUARY 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9290.	8998.	8726.	8537.	8431.
GEOCENTRIC LATITUDE (DEGREES N)	-23.580	-23.496	-23.564	-23.862	-24.304
GEODETTIC LATITUDE (DEGREES N)	-23.717	-23.633	-23.701	-24.001	-24.445
LONGITUDE (DEGREES E)	139.885	118.352	98.650	84.953	77.111
ALTITUDE ABOVE THE GEOID (KILOMETERS)	204.699	201.542	198.362	196.112	195.021
RADIUS (KILOMETERS)	6579.429	6576.295	6573.096	6570.764	6569.549
INERTIAL VELOCITY (METERS/SECOND)	7791.46	7794.36	7797.41	7799.54	7800.47
INERTIAL FLIGHT- PATH ANGLE (DEGREES)	0.023	0.038	0.045	0.046	0.047
INERTIAL HEADING (DEGREES)	66.847	71.680	73.547	71.637	66.760
WEIGHT (POUNDS)	296159.	297501.	298023.	297700.	296541.

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TABLE 5-VIII TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 3 FEBRUARY 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14602.	14309.	14036.	13845.	13738.
GEOCENTRIC LATITUDE (DEGREES N)	-23.318	-23.250	-23.326	-23.623	-24.036
GEODEIC LATITUDE (DEGREES N)	-23.454	-23.386	-23.462	-23.761	-24.175
LONGITUDE (DEGREES E)	117.892	96.487	76.850	63.078	55.158
ALTITUDE ABOVE THE GEOID (KILOMETERS)	210.140	206.904	203.622	201.281	200.143
RADIUS (KILOMETERS)	6584.941	6581.724	6578.420	6575.999	6574.747
INERTIAL VELOCITY (METERS/SECOND)	7788.01	7791.00	7794.18	7796.42	7797.42
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.023	0.040	0.048	0.050	0.051
INERTIAL HEADING (DEGREES)	66.582	71.361	73.200	71.323	66.480
WEIGHT (POUNDS)	295138.	296475.	296991.	296666.	295506.

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TABLE 5-IX TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 4 FEBRUARY 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9158.	8834.	8544.	8380.	8309.
GEOCENTRIC LATITUDE (DEGREES N)	-26.821	-26.539	-26.491	-26.800	-27.332
GEODETTIC LATITUDE (DEGREES N)	-26.971	-26.689	-26.641	-26.950	-27.485
LONGITUDE (DEGREES E)	131.214	107.219	86.149	74.254	69.040
ALTITUDE ABOVE THE GEOID (KILOMETERS)	205.153	201.508	198.071	195.972	195.118
RADIUS (KILOMETERS)	6578.948	6575.388	6571.965	6569.774	6568.758
INERTIAL VELOCITY (METERS/SECOND)	7791.44	7794.86	7798.18	7800.14	7800.84
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.026	0.039	0.042	0.042	0.043
INERTIAL HEADING (DEGREES)	70.792	76.708	79.194	76.522	70.513
WEIGHT (POUNDS)	296182.	297532.	298060.	297733.	296567.

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TABLE 5-X TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 4 FEBRUARY 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14471.	14145.	13854.	13688.	13617.
GEOCENTRIC LATITUDE (DEGREES N)	-26.575	-26.355	-26.330	-26.619	-27.078
GEODEIC LATITUDE (DEGREES N)	-26.724	-26.504	-26.478	-26.769	-27.230
LONGITUDE (DEGREES E)	109.336	85.409	64.408	52.433	47.201
ALTITUDE ABOVE THE GEOID (KILOMETERS)	210.580	206.835	203.271	201.081	200.187
RADIUS (KILOMETERS)	6584.449	6580.770	6577.214	6574.938	6573.905
INERTIAL VELOCITY (METERS/SECOND)	7788.01	7791.56	7795.03	7797.11	7797.85
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.028	0.042	0.045	0.045	0.047
INERTIAL HEADING (DEGREES)	70.440	76.324	78.780	76.147	70.147
WEIGHT (POUNDS)	295159.	296502.	297025.	296697.	295530.

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TABLE 5-XI
 TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING
 REIGNITION FOR 1 MARCH 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9345.	9065.	8798.	8603.	8484.
GEOCENTRIC LATITUDE (DEGREES N)	-22.071	-21.999	-22.098	-22.382	-22.841
GEODETTIC LATITUDE (DEGREES N)	-22.201	-22.129	-22.229	-22.513	-22.975
LONGITUDE (DEGREES E)	143.354	122.727	103.411	89.280	80.481
ALTITUDE ABOVE THE GEOID (KILOMETERS)	204.474	201.500	198.430	196.152	194.981
RADIUS (KILOMETERS)	6579.607	6576.653	6573.556	6571.204	6569.911
INERTIAL VELOCITY (METERS/SECOND)	7791.51	7794.19	7797.12	7799.28	7800.30
INERTIAL FLIGHT- PATH ANGLE (DEGREES)	0.022	0.037	0.045	0.047	0.049
INERTIAL HEADING (DEGREES)	65.408	69.875	71.577	69.824	65.319
WEIGHT (POUNDS)	296149.	297489.	298009.	297687.	296530.

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TABLE 5-XII TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 1 MARCH 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14658.	14376.	14108.	13911.	13791.
GEOCENTRIC LATITUDE (DEGREES N)	-21.767	-21.732	-21.835	-22.122	-22.559
GEODETTIC LATITUDE (DEGREES N)	-21.896	-21.860	-21.964	-22.252	-22.691
LONGITUDE (DEGREES E)	121.404	100.838	81.586	67.383	58.509
ALTITUDE ABOVE THE GEOID (KILOMETERS)	209.913	206.876	203.712	201.347	200.127
RADIUS (KILOMETERS)	6585.126	6582.098	6578.907	6576.467	6575.133
INERTIAL VELOCITY (METERS/SECOND)	7788.04	7790.81	7793.86	7796.12	7797.21
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.021	0.038	0.048	0.051	0.052
INERTIAL HEADING (DEGREES)	65.142	69.584	71.260	69.536	65.063
WEIGHT (POUNDS)	295130.	296464.	296979.	296654.	295495.

TABLE 5-XIII TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 3 MARCH 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9084.	8730.	8418.	8282.	8242.
GEOCENTRIC LATITUDE (DEGREES N)	-28.369	-27.950	-27.779	-28.161	-28.766
GEODEIC LATITUDE (DEGREES N)	-28.525	-28.104	-27.933	-28.317	-28.923
LONGITUDE (DEGREES E)	126.137	99.873	77.164	67.312	64.420
ALTITUDE ABOVE THE GEOID (KILOMETERS)	205.333	201.358	197.730	195.827	195.159
RADIUS (KILOMETERS)	6578.653	6574.808	6571.234	6569.212	6568.354
INERTIAL VELOCITY (METERS/SECOND)	7791.49	7795.25	7798.75	7800.52	7801.03
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.028	0.039	0.039	0.038	0.041
INERTIAL HEADING (DEGREES)	73.295	80.283	83.551	79.926	72.824
WEIGHT (POUNDS)	296196.	297552.	298086.	297754.	296582.

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TABLE 5-XIV TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 3 MARCH 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14398.	14043.	13733.	13593.	13551.
GEOCENTRIC LATITUDE (DEGREES N)	-28.132	-27.788	-27.638	-27.986	-28.518
GEODETTIC LATITUDE (DEGREES N)	-28.287	-27.942	-27.791	-28.141	-28.675
LONGITUDE (DEGREES E)	104.359	78.238	55.816	45.735	42.678
ALTITUDE ABOVE THE GEOID (KILOMETERS)	210.751	206.663	202.908	200.907	200.202
RADIUS (KILOMETERS)	6584.145	6580.163	6576.455	6574.346	6573.476
INERTIAL VELOCITY (METERS/SECOND)	7788.07	7791.98	7795.64	7797.52	7798.07
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.030	0.042	0.043	0.042	0.044
INERTIAL HEADING (DEGREES)	72.874	79.795	82.926	79.413	72.391
WEIGHT (POUNDS)	295170.	296520.	297048.	296716.	295543.

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TABLE 5-XV TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 5 MARCH 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9005.	8621.	8280.	8198.	8189.
GEOCENTRIC LATITUDE (DEGREES N)	-29.781	-28.946	-28.425	-29.009	-29.772
GEODETTIC LATITUDE (DEGREES N)	-29.942	-29.104	-28.581	-29.168	-29.933
LONGITUDE (DEGREES E)	120.554	91.988	67.132	61.232	60.675
ALTITUDE ABOVE THE GEOID (KILOMETERS)	205.452	201.070	197.203	195.654	195.180
RADIUS (KILOMETERS)	6578.323	6574.209	6570.505	6568.772	6568.054
INERTIAL VELOCITY (METERS/SECOND)	7791.59	7795.72	7799.42	7800.84	7801.17
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.029	0.038	0.034	0.034	0.038
INERTIAL HEADING (DEGREES)	76.177	84.271	88.571	83.014	74.768
WEIGHT (POUNDS)	296210.	297574.	298115.	297772.	296593.

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TABLE 5-XVI
 TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING
 REIGNITION FOR 5 MARCH 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES 108 DEGREES
FLIGHT TIME (SECONDS)	14326.	13945.	13604.	13519. 13504.
GEOCENTRIC LATITUDE (DEGREES N)	-29.463	-28.764	-28.364	-28.794 -29.439
GEODEIC LATITUDE (DEGREES N)	-29.623	-28.921	-28.520	-28.952 -29.599
LONGITUDE (DEGREES E)	99.307	71.184	46.471	40.406 39.381
ALTITUDE ABOVE THE GEOID (KILOMETERS)	210.855	206.388	202.386	200.733 200.204
RADIUS (KILOMETERS)	6583.828	6579.584	6575.707	6573.920 6573.185
INERTIAL VELOCITY (METERS/SECOND)	7788.18	7792.44	7796.32	7797.84 7798.22
INERTIAL FLIGHT- PATH ANGLE (DEGREES)	0.031	0.041	0.038	0.039 0.042
INERTIAL HEADING (DEGREES)	75.460	83.343	87.586	82.101 74.088
WEIGHT (POUNDS)	295182.	296538.	297074.	296731. 295553.

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TABLE 5-XVII TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 7 MARCH 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9181.	8888.	8625.	8459.
GEOCENTRIC LATITUDE (DEGREES N)	-26.299	-25.642	-25.335	-25.431
GEODETTIC LATITUDE (DEGREES N)	-26.447	-25.788	-25.480	-25.576
LONGITUDE (DEGREES E)	132.760	110.949	91.791	73.968
ALTITUDE ABOVE THE GEOID (KILOMETERS)	205.085	201.544	198.226	196.054
RADIUS (KILOMETERS)	6579.037	6575.689	6572.460	6570.261
INERTIAL VELOCITY (METERS/SECOND)	7791.44	7794.68	7797.83	7799.84
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.026	0.039	0.044	0.046
INERTIAL HEADING (DEGREES)	70.056	74.963	76.572	73.968
WEIGHT (POUNDS)	296178.	297522.	298043.	297717.

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TABLE 5-XVIII TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 7 MARCH 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14507.	14213.	13950.	13781.	13691.
GEOCENTRIC LATITUDE (DEGREES N)	-25.736	-25.180	-24.891	-24.948	-25.275
GEODETTIC LATITUDE (DEGREES N)	-25.882	-25.324	-25.033	-25.091	-25.420
LONGITUDE (DEGREES E)	111.734	90.074	71.052	58.806	52.119
ALTITUDE ABOVE THE GEOID (KILOMETERS)	210.474	206.891	203.481	201.210	200.161
RADIUS (KILOMETERS)	6584.592	6581.170	6577.844	6575.556	6574.412
INERTIAL VELOCITY (METERS/SECOND)	7788.00	7791.31	7794.57	7796.70	7797.59
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.027	0.041	0.047	0.048	0.050
INERTIAL HEADING (DEGREES)	69.313	74.166	75.724	73.195	67.834
WEIGHT (POUNDS)	295153.	296490.	297007.	296678.	295515.

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TABLE 5-XIX TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 31 MARCH 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9027.	8639.	8288.	8201.	8194.
GEOCENTRIC LATITUDE (DEGREES N)	-29.414	-28.817	-28.410	-28.984	-29.682
GEODETTIC LATITUDE (DEGREES N)	-29.574	-28.975	-28.566	-29.143	-29.843
LONGITUDE (DEGREES E)	122.125	93.300	67.716	61.450	61.032
ALTITUDE ABOVE THE GEOID (KILOMETERS)	205.427	201.127	197.238	195.660	195.178
RADIUS (KILOMETERS)	6578.416	6574.307	6570.545	6568.787	6568.081
INERTIAL VELOCITY (METERS/SECOND)	7791.56	7795.64	7799.38	7800.83	7801.16
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.029	0.038	0.035	0.035	0.039
INERTIAL HEADING (DEGREES)	75.354	83.599	88.276	82.901	74.581
WEIGHT (POUNDS)	296206.	297570.	298113.	297772.	296592.

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TABLE 5-XX TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 31 MARCH 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14342.	13959.	13609.	13518.	13503.
GEOCENTRIC LATITUDE (DEGREES N)	-29.185	-28.649	-28.349	-28.803	-29.458
GEODETTIC LATITUDE (DEGREES N)	-29.344	-28.806	-28.505	-28.961	-29.618
LONGITUDE (DEGREES E)	100.441	72.199	46.835	40.333	39.310
ALTITUDE ABOVE THE GEOID (KILOMETERS)	210.838	206.434	202.408	200.731	200.204
RADIUS (KILOMETERS)	6583.900	6579.666	6575.735	6573.914	6573.179
INERTIAL VELOCITY (METERS/SECOND)	7788.15	7792.37	7796.30	7797.84	7798.23
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.031	0.041	0.039	0.039	0.042
INERTIAL HEADING (DEGREES)	74.871	82.825	87.403	82.138	74.125
WEIGHT (POUNDS)	295179.	296535.	297073.	296731.	295553.

TABLE 5-XXII

TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING
REIGNITION FOR 2 APRIL 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES 108 DEGREES
FLIGHT TIME (SECONDS)	14360.	14003.	13697.	13577. 13541.
GEOCENTRIC LATITUDE (DEGREES N)	-28.861	-28.235	-27.912	-28.180 -28.722
GEODETTIC LATITUDE (DEGREES N)	-29.018	-28.391	-28.066	-28.336 -28.879
LONGITUDE (DEGREES E)	101.709	75.375	53.222	44.590 41.982
ALTITUDE ABOVE THE GEOID (KILOMETERS)	210.815	206.564	202.777	200.873 200.204
RADIUS (KILOMETERS)	6583.980	6579.926	6576.239	6574.251 6573.413
INERTIAL VELOCITY (METERS/SECOND)	7788.12	7792.16	7795.83	7797.59 7798.10
INERTIAL FLIGHT- PATH ANGLE (DEGREES)	0.030	0.042	0.041	0.041 0.044
INERTIAL HEADING (DEGREES)	74.217	81.221	84.208	79.984 72.746
WEIGHT (POUNDS)	295176.	296527.	297055.	296719. 295545.

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TABLE 5-XXIII TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 4 APRIL 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9260.	8984.	8731.	8553.	8449.
GEOCENTRIC LATITUDE (DEGREES N)	-24.366	-23.792	-23.468	-23.516	-23.817
GEODETTIC LATITUDE (DEGREES N)	-24.507	-23.930	-23.604	-23.653	-23.955
LONGITUDE (DEGREES E)	137.957	117.425	98.985	86.011	78.265
ALTITUDE ABOVE THE GEOID (KILOMETERS)	204.814	201.547	198.368	196.122	195.007
RADIUS (KILOMETERS)	6579.325	6576.218	6573.128	6570.870	6569.671
INERTIAL VELOCITY (METERS/SECOND)	7791.45	7794.40	7797.39	7799.48	7800.42
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.024	0.038	0.045	0.047	0.048
INERTIAL HEADING (DEGREES)	67.683	72.077	73.405	71.184	66.257
WEIGHT (POUNDS)	296164.	297504.	298022.	297697.	296538.

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TABLE 5-XXIV TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 4 APRIL 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14584.	14309.	14055.	13875.	13767.
GEOCENTRIC LATITUDE (DEGREES N)	-23.798	-23.250	-22.948	-22.957	-23.238
GEODETTIC LATITUDE (DEGREES N)	-23.936	-23.386	-23.082	-23.092	-23.373
LONGITUDE (DEGREES E)	116.745	96.487	78.111	65.047	57.002
ALTITUDE ABOVE THE GEOID (KILOMETERS)	210.208	206.904	203.647	201.312	200.134
RADIUS (KILOMETERS)	6584.878	6581.724	6578.549	6576.211	6574.957
INERTIAL VELOCITY (METERS/SECOND)	7788.00	7791.00	7794.09	7796.28	7797.31
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.024	0.040	0.048	0.050	0.052
INERTIAL HEADING (DEGREES)	67.072	71.361	72.673	70.492	65.690
WEIGHT (POUNDS)	295141.	296475.	296988.	296660.	295500.

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TABLE 5-XXV TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 6 APRIL 1968, FIRST OPPORTUNITY

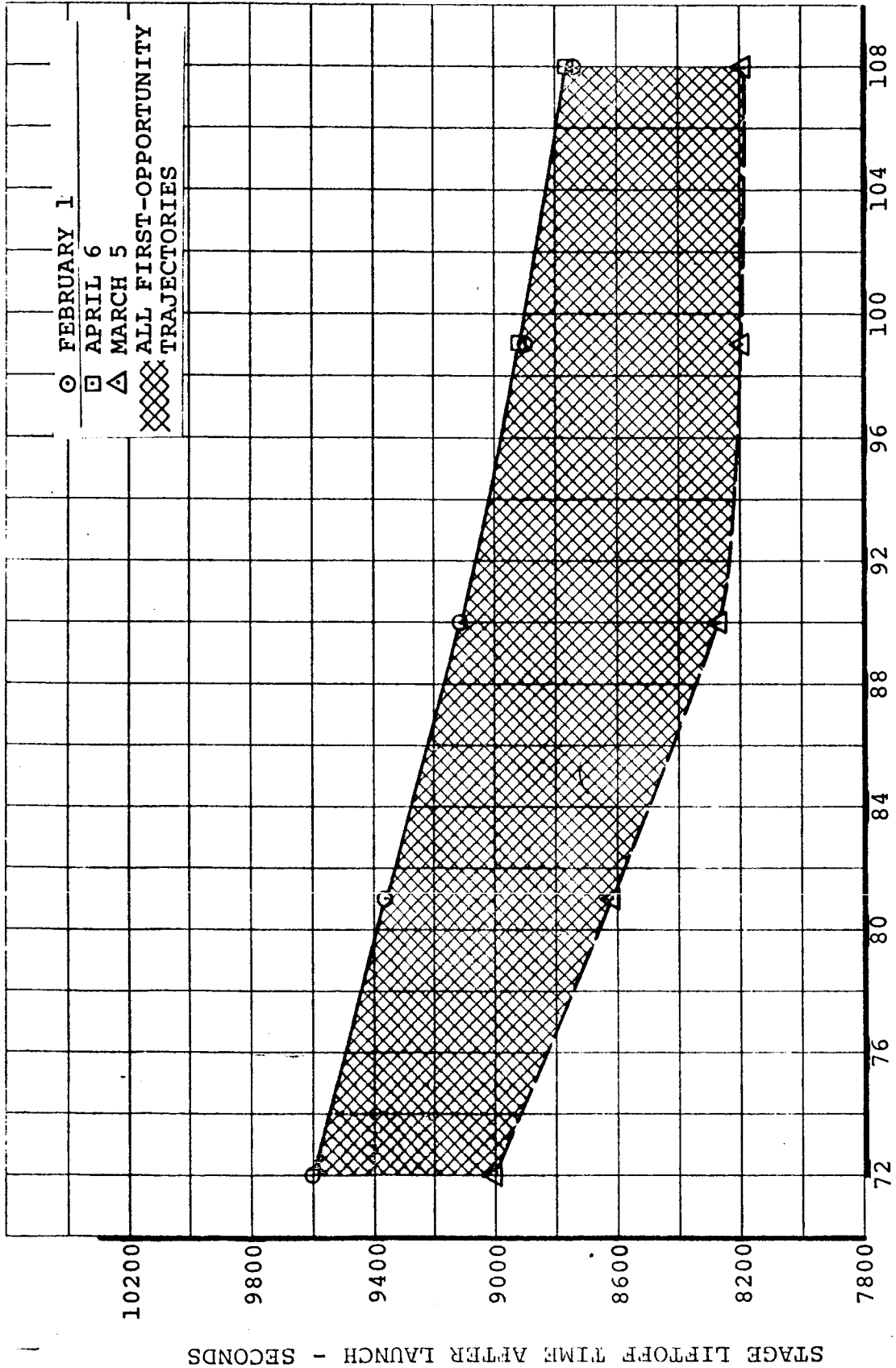
	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9568.	9337.	9102.	8902.	8755.
GEOCENTRIC LATITUDE (DEGREES N)	-15.197	-14.733	-14.406	-14.261	-14.282
GEODETTIC LATITUDE (DEGREES N)	-15.292	-14.825	-14.496	-14.351	-14.371
LONGITUDE (DEGREES E)	156.647	139.485	122.337	107.674	96.577
ALTITUDE ABOVE THE GEOID (KILOMETERS)	203.481	201.184	198.621	196.397	194.987
RADIUS (KILOMETERS)	6580.170	6577.960	6575.456	6573.259	6571.845
INERTIAL VELOCITY (METERS/SECOND)	7791.81	7793.69	7795.99	7798.02	7799.24
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.012	0.029	0.042	0.048	0.051
INERTIAL HEADING (DEGREES)	60.821	64.168	65.160	63.561	59.767
WEIGHT (POUNDS)	296111.	297440.	297952.	297629.	296476.

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TABLE 5-XXVI TRAJECTORY CHARACTERISTICS AT S-IVB STAGE LIFTOFF FOLLOWING REIGNITION FOR 6 APRIL 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14893.	14662.	14427.	14225.
GEOCENTRIC LATITUDE (DEGREES N)	-14.453	-13.989	-13.637	-13.481
GEODEIC LATITUDE (DEGREES N)	-14.543	-14.077	-13.723	-13.566
LONGITUDE (DEGREES E)	135.305	118.331	101.302	75.195
ALTITUDE ABOVE THE GEOID (KILOMETERS)	208.870	206.587	204.009	201.739
RADIUS (KILOMETERS)	6585.697	6583.497	6580.980	6578.737
INERTIAL VELOCITY (METERS/SECOND)	7788.36	7790.22	7792.54	7794.64
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	0.010	0.029	0.043	0.050
INERTIAL HEADING (DEGREES)	60.470	63.777	64.747	63.176
WEIGHT (POUNDS)	295095.	296419.	296926.	296598.

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LAUNCH AZIMUTH - DEGREES

FIGURE 5-17. S-IVB LIFTOFF TIMES FOR FIRST-OPPORTUNITY INJECTION BOOSTS

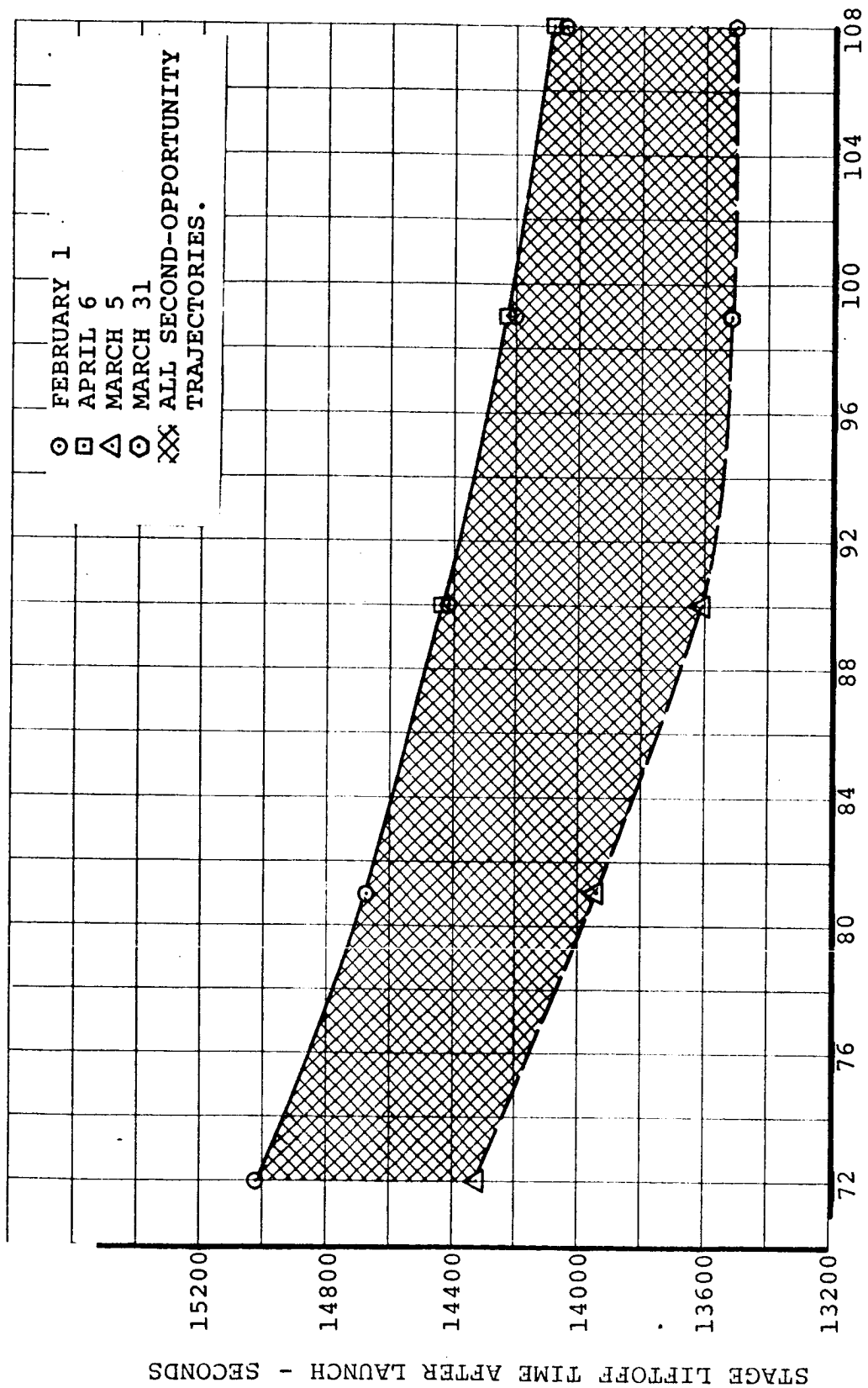


FIGURE 5-18. S-IVB LIFTOFF TIMES FOR SECOND-OPPORTUNITY INJECTION BOOSTS

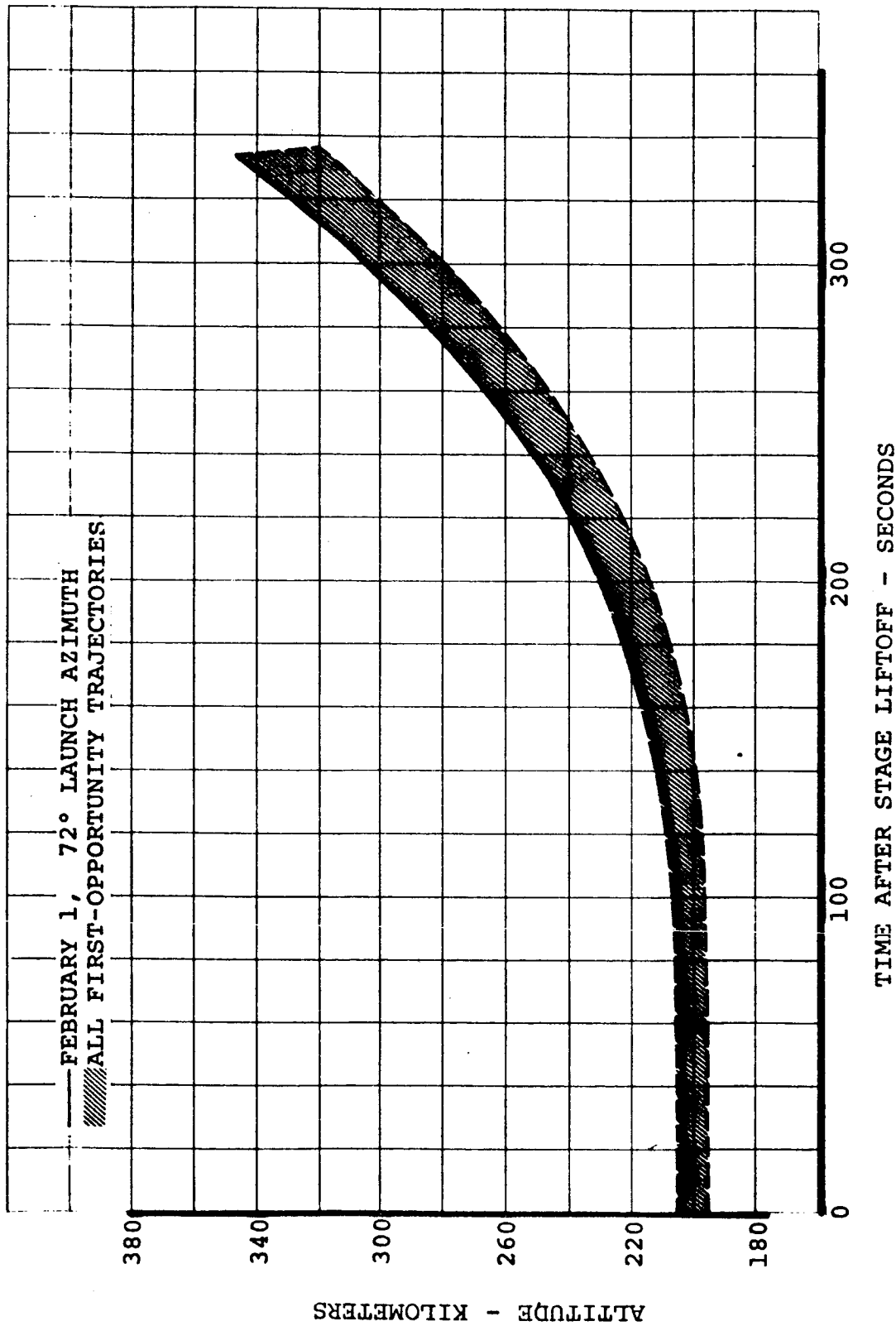


FIGURE 5-19. ALTITUDE DURING FIRST-OPPORTUNITY TRANSLUNAR INJECTION BOOST

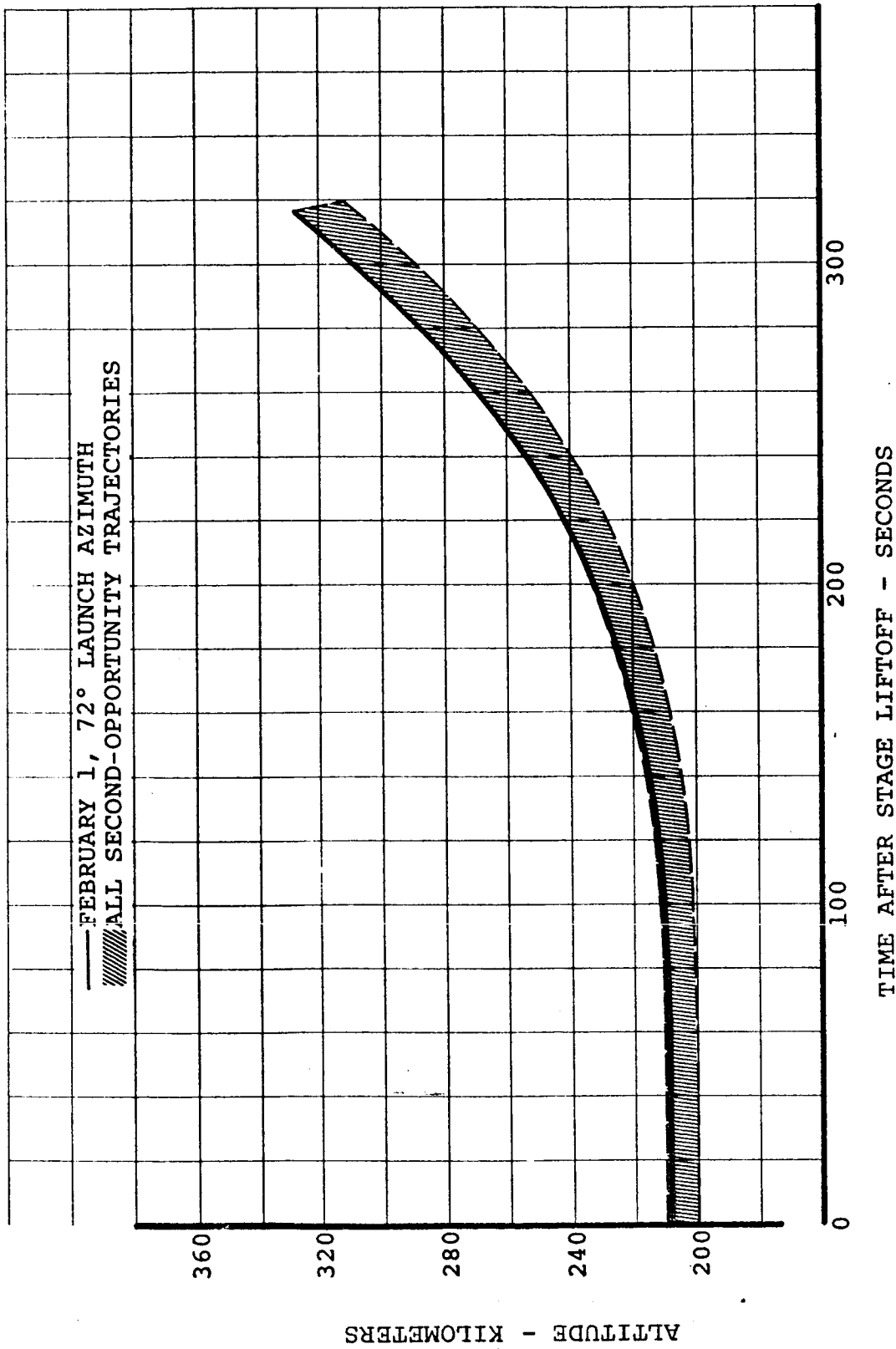


FIGURE 5-20. ALTITUDE DURING SECOND-OPPORTUNITY TRANSLUNAR INJECTION BOOST

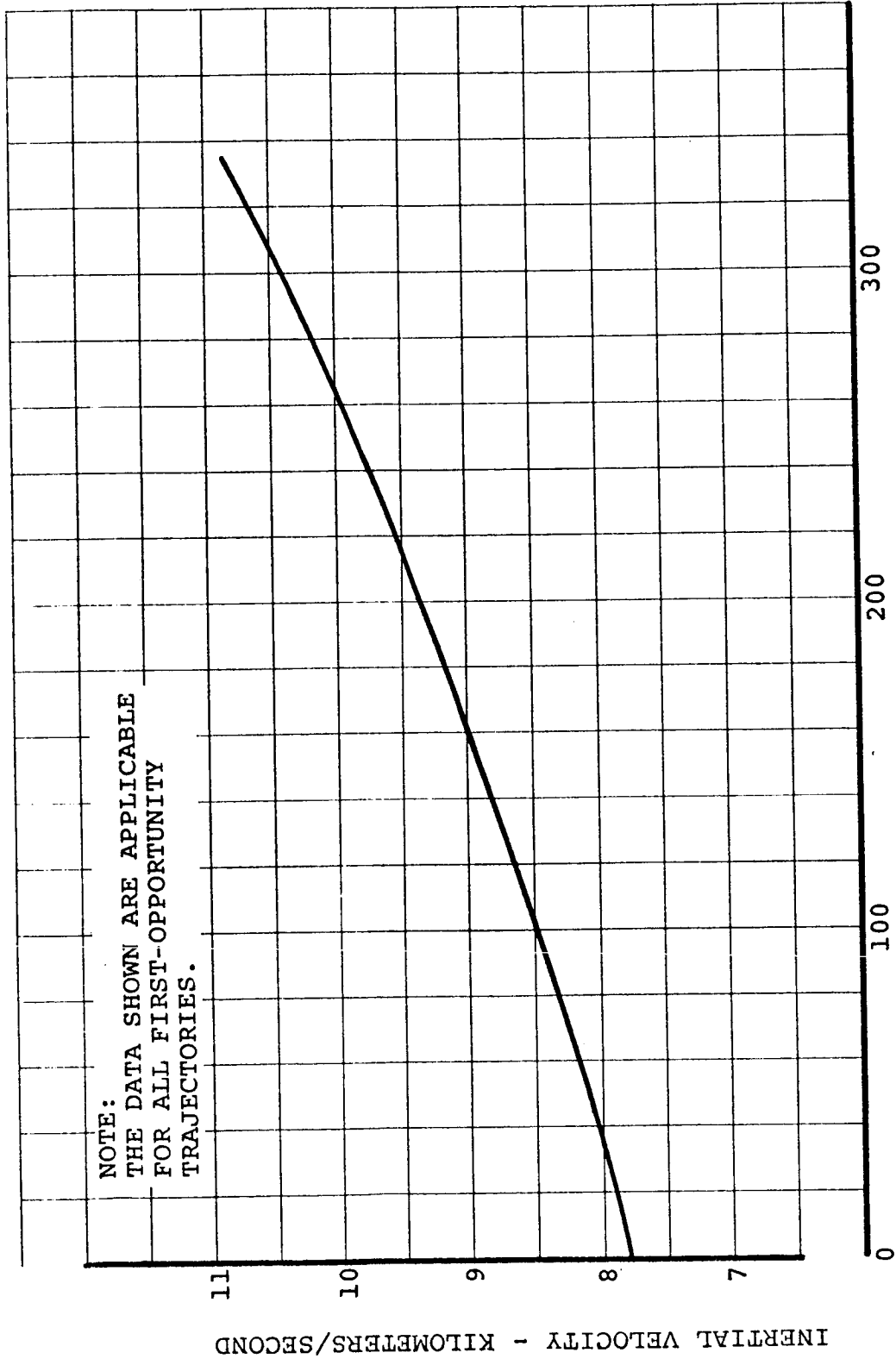


FIGURE 5-21. INERTIAL VELOCITY DURING FIRST-OPPORTUNITY
TRANSLUNAR INJECTION BOOST

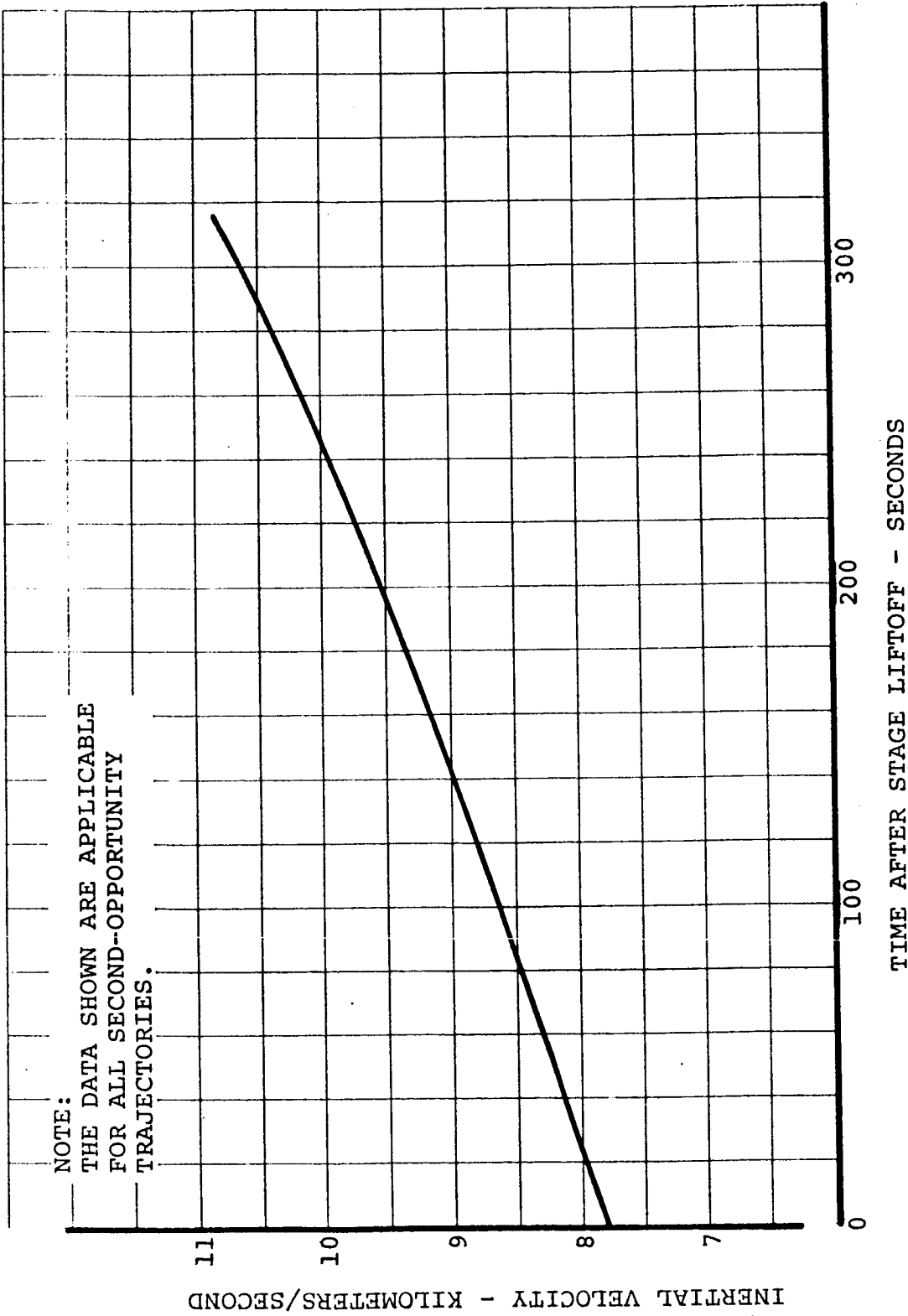


FIGURE 5-22. INERTIAL VELOCITY DURING SECOND-OPPORTUNITY
TRANSLUNAR INJECTION BOOST

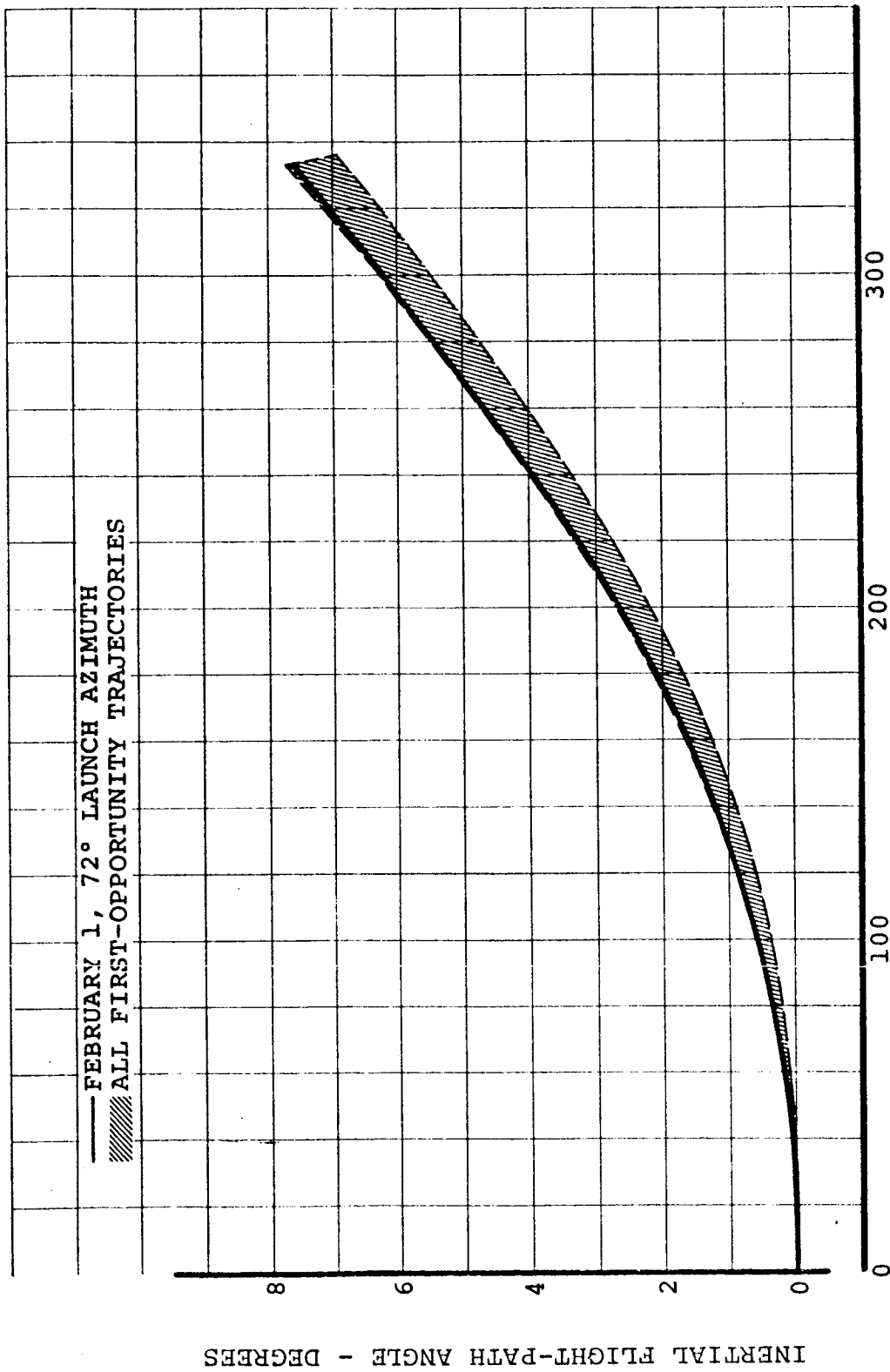


FIGURE 5-23. INERTIAL FLIGHT-PATH ANGLE DURING FIRST-OPPORTUNITY TRANSLUNAR INJECTION BOOST

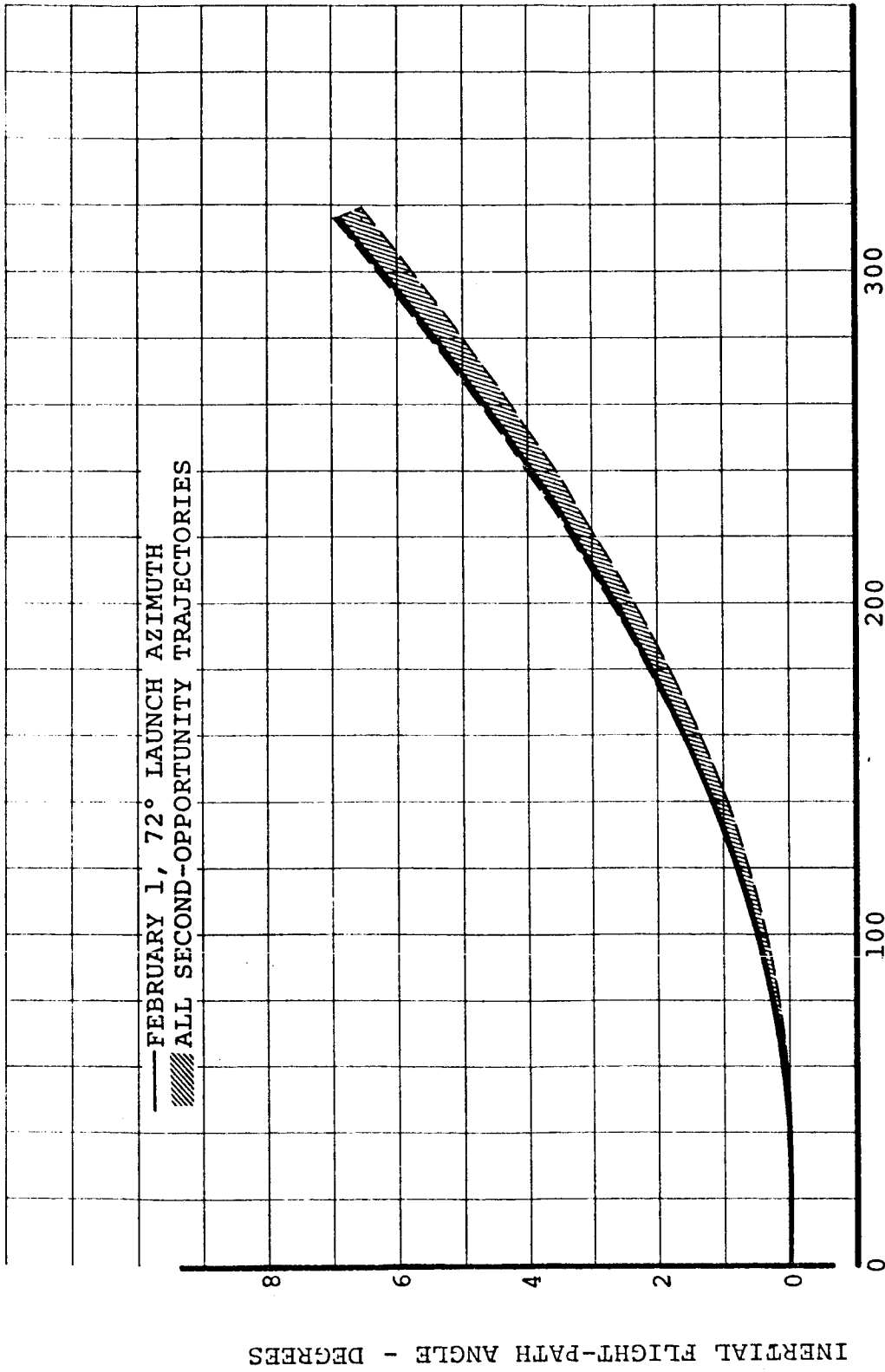


FIGURE 5-24. INERTIAL FLIGHT-PATH ANGLE DURING SECOND-OPPORTUNITY TRANSLUNAR INJECTION BOOST

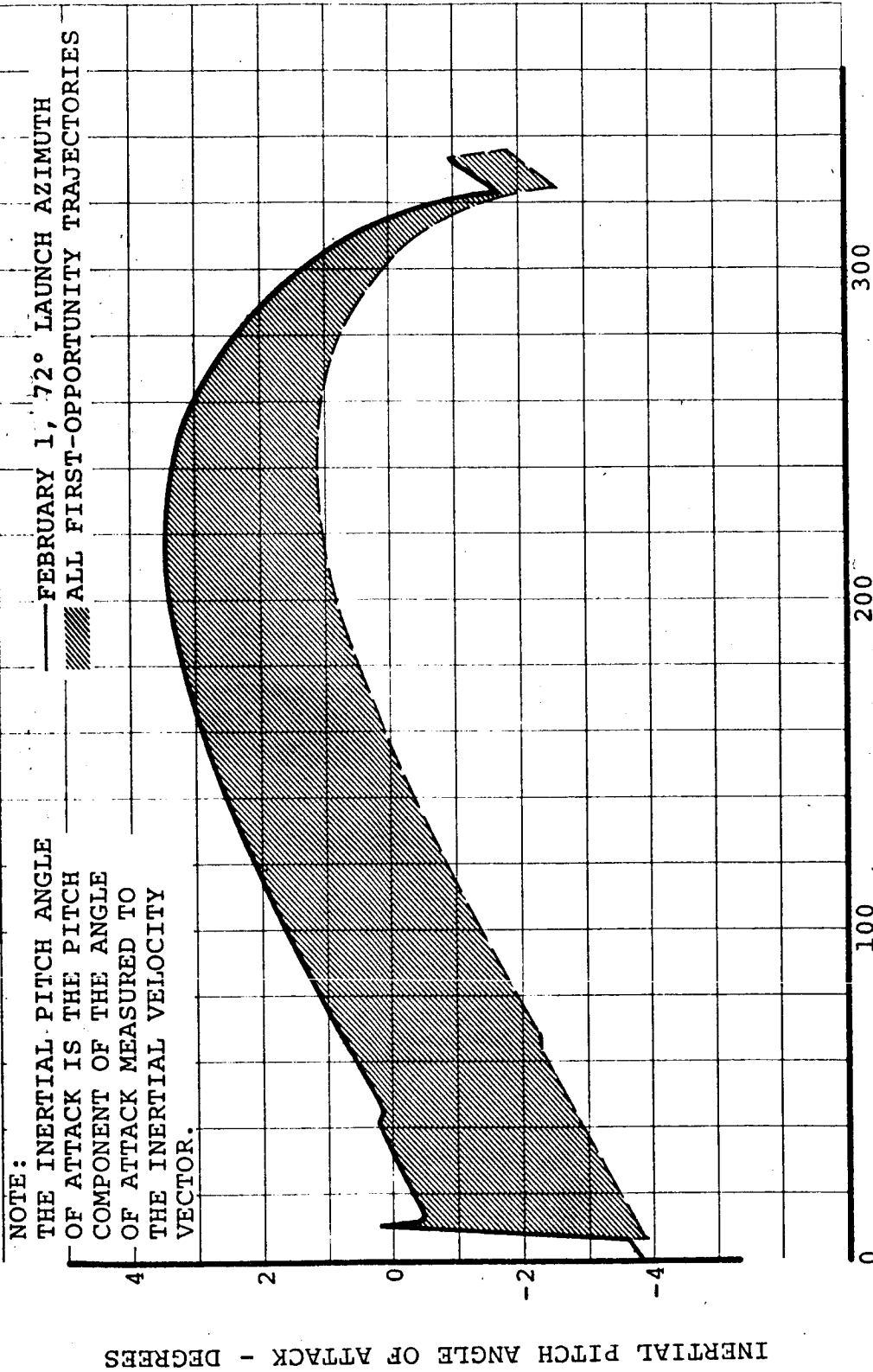


FIGURE 5-25. INERTIAL PITCH ANGLE OF ATTACK DURING FIRST-OPPORTUNITY TRANSLUNAR INJECTION BOOST

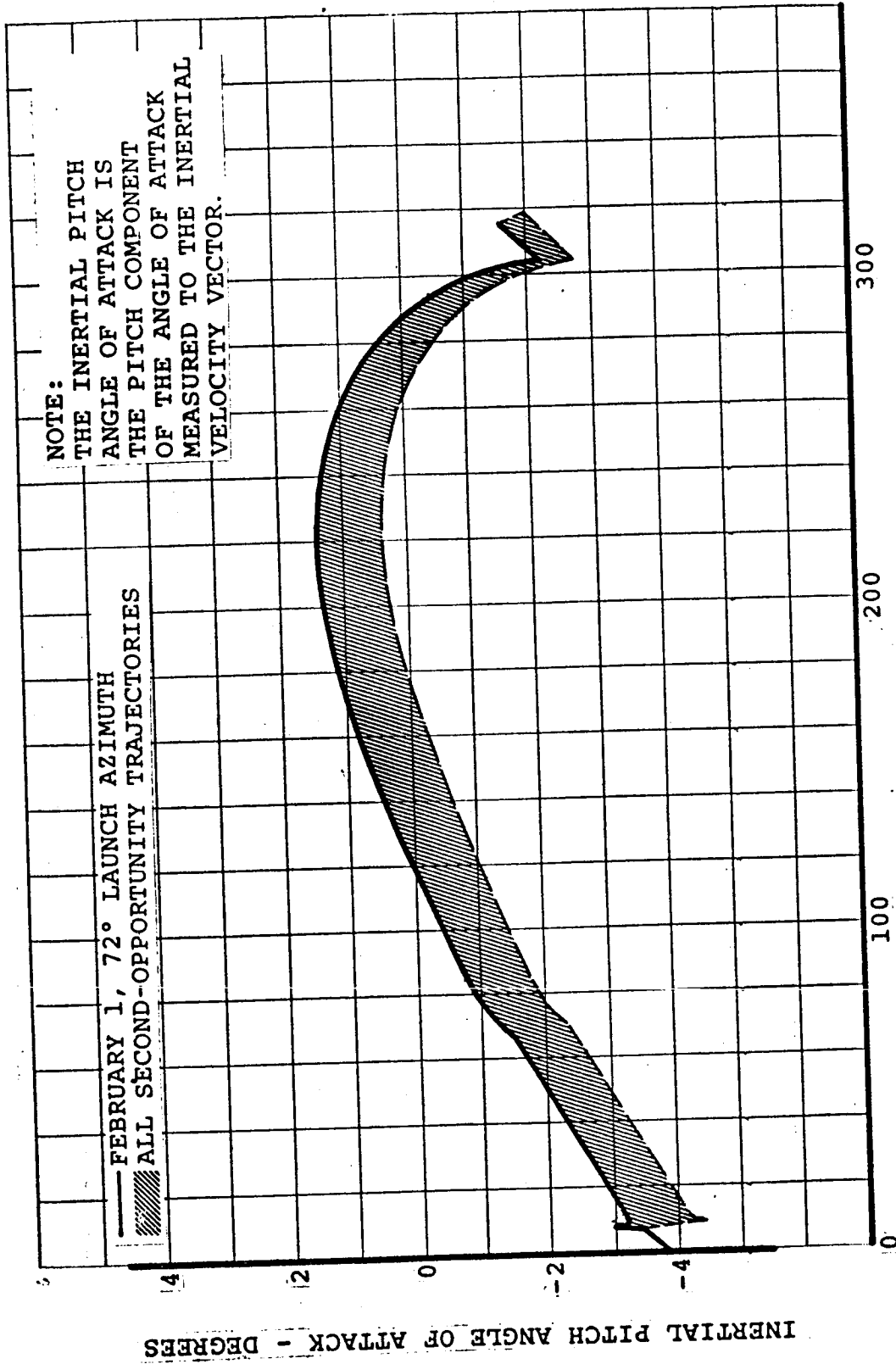


FIGURE 5-26. INERTIAL PITCH ANGLE OF ATTACK DURING SECOND-OPPORTUNITY TRANSLUNAR INJECTION BOOST

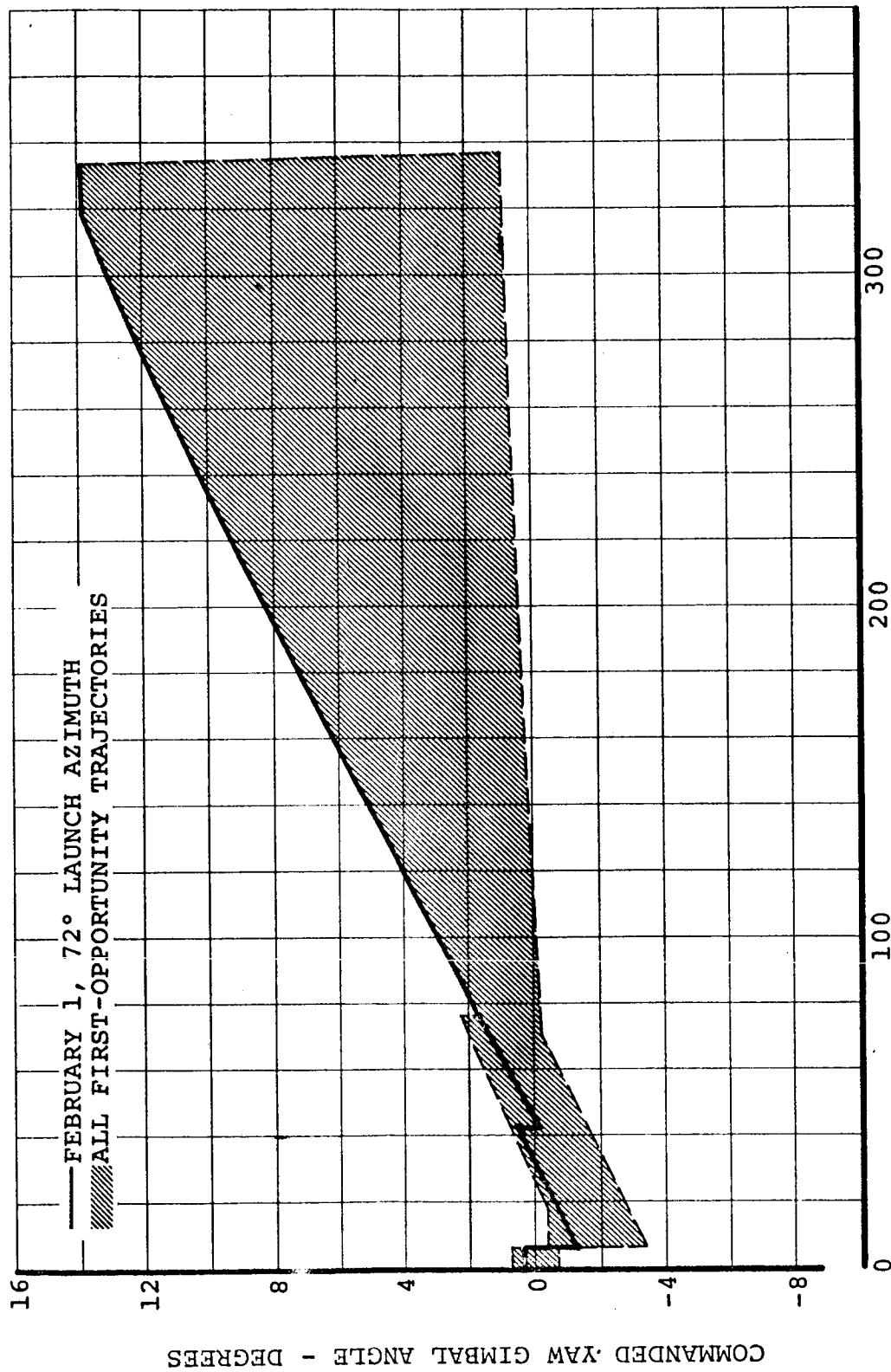


FIGURE 5-27. COMMANDED YAW GIMBAL ANGLE DURING FIRST-OPPORTUNITY TRANSLUNAR INJECTION BOOST

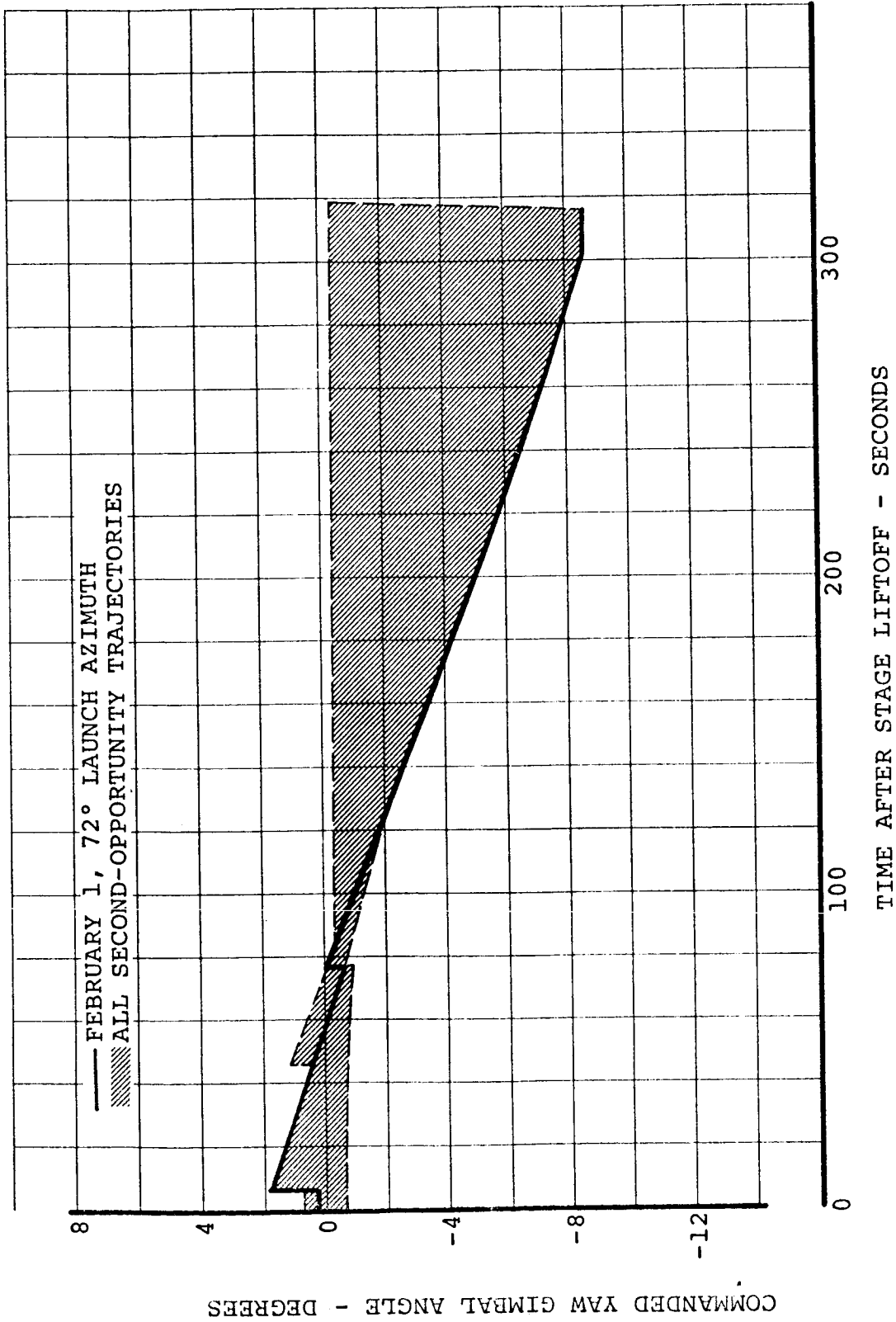


FIGURE 5-28. COMMANDED YAW GIMBAL ANGLE DURING SECOND-OPPORTUNITY TRANSLUNAR INJECTION BOOST

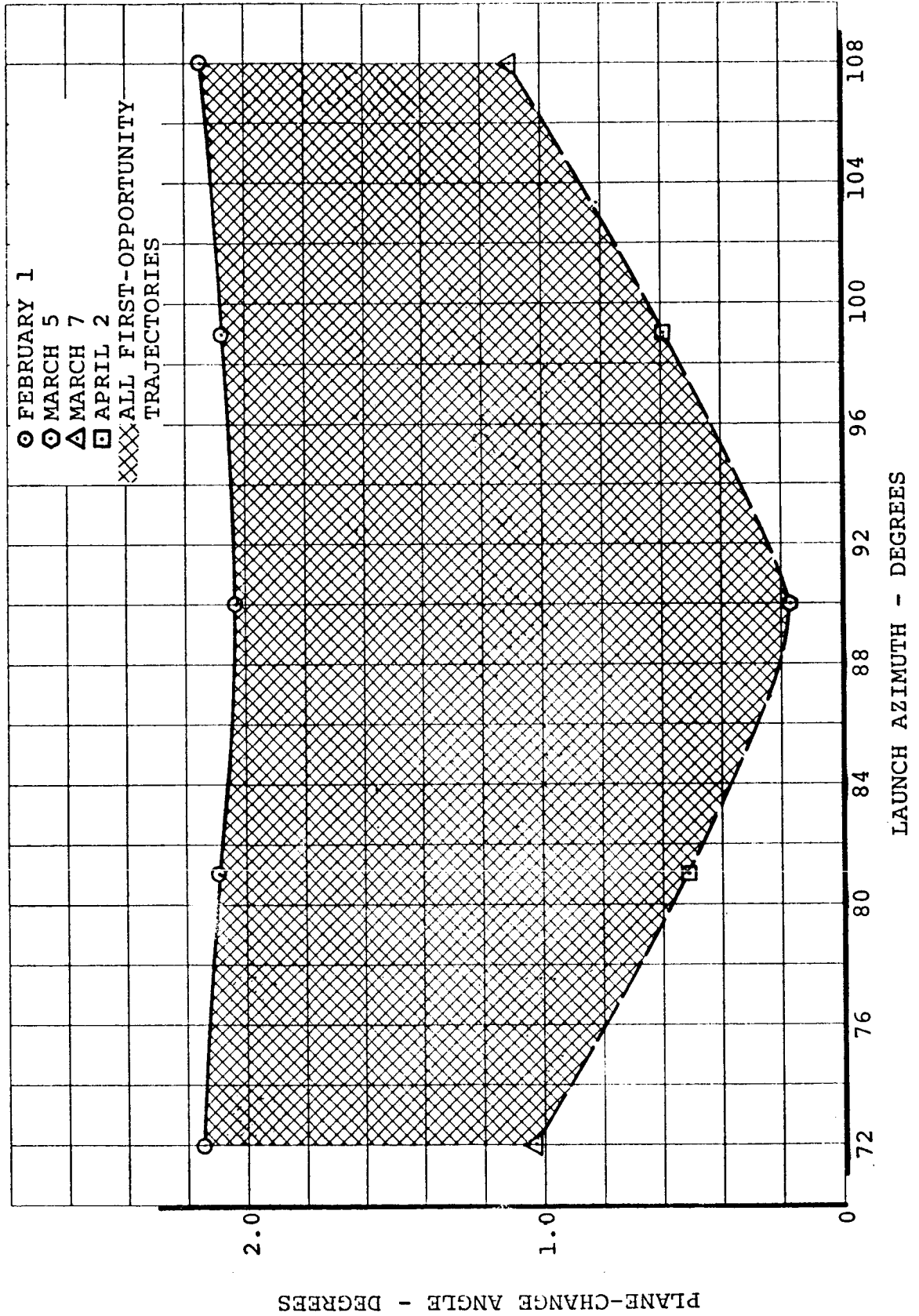
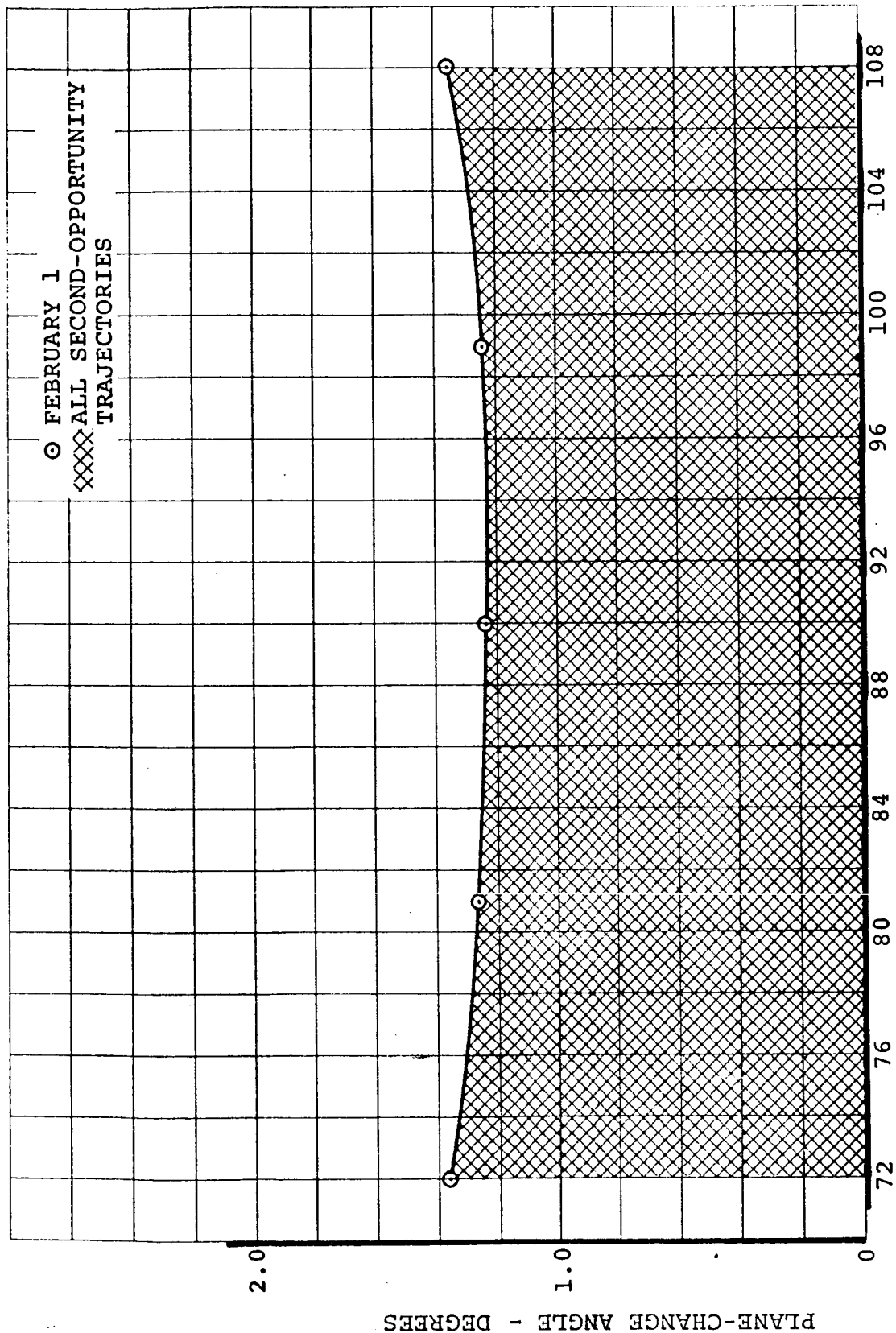


FIGURE 5-29. PLANE-CHANGE ANGLE DURING FIRST-OPPORTUNITY INJECTION



LAUNCH AZIMUTH - DEGREES
FIGURE 5-30. PLANE-CHANGE ANGLE DURING SECOND-OPPORTUNITY INJECTION

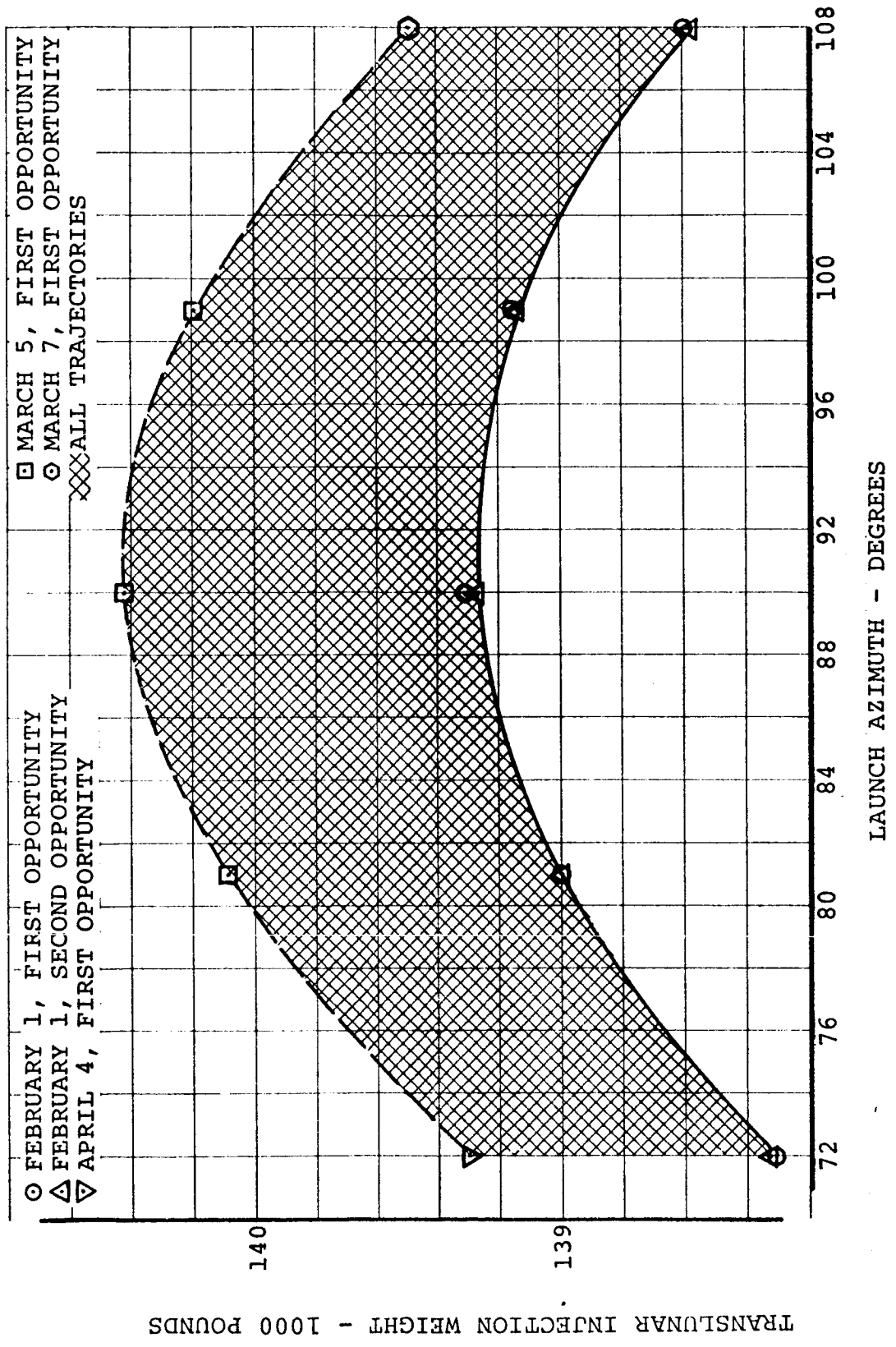


FIGURE 5-31. TRANSLUNAR INJECTION WEIGHT

TABLE 5-XXVII TRANSLUNAR INJECTION CONDITIONS FOR 1 FEBRUARY 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9937.232	9694.900	9443.903	9228.272	9069.786
TIME, GMT (HRS:MIN:SEC)	18:23:05.842	19:35:23.810	20:49:40.263	21:54:26.202	22:43:41.466
GEOCENTRIC LATITUDE (DEGREES N)	-0.4449	-1.7671	-2.3760	-2.1372	-1.1684
GEODETTIC LATITUDE (DEGREES N)	-0.4498	-1.7805	-2.3933	-2.1529	-1.1780
LONGITUDE (DEGREES E)	-179.9352	163.1175	145.3168	129.4519	116.8992
ALTITUDE ABOVE THE GEOID (KILOMETERS)	345.902	343.978	340.934	342.077	340.834
RADIUS (KILOMETERS)	6724.066	6722.122	6719.062	6720.212	6718.990
INERTIAL VELOCITY (M/SEC)	10825.72	10827.63	10830.24	10829.16	10829.80

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TABLE 5-XXVII TRANSLUNAR INJECTION CONDITIONS FOR 1 FEBRUARY 1968, FIRST OPPORTUNITY (Continued)

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES 108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	7.599	7.617	7.646	7.683 7.692
INERTIAL HEADING (DEGREES)	59.451	62.504	63.464	62.157 58.809
ECCENTRICITY	0.977398	0.977525	0.977580	0.977529 0.977404
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.36398	-1.35680	-1.35430	-1.35737 -1.36525
TRUE ANOMALY (DEGREES)	15.375	15.409	15.468	15.543 15.563
INCLINATION (DEGREES)	30.5518	27.5485	26.6346	27.9186 31.2109
WEIGHT (POUNDS)	138307.	138997.	139307.	139147. 138588.
PLANE-CHANGE ANGLE (DEGREES)	2.149	2.087	2.032	2.077 2.146

TABLE 5-XXVIII TRANSLUNAR INJECTION CONDITIONS FOR 1 FEBRUARY 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	15231.592	14987.210	14735.210	14517.438	14357.911
TIME, GMT (HRS:MIN:SEC)	19:51:20.202	21:03:36.120	22:17:51.570	23:22:35.368	00:11:49.591 (2 FEBRUARY)
GEOCENTRIC LATITUDE (DEGREES N)	-0.4051	-1.6872	-2.2727	-2.0853	-1.1875
GEODETTIC LATITUDE (DEGREES N)	-0.4097	-1.7000	-2.2894	-2.1007	-1.1972
LONGITUDE (DEGREES E)	156.7471	139.8343	122.0840	106.1646	93.5626
ALTITUDE ABOVE THE GEOID (KILOMETERS)	327.596	327.272	326.215	324.384	323.003
RADIUS (KILOMETERS)	6705.760	6705.419	6704.346	6702.520	6701.158
INERTIAL VELOCITY (M/SEC)	10840.65	10841.26	10842.26	10843.62	10844.36

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TABLE 5-XXVIII TRANSLUNAR INJECTION CONDITIONS FOR 1 FEBRUARY 1968, SECOND OPPORTUNITY (Continued)

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES 108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.898	6.901	6.945	6.958 6.966
INERTIAL HEADING (DEGREES)	56.116	59.370	60.454	59.136 55.651
ECCENTRICITY	0.977387	0.977506	0.977557	0.977516 0.977387
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.36408	-1.35700	-1.35436	-1.35727 -1.36540
TRUE ANOMALY (DEGREES)	13.957	13.962	14.050	14.077 14.093
INCLINATION (DEGREES)	33.8857	30.6717	29.6256	30.9276 34.3666
WEIGHT (POUNDS)	138327.	138999.	139262.	139130. 138563.
PLANE-CHANGE ANGLE (DEGREES)	1.360	1.266	1.237	1.243 1.346

TABLE 5-XXIX

TRANSLUNAR INJECTION CONDITIONS FOR 2 FEBRUARY 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9777.466	9515.243	9254.269	9051.614	8915.132
TIME, GMT (HRS:MIN:SEC)	19:42:27.906	21:00:51.703	22:17:37.109	23:19:15.384	00:02:01.462 (3 FEBRUARY)
GEOCENTRIC LATITUDE (DEGREES N)	-6.2294	-7.6768	-8.3930	-8.0023	-6.8594
GEODETTIC LATITUDE (DEGREES N)	-6.2725	-7.7274	-8.4481	-8.0550	-6.9050
LONGITUDE (DEGREES E)	171.5672	153.1750	134.6872	119.6927	108.7025
ALTITUDE ABOVE THE GEOID (KILOMETERS)	342.755	341.036	337.458	338.341	337.388
RADIUS (KILOMETERS)	6720.667	6718.817	6715.165	6716.090	6715.246
INERTIAL VELOCITY (M/SEC)	10828.54	10830.46	10833.58	10832.66	10832.90

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TABLE 5-XXIX TRANSLUNAR INJECTION CONDITIONS FOR 2 FEBRUARY 1968, FIRST
OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	7.531	7.532	7.488	7.589	7.607
INERTIAL HEADING (DEGREES)	59.821	63.196	64.371	62.923	59.305
ECCENTRICITY	0.977421	0.977574	0.977633	0.977580	0.977427
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.36286	-1.35401	-1.35088	-1.35452	-1.36406
TRUE ANOMALY (DEGREES)	15.238	15.238	15.149	15.352	15.391
INCLINATION (DEGREES)	30.7558	27.8033	26.8798	28.1490	31.3789
WEIGHT (POUNDS)	138420.	139099.	139426.	139270.	138681.
PLANE-CHANGE ANGLE (DEGREES)	2.022	1.944	1.910	1.940	2.016

TABLE 5-XXX TRANSUNAR INJECTION CONDITIONS FOR 2 FEBRUARY 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	15071.772	14808.430	14547.446	14341.708	14204.146
TIME, GMT (HRS:MIN:SEC)	21:10:42.212	22:29:04.890	23:45:50.286	0:47:25.478 (3 FEBRUARY)	1:30:10.476 (3 FEBRUARY)
GEOCENTRIC LATITUDE (DEGREES N)	-6.2248	-7.5988	-8.2672	-7.9484	-6.8706
GEODETTIC LATITUDE (DEGREES N)	-6.2666	-7.6491	-8.3216	-8.0009	-6.9165
LONGITUDE (DEGREES E)	148.2734	129.9804	111.5996	96.4877	85.4401
ALTITUDE ABOVE THE GEOID (KILOMETERS)	327.024	324.670	322.404	321.170	319.941
RADIUS (KILOMETERS)	6704.936	6702.459	6700.125	6698.925	6697.799
INERTIAL VELOCITY (M/SEC)	10841.38	10843.82	10845.89	10846.69	10847.17

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TABLE 5-XXX TRANSLUNAR INJECTION CONDITIONS FOR 2 FEBRUARY 1968, SECOND OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.806	6.832	6.836	6.875	6.888
INERTIAL HEADING (DEGREES)	56.860	60.485	61.780	60.296	56.489
ECCENTRICITY	0.977401	0.977559	0.977624	0.977569	0.977412
VIS-VIVA ENERGY, C3 (KM ² /SEC ²)	-1.36286	-1.35399	-1.35057	-1.35435	-1.36413
TRUF ANOMALY (DEGREES)	13.770	13.821	13.829	13.909	13.936
INCLINATION (DEGREES)	33.6543	30.3924	29.3101	30.6550	34.1270
WEIGHT (POUNDS)	138435.	139122.	139404.	139256.	138685.
PLANE-CHANGE ANGLE (DEGREES)	1.170	1.040	0.973	1.023	1.154

TABLE 5-XXXXI TRANSLUNAR INJECTION CONDITIONS FOR 3 FEBRUARY 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9623.614	9333.442	9062.548	8873.850	8767.276
TIME, GMT (HRS:MIN:SEC)	21:04:38.634	22:31:44.812	23:52:31.768	0:49:29.890 (4 FEBRUARY)	01:23:20.446 (4 FEBRUARY)
GEOCENTRIC LATITUDE (DEGREES N)	-11.6530	-13.3873	-14.1493	-13.6337	-12.1451
GEODETTIC LATITUDE (DEGREES N)	-11.7277	-13.4720	-14.2384	-13.7198	-12.2226
LONGITUDE (DEGREES E)	163.1948	142.8229	123.5803	109.5639	100.6612
ALTITUDE ABOVE THE GEOID (KILOMETERS)	340.267	338.790	336.826	335.178	334.555
RADIUS (KILOMETERS)	6717.555	6715.803	6713.708	6712.150	6711.769
INERTIAL VELOCITY (M/SEC)	10830.12	10831.75	10833.50	10834.63	10834.63

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TABLE 5-XXXI TRANSLUNAR INJECTION CONDITIONS FOR 3 FEBRUARY 1968, FIRST OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	7.466	7.455	7.479	7.501	7.529
INERTIAL HEADING (DEGREES)	61.041	65.059	66.507	64.764	60.529
ECCENTRICITY	0.977080	0.977156	0.977183	0.977140	0.977031
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.38367	-1.37933	-1.37830	-1.38138	-1.38821
TRUE ANOMALY (DEGREES)	15.108	15.085	15.133	15.178	15.237
INCLINATION (DEGREES)	31.0257	28.1024	27.2168	28.4691	31.6661
WEIGHT (POUNDS)	138573.	139282.	139603.	139456.	138868.
PLANE-CHANGE ANGLE (DEGREES)	1.886	1.788	1.748	1.783	1.879

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TABLE 5-XXXII TRANSLUNAR INJECTION CONDITIONS FOR 3 FEBRUARY 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14917.895	14626.602	14354.680	14163.947	14056.346
TIME, GMT (HRS:MIN:SEC)	22:32:59.915	23:59:57.972	1:20:43.900 (4 FEBRUARY)	02:17:39.987 (4 FEBRUARY)	02:51:29.516 (4 FEBRUARY)
GEOCENTRIC LATITUDE (DEGREES N)	-11.6717	-13.3384	-14.0809	-13.6074	-12.1799
GEODETTIC LATITUDE (DEGREES N)	-11.7467	-13.4231	-14.1698	-13.6936	-12.2579
LONGITUDE (DEGREES E)	139.9310	119.6576	100.4727	86.3934	77.4330
ALTITUDE ABOVE THE GEOID (KILOMETERS)	323.835	321.694	320.101	317.643	316.829
RADIUS (KILOMETERS)	6701.121	6698.716	6696.995	6694.620	6694.038
INERTIAL VELOCITY (M/SEC)	10843.47	10845.65	10847.12	10848.92	10849.07

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TABLE 5-XXXII TRANSLUNAR INJECTION CONDITIONS FOR 3 FEBRUARY 1968, SECOND OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.715	6.722	6.768	6.768	6.795
INERTIAL HEADING (DEGREES)	58.482	62.794	64.413	62.603	58.134
ECCENTRICITY	0.977034	0.977119	0.977150	0.977105	0.976993
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.38528	-1.38065	-1.37944	-1.38260	-1.38965
TRUE ANOMALY (DEGREES)	13.589	13.602	13.695	13.695	13.751
INCLINATION (DEGREES)	33.3998	30.0742	28.9749	30.3543	33.884
WEIGHT (POUNDS)	138570.	139282.	139570.	139415.	138825.
PLANE-CHANGE ANGLE (DEGREES)	0.971	0.772	0.679	0.757	0.942

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TABLE 5-XXXIII TRANSLUNAR INJECTION CONDITIONS FOR 4 FEBRUARY 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9491.746	9169.636	8880.907	8717.152	8645.488
TIME, GMT (HRS:MIN:SEC)	22:24:46.696	00:02:14.936 (5 FEBRUARY)	01:28:39.115 (5 FEBRUARY)	02:18:30.402 (5 FEBRUARY)	02:41:36.618 (5 FEBRUARY)
GEOCENTRIC LATITUDE (DEGREES N)	-16.0825	-18.1125	-19.0518	-18.2100	-16.3050
GEODETTIC LATITUDE (DEGREES N)	-16.1821	-18.2228	-19.1669	-18.3209	-16.4059
LONGITUDE (DEGREES E)	155.7504	133.0584	112.5325	100.2259	93.7957
ALTITUDE ABOVE THE GEOID (KILOMETERS)	338.000	336.266	334.351	333.217	331.952
RADIUS (KILOMETERS)	6714.517	6712.356	6710.228	6709.285	6708.425
INERTIAL VELOCITY (M/SEC)	10831.83	10833.98	10835.90	10836.42	10836.65

TABLE 5-XXXIII TRANSLUNAR INJECTION CONDITIONS FOR 4 FEBRUARY 1968, FIRST OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	7.354	7.369	7.402	7.441	7.448
INERTIAL HEADING (DEGREES)	62.810	67.701	69.733	67.358	62.216
ECCENTRICITY	0.976805	0.976951	0.977026	0.976945	0.976777
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.40020	-1.39191	-1.38800	-1.39339	-1.40371
TRUE ANOMALY (DEGREES)	14.883	14.913	14.979	15.059	15.075
INCLINATION (DEGREES)	31.2748	28.4335	27.5384	28.7527	31.8826
WEIGHT (POUNDS)	138707.	139449.	139736.	139585.	138983.
PLANE-CHANGE ANGLE (DEGREES)	1.723	1.626	1.607	1.626	1.714

TABLE 5-XXXIV TRANSLUNAR INJECTION CONDITIONS FOR 4 FEBRUARY 1968, SECOND OPPORTUNITY

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
LAUNCH AZIMUTH					
FLIGHT TIME (SECONDS)	14786.950	14462.784	14172.991	14007.186	13935.445
TIME, GMT (HRS:MIN:SEC)	23:53:01.900 (5 FEBRUARY)	01:30:28.084 (5 FEBRUARY)	2:56:51.201 (5 FEBRUARY)	03:46:40.436 (5 FEBRUARY)	04:09:46.575 (5 FEBRUARY)
GEOCENTRIC LATITUDE (DEGREES N)	-16.0888	-18.0987	-19.0191	-18.2146	-16.3360
GEODETTIC LATITUDE (DEGREES N)	-16.1887	-18.2092	-19.1344	-18.3258	-16.4373
LONGITUDE (DEGREES E)	132.5733	109.9279	89.4585	77.0812	70.6396
ALTITUDE ABOVE THE GEOID (KILOMETERS)	318.504	318.833	317.130	314.952	314.375
RADIUS (KILOMETERS)	6695.019	6694.926	6693.015	6691.019	6690.841
INERTIAL VELOCITY (M/SEC)	10847.74	10848.22	10849.98	10851.35	10851.01

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TABLE 5-XXXIV TRANS-LUNAR INJECTION CONDITIONS FOR 4 FEBRUARY 1968, SECOND OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.601	6.618	6.669	6.678	6.713
INERTIAL HEADING (DEGREES)	60.702	66.081	68.307	65.793	60.286
ECCENTRICITY	0.976781	0.976928	0.977008	0.976921	0.976752
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.40114	-1.39239	-1.38821	-1.39394	-1.40439
TRUE ANOMALY (DEGREES)	13.359	13.392	13.495	13.514	13.586
INCLINATION (DEGREES)	33.0780	29.6699	28.5434	29.9604	33.5452
WEIGHT (POUNDS)	138711.	139424.	139698.	139553.	138977.
PLANE-CHANGE ANGLE (DEGREES)	0.640	0.301	0.127	0.292	0.595

TABLE 5-XXXV TRANSLUNAR INJECTION CONDITIONS FOR 1 MARCH 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9678.594	9400.350	9134.481	8939.779	8820.212
TIME, GMT (HRS:MIN:SEC)	18:44:24.974	20:07:52.110	21:26:54.691	22:25:56.839	23:03:29.232
GEOCENTRIC LATITUDE (DEGREES N)	-9.7426	-11.3295	-12.0500	-11.5899	-10.2759
GEODETTIC LATITUDE (DEGREES N)	-9.8057	-11.4021	-12.1269	-11.6640	-10.3422
LONGITUDE (DEGREES E)	166.2190	146.6849	127.8063	113.3681	103.5711
ALTITUDE ABOVE THE GEOID (KILOMETERS)	341.477	339.151	337.559	336.985	335.463
RADIUS (KILOMETERS)	6719.027	6716.487	6714.787	6714.283	6712.944
INERTIAL VELOCITY (M/SEC)	10829.58	10832.03	10833.57	10833.82	10834.51

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TABLE 5-XXXV

TRANSLUNAR INJECTION CONDITIONS FOR 1 MARCH 1968, FIRST OPPORTUNITY (Continued)

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	7.478	7.481	7.500	7.555	7.555
INERTIAL HEADING (DEGREES)	60.516	64.230	65.568	63.939	59.976
ECCENTRICITY	0.977316	0.977460	0.977522	0.977470	0.977332
VIS-VIVA ENERGY, C3 (KM ² /SEC ²)	-1.36918	-1.36100	-1.35774	-1.36135	-1.36997
TRUE ANOMALY (DEGREES)	15.130	15.136	15.173	15.285	15.287
INCLINATION (DEGREES)	30.9136	27.9940	27.0771	28.3563	31.5779
WEIGHT (POUNDS)	138501.	139223.	139517.	139378.	138806.
PLANE-CHANGE ANGLE (DEGREES)	1.937	1.842	1.808	1.840	1.931

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TABLE 5-XXXVI TRANSLUNAR INJECTION CONDITIONS FOR 1 MARCH 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14973.87	14693.55	14426.61	14229.88	14109.29
TIME, GMT (HRS:MIN:SEC)	20:12:40.245	21:36:05.311	22:55:06.814	23:54:06.942	00:31:38.309 (2 MARCH)
GEOCENTRIC LATITUDE (DEGREES N)	-9.7185	-11.2721	-11.9695	-11.5541	-10.3036
GEODETTIC LATITUDE (DEGREES N)	-9.7816	-11.3446	-12.0461	-11.6282	-10.3703
LONGITUDE (DEGREES E)	142.9957	123.5088	104.6833	90.1865	80.3341
ALTITUDE ABOVE THE GEOID (KILOMETERS)	326.104	322.832	321.071	319.481	318.0238
RADIUS (KILOMETERS)	6703.657	6700.176	6698.312	6696.784	6695.502
INERTIAL VELOCITY (M/SEC)	10842.14	10845.38	10847.07	10848.15	10848.78

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TABLE 5-XXXVI TRANSLUNAR INJECTION CONDITIONS FOR 1 MARCH 1968, SECOND OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.768	6.763	6.799	6.828	6.832
INERTIAL HEADING (DEGREES)	57.795	61.818	63.290	61.618	57.457
ECCENTRICITY	0.977297	0.977451	0.977517	0.977465	0.977317
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.36920	-1.36053	-1.35719	-1.36076	-1.36999
TRUE ANOMALY (DEGREES)	13.695	13.683	13.755	13.815	13.824
INCLINATION (DEGREES)	33.4876	30.1804	29.0879	30.4619	33.9631
WEIGHT (POUNDS)	138512.	139216.	139499.	139342.	138766.
PLANE-CHANGE ANGLE (DEGREES)	1.032	0.852	0.772	0.833	1.006

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TABLE 5-XXXVII TRANSLUNAR INJECTION CONDITIONS FOR 3 MARCH 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9417.779	9065.758	8754.870	8619.303	8578.627
TIME, GMT (HRS:MIN:SEC)	21:25:47.389	23:12:29.258	00:44:42.340 (4 MARCH)	01:27:06.403 (4 MARCH)	01:40:58.647 (4 MARCH)
GEOCENTRIC LATITUDE (DEGREES N)	-18.4343	-20.8145	-21.9745	-20.8003	-18.4842
GEODETTIC LATITUDE (DEGREES N)	-18.5462	-20.9382	-22.1037	-20.9240	-18.5965
LONGITUDE (DEGREES E)	151.4318	126.5918	104.4775	94.1441	89.9013
ALTITUDE ABOVE THE GEOID (KILOMETERS)	334.815	334.444	329.296	330.896	330.377
RADIUS (KILOMETERS)	6710.833	6709.898	6704.456	6706.353	6706.384
INERTIAL VELOCITY (M/SEC)	10834.93	10836.09	10840.75	10838.90	10838.39

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TABLE 5-XXXVII TRANSLUNAR INJECTION CONDITIONS FOR 3 MARCH 1968, FIRST OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	7.293	7.307	7.237	7.366	7.397
INERTIAL HEADING (DEGREES)	64.055	69.842	72.386	69.385	63.398
ECCENTRICITY	0.976845	0.976989	0.977077	0.976977	0.976808
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.39816	-1.38971	-1.38507	-1.39157	-1.40197
TRUE ANOMALY (DEGREES)	14.761	14.787	14.645	14.907	14.971
INCLINATION (DEGREES)	31.4527	28.6601	27.8866	28.9593	32.0042
WEIGHT (POUNDS)	138804.	139560.	139973.	139688.	139037.
PLANE-CHANGE ANGLE (DEGREES)	1.640	1.492	1.256	1.494	1.646

TABLE 5-XXXVIII TRANSLUNAR INJECTION CONDITIONS FOR 3 MARCH 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14714.00	14361.05	14052.38	13912.47	13869.58
TIME, GMT (HRS:MIN:SEC)	22:54:03.613 (4 MARCH)	00:40:44.548 (4 MARCH)	02:12:59.850 (4 MARCH)	02:55:19.574 (4 MARCH)	03:09:09.596 (4 MARCH)
GEOCENTRIC LATITUDE (DEGREES N)	-18.4358	-20.7707	-21.8545	-20.7459	-18.4982
GEODETTIC LATITUDE (DEGREES N)	-18.5480	-20.8945	-21.9834	-20.8696	-18.6108
LONGITUDE (DEGREES E)	128.3250	103.6154	81.7753	71.2102	66.8149
ALTITUDE ABOVE THE GEOID (KILOMETERS)	318.644	318.762	317.026	315.234	313.470
RADIUS (KILOMETERS)	6694.662	6694.227	6692.216	6690.705	6689.473
INERTIAL VELOCITY (M/SEC)	10848.12	10848.91	10850.78	10851.72	10852.22

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TABLE 5-XXXVIII TRANSLUNAR INJECTION CONDITIONS FOR 3 MARCH 1968, SECOND OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.568	6.614	6.669	6.691	6.680
INERTIAL HEADING (DEGREES)	62.332	68.616	71.295	68.150	61.750
ECCENTRICITY	0.976812	0.976974	0.977063	0.976963	0.976782
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.39916	-1.38972	-1.38508	-1.39156	-1.40269
TRUE ANOMALY (DEGREES)	13.292	13.385	13.495	13.541	13.520
INCLINATION (DEGREES)	32.8385	29.4673	28.4647	29.7752	33.3443
WEIGHT (POUNDS)	138784.	139447.	139706.	139574.	139028.
PLANE-CHANGE ANGLE (DEGREES)	0.368	0.	0.	0.	0.341

TABLE 5-XXXIX TRANSLUNAR INJECTION CONDITIONS FOR 5 MARCH 1968, FIRST
OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	7.041	6.942	6.926	7.006	7.183
INERTIAL HEADING (DEGREES)	65.377	71.842	75.317	70.773	64.177
ECCENTRICITY	0.975840	0.975906	0.975950	0.975880	0.975798
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.45848	-1.45527	-1.45339	-1.45798	-1.46310
TRUE ANOMALY (DEGREES)	14.257	14.055	14.024	14.186	14.545
INCLINATION (DEGREES)	31.8095	29.2049	28.3992	29.4596	32.3065
WEIGHT (POUNDS)	139168.	140083.	140419.	140192.	139378.
PLANE-CHANGE ANGLE (DEGREES)	1.194	0.550	0.171	0.625	1.247

TABLE 5-XL TRANSLUNAR INJECTION CONDITIONS FOR 5 MARCH 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14641.94	14263.13	13923.58	13838.51	13822.49
TIME, GMT (HRS:MIN:SEC)	00:56:12.188 (6 MARCH)	02:51:42.700 (6 MARCH)	04:33:32.069 (6 MARCH)	04:59:11.839 (6 MARCH)	05:04:35.704 (6 MARCH)
GEOCENTRIC LATITUDE (DEGREES N)	-20.6552	-23.0602	-24.4056	-22.5418	-20.0017
GEODETTIC LATITUDE (DEGREES N)	-20.7780	-23.1941	-24.5452	-22.6734	-20.1214
LONGITUDE (DEGREES E)	124.0055	97.3060	73.2209	66.4726	64.0216
ALTITUDE ABOVE THE GEOID (KILOMETERS)	319.534	318.763	316.574	314.380	312.153
RADIUS (KILOMETERS)	6695.028	6693.635	6691.074	6689.390	6687.806
INERTIAL VELOCITY (M/SEC)	10845.02	10846.31	10848.49	10849.67	10850.72

TABLE 5-XL
 TRANSLUNAR INJECTION CONDITIONS FOR 5 MARCH 1968, SECOND
 OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.526	6.613	6.656	6.661	6.632
INERTIAL HEADING (DEGREES)	64.241	71.133	74.884	70.018	63.026
ECCENTRICITY	0.975799	0.975867	0.975909	0.975842	0.975755
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.45994	-1.45665	-1.45496	-1.45942	-1.46480
TRUE ANOMALY (DEGREES)	13.214	13.391	13.477	13.487	13.430
INCLINATION (DEGREES)	32.5697	29.4646	28.4620	29.7730	33.1275
WEIGHT (POUNDS)	138912.	139555.	139825.	139684.	139148.
PLANE-CHANGE ANGLE (DEGREES)	0.	0.	0.	0.	0.

TABLE 5-XLI
 TRANSLUNAR INJECTION CONDITIONS FOR 7 MARCH 1968, FIRST
 OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9513.459	9222.149	8960.292	8794.614	8708.199
TIME, GMT (HRS:MIN:SEC)	00:19:13.159 (8 MARCH)	01:48:02.509 (8 MARCH)	03:06:27.592 (8 MARCH)	03:57:38.634 (8 MARCH)	04:26:18.199 (8 MARCH)
GEOCENTRIC LATITUDE (DEGREES N)	-15.2906	-16.5384	-16.8630	-15.8961	-14.1182
GEODEIC LATITUDE (DEGREES N)	-15.3848	-16.6394	-16.9657	-15.9936	-14.2058
LONGITUDE (DEGREES E)	156.9641	136.1968	117.3909	104.8567	97.3314
ALTITUDE ABOVE THE GEOID (KILOMETERS)	324.481	323.347	320.265	320.190	321.075
RADIUS (KILOMETERS)	6701.153	6699.772	6696.623	6696.744	6697.962
INERTIAL VELOCITY (M/SEC)	10838.58	10840.06	10842.75	10842.38	10840.92

TABLE 5-XLI TRANSLUNAR INJECTION CONDITIONS FOR 7 MARCH 1968, FIRST OPPORTUNITY (Continued)

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES 108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.895	6.936	6.927	7.006 7.088
INERTIAL HEADING (DEGREES)	61.831	65.826	67.163	65.104 60.714
ECCENTRICITY	0.975302	0.975439	0.975488	0.975399 0.975237
VIS-VIVA ENERGY, C3 (KM ² /SEC ²)	-1.49084	-1.48317	-1.48085	-1.48668 -1.49673
TRUE ANOMALY (DEGREES)	13.965	14.047	14.030	14.189 14.357
INCLINATION (DEGREES)	31.7498	29.0065	28.1177	29.2625 32.2373
WEIGHT (POUNDS)	139292.	140079.	140377.	140188. 139489.
PLANE-CHANGE ANGLE (DEGREES)	1.034	0.639	0.508	0.696 1.104

TABLE 5-XLII TRANSLUNAR INJECTION CONDITIONS FOR 7 MARCH 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	14822.336	14530.252	14268.390	14099.549	14008.755
TIME, GMT (HRS:MIN:SEC)	01:47:42.036 (8 APRIL)	03:16:30.612 (8 APRIL)	04:34:55.690 (8 APRIL)	05:26:03.569 (8 APRIL)	05:54:38.755 (8 APRIL)
GEOCENTRIC LATITUDE (DEGREES N)	-14.9929	-16.2480	-16.550	-15.609	-13.912
GEODETTIC LATITUDE (DEGREES N)	-15.0856	-16.3476	-16.6511	-15.7052	-13.9987
LONGITUDE (DEGREES E)	134.6190	114.0097	95.329	82.642	74.828
ALTITUDE ABOVE THE GEOID (KILOMETERS)	318.765	318.646	316.801	314.644	311.698
RADIUS (KILOMETERS)	6695.493	6695.130	6693.224	6691.255	6688.621
INERTIAL VELOCITY (M/SEC)	10843.15	10843.79	10845.44	10846.79	10848.51

TABLE 5-XLII TRANSLUNAR INJECTION CONDITIONS FOR 7 MARCH 1968, SECOND OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.521	6.612	6.657	6.663	6.613
INERTIAL HEADING (DEGREES)	60.735	65.067	66.498	64.311	59.620
ECCENTRICITY	0.975260	0.975396	0.975439	0.975351	0.975197
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.49232	-1.48479	-1.48284	-1.48865	-1.49826
TRUE ANOMALY (DEGREES)	13.208	13.391	13.482	13.495	13.394
INCLINATION (DEGREES)	32.5768	29.4732	28.4714	29.7817	33.1350
WEIGHT (POUNDS)	138962.	139584.	139839.	139709.	139187.
PLANE-CHANGE ANGLE (DEGREES)	0.	0.	0.	0.	0.

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TABLE 5-XLIII TRANSLUNAR INJECTION CONDITIONS FOR 31 MARCH 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9360.895	8974.567	8624.826	8538.122	8530.727
TIME, GMT (HRS:MIN:SEC)	20:25:27.435	22:21:05.317	00:05:26.106 (1 APRIL)	00:32:59.702 (1 APRIL)	00:38:23.857 (1 APRIL)
GEOCENTRIC LATITUDE (DEGREES N)	-20.1772	-22.9210	-24.4887	-22.7276	-19.9896
GEODETTIC LATITUDE (DEGREES N)	-20.2978	-23.0546	-24.6291	-22.8603	-20.1094
LONGITUDE (DEGREES E)	148.0196	120.7148	95.8141	88.9290	87.0457
ALTITUDE ABOVE THE GEOID (KILOMETERS)	335.974	328.010	323.523	324.588	329.732
RADIUS (KILOMETERS)	6711.585	6702.919	6698.000	6699.549	6705.388
INERTIAL VELOCITY (M/SEC)	10834.26	10841.63	10845.87	10844.30	10839.15

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TABLE 5-XLIIII TRANSLUNAR INJECTION CONDITIONS FOR 31 MARCH 1968, FIRST OPPORTUNITY (Continued)

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	7.262	7.090	7.045	7.156
INERTIAL HEADING (DEGREES)	65.218	71.795	75.502	71.085
ECCENTRICITY	0.976818	0.976931	0.977019	0.976917
VIS-VIVA ENERGY, C3 (KM ² /SEC ²)	-1.39944	-1.39333	-1.38877	-1.39527
TRUE ANOMALY (DEGREES)	14.698	14.348	14.257	14.482
INCLINATION (DEGREES)	31.5493	28.9624	28.2289	29.2441
WEIGHT (POUNDS)	138836.	139804.	140226.	139923.
PLANE-CHANGE ANGLE (DEGREES)	1.598	1.092	0.734	1.115

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TABLE 5-XLIV TRANSLUNAR INJECTION CONDITIONS FOR 31 MARCH 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES 108 DEGREES
FLIGHT TIME (SECONDS)	14658.09	14277.29	13928.77	13837.72 13821.69
TIME, GMT (HRS:MIN:SEC)	21:53:44.626	23:49:28.037	01:33:50.054 (1 APRIL)	02:01:19.295 (1 APRIL) 02:06:34.820 (1 APRIL)
GEOCENTRIC LATITUDE (DEGREES N)	-20.1664	-22.7452	-24.3120	-22.5588 -20.0181
GEODETTIC LATITUDE (DEGREES N)	-20.2873	-22.8781	-24.4518	-22.6910 -20.1383
LONGITUDE (DEGREES E)	124.9854	98.2353	73.5769	66.4253 63.9743
ALTITUDE ABOVE THE GEOID (KILOMETERS)	320.174	319.251	317.233	314.981 312.445
RADIUS (KILOMETERS)	6695.788	6694.207	6691.760	6689.986 6688.095
INERTIAL VELOCITY (M/SEC)	10847.13	10848.75	10850.98	10852.11 10853.27

TABLE 5-XLIV TRANSLUNAR INJECTION CONDITIONS FOR 31 MARCH 1968, SECOND OPPORTUNITY (Continued)

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.552	6.631	6.681	6.683	6.643
INERTIAL HEADING (DEGREES)	63.783	70.747	74.727	70.037	62.977
ECCENTRICITY	0.976783	0.976910	0.977005	0.976895	0.976757
VIS-VIVA ENERGY, C3 (KM ² /SEC ²)	-1.40058	-1.39370	-1.38876	-1.39578	-1.40428
TRUE ANOMALY (DEGREES)	13.260	13.418	13.520	13.525	13.445
INCLINATION (DEGREES)	32.6347	29.4650	28.4622	29.7730	33.1748
WEIGHT (POUNDS)	138819.	139458.	139722.	139586.	139054.
PLANE-CHANGE ANGLE (DEGREES)	0.097	0.	0.	0.	0.089

TABLE 5-XLV TRANSLUNAR INJECTION CONDITIONS FOR 2 APRIL 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES 108 DEGREES
FLIGHT TIME (SECONDS)	9370.149	9012.970	8708.297	8591.474 8559.961
TIME, GMT (HRS:MIN:SEC)	22:01:26.699	23:48:53.110	01:20:12.977 (3 APRIL)	01:56:42.994 (3 APRIL) 02:08:52.251 (3 APRIL)
GEOCENTRIC LATITUDE (DEGREES N)	-19.8404	-21.9855	-22.8525	-21.3999 -19.0243
GEODETTIC LATITUDE (DEGREES N)	-19.9591	-22.1145	-22.9855	-21.5262 -19.1390
LONGITUDE (DEGREES E)	148.5626	123.1908	101.3956	92.3491 88.7756
ALTITUDE ABOVE THE GEOID (KILOMETERS)	326.631	322.783	320.130	319.964 322.020
RADIUS (KILOMETERS)	6702.323	6697.940	6695.058	6695.271 6697.903
INERTIAL VELOCITY (M/SEC)	10840.45	10844.68	10847.43	10846.67 10843.79

TABLE 5-XLV

TRANSLUNAR INJECTION CONDITIONS FOR 2 APRIL 1968, FIRST OPPORTUNITY (Continued)

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	7.007	6.911	6.927	7.000	7.119
INERTIAL HEADING (DEGREES)	64.571	70.305	72.759	69.285	63.354
ECCENTRICITY	0.976327	0.976564	0.976715	0.976511	0.976253
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.42942	-1.41544	-1.40703	-1.41975	-1.43554
TRUE ANOMALY (DEGREES)	14.184	13.989	14.021	14.170	14.413
INCLINATION (DEGREES)	31.8416	29.1869	28.3457	29.4403	32.3308
WEIGHT (POUNDS)	139180.	140026.	140330.	140137.	139391.
PLANE-CHANGE ANGLE (DEGREES)	1.083	0.521	0.253	0.595	1.150

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TABLE 5-XLVI TRANSLUNAR INJECTION CONDITIONS FOR 2 APRIL 1968, SECOND OPPORTUNITY

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
LAUNCH AZIMUTH					
FLIGHT TIME (SECONDS)	14675.93	14321.08	14016.42	13896.43	13859.45
TIME, GMT (HRS:MIN:SEC)	23:29:52.485	01:17:21.219 (3 APRIL)	02:48:41.101 (3 APRIL)	03:25:07.953 (3 APRIL)	03:37:11.744 (3 APRIL)
GEOCENTRIC LATITUDE (DEGREES N)	-19.6400	-21.7393	-22.6207	-21.1501	-18.8480
GEODETTIC LATITUDE (DEGREES N)	-19.7579	-21.8672	-22.7526	-21.2753	-18.9620
LONGITUDE (DEGREES E)	126.0662	101.0670	79.4210	70.1926	66.2313
ALTITUDE ABOVE THE GEOID (KILOMETERS)	319.493	318.666	317.464	315.068	312.243
RADIUS (KILOMETERS)	6695.233	6693.886	6692.453	6690.438	6688.167
INERTIAL VELOCITY (M/SEC)	10846.19	10847.91	10849.48	10850.55	10851.70

TABLE 5-XLVI TRANSLUNAR INJECTION CONDITIONS FOR 2 APRIL 1968, SECOND OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.551	6.610	6.686	6.685	6.636
INERTIAL HEADING (DEGREES)	63.487	69.614	72.259	68.553	62.251
ECCENTRICITY	0.976281	0.976515	0.976667	0.976464	0.976213
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.43096	-1.41747	-1.40902	-1.42174	-1.43709
TRUE ANOMALY (DEGREES)	13.263	13.380	13.532	13.531	13.434
INCLINATION (DEGREES)	32.5659	29.4597	28.4571	29.7662	33.1189
WEIGHT (POUNDS)	138868.	139491.	139745.	139621.	139103.
PLANE-CHANGE ANGLE (DEGREES)	0.	0.	0.	0.	0.

TABLE 5-XLVII TRANSLUNAR INJECTION CONDITIONS FOR 4 APRIL 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES 108 DEGREES
FLIGHT TIME (SECONDS)	9592.210	9317.844	9065.941	8888.296 8783.927
TIME, GMT (HRS:MIN:SEC)	22:40:39.051 (5 APRIL)	00:03:43.744 (5 APRIL)	01:19:27.801 (5 APRIL)	02:13:50.136 (5 APRIL) 02:47:46.347 (5 APRIL)
GEOCENTRIC LATITUDE (DEGREES N)	-12.6412	-13.7370	-13.9247	-13.0784 -11.4779
GEODETTIC LATITUDE (DEGREES N)	-12.7205	-13.8226	-14.0114	-13.1603 -11.5505
LONGITUDE (DEGREES E)	161.4006	141.8607	123.7303	110.3555 101.5421
ALTITUDE ABOVE THE GEOID (KILOMETERS)	326.901	323.479	321.394	320.445 320.971
RADIUS (KILOMETERS)	6704.037	6700.433	6698.315	6697.510 6698.286
INERTIAL VELOCITY (M/SEC)	10835.66	10838.68	10840.41	10840.94 10840.08

TABLE 5-XLVII TRANSLUNAR INJECTION CONDITIONS FOR 4 APRIL 1968, FIRST OPPORTUNITY (Continued)

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.971	6.943	6.964	7.011
INERTIAL HEADING (DEGREES)	60.695	64.316	65.457	63.703
ECCENTRICITY	0.975100	0.975136	0.975144	0.975106
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.50290	-1.50136	-1.50149	-1.50427
TRUE ANOMALY (DEGREES)	14.120	14.064	14.107	14.202
INCLINATION (DEGREES)	31.6915	28.9053	28.0034	29.1607
WEIGHT (POUNDS)	139294.	140075.	140369.	140178.
PLANE-CHANGE ANGLE (DEGREES)	1.049	0.710	0.597	0.763
				1.121

TABLE 5-XLVIII TRANSLUNAR INJECTION CONDITIONS FOR 4 APRIL 1968, SECOND OPPORTUNITY

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
LAUNCH AZIMUTH					
FLIGHT TIME (SECONDS)	14899.090	14625.926	14373.014	14193.198	14084.471
TIME, GMT (HRS:MIN:SEC)	0:09:05.930 (5 APRIL)	1:32:11.826 (5 APRIL)	2:47:54.874 (5 APRIL)	3:42:15.038 (5 APRIL)	4:16:06.891 (5 APRIL)
GEOCENTRIC LATITUDE (DEGREES N)	-12.4084	-13.4342	-13.6199	-12.7818	-11.2767
GEODETTIC LATITUDE (DEGREES N)	-12.4865	-13.5182	-13.7050	-12.8621	-11.3482
LONGITUDE (DEGREES E)	138.9347	119.6467	101.5783	88.1151	79.0246
ALTITUDE ABOVE THE GEOID (KILOMETERS)	318.771	318.744	317.140	315.005	312.816
RADIUS (KILOMETERS)	6695.944	6695.750	6694.114	6692.118	6690.160
INERTIAL VELOCITY (M/SEC)	10842.18	10842.43	10843.76	10845.26	10846.66

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TABLE 5-XLVIII TRANSLUNAR INJECTION CONDITIONS FOR 4 APRIL 1968, SECOND OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.528	6.616	6.661	6.670	6.609
INERTIAL HEADING (DEGREES)	59.636	63.522	64.761	62.879	58.644
ECCENTRICITY	0.975045	0.975086	0.975094	0.975054	0.974978
VIS-VIVA ENERGY, C3 (KM2/SEC2)	-1.50526	-1.50334	-1.50351	-1.50644	-1.51108
TRUE ANOMALY (DEGREES)	13.224	13.402	13.492	13.511	13.389
INCLINATION (DEGREES)	32.5763	29.4699	28.4660	29.7743	33.1262
WEIGHT (POUNDS)	138981.	139608.	139863.	139728.	139199.
PLANE-CHANGE ANGLE (DEGREES)	0.	0.	0.	0.	0.

TABLE 5-XLIX TRANSLUNAR INJECTION CONDITIONS FOR 6 APRIL 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	9899.376	9669.901	9435.911	9236.284	9088.976
TIME, GMT (HRS:MIN:SEC)	22:58:03.726	00:07:21.131 (7 APRIL)	01:17:35.101 (7 APRIL)	02:18:50.244 (7 APRIL)	03:06:25.916 (7 APRIL)
GEOCENTRIC LATITUDE (DEGREES N)	-1.7063	-2.4586	-2.4942	-1.7350	-0.3514
GEODETTIC LATITUDE (DEGREES N)	-1.7175	-2.4745	-2.5104	-1.7463	-0.3538
LONGITUDE (DEGREES E)	177.9972	161.6767	144.8043	129.8310	117.8565
ALTITUDE ABOVE THE GEOID (KILOMETERS)	326.937	324.510	322.676	322.114	322.638
RADIUS (KILOMETERS)	6705.083	6702.635	6700.801	6700.259	6700.802
INERTIAL VELOCITY (M/SEC)	10833.69	10836.00	10837.53	10837.72	10836.79

TABLE 5-XLIX TRANS-LUNAR INJECTION CONDITIONS FOR 6 APRIL 1968, FIRST OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.987	6.976	6.980	7.028	7.095
INERTIAL HEADING (DEGREES)	58.599	61.502	62.432	61.186	58.062
ECCENTRICITY	0.974698	0.974818	0.974833	0.974751	0.974581
VIS-VIVA ENERGY, C3 (KM ² /SEC ²)	-1.52705	-1.52027	-1.51979	-1.52519	-1.53581
TRUE ANOMALY (DEGREES)	14.156	14.132	14.140	14.238	14.376
INCLINATION (DEGREES)	31.4426	28.5948	27.6716	28.8614	31.9401
WEIGHT (POUNDS)	139251.	139994.	140276.	140089.	139425.
PLANE-CHANGE ANGLE (DEGREES)	1.172	0.919	0.839	0.960	1.237

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TABLE 5-L TRANSLUNAR INJECTION CONDITIONS FOR 6 APRIL 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (SECONDS)	15207.232	14977.948	14743.948	14542.132	14390.474
TIME, GMT (HRS:MIN:SEC)	0:26:31.582 (7 APRIL)	1:35:49.178 (7 APRIL)	2:46:03.138 (7 APRIL)	3:47:16.092 (7 APRIL)	4:34:47.414 (7 APRIL)
GEOCENTRIC LATITUDE (DEGREES N)	-1.4246	-2.1229	-2.1182	-1.3791	-0.1068
GEODETTIC LATITUDE (DEGREES N)	-1.4340	-2.1368	-2.1319	-1.3881	-0.1077
LONGITUDE (DEGREES E)	155.5399	139.3932	122.6282	107.5774	95.3517
ALTITUDE ABOVE THE GEOID (KILOMETERS)	316.520	317.954	318.336	316.540	313.367
RADIUS (KILOMETERS)	6694.672	6696.090	6696.472	6694.693	6691.531
INERTIAL VELOCITY (M/SEC)	10842.08	10841.24	10840.96	10842.16	10844.28

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TABLE 5-L TRANSLUNAR INJECTION CONDITIONS FOR 6 APRIL 1968, SECOND OPPORTUNITY (Continued)

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
INERTIAL FLIGHT-PATH ANGLE (DEGREES)	6.539	6.606	6.665	6.675	6.615
INERTIAL HEADING (DEGREES)	57.436	60.584	61.591	60.241	56.863
ECCENTRICITY	0.974641	0.974757	0.974776	0.974690	0.974524
VIS-VIVA ENERGY, C3 (KM ² /SEC ²)	-1.53000	-1.52306	-1.52222	-1.52785	-1.53825
TRUE ANOMALY (DEGREES)	13.248	13.384	13.503	13.525	13.404
INCLINATION (DEGREES)	32.5915	29.4853	28.4812	29.7878	33.1376
WEIGHT (POUNDS)	139010.	139616.	139857.	139722.	139205.
PLANE-CHANGE ANGLE (DEGREES)	0.	0.	0.	0.	0.

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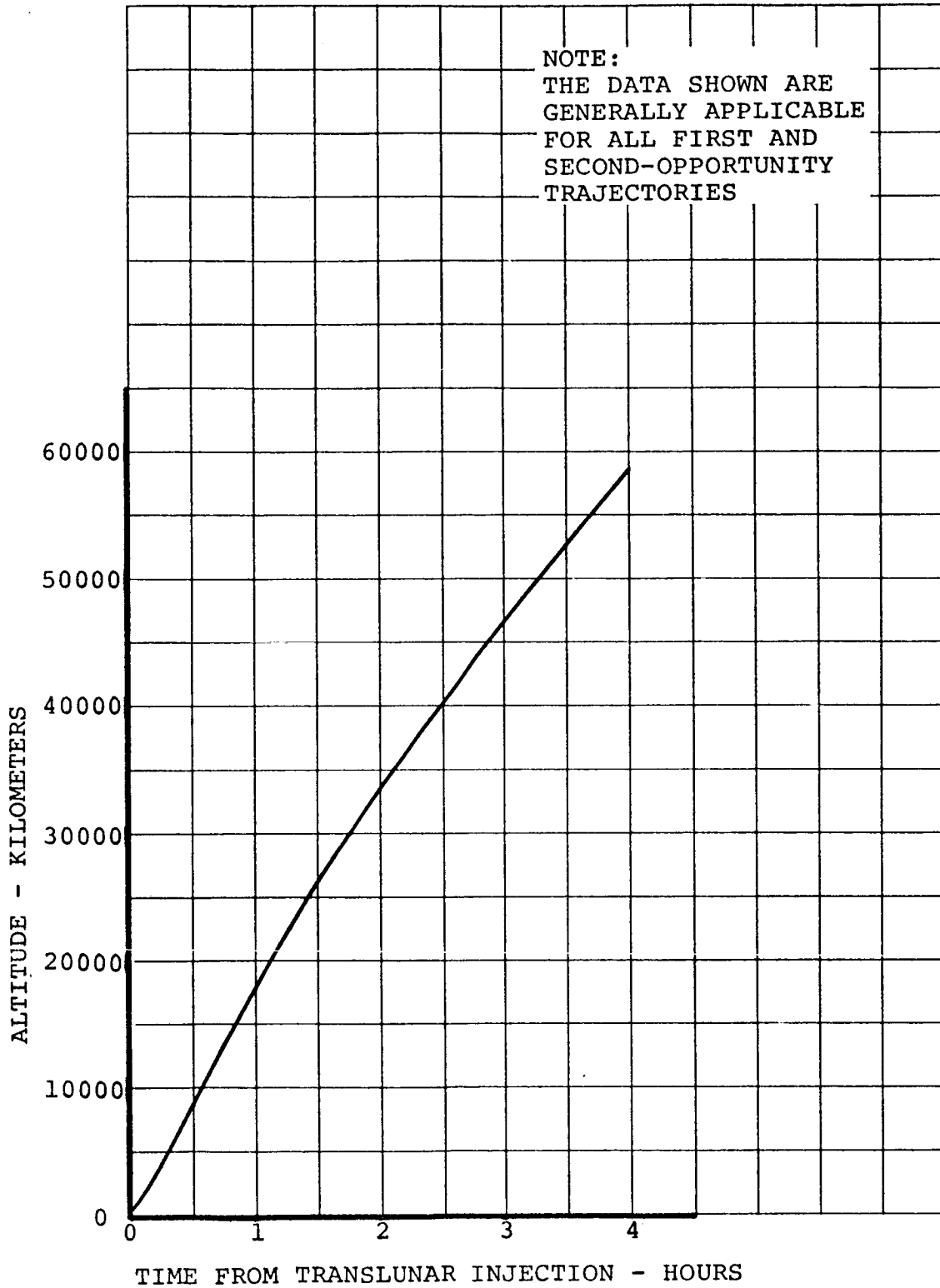


FIGURE 5-32. ALTITUDE DURING FIRST FOUR HOURS AFTER TRANSLUNAR INJECTION

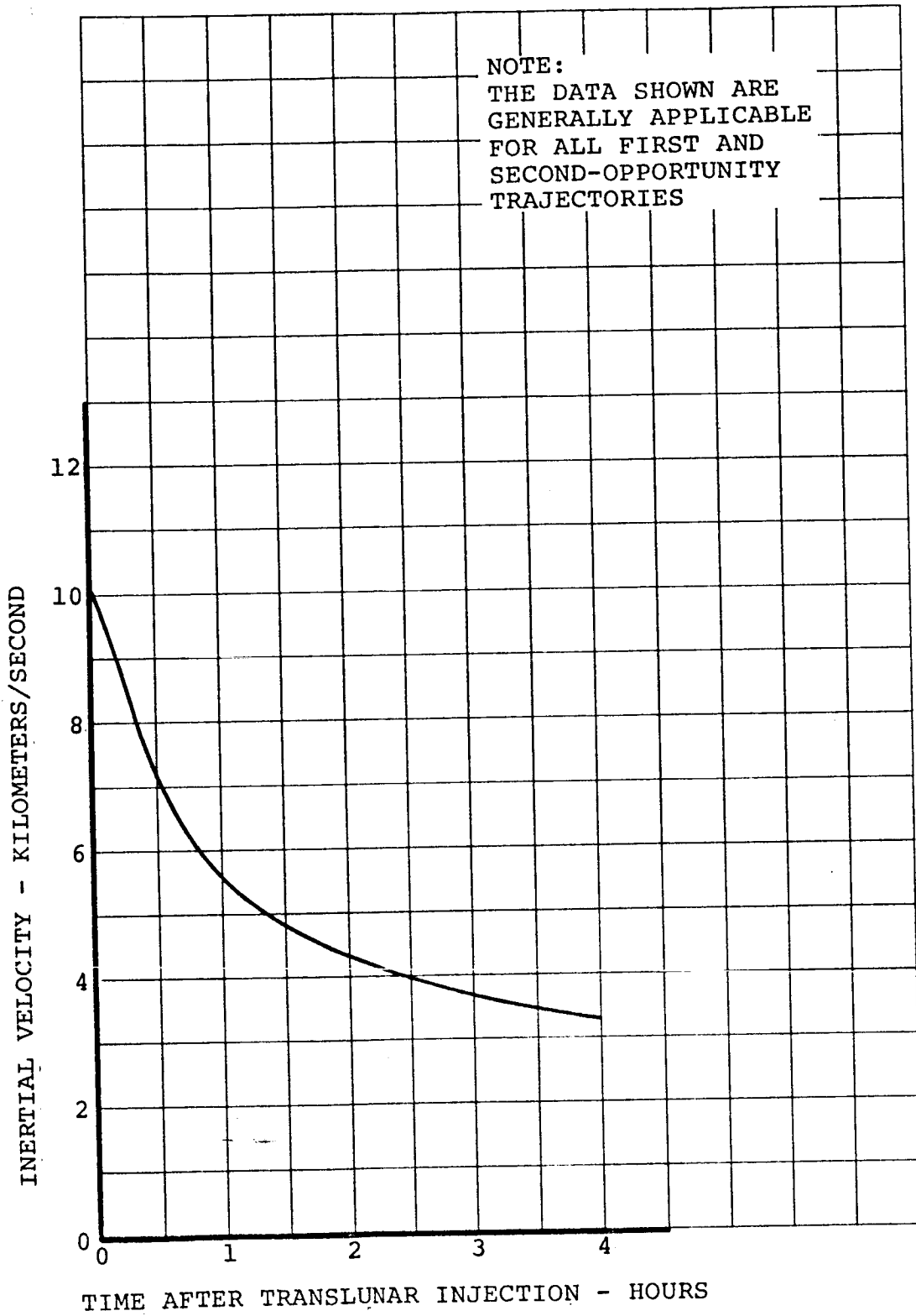


FIGURE 5-33. INERTIAL VELOCITY DURING FIRST FOUR HOURS AFTER TRANSLUNAR INJECTION

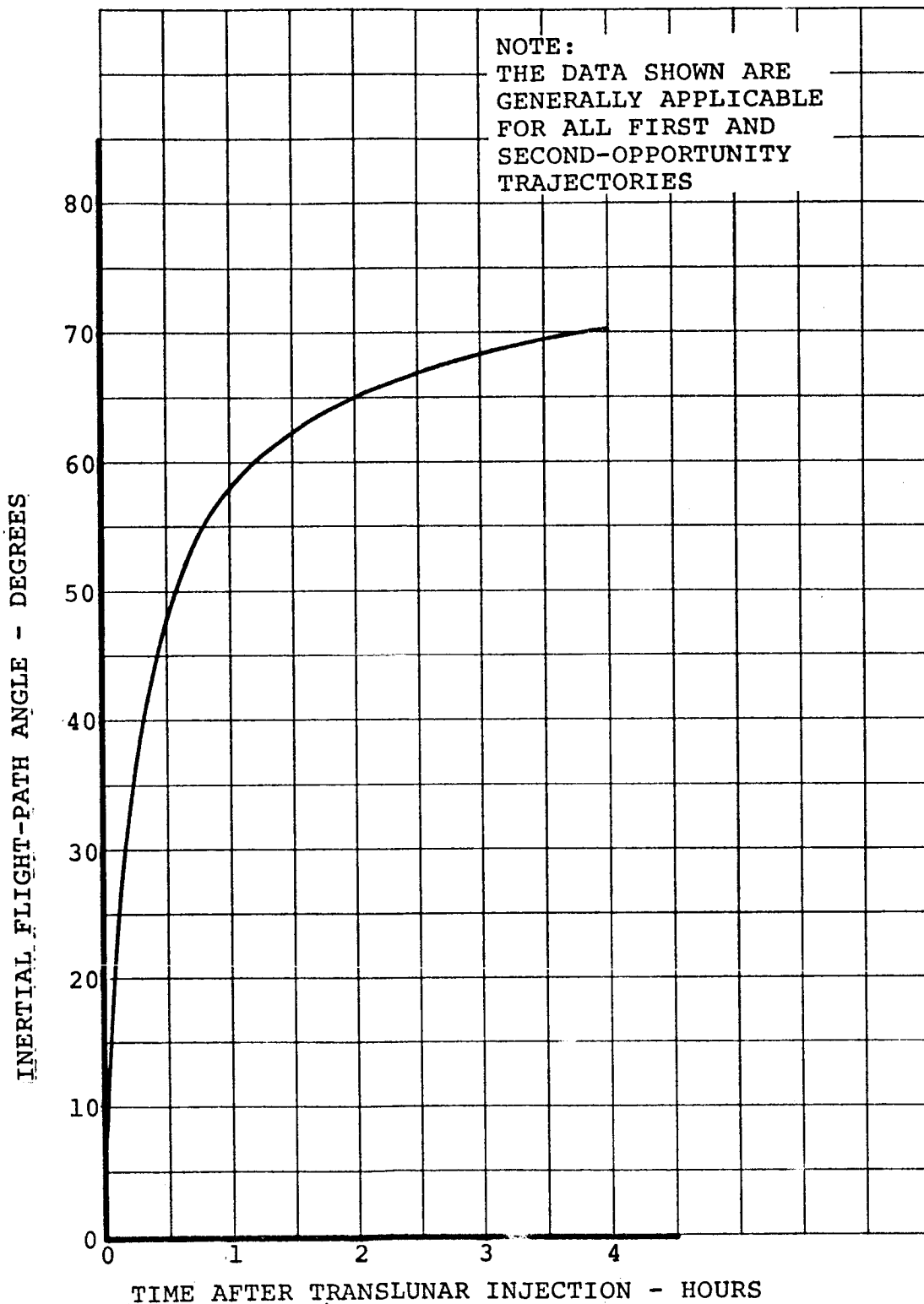


FIGURE 5-34. INERTIAL FLIGHT-PATH ANGLE DURING FIRST FOUR HOURS AFTER TRANSLUNAR INJECTION

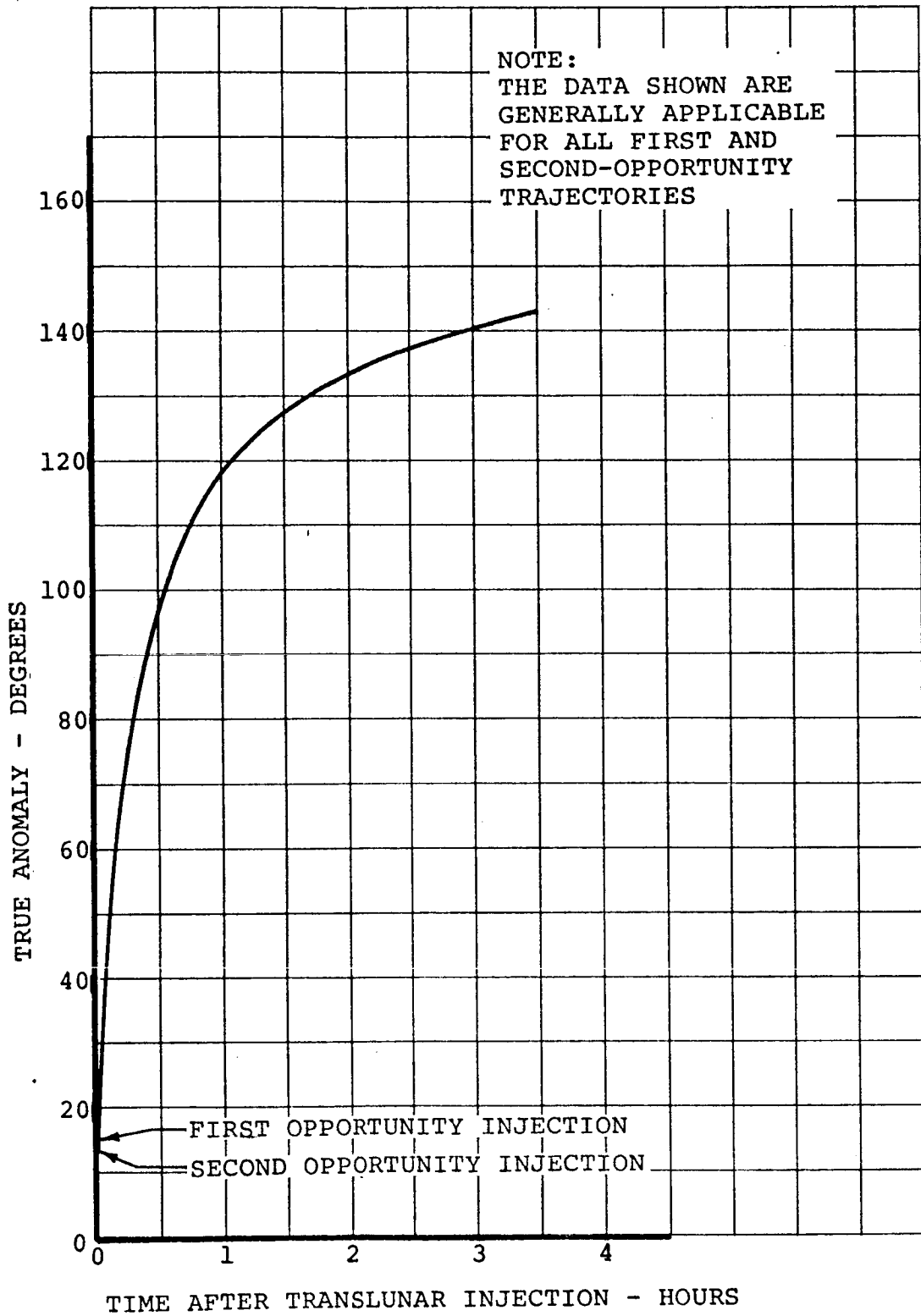


FIGURE 5-35. TRUE ANOMALY DURING FIRST FOUR HOURS AFTER TRANSLUNAR INJECTION

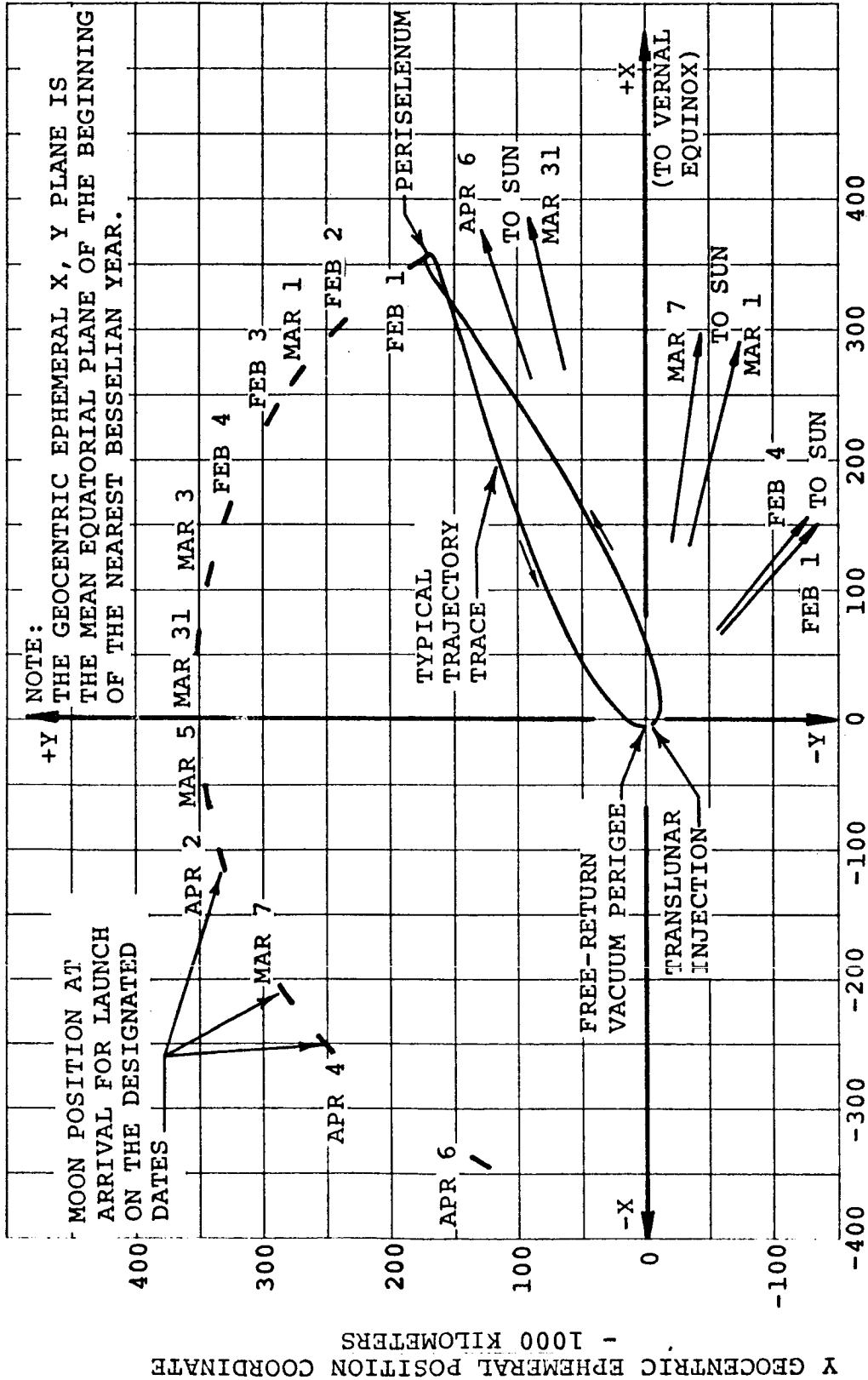
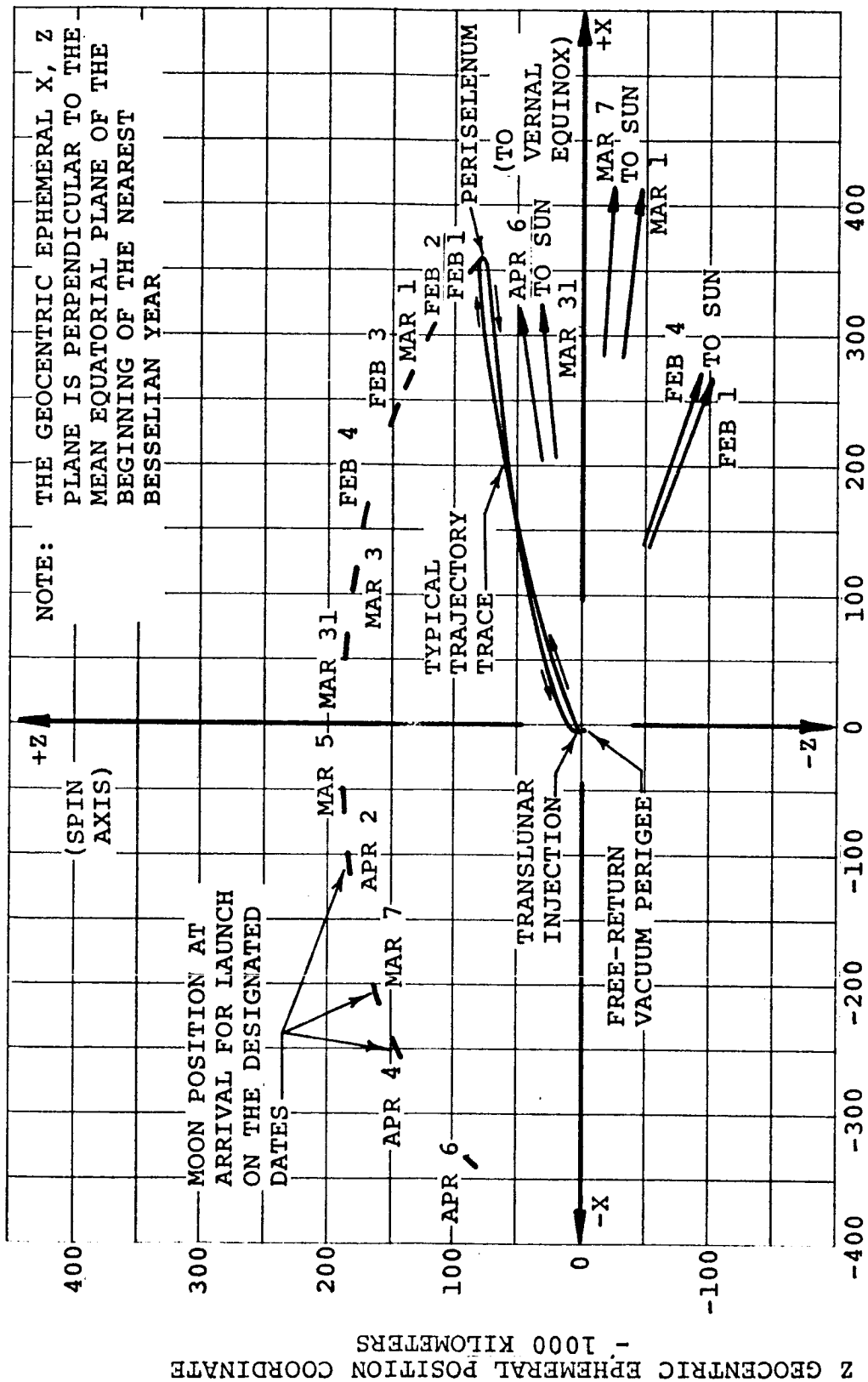


FIGURE 5-36. COMPOSITE AS-504 LUNAR EPHEMERIS AND TRAJECTORY PROJECTION IN THE GEOCENTRIC EPHEMERAL X, Y PLANE



X GEOCENTRIC EPHEMERAL POSITION COORDINATE - 1000 KILOMETERS

FIGURE 5-37. COMPOSITE AS-504 LUNAR EPHEMERIS AND TRAJECTORY PROJECTION IN THE GEOCENTRIC EPHEMERAL X, Z PLANE

TABLE 5-LI PERISELENUM CONDITIONS FOR LAUNCH ON 1 FEBRUARY 1968, FIRST OPPORTUNITY

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
LAUNCH AZIMUTH					
FLIGHT TIME (HRS:MIN:SEC)	77:30:46.055	77:12:58.553	77:05:43.972	77:11:20.056	77:28:44.971
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	21:08:14.665 (4 FEB)	22:06:47.463 (4 FEB)	23:18:00.332 (4 FEB)	00:31:57.986 (5 FEB)	01:41:16.651 (5 FEB)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	146.101	153.809	165.383	185.430	213.846
SELENOGRAPHIC RADIUS (KILOMETERS)	1884.190	1891.898	1903.473	1923.519	1951.936
SELENOGRAPHIC LATI- TUDE (DEGREES N)	-5.6305	-5.6348	-5.5288	-5.4099	-5.3360
SELENOGRAPHIC LON- GITUDE (DEGREES E)	179.3959	179.8072	179.9870	179.9600	179.9641
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	25.7796	27.4023	27.5199	26.5412	25.0758
GEODETTIC LATITUDE (DEGREES N)	11.0832	11.2969	11.5558	11.8230	12.0717
GEOGRAPHIC LONGITUDE (DEGREES E)	294.1279	279.8973	262.5868	244.6084	227.7603

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TABLE 5-LII PERISELENUM CONDITIONS FOR LAUNCH ON 1 FEBRUARY 1968, SECOND OPPORTUNITY

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
LAUNCH AZIMUTH					
FLIGHT TIME (HRS:MIN:SEC)	79:06:36.892	78:48:07.256	78:39:34.717	78:43:45.705	79:00:11.937
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	22:44:05.502 (4 FEBRUARY)	23:41:56.166 (4 FEBRUARY)	00:51:51.077 (4 FEBRUARY)	02:04:23.635 (4 FEBRUARY)	03:12:43.617 (4 FEBRUARY)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	170.395	162.346	153.381	142.025	128.355
SELENOGRAPHIC RADIUS (KILOMETERS)	1908.484	1900.435	1891.471	1880.115	1866.444
SELENOGRAPHIC LATI- TUDE (DEGREES N)	-5.4742	-5.5028	-5.5622	-5.6430	-5.7723
SELENOGRAPHIC LON- GITUDE (DEGREES E)	179.4552	179.7354	179.7775	179.5158	178.9784
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	24.4195	25.8918	26.8410	26.8660	26.2555
GEODETTIC LATITUDE (DEGREES N)	11.4322	11.6421	11.8492	12.1540	12.3971
GEOGRAPHIC LONGITUDE (DEGREES E)	270.8282	256.7686	239.7744	222.1410	205.5304

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TABLE 5-LIII PERISELENUM CONDITIONS FOR LAUNCH ON 2 FEBRUARY 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	77:48:08.970	77:24:27.965	77:13:32.175	77:1820.011	77:37:57.570
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	22:47:39.410 (5 FEBRUARY)	23:46:44.425 (5 FEBRUARY)	00:56:55.015 (5 FEBRUARY)	02:06:43.781 (5 FEBRUARY)	03:11:23.900 (5 FEBRUARY)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	108.776	133.228	146.876	139.912	140.170
SELENOGRAPHIC RADIUS (KILOMETERS)	1846.866	1871.317	1884.966	1878.002	1878.259
SELENOGRAPHIC LATI- TUDE (DEGREES N)	-5.6554	-5.5299	-5.4821	-5.1849	-5.2275
SELENOGRAPHIC LONGI- TITUDE (DEGREES E)	178.7150	179.3581	179.6183	179.3150	178.8201
SELENOGRAPHIC LONGI- TITUDE OF THE ASCEND- ING NODE (DEGREES E)	31.3619	33.3624	34.4587	31.2782	29.4425
GEODETTIC LATITUDE (DEGREES N)	16.4091	16.6015	16.8279	17.0523	17.2570
GEOGRAPHIC LONGITUDE (DEGREES E)	280.0981	265.7555	248.7190	231.7690	216.0685

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TABLE 5-LIV PERISELENUM CONDITIONS FOR LAUNCH ON 2 FEBRUARY 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	79:22:28.066	78:57:18.531	78:44:52.519	78:49:24.111	79:08:45.536
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	00:21:58.506 (6 FEBRUARY)	01:19:34.991 (6 FEBRUARY)	02:28:15.359 (6 FEBRUARY)	03:37:47.881 (6 FEBRUARY)	04:42:11.866 (6 FEBRUARY)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	164.091	155.384	147.533	130.258	109.005
SELENOGRAPHIC RADIUS (KILOMETERS)	1902.181	1893.473	1885.623	1868.348	1847.094
SELENOGRAPHIC LATI- TUDE (DEGREES N)	-5.3080	-5.2837	-5.2604	-5.3391	-5.4876
SELENOGRAPHIC LON- GITUDE (DEGREES E)	179.0619	179.4341	179.5259	179.1782	178.4948
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	28.4171	30.6009	31.6026	31.4081	30.1888
GEODETTIC LATITUDE (DEGREES N)	16.7152	16.9010	17.1206	17.3407	17.5424
GEOGRAPHIC LONGITUDE (DEGREES E)	257.1993	243.2151	226.5445	209.6621	194.0278

TABLE 5-LV

PERISELENUM CONDITIONS FOR LAUNCH ON 3 FEBRUARY 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	78:06:58.848	77:45:12.269	77:36:15.554	77:40:59.920	77:58:19.920
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	00:31:13.868 (7 FEBRUARY)	01:41:23.639 (7 FEBRUARY)	02:57:44.774 (7 FEBRUARY)	04:02:35.960 (7 FEBRUARY)	04:55:33.090 (7 FEBRUARY)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	117.036	94.736	146.497	174.969	199.138
SELENOGRAPHIC RADIUS (KILOMETERS)	1855.126	1832.825	1884.586	1913.059	1937.228
SELENOGRAPHIC LATI- TUDE (DEGREES N)	-1.8222	-1.7156	-1.7010	-1.6947	-1.6990
SELENOGRAPHIC LON- GITUDE (DEGREES E)	177.3035	177.4325	177.9955	178.0531	177.8172
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	8.1940	8.7081	9.8868	9.5906	8.4387
GEODETTIC LATITUDE (DEGREES N)	21.0448	21.2351	21.4388	21.6098	21.7477
GEOGRAPHIC LONGITUDE (DEGREES E)	265.6248	248.6215	230.1223	214.4088	201.5784

TABLE 5-LVI

PERISELENUM CONDITIONS FOR LAUNCH ON 3 FEBRUARY 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	79:41:20.616	79:19:01.386	79:07:37.420	79:11:02.635	79:27:17.881
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	02:05:35.636 (7 FEBRUARY)	03:15:12.756 (7 FEBRUARY)	04:29:06.640 (7 FEBRUARY)	05:32:38.675 (7 FEBRUARY)	06:24:31.051 (7 FEBRUARY)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	157.792	149.118	145.522	132.652	110.871
SELENOGRAPHIC RADIUS (KILOMETERS)	1895.881	1887.208	1883.612	1870.742	1848.961
SELENOGRAPHIC LATI- TUDE (DEGREES N)	-1.3718	-1.3495	-1.3204	-1.3557	-1.4773
SELENOGRAPHIC LON- GITUDE (DEGREES E)	177.4446	177.7389	177.8249	177.5222	176.8833
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	5.1103	6.0603	6.4009	6.1048	5.5577
GEODETTIC LATITUDE (DEGREES N)	21.3007	21.4864	21.6811	21.8462	21.9791
GEOGRAPHIC LONGITUDE (DEGREES E)	242.7568	225.8884	207.9839	192.5902	180.0210

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TABLE 5-LVII PERISELENUM CONDITIONS FOR LAUNCH ON 4 FEBRUARY 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	77:38:27.093	77:09:26.691	76:51:24.431	76:59:01.597	77:23:32.350
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	01:25:02.043 (8 FEBRUARY)	02:38:51.991 (8 FEBRUARY)	03:52:02.641 (8 FEBRUARY)	04:52:14.847 (8 FEBRUARY)	05:41:03.480 (8 FEBRUARY)
SELENOGRAPHIC ALTITUDE (KILOMETERS)	32.904	133.866	155.826	126.869	124.344
SELENOGRAPHIC RADIUS (KILOMETERS)	1770.994	1871.955	1893.916	1864.958	1862.434
SELENOGRAPHIC LATITUDE (DEGREES N)	-1.6230	-1.5725	-1.5861	-1.2764	-1.3798
SELENOGRAPHIC LONGITUDE (DEGREES E)	176.1515	177.5818	178.0116	177.4437	176.8316
SELENOGRAPHIC LONGITUDE OF THE ASCENDING NODE (DEGREES E)	11.1107	16.1096	19.7752	12.5340	10.2511
GEODETTIC LATITUDE (DEGREES N)	24.6168	24.7659	24.9112	25.0301	25.1232
GEOGRAPHIC LONGITUDE (DEGREES E)	263.9663	246.1189	228.4271	213.8684	202.0653

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TABLE 5-LVIII PERISELENUM CONDITIONS FOR LAUNCH ON 4 FEBRUARY 1968, SECOND OPPORTUNITY

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
LAUNCH AZIMUTH					
FLIGHT TIME (HRS:MIN:SEC)	79:12:30.670	78:38:05.880	78:18:30.844	78:26:38.347	78:50:09.539
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	02:59:05.620 (8 FEBRUARY)	04:07:31.180 (8 FEBRUARY)	05:19:09.054 (8 FEBRUARY)	06:19:51.597 (8 FEBRUARY)	07:07:40.669 (8 FEBRUARY)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	178.330	156.604	151.801	124.214	77.874
SELENOGRAPHIC RADIUS (KILOMETERS)	1916.420	1894.693	1889.891	1862.303	1815.964
SELENOGRAPHIC LATI- TUDE (DEGREES N)	-1.2374	-1.1032	-1.0725	-1.0764	-1.1143
SELENOGRAPHIC LON- GITUDE (DEGREES E)	177.3312	177.6975	177.9120	177.3621	176.3333
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	7.8499	9.2550	10.7699	9.0891	6.2559
GEODETTIC LATITUDE (DEGREES N)	24.8071	24.9435	25.0829	25.1987	25.2883
GEOGRAPHIC LONGITUDE (DEGREES E)	241.2265	224.6834	207.3666	192.6878	181.1240

TABLE 5-LIX

PERISELENUM CONDITIONS FOR LAUNCH ON 1 MARCH 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	77:57:37.218	77:33:03.080	77:21:08.692	77:27:50.098	77:48:26.413
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	22:00:43.598 (4 MARCH)	23:04:14.840 (4 MARCH)	00:15:48.902 (5 MARCH)	01:24:47.158 (5 MARCH)	02:24:55.433 (5 MARCH)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	114.713	130.276	148.441	182.121	212.129
SELENOGRAPHIC RADIUS (KILOMETERS)	1852.803	1868.366	1886.531	1920.211	1950.219
SELENOGRAPHIC LATI- TUDE (DEGREES N)	-3.7679	-3.6259	-3.6003	-3.5490	-3.4776
SELENOGRAPHIC LON- GITUDE (DEGREES E)	177.5724	178.1303	178.4453	178.5142	178.2636
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	21.0277	22.7300	24.1139	23.1933	20.6120
GEODETTIC LATITUDE (DEGREES N)	19.4332	19.6215	19.8308	20.0303	20.2025
GEOGRAPHIC LONGITUDE (DEGREES E)	271.4599	256.0561	238.7009	221.9758	207.3922

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TABLE 5-LX PERISELENUM CONDITIONS FOR LAUNCH ON 1 MARCH 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	79:31:28.686	79:04:47.253	78:51:39.609	78:57:37.666	79:16:18.315
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	23:34:35.066 (4 MARCH)	00:35:59.013 (5 MARCH)	01:46:19.819 (5 MARCH)	02:54:34.726 (5 MARCH)	03:52:47.335 (5 MARCH)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	161.613	154.375	146.927	166.399	104.267
SELENOGRAPHIC RADIUS (KILOMETERS)	1899.703	1892.464	1885.017	1904.488	1842.357
SELENOGRAPHIC LATI- TUDE (DEGREES N)	-3.3520	-3.3259	-3.2993	-3.5946	-3.4549
SELENOGRAPHIC LON- GITUDE (DEGREES E)	177.8237	178.2310	178.3301	178.3263	177.2275
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	17.5244	19.6039	20.5434	22.5702	18.5591
GEODETTIC LATITUDE (DEGREES N)	19.7107	19.8903	20.0938	20.2875	20.4531
GEOGRAPHIC LONGITUDE (DEGREES E)	248.6968	233.8086	216.7502	200.2021	186.0831

TABLE 5-LXI PERISELENUM CONDITIONS FOR LAUNCH ON 3 MARCH 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	77:34:46.788	76:59:45.875	76:38:28.384	76:50:41.759	77:17:59.781
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	00:23:36.398 (7 MARCH)	01:41:09.375 (7 MARCH)	02:57:15.854 (7 MARCH)	03:54:08.859 (7 MARCH)	04:35:59.801 (7 MARCH)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	130.113	134.068	135.024	132.625	128.958
SELENOGRAPHIC RADIUS (KILOMETERS)	1868.203	1872.158	1873.114	1870.714	1867.047
SELENOGRAPHIC LATI- TUDE (DEGREES N)	-0.1661	0.0332	0.1392	0.0491	-0.0905
SELENOGRAPHIC LON- GITUDE (DEGREES E)	176.0702	176.6529	176.9354	176.5588	175.9008
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	-1.9375	-3.9254	-6.2055	-4.3526	-2.9192
GEODETTIC LATITUDE (DEGREES N)	26.4159	26.5359	26.6497	26.7316	26.7902
GEOGRAPHIC LONGITUDE (DEGREES E)	259.6520	240.9196	222.5357	208.7938	198.6826

TABLE 5-LXII

PERISELENUM CONDITIONS FOR LAUNCH ON 3 MARCH 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	79:04:21.977	78:27:15.267	78:05:49.221	78:17:58.953	78:44:09.486
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	01:53:11.587 (7 MARCH)	03:08:38.767 (7 MARCH)	04:24:36.691 (7 MARCH)	05:21:26.053 (7 MARCH)	06:02:09.506 (7 MARCH)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	150.849	157.7583	157.677	156.000	74.567
SELENOGRAPHIC RADIUS (KILOMETERS)	1888.939	1895.848	1895.767	1894.089	1812.657
SELENOGRAPHIC LATI- TUDE (DEGREES N)	0.1905	0.2544	0.3038	0.2766	0.3250
SELENOGRAPHIC LON- GITUDE (DEGREES E)	176.1522	176.8290	177.1087	176.7344	175.3315
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	-5.8723	-7.1137	-8.9845	-7.7915	-8.3057
GEODETTIC LATITUDE (DEGREES N)	26.5542	26.6665	26.7761	26.8553	26.9118
GEOGRAPHIC LONGITUDE (DEGREES E)	238.0091	219.7858	201.4385	187.7127	177.8703

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TABLE 5-LXIII PERISELENUM CONDITIONS FOR LAUNCH ON 5 MARCH 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	76:29:38.267	76:00:01.592	75:39:04.094	75:50:35.889	76:08:49.587
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	01:21:48.517 (9 MARCH)	02:54:01.162 (9 MARCH)	04:20:32.584 (9 MARCH)	04:59:09.219 (9 MARCH)	05:23:02.797 (9 MARCH)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	151.448	152.393	151.195	152.007	147.236
SELENOGRAPHIC RADIUS (KILOMETERS)	1889.537	1890.483	1889.284	1890.096	1885.325
SELENOGRAPHIC LATI- TUDE (DEGREES N)	3.6043	3.7363	3.8127	3.7288	3.5888
SELENOGRAPHIC LON- GITUDE (DEGREES E)	174.4468	174.8310	175.0286	174.7309	174.2757
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	-75.0359	-101.7777	-115.9905	-102.0059	-78.6132
GEODETTIC LATITUDE (DEGREES N)	28.3366	28.3042	28.2682	28.2500	28.2379
GEOGRAPHIC LONGITUDE (DEGREES E)	270.8869	248.6720	227.8270	218.5231	212.7643

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TABLE 5-LXIV PERISELENUM CONDITIONS FOR LAUNCH ON 5 MARCH 1968, SECOND OPPORTUNITY

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
LAUNCH AZIMUTH					
FLIGHT TIME (HRS:MIN:SEC)	77:56:03.902	77:26:01.403	77:05:05.754	77:16:33.466	77:35:21.615
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	02:48:14.152 (9 MARCH)	04:20:00.973 (9 MARCH)	05:46:34.244 (9 MARCH)	06:25:06.796 (9 MARCH)	06:49:34.825 (9 MARCH)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	160.009	158.122	157.202	156.836	156.902
SELENOGRAPHIC RADIUS (KILOMETERS)	1898.098	1896.211	1895.292	1894.925	1894.992
SELENOGRAPHIC LATI- TUDE (DEGREES N)	3.8119	3.8456	3.8738	3.8443	3.8133
SELENOGRAPHIC LON- GITUDE (DEGREES E)	174.4752	174.8479	175.0447	174.7383	174.3081
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	-71.0773	-99.1136	-115.0984	-99.0037	-74.0206
GEODETTIC LATITUDE (DEGREES N)	28.3069	28.2686	28.2271	28.2069	28.1935
GEOGRAPHIC LONGITUDE (DEGREES E)	250.0635	227.9529	207.1011	197.8139	191.9170

TABLE 5-LXV

PERISELENUM CONDITIONS FOR LAUNCH ON 7 MARCH 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	73:53:10.016	73:25:20.401	73:10:05.597	73:14:32.687	73:30:57.176
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	23:33:49.716 (10 MARCH)	00:39:40.761 (11 MARCH)	01:47:12.897 (11 MARCH)	02:45:36.707 (11 MARCH)	03:32:07.176 (11 MARCH)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	162.215	157.465	156.514	156.861	156.588
SELENOGRAPHIC RADIUS (KILOMETERS)	1900.305	1895.554	1894.603	1894.951	1894.677
SELENOGRAPHIC LATI- TUDE (DEGREES N)	2.2964	2.4204	2.4613	2.4126	2.3207
SELENOGRAPHIC LON- GITUDE (DEGREES E)	174.5076	174.8617	174.9971	174.7736	174.3382
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	-156.5384	-160.0966	-161.2147	-160.2792	-156.7369
GEODETTIC LATITUDE (DEGREES N)	24.7296	24.5797	24.4227	24.2845	24.1729
GEOGRAPHIC LONGITUDE (DEGREES E)	323.0301	307.1599	290.8816	276.8037	265.5901

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TABLE 5-LXVI

PERISELENUM: CONDITIONS FOR LAUNCH ON 7 MARCH 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	75:17:42.452	74:50:02.741	74:35:23.807	74:39:44.967	74:55:29.355
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	00:58:22.152 (11 MARCH)	02:04:23.101 (11 MARCH)	03:12:31.107 (11 MARCH)	04:10:48.987 (11 MARCH)	04:56:39.355 (11 MARCH)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	156.852	155.446	155.995	155.604	156.631
SELENOGRAPHIC RADIUS (KILOMETERS)	1894.942	1893.536	1894.085	1893.693	1894.721
SELENOGRAPHIC LATI- TUDE (DEGREES N)	2.4156	2.4834	2.5189	2.4917	2.4489
SELENOGRAPHIC LON- GITUDE (DEGREES E)	174.4629	174.8387	174.9716	174.7460	174.3436
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	-153.3705	-158.7774	-160.1922	-158.6922	-153.3139
GEODETTIC LATITUDE (DEGREES N)	24.5369	24.3826	24.2203	24.0792	23.9668
GEOGRAPHIC LONGITUDE (DEGREES E)	302.6528	286.7420	270.3188	256.2639	245.2110

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TABLE 5-LXVII PERISELENUM CONDITIONS FOR LAUNCH ON 31 MARCH 1968, FIRST OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	77:40:05.094	77:07:28.319	76:43:20.742	77:00:22.622	77:25:27.524
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	23:29:31.634 (3 APRIL)	00:58:59.069 (4 APRIL)	02:25:02.022 (4 APRIL)	03:11:04.202 (4 APRIL)	03:41:40.654 (4 APRIL)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	121.122	135.176	128.899	149.858	137.914
SELENOGRAPHIC RADIUS (KILOMETERS)	1859.211	1873.266	1866.989	1887.948	1876.004
SELENOGRAPHIC LATI- TUDE (DEGREES N)	1.5060	1.7637	2.0207	1.8374	1.5672
SELENOGRAPHIC LON- GITUDE (DEGREES E)	175.1994	175.7936	176.0305	175.8044	175.1428
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	-26.4325	-43.9410	-63.7362	-46.2153	-29.2997
GEODETTIC LATITUDE (DEGREES N)	27.6980	27.7858	27.8657	27.9048	27.9296
GEOGRAPHIC LONGITUDE (DEGREES E)	254.1647	232.5721	211.8020	200.6890	193.2980

TABLE 5-LXVIII PERISELENUM CONDITIONS FOR LAUNCH ON 31 MARCH 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	79:10;23.744	78:35;46.395	78:10;47.323	78:28;11.059	78;52:42.670
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	00;59:50.284 (4 APRIL)	02;27:17.145 (4 APRIL)	03;52:28.603 (4 APRIL)	04;38:52.639 (4 APRIL)	05;08:55.800 (4 APRIL)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	158.077	157.552	156.643	155.839	98.117
SELENOGRAPHIC RADIUS (KILOMETERS)	1896.166	1895.642	1894.732	1893.928	1836.207
SELENOGRAPHIC LATI- TUDE (DEGREES N)	1.8631	2.0147	2.0757	2.0351	2.0666
SELENOGRAPHIC LON- GITUDE (DEGREES E)	175.4162	175.9334	176.2476	175.8006	174.6867
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	~27.6968	~43.0038	~62.0606	~44.8066	~31.4119
GEODETTIC LATITUDE (DEGREES N)	27.7867	27.8674	27.9410	27.9788	28.0032
GEOGRAPHIC LONGITUDE (DEGREES E)	232.3640	211.2579	190.6972	179.4958	172.2369

TABLE 5-LXIX

PERISELENUM CONDITIONS FOR LAUNCH ON 2 APRIL 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	76:03:51.862	75:21:01.730	74:54:08.088	75:14:57.027	75:47:37.550
ARRIVAL TIME AND DATE, GMT	23:29:08.412 (5 APRIL)	00:39:41.870 (6 APRIL)	01:49:12.768 (6 APRIL)	02:48:28.547 (6 APRIL)	03:33:49.840 (6 APRIL)
(HRS:MIN:SEC)					
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	124.813	141.107	155.018	155.745	153.843
SELENOGRAPHIC RADIUS (KILOMETERS)	1862.903	1879.197	1893.107	1893.834	1891.933
SELENOGRAPHIC LATI- TUDE (DEGREES N)	1.9005	2.0463	2.0688	2.0550	1.9565
SELENOGRAPHIC LON- GITUDE (DEGREES E)	174.2575	175.0943	175.5990	175.0554	174.2920
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	-143.2690	-155.3103	-159.0651	-155.1115	-143.8954
GEODETTIC LATITUDE (DEGREES N)	27.8955	27.8309	27.7634	27.7039	27.6566
GEOGRAPHIC LONGITUDE (DEGREES E)	279.6155	262.6094	245.8529	231.5623	220.6235

TABLE 5-LXX PERISELENUM CONDITIONS FOR LAUNCH ON 2 APRIL 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	77:31;31,313	76:48;39,711	76:21;02,968	76:41;53,988	77:13;57,133
ARRIVAL TIME AND DATE, GMT	00:56;47,863	02:07;19,851	03:16;07,648	04:15;25,508	05:00;09,423
(HRS:MIN:SEC)	(6 APRIL)	(6 APRIL)	(6 APRIL)	(6 APRIL)	(6 APRIL)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	159.719	157.833	157.358	156.749	157.110
SELENOGRAPHIC RADIUS (KILOMETERS)	1897.809	1895.923	1895.447	1894.839	1895.199
SELENOGRAPHIC LATI- TUDE (DEGREES N)	2.1087	2.1537	2.1218	2.1588	2.1516
SELENOGRAPHIC LON- GITUDE (DEGREES E)	174.5267	175.1845	175.5639	175.0119	174.2883
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	-134.2879	-152.6917	-158.2093	-152.5915	-135.7606
GEODETC LATITUDE (DEGREES N)	27.8150	27.7460	27.6752	27.6125	27.5636
GEOGRAPHIC LONGITUDE (DEGREES E)	258.4839	241.4827	224.8985	210.5994	199.8109

TABLE 5-LXXI

PERISELENUM CONDITIONS FOR LAUNCH ON 4 APRIL 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	74:39:22.776	74:22:33.074	74:11:32.804	74:10:37.893	74:17:58.426
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	22:40:09.616 (7 APRIL)	23:50:58.974 (7 APRIL)	00:59:54.664 (8 APRIL)	01:56:19.733 (8 APRIL)	02:39:20.846 (8 APRIL)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	151.370	157.436	163.032	179.805	206.443
SELENOGRAPHIC RADIUS (KILOMETERS)	1889.459	1895.526	1901.122	1917.895	1944.533
SELENOGRAPHIC LATI- TUDE (DEGREES N)	3.7477	3.8079	3.8441	3.7821	3.6320
SELENOGRAPHIC LON- GITUDE (DEGREES E)	172.8589	173.0774	173.1852	173.2284	173.2263
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	-142.2873	-148.0719	-149.6337	-148.1746	-143.8628
GEODETTIC LATITUDE (DEGREES N)	22.7191	22.5240	22.3313	22.1710	22.0470
GEOGRAPHIC LONGITUDE (DEGREES E)	316.7733	299.6787	283.0400	269.4202	259.0344

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TABLE 5-LXXII PERISELENUM CONDITIONS FOR LAUNCH ON 4 APRIL 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	76:05:04.950	75:47:18.538	75:36:06.498	75:34:51.161	75:41:03.918
ARRIVAL TIME AND DATE, GMT	00:05:51.790 (8 APRIL)	01:15:44.438 (8 APRIL)	02:24:28.358 (8 APRIL)	03:20:33.001 (8 APRIL)	04:02:26.338 (8 APRIL)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	156.872	155.793	155.105	154.631	155.457
SELENOGRAPHIC RADIUS (KILOMETERS)	1894.961	1893.882	1893.195	1892.720	1893.546
SELENOGRAPHIC LATI- TUDE (DEGREES N)	3.8179	3.8723	3.9047	3.8727	3.8102
SELENOGRAPHIC LON- GITUDE (DEGREES E)	172.8771	173.0513	173.1040	172.9947	172.7842
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	-139.5207	-146.3872	-148.3084	-146.2966	-139.8745
GEODETTIC LATITUDE (DEGREES N)	22.4829	22.2870	22.0915	21.9299	21.8079
GEOGRAPHIC LONGITUDE (DEGREES E)	296.0856	279.2179	262.6254	249.0863	238.9717

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LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	71:11:35.402	70:51:45.448	70:41:21.669	70:41:12.229	70:51:10.484
ARRIVAL TIME AND DATE, GMT	19:24:39.752 (9 APRIL)	20:17:56.678 (9 APRIL)	21:21:40.859 (9 APRIL)	22:26:06.189 (9 APRIL)	23:26:07.424 (9 APRIL)
SELENOGRAPHIC ALTI- TUDE (KILOMETERS)	146.541	157.089	164.989	178.323	199.563
SELENOGRAPHIC RADIUS (KILOMETERS)	1884.631	1895.178	1903.078	1916.413	1937.653
SELENOGRAPHIC LATI- TUDE (DEGREES N)	0.2964	0.3042	0.3226	0.3042	0.2909
SELENOGRAPHIC LON- GITUDE (DEGREES E)	173.9868	174.3707	174.5166	174.5061	174.3743
SELENOGRAPHIC LONGI- TUDE OF THE ASCEND- ING NODE (DEGREES E)	176.0484	176.3222	176.5400	176.4779	176.4385
GEODETC LATITUDE (DEGREES N)	13.4065	13.1863	12.9220	12.6533	12.4016
GEOGRAPHIC LONGITUDE (DEGREES E)	28.2097	15.3291	359.9194	344.3427	329.8293

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TABLE 5-LXXIV

PERISELENUM CONDITIONS FOR LAUNCH ON 6 APRIL 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	72:37:39.705	72:17:07.089	72:05:54.233	72:05:40.024	72:14:50.147
ARRIVAL TIME AND DATE, GMT (HRS:MIN:SEC)	20:50:44.055 (9 APRIL)	21:43:18.319 (9 APRIL)	22:46:13.423 (9 APRIL)	23:50:33.984 (9 APRIL)	00:49:47.087 (10 APRIL)
SELENOGRAPHIC ALTI- TITUDE (KILOMETERS)	154.995	154.571	156.396	154.806	155.657
SELENOGRAPHIC RADIUS (KILOMETERS)	1893.085	1892.661	1894.486	1892.896	1893.746
SELENOGRAPHIC LATI- TITUDE (DEGREES N)	0.3149	0.3314	0.3445	0.3342	0.3197
SELENOGRAPHIC LON- GITUDE (DEGREES E)	174.0489	174.3467	174.4548	174.3056	174.0029
SELENOGRAPHIC LONGI- TITUDE OF THE ASCEND- ING NODE (DEGREES E)	176.3233	176.5331	176.6682	176.5299	176.3493
GEODETTIC LATITUDE (DEGREES N)	13.0513	12.8326	12.5697	12.2996	12.0499
GEOGRAPHIC LONGITUDE (DEGREES E)	7.3996	354.6901	339.4775	323.9189	309.5984

FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 1 FEBRUARY 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	149:38:46.90	149:41:44.65	149:45:08.16	149:52:35.90	150:04:37.77
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	21:16:15.511 (7 FEBRUARY)	22:35:33.559 (7 FEBRUARY)	23:57:24.516 (7 FEBRUARY)	01:13:13.831 (8 FEBRUARY)	02:17:09.455 (8 FEBRUARY)
GEODETTIC LATITUDE (DEGREES N)	-5.9382	-5.9027	-6.2013	-6.7544	-7.4576
LONGITUDE (DEGREES E)	100.5188	81.4583	61.6847	43.3392	27.9120
ALTITUDE ABOVE THE GEOID (KILOMETERS)	530.489	380.399	150.134	-198.850	-650.957
RADIUS (KILOMETERS)	6908.426	6758.339	6528.051	6179.021	5726.850
INERTIAL VELOCITY (METERS/SECOND)	10682.22	10801.05	10991.91	11301.64	11744.40
RELATIVE VELOCITY (METERS/SECOND)	10262.91	10405.06	10612.83	10937.43	11396.99
INERTIAL HEADING (DEGREES)	122.454	125.351	126.034	124.859	122.421
RELATIVE HEADING (DEGREES)	123.955	126.913	127.537	126.199	123.537

TABLE 5-LXXVI FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 1 FEBRUARY 1968, SECOND OPPORTUNITY

		LAUNCH AZIMUTH				
		72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)		151:09:41.64	151:06:11.07	151:01:30.89	150:55:46.37	150:49:48.56
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)		22:47:10.249 (7 FEBRUARY)	23:59:59.979 (7 FEBRUARY)	01:13:47.247 (8 FEBRUARY)	02:16:24.296 (8 FEBRUARY)	03:02:20.244 (8 FEBRUARY)
GEODETIC LATITUDE (DEGREES N)		-6.9282	-6.7405	-6.7134	-6.8345	-7.0268
LONGITUDE (DEGREES E)		78.8658	61.2001	43.2931	28.0125	16.7235
ALTITUDE ABOVE THE GEOID (KILOMETERS)		-438.718	-286.539	-140.422	55.662	305.306
RADIUS (KILOMETERS)		5939.138	6091.333	6237.452	6433.526	6683.152
INERTIAL VELOCITY (METERS/SECOND)		11531.09	11384.18	11248.51	11074.16	10863.72
RELATIVE VELOCITY (METERS/SECOND)		11161.63	11018.20	10882.87	10698.77	10469.95
INERTIAL HEADING (DEGREES)		120.215	123.320	125.287	125.591	124.761
RELATIVE HEADING (DEGREES)		121.326	124.580	126.661	127.043	126.271

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	150:13:7.28	150:20:15.78	150:23:41.25	150:11:46.32	150:10:24.71
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	23:12:37.721 (8 FEBRUARY)	00:42:32.242 (9 FEBRUARY)	02:07:4.088 (9 FEBRUARY)	03:00:10.091 (9 FEBRUARY)	03:43:51.038 (9 FEBRUARY)
GEODETIC LATITUDE (DEGREES N)	-9.3748	-9.5673	-9.7823	-10.3325	-10.7183
LONGITUDE (DEGREES E)	82.8314	61.3789	41.0522	27.9464	17.1959
ALTITUDE ABOVE THE GEOID (KILOMETERS)	1351.831	903.807	693.110	562.231	558.062
RADIUS (KILOMETERS)	7729.431	7281.385	7070.662	6939.713	6935.492
INERTIAL VELOCITY (METERS/SECOND)	10092.37	10401.24	10556.61	10657.40	10661.28
RELATIVE VELOCITY (METERS/SECOND)	9714.07	10064.86	10241.46	10327.73	10317.61
INERTIAL HEADING (DEGREES)	135.976	138.918	140.583	137.532	135.283
RELATIVE HEADING (DEGREES)	138.336	141.165	142.780	139.571	137.245

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TABLE 5-LXXVIII FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 2 FEBRUARY 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	151:50:55.18	151:45:09.54	151:38:25.67	151:28:26.60	151:18:09.67
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	00:50:25.617 (9 FEBRUARY)	02:07:26.000 (9 FEBRUARY)	03:21:48.511 (9 FEBRUARY)	04:16:50.366 (9 FEBRUARY)	04:51:36.000 (9 FEBRUARY)
GEODETTIC LATITUDE (DEGREES N)	-10.7821	-10.5882	-10.6099	-10.6715	-10.7829
LONGITUDE (DEGREES E)	59.7125	41.1046	23.0845	9.5888	0.8938
ALTITUDE ABOVE THE GEOID (KILOMETERS)	-405.927	-184.063	-35.509	285.714	688.085
RADIUS (KILOMETERS)	5971.495	6193.385	6341.936	6663.151	7065.507
INERTIAL VELOCITY (METERS/SECOND)	11499.41	11288.80	11154.20	10879.35	10562.26
RELATIVE VELOCITY (METERS/SECOND)	11195.04	10991.29	10858.45	10566.06	10218.19
INERTIAL HEADING (DEGREES)	133.900	137.090	138.529	138.049	136.166
RELATIVE HEADING (DEGREES)	135.418	138.786	140.327	139.976	138.214

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TABLE 5-LXXIX

FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 3 FEBRUARY 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
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FLIGHT TIME (HRS:MIN:SEC)	149:59:10.73	149:45:38.27	150:03:53.51	150:12:01.89	150:18:49.64
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ARRIVAL DATE AND TIME, GMT	00:23:25.749	01:41:49.641	03:25:22.731	04:33:37.928	05:16:02.809
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(HRS:MIN:SEC)	(10 FEBRUARY)	(10 FEBRUARY)	(10 FEBRUARY)	(10 FEBRUARY)	(10 FEBRUARY)
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GEODETIC LATITUDE (DEGREES N)	-16.5408	-16.1808	-16.4693	-16.9559	-17.6596
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LONGITUDE (DEGREES E)	74.5730	55.4567	30.9604	14.6314	4.4384
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ALTITUDE ABOVE THE GEOID (KILOMETERS)	973.669	1449.843	540.678	39.311	-391.659
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RADIUS (KILOMETERS)	7350.112	7826.357	6917.136	6415.670	5984.553
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INERTIAL VELOCITY (METERS/SECOND)	10353.34	10029.23	10675.18	11089.14	11486.17
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RELATIVE VELOCITY (METERS/SECOND)	9902.69	9563.58	10274.00	10713.63	11123.90
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INERTIAL HEADING (DEGREES)	118.062	121.038	123.274	122.366	118.956
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RELATIVE HEADING (DEGREES)	119.462	122.732	124.755	123.648	119.994
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TABLE 5-LXXX FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 3 FEBRUARY 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES 108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	151:34:48.86	151:27:12.38	151:20:34.23	151:09:56.62 150:56:58.25
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	01:59:03.876 (10 FEBRUARY)	03:23:23.748 (10 FEBRUARY)	04:42:03.451 (10 FEBRUARY)	05:31:32.660 (10 FEBRUARY) 05:54:11.422 (10 FEBRUARY)
GEODEIC LATITUDE (DEGREES N)	-17.8490	-17.4574	-17.4060	-17.6115 -17.9350
LONGITUDE (DEGREES E)	51.7512	31.3613	12.3409	0.2046 354.4115
ALTITUDE ABOVE THE GEOID (KILOMETERS)	-80.538	87.039	155.730	361.584 750.470
RADIUS (KILOMETERS)	6295.633	6463.293	6531.995	6737.805 7126.621
INERTIAL VELOCITY (METERS/SECOND)	11196.54	11048.36	10989.30	10818.63 10516.82
RELATIVE VELOCITY (METERS/SECOND)	10794.83	10649.50	10593.22	10406.84 10072.05
INERTIAL HEADING (DEGREES)	112.817	117.005	118.846	117.902 115.369
RELATIVE HEADING (DEGREES)	113.717	118.104	120.033	119.109 116.574

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LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	148:49:39.46	149:26:46.20	149:30:29.49	149:04:58.03	149:01:56.66
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	00:36:14.410	02:56:11.498	04:31:07.703	04:58:11.276	05:19:27.786
	(11 FEBRUARY)	(11 FEBRUARY)	(11 FEBRUARY)	(11 FEBRUARY)	(11 FEBRUARY)
GEODETIC LATITUDE (DEGREES N)	-18.3329	-18.5073	-18.4596	-19.0198	-19.5648
LONGITUDE (DEGREES E)	82.4038	49.9244	27.3532	20.3523	14.8841
ALTITUDE ABOVE THE GEOID (KILOMETERS)	2874.734	1107.602	856.879	983.048	1019.081
RADIUS (KILOMETERS)	9250.795	7483.626	7232.914	7358.957	7394.863
INERTIAL VELOCITY (METERS/SECOND)	9215.12	10257.64	10435.44	10345.40	10320.68
RELATIVE VELOCITY (METERS/SECOND)	8709.83	9887.21	10098.55	9971.74	9921.57
INERTIAL HEADING (DEGREES)	126.691	133.303	136.678	131.642	127.400
RELATIVE HEADING (DEGREES)	129.210	135.362	138.744	133.580	129.184

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TABLE 5-LXXXII FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 4 FEBRUARY 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	151:05:53.93	150:47:21.79	150:36:43.29	150:18:07.31	149:53:29.55
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	02:52:28.880 (11 FEBRUARY)	04:16:47.090 (11 FEBRUARY)	05:37:21.496 (11 FEBRUARY)	06:11:20.557 (11 FEBRUARY)	06:11:00.681 (11 FEBRUARY)
GEODEIC LATITUDE (DEGREES N)	-20.1490	-19.6257	-19.4516	-19.6687	-20.0862
LONGITUDE (DEGREES E)	50.9940	30.6855	11.3662	2.7572	2.0861
ALTITUDE ABOVE THE GEOID (KILOMETERS)	-391.628	-6.787	79.877	499.702	1252.806
RADIUS (KILOMETERS)	5984.019	6368.983	6455.687	6875.461	7628.465
INERTIAL VELOCITY (METERS/SECOND)	11486.32	11129.63	11053.52	10707.58	10160.44
RELATIVE VELOCITY (METERS/SECOND)	11152.14	10795.23	10728.58	10345.94	9729.42
INERTIAL HEADING (DEGREES)	124.810	129.464	132.197	129.230	123.622
RELATIVE HEADING (DEGREES)	126.013	130.941	133.790	130.885	125.327

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TABLE 5-LXXXIII FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 1 MARCH 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	150:30:30.21	150:33:03.19	150:38:04.46	150:50:19.78	151:00:05.74
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	22:33:36.590 (7 MARCH)	00:04:14.946 (8 MARCH)	01:32:44.673 (8 MARCH)	02:47:16.840 (8 MARCH)	03:36:34.758 (8 MARCH)
GEODETIC LATITUDE (DEGREES N)	-13.1974	-13.2446	-13.4121	-13.9761	-14.7400
LONGITUDE (DEGREES E)	71.4621	49.7898	28.5939	10.7033	358.8003
ALTITUDE ABOVE THE GEOID (KILOMETERS)	1297.718	1004.756	709.283	118.262	-469.953
RADIUS (KILOMETERS)	7674.776	7381.805	7086.305	6495.188	5906.838
INERTIAL VELOCITY (METERS/SECOND)	10128.50	10329.26	10544.61	11019.50	11561.61
RELATIVE VELOCITY (METERS/SECOND)	9719.46	9954.09	10197.46	10697.79	11253.09
INERTIAL HEADING (DEGREES)	130.338	133.268	135.341	134.737	131.545
RELATIVE HEADING (DEGREES)	132.419	135.337	137.351	136.471	132.952

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TABLE 5-LXXXIV FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 1 MARCH 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	152:05:08.14	151:58:53.49	151:51:46.83	152:02:34.43	151:28:04.62
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	00:08:14.518 (8 MARCH)	01:30:05.250 (8 MARCH)	02:46:27.040 (8 MARCH)	03:59:31.491 (8 MARCH)	04:04:33.636 (8 MARCH)
GEODETTIC LATITUDE (DEGREES N)	-14.5696	-14.3035	-14.2836	-14.3685	-14.6073
LONGITUDE (DEGREES E)	49.0086	29.2898	10.8120	353.3165	351.3253
ALTITUDE ABOVE THE GEOID (KILOMETERS)	-230.019	-80.393	50.7222	-101.111	811.556
RADIUS (KILOMETERS)	6146.803	6296.477	6427.595	6275.747	7188.370
INERTIAL VELOCITY (METERS/SECOND)	11332.20	11194.71	11078.51	11213.14	10470.42
RELATIVE VELOCITY (METERS/SECOND)	10987.55	10860.49	10746.49	10898.95	10079.19
INERTIAL HEADING (DEGREES)	126.757	130.575	132.249	134.087	128.664
RELATIVE HEADING (DEGREES)	128.111	132.103	133.878	135.710	130.466

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LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	149:34:34.82	149:25:15.29	149:14:05.35	149:11:14.42	149:08:55.46
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	00:23:24.426 (10 MARCH)	02:06:38.785 (10 MARCH)	03:32:52.823 (10 MARCH)	04:14:41.517 (10 MARCH)	04:26:55.479 (10 MARCH)
GEODETTIC LATITUDE (DEGREES N)	-21.3283	-20.8851	-20.7595	-21.0567	-21.6981
LONGITUDE (DEGREES E)	66.8762	42.3315	21.7788	11.4020	8.0476
ALTITUDE ABOVE THE GEOID (KILOMETERS)	925.098	884.772	795.181	931.573	973.231
RADIUS (KILOMETERS)	7300.452	7260.236	7170.677	7306.994	7348.492
INERTIAL VELOCITY (METERS/SECOND)	10387.68	10415.99	10481.30	10382.22	10353.27
RELATIVE VELOCITY (METERS/SECOND)	9985.49	10043.20	10128.47	10008.25	9949.94
INERTIAL HEADING (DEGREES)	125.056	130.237	132.923	130.365	125.142
RELATIVE HEADING (DEGREES)	126.691	132.061	134.808	132.210	126.794

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TABLE 5-LXXXVI FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 3 MARCH 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	150:57:32.05	150:51:46.93	150:41:59.90	150:37:07.56	149:55:54.57
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	01:46:21.658 (10 MARCH)	03:33:10.428 (10 MARCH)	05:00:47.373 (10 MARCH)	05:40:34.664 (10 MARCH)	05:13:54.590 (10 MARCH)
GEODETIC LATITUDE (DEGREES N)	-22.2803	-21.6235	-21.3859	-21.7963	-22.3427
LONGITUDE (DEGREES E)	47.1098	21.7447	0.8284	350.9782	356.2245
ALTITUDE ABOVE THE GEOID (KILOMETERS)	34.339	11.940	25.876	48.146	1305.141
RADIUS (KILOMETERS)	6409.452	6387.222	6401.218	6423.383	7680.234
INERTIAL VELOCITY (METERS/SECOND)	11094.45	11113.13	11100.51	11081.47	10125.52
RELATIVE VELOCITY (METERS/SECOND)	10727.08	10776.66	10779.68	10744.01	9680.46
INERTIAL HEADING (DEGREES)	121.342	128.359	131.718	128.458	120.091
RELATIVE HEADING (DEGREES)	122.545	129.789	133.256	129.902	121.630

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TABLE 5-LXXXVII FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 5 MARCH 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

72 DEGREES 81 DEGREES 90 DEGREES 99 DEGREES 108 DEGREES

FLIGHT TIME (HRS:MIN:SEC) 146:13:44.21 145:55:15.06 145:37:19.12 145:37:05.10 145:36:40.73

ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC) 23:05:54.464 (11 MARCH) 00:49:14.626 (12 MARCH) 02:18:47.606 (12 MARCH) 02:45:38.428 (12 MARCH) 02:50:53.943 (12 MARCH)

GEODETIC LATITUDE (DEGREES N) -26.4728 -25.5623 -25.0507 -25.6550 -26.5152

LONGITUDE (DEGREES E) 110.7070 86.1560 64.8550 58.1163 56.5350

ALTITUDE ABOVE THE GEOID (KILOMETERS) 307.462 237.004 196.494 252.930 387.739

RADIUS (KILOMETERS) 6681.405 6611.214 6570.850 6627.112 6761.669

INERTIAL VELOCITY (METERS/SECOND) 10863.09 10920.86 10954.57 10907.62 10797.72

RELATIVE VELOCITY (METERS/SECOND) 10444.15 10519.94 10566.32 10503.15 10372.07

INERTIAL HEADING (DEGREES) 106.061 112.515 116.185 111.537 105.205

RELATIVE HEADING (DEGREES) 106.724 113.423 117.225 112.411 105.845

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TABLE 5-LXXXVIII FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 5 MARCH 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	147:34:39.42	147:16:20.65	146:59:41.22	146:57:29.08	146:57:43.13
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	00:26:49.666 (12 MARCH)	02:10:20.220 (12 MARCH)	03:41:09.711 (12 MARCH)	04:06:02.410 (12 MARCH)	04:11:56.338 (12 MARCH)
GEODETTIC LATITUDE (DEGREES N)	-26.9586	-25.8330	-25.2049	-25.9352	-27.0176
LONGITUDE (DEGREES E)	91.4187	66.7487	45.1099	38.8733	37.2387
ALTITUDE ABOVE THE GEOID (KILOMETERS)	-35.158	-1.743	23.078	22.375	26.042
RADIUS (KILOMETERS)	6338.641	6372.389	6397.391	6396.477	6399.823
INERTIAL VELOCITY (METERS/SECOND)	11156.05	11125.81	11103.63	11104.63	11102.03
RELATIVE VELOCITY (METERS/SECOND)	10754.35	10735.40	10722.81	10710.13	10694.98
INERTIAL HEADING (DEGREES)	102.935	110.818	115.214	109.693	101.889
RELATIVE HEADING (DEGREES)	103.427	111.613	116.176	110.450	102.348

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TABLE 5-LXXXIX FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 7 MARCH 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	141:36:07.25	141:15:46.41	141:00:51.70	140:55:01.02	140:53:49.96
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	19:16:46.946 (13 MARCH)	20:30:06.775 (13 MARCH)	21:37:59.000 (13 MARCH)	22:26:05.035 (13 MARCH)	22:54:59.957 (13 MARCH)
GEODETIC LATITUDE (DEGREES N)	-22.5898	-21.9235	-21.6190	-21.8188	-22.3913
LONGITUDE (DEGREES E)	193.8866	176.4720	160.2590	148.5218	141.3130
ALTITUDE ABOVE THE GEOID (KILOMETERS)	249.908	207.584	162.075	233.534	331.476
RADIUS (KILOMETERS)	6624.939	6582.788	6537.357	6608.765	6706.558
INERTIAL VELOCITY (METERS/SECOND)	10907.74	10942.73	10981.00	10920.94	10840.42
RELATIVE VELOCITY (METERS/SECOND)	10490.39	10538.04	10582.47	10509.90	10410.57
INERTIAL HEADING (DEGREES)	110.382	114.281	115.531	112.908	107.864
RELATIVE HEADING (DEGREES)	111.231	115.278	116.566	113.858	108.628

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TABLE 5-XC
 FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 7 MARCH 1968, SECOND
 OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	142:48:07.08	142:31:07.77	142:17:37.73	142:10:39.21	142:08:11.67
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	20:28:46.778 (13 MARCH)	21:45:28.126 (13 MARCH)	22:54:45.031 (13 MARCH)	23:41:43.235 (13 MARCH)	00:09:21.673 (14 MARCH)
GEODETIC LATITUDE (DEGREES N)	-22.7977	-22.0089	-21.6780	-21.9278	-22.6070
LONGITUDE (DEGREES E)	176.6917	158.4189	141.8447	130.4094	123.6111
ALTITUDE ABOVE THE GEOID (KILOMETERS)	21.355	34.584	11.989	48.267	21.831
RADIUS (KILOMETERS)	6396.332	6409.766	6387.257	6423.471	6396.858
INERTIAL VELOCITY (METERS/SECOND)	11103.31	11091.17	11110.77	11079.20	11102.79
RELATIVE VELOCITY (METERS/SECOND)	10694.55	10691.96	10716.27	10674.32	10687.73
INERTIAL HEADING (DEGREES)	107.903	112.578	113.943	111.005	105.348
RELATIVE HEADING (DEGREES)	108.612	113.470	114.883	111.842	105.960

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TABLE 5-XCI

FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 31 MARCH 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	149:48:40.42	149:41:39.17	149:22:36.54	149:34:22.65	149:31:11.28
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	23:38:06.959 (6 APRIL)	01:33:09.919 (7 APRIL)	03:04:17.825 (7 APRIL)	03:45:04.228 (7 APRIL)	03:47:24.415 (7 APRIL)
GEODETTIC LATITUDE (DEGREES N)	-23.7033	-23.1814	-22.9812	-23.4756	-24.0645
LONGITUDE (DEGREES E)	58.4072	31.1325	9.4169	359.4179	358.3930
ALTITUDE ABOVE THE GEOID (KILOMETERS)	1000.177	740.766	642.764	470.969	743.618
RADIUS (KILOMETERS)	7374.908	7115.639	7017.690	6845.763	7118.249
INERTIAL VELOCITY (METERS/SECOND)	10334.35	10522.43	10596.29	10730.12	10521.05
RELATIVE VELOCITY (METERS/SECOND)	9901.90	10128.31	10220.15	10349.61	10104.23
INERTIAL HEADING (DEGREES)	118.009	123.620	126.317	123.192	117.904
RELATIVE HEADING (DEGREES)	119.349	125.116	127.883	124.581	119.163

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TABLE 5- XCII FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 31 MARCH 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	151:21:55.24	151:09:51.19	150:57:07.35	150:55:22.54	150:27:22.98
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	01:11:21.778 (7 APRIL)	03:01:21.939 (7 APRIL)	04:38:48.627 (7 APRIL)	05:06:04.117 (7 APRIL)	04:43:36.107 (7 APRIL)
GEODETTIC LATITUDE (DEGREES N)	-24.6343	-23.8448	-23.3705	-24.0026	-24.8602
LONGITUDE (DEGREES E)	36.3210	10.1107	346.9189	339.9902	344.4493
ALTITUDE ABOVE THE GEOID (KILOMETERS)	-16.468	9.230	12.583	44.168	952.733
RADIUS (KILOMETERS)	6358.007	6383.974	6387.406	6418.819	7327.142
INERTIAL VELOCITY (METERS/SECOND)	11139.26	11115.77	11112.43	11085.28	10368.97
RELATIVE VELOCITY (METERS/SECOND)	10755.68	10753.56	10769.20	10720.02	9921.64
INERTIAL HEADING (DEGREES)	114.162	121.233	126.020	120.847	112.285
RELATIVE HEADING (DEGREES)	115.082	122.411	127.360	122.020	113.348

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TABLE 5-XCIII

FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 2 APRIL 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	146:30:31.36	146:16:20.10	146:07:07.40	146:06:13.42	146:09:15.11
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	21:55:47.906 (8 APRIL)	23:35:00.238 (8 APRIL)	01:02:12.080 (9 APRIL)	01:39:44.937 (9 APRIL)	01:55:27.395 (9 APRIL)
GEODETTIC LATITUDE (DEGREES N)	-23.8898	-23.1237	-22.7149	-23.2078	-24.0051
LONGITUDE (DEGREES E)	109.4943	86.4001	65.9182	56.3847	51.9895
ALTITUDE ABOVE THE GEOID (KILOMETERS)	931.065	487.949	202.109	314.251	495.122
RADIUS (KILOMETERS)	7305.744	6862.837	6577.107	6689.117	6869.770
INERTIAL VELOCITY (METERS/SECOND)	10382.97	10715.90	10948.34	10855.63	10710.91
RELATIVE VELOCITY (METERS/SECOND)	9967.17	10356.20	10624.77	10500.29	10314.81
INERTIAL HEADING (DEGREES)	120.772	127.891	132.260	126.914	119.533
RELATIVE HEADING (DEGREES)	122.206	129.456	133.866	128.384	120.788

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TABLE 5-XCIV FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 2 APRIL 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	148:01:15.32	147:42:15.66	147:27:05.45	147:23:35.25	147:24:22.39
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	23:26:31.872 (8 APRIL)	01:00:55.797 (9 APRIL)	02:22:10.129 (9 APRIL)	02:57:06.766 (9 APRIL)	03:10:34.678 (9 APRIL)
GEODETTIC LATITUDE (DEGREES N)	-24.3947	-23.3724	-22.8174	-23.4160	-24.4084
LONGITUDE (DEGREES E)	88.1261	65.8934	46.6934	37.8207	34.0964
ALTITUDE ABOVE THE GEOID (KILOMETERS)	-20.706	27.923	35.410	56.403	26.660
RADIUS (KILOMETERS)	6353.836	6402.746	6410.381	6431.214	6401.198
INERTIAL VELOCITY (METERS/SECOND)	11142.16	11098.46	11091.44	11073.67	11100.49
RELATIVE VELOCITY (METERS/SECOND)	10774.44	10758.17	10771.08	10724.98	10722.86
INERTIAL HEADING (DEGREES)	118.951	126.837	131.281	125.303	116.940
RELATIVE HEADING (DEGREES)	120.039	128.208	132.795	126.633	117.970

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TABLE 5-XCV

FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 4 APRIL 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	141:43:43.82	141:31:30.81	141:20:11.76	141:19:53.82	141:28:52.83
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	17:44:30.663 (10 APRIL)	18:59:56.714 (10 APRIL)	20:08:33.616 (10 APRIL)	21:05:35.658 (10 APRIL)	21:50:15.249 (10 APRIL)
GEODETTIC LATITUDE (DEGREES N)	-23.0587	-22.3777	-22.0826	-22.1817	-22.5578
LONGITUDE (DEGREES E)	196.8170	178.7279	162.3098	148.7125	138.1633
ALTITUDE ABOVE THE GEOID (KILOMETERS)	212.494	137.230	21.850	-192.686	-496.989
RADIUS (KILOMETERS)	6587.400	6512.317	6397.014	6182.453	5878.053
INERTIAL VELOCITY (METERS/SECOND)	10940.71	11004.06	11103.76	11296.72	11588.42
RELATIVE VELOCITY (METERS/SECOND)	10499.33	10568.13	10675.46	10881.48	11192.67
INERTIAL HEADING (DEGREES)	93.853	97.192	97.986	96.326	92.858
RELATIVE HEADING (DEGREES)	94.015	97.491	98.308	96.568	92.959

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TABLE 5-XCVI FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 4 APRIL 1968, SECOND OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	143:03:15.18	142:47:43.86	142:33:45.68	142:25:17.29	142:21:24.01
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	19:04:02.015 (10 APRIL)	20:16:09.763 (10 APRIL)	21:22:07.539 (10 APRIL)	22:10:59.128 (10 APRIL)	22:42:46.430 (10 APRIL)
GEODETIC LATITUDE (DEGREES N)	-23.1710	-22.4424	-22.1298	-22.2997	-22.8512
LONGITUDE (DEGREES E)	177.843	160.461	144.6029	132.8235	125.2034
ALTITUDE ABOVE THE GEOID (KILOMETERS)	18.338	42.271	34.197	57.854	63.153
RADIUS (KILOMETERS)	6393.216	6417.341	6409.348	6432.961	6438.116
INERTIAL VELOCITY (METERS/SECOND)	11107.41	11086.12	11093.06	11072.50	11068.14
RELATIVE VELOCITY (METERS/SECOND)	10678.53	10655.05	10662.21	10639.07	10635.12
INERTIAL HEADING (DEGREES)	91.542	95.213	96.046	93.805	89.241
RELATIVE HEADING (DEGREES)	91.604	95.424	96.291	93.960	89.210

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TABLE 5-XCVII FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 6 APRIL 1968, FIRST OPPORTUNITY

LAUNCH AZIMUTH

	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	136:17:50.17	136:09:52.14	136:01:25.91	135:58:17.16	136:01:55.10
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	12:30:54.521 (12 PARIL)	13:36:03.369 (12 PARIL)	14:41:45.098 (12 APRIL)	15:43:11.118 (12 APRIL)	16:36:52.042 (12 APRIL)
GEODETIC LATITUDE (DEGREES N)	-12.7560	-12.0947	-11.7740	-11.7865	-12.1248
LONGITUDE (DEGREES E)	298.6979	283.1515	267.3939	252.6506	239.8216
ALTITUDE ABOVE THE GEOID (KILOMETERS)	370.807	206.497	93.059	-82.674	-351.140
RADIUS (KILOMETERS)	6747.937	6583.730	6470.340	6294.605	6026.089
INERTIAL VELOCITY (METERS/SECOND)	10805.42	10940.53	11036.93	11191.69	11441.23
RELATIVE VELOCITY (METERS/SECOND)	10334.40	10485.85	10590.74	10754.16	11016.94
INERTIAL HEADING (DEGREES)	100.900	104.159	104.732	102.965	98.982
RELATIVE HEADING (DEGREES)	101.403	104.787	105.367	103.502	99.331

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TABLE 5-XCVIII FREE-RETURN VACUUM-PERIGEE CONDITIONS FOR 6 APRIL 1968, SECOND OPPORTUNITY

	LAUNCH AZIMUTH			
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES 108 DEGREES
FLIGHT TIME (HRS:MIN:SEC)	137:38:00.34	137:24:53.08	137:13:24.48	137:03:02.92 136:56:57.17
ARRIVAL DATE AND TIME, GMT (HRS:MIN:SEC)	13:51:04.686 (12 APRIL)	14:51:04.309 (12 APRIL)	15:53:43.666 (12 APRIL)	16:47:56.878 (12 APRIL) 17:31:54.113 (12 APRIL)
GEOETIC LATITUDE (DEGREES N)	-12.7075	-12.0374	-11.7025	-11.7562 -12.1560
LONGITUDE (DEGREES E)	279.5681	265.1477	250.0747	236.9480 226.3186
ALTITUDE ABOVE THE GEOID (KILOMETERS)	63.337	57.240	20.524	48.618 46.203
RADIUS (KILOMETERS)	6440.475	6434.482	6397.816	6425.902 6423.426
INERTIAL VELOCITY (METERS/SECOND)	11063.40	11068.30	11100.21	11075.75 11078.17
RELATIVE VELOCITY (METERS/SECOND)	10611.04	10620.12	10655.05	10624.82 10622.70
INERTIAL HEADING (DEGREES)	99.039	102.218	102.778	100.455 95.930
RELATIVE HEADING (DEGREES)	99.428	102.742	103.321	100.904 96.186

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TABLE 5-XCIX MIDCOURSE CORRECTION VELOCITY REQUIREMENTS FOR
FIRST-OPPORTUNITY TRAJECTORIES

LAUNCH DATE	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FEBRUARY 1	2.302	2.579	2.597	2.731	3.195
FEBRUARY 2	2.677	2.849	2.999	2.978	3.064
FEBRUARY 3	1.048	0.857	1.438	1.810	2.195
FEBRUARY 4	0.926	2.125	2.386	2.106	1.958
MARCH 1	2.254	2.299	2.584	3.041	3.271
MARCH 3	1.641	1.987	1.847	2.066	1.805
MARCH 5	0.714	0.542	0.363	0.581	0.725
MARCH 7	1.517	0.727	0.400	1.145	1.551
MARCH 31	1.048	1.225	1.013	1.428	1.455
APRIL 2	1.125	0.876	0.676	1.188	1.667
APRIL 4	0.395	0.501	0.523	0.761	1.177
APRIL 6	1.323	0.978	1.118	1.225	1.727

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* THE VELOCITY INCREMENT REQUIRED AT THE VEHICLE POSITION 4 HOURS AFTER INJECTION TO ACHIEVE THE PERISELENUM AND VACUUM-PERIGEE TARGETING CONDITIONS.

TABLE 5-C MIDCOURSE CORRECTION VELOCITY REQUIREMENTS FOR SECOND-OPPORTUNITY TRAJECTORIES

LAUNCH DATE	MIDCOURSE CORRECTION VELOCITY INCREMENT* FOR THE DESIGNATED LAUNCH AZIMUTHS (M/SEC)				
	72 DEGREES	81 DEGREES	90 DEGREES	99 DEGREES	108 DEGREES
FEBRUARY 1	1.830	1.336	1.706	1.882	2.172
FEBRUARY 2	1.618	1.286	1.236	1.645	1.962
FEBRUARY 3	0.503	0.483	0.442	0.688	1.007
FEBRUARY 4	0.503	0.147	0.111	0.430	1.388
MARCH 1	0.877	0.960	0.939	0.776	1.569
MARCH 3	0.316	0.010	0.093	0.054	1.192
MARCH 5	0.020	0.032	0.045	0.028	0.020
MARCH 7	0.393	0.258	0.120	0.227	0.067
MARCH 31	0.081	0.009	0.063	0.0	0.734
APRIL 2	0.036	0.387	0.274	0.262	0.063
APRIL 4	0.060	0.140	0.012	0.0	0.0
APRIL 6	0.0	0.0	0.150	0.0	0.0

* THE VELOCITY INCREMENT REQUIRED AT THE VEHICLE POSITION AT THE VEHICLE POSITION 4 HOURS AFTER INJECTION TO ACHIEVE THE PERISELENUM AND VACUUM-PERIGEE TARGETING CONDITIONS.

SECTION 6

TRACKING AND COMMUNICATIONS COVERAGE SUMMARY

Tracking and communications coverage for Apollo/Saturn missions is provided by the Manned Space Flight Network (MSFN). MSFN coverage availability for the AS-504 mission was taken from Reference 20 and is summarized in this section.

The MSFN ground stations considered in preparing the Reference 20 study are listed in Table 6-I together with a summary of their equipment capability. Station coverage of the insertion boost and of parking orbit until second-opportunity reignition is shown in Figure 6-1. Station coverage of the ten February-1 first and second-opportunity translunar-injection boosts is shown in Figure 6-2. Vehicle tracking by a deep-space tracking station begins during the first 4 hours after translunar injection; after acquisition by a deep-space station, continuous coverage is available until the vehicle passes behind the moon. Coverage of the first 4 hours of translunar coast is shown in Figure 6-3 for the 72-degree-azimuth, first-opportunity trajectory of February 1. Ship and airplane coverage of these trajectories was not available at the time of document publication.

TABLE 6-I. TRACKING AND TELEMETRY NETWORK FOR APOLLO/SATURN AS-504 FLIGHT

FLIGHT PHASE				SYSTEM	STATION	GEODETC ¹ LATITUDE NORTH (DEG)	LONGITUDE ¹ EAST (DEG)	HEIGHT ¹ ABOVE ELLIPSOID (METERS)
1st BURN	PARKING ORBIT	PREIGNITION SEQUENCING/ SECOND BURN	POST SECOND BURN					
✓				ODOP	Transmitter 1.3.7	28.444373	-80.579973	5.14
✓				GLOTRAC	GLOTRAC I	28.413386	-80.592262	10.95
✓					Atlantic	34.881507	-76.353404	2.92
✓					Eleuthera	25.268375	-76.313049	31.83
✓					Grand Turk	21.433765	-71.145032	21.00
✓					Bermuda	32.254488	-64.838675	87.09
✓					Antigua	17.143313	-61.778437	13.93
✓	✓		✓	C-Band Radar	MILA	28.424862	-80.664404	12.02
✓	✓		✓		Patrick	28.226553	-80.599293	15.51
✓	✓		✓		Cape Kennedy	28.481766	-80.576515	14.39
✓	✓		✓		Grand Bahama	26.615778	-78.347833	13.98
✓	✓		✓		Grand Turk	21.462890	-71.132114	28.45
✓	✓		✓		Bermuda	32.348103	-64.653801	24.31
✓	✓		✓		Antigua	17.144031	-61.792859	49.37
✓	✓		✓		Canary Island	27.742797	-15.598103	35.00
✓	✓		✓		Ascension Island	-7.951320	-14.412634	152.43
✓	✓	✓	✓		Pretoria	-25.945553	28.361997	1626.00
✓	✓	✓	✓		Carnarvon	-24.897356	113.716067	64.00
✓	✓	✓	✓		Woomera	-30.819711	136.836969	151.00
✓	✓	✓	✓		Hawaii	22.125267	-159.667619	1142.00
✓	✓	✓	✓		Point Arguello	34.582903	-120.561150	646.00
✓	✓	✓	✓		White Sands	32.358223	-106.369564	1233.31
✓	✓	✓	✓		Eglin	30.421767	-86.798114	28.00
✓	✓		✓		USB	Cape Kennedy	28.481767	-80.576514
✓	✓		✓	Grand Bahama ²		26.615786	-78.347850	--
✓	✓		✓	Bermuda		32.347766	-64.653644	21.00
✓	✓		✓	Antigua ²		17.143797	-61.792683	--
✓	✓		✓	Woomera		-31.383136	136.886139	173.00
✓	✓		✓	Canary Island ²		27.735522	-15.600006	--
✓	✓		✓	Ascension Island ²		-7.972944	-14.401694	--
✓	✓		✓	Madrid		40.416667	-3.666667	50.00
✓	✓		✓	Carnarvon		-24.897356	113.716067	57.00
✓	✓		✓	Canberra		-35.311528	149.135833	50.00
✓	✓		✓	Guam		13.583333	144.925000	20.00
✓	✓		✓	Hawaii ²		22.125267	-159.667619	--
✓	✓		✓	Goldstone ²		35.389639	-116.848777	--
✓	✓		✓	Guaymas	27.958406	-110.720792	18.00	
✓	✓		✓	Corpus Christi ²	27.655394	-97.380255	--	
✓	✓		✓	Telemetry	New Smyrna ²	29.066667	-80.916667	--
✓	✓		✓		Cape Tel 4 ²	28.463713	-80.653029	--
✓	✓		✓		MILA-CIF ²	28.542366	-80.643533	--
✓	✓		✓		Vero Beach ²	27.666667	-80.350000	--
✓	✓		✓		Grand Bahama ²	26.628514	-78.299444	--
✓	✓		✓		Grand Turk ²	21.446016	-71.147500	--
✓	✓		✓		Bermuda	32.348102	-64.653800	18.00
✓	✓		✓		Antigua	17.137333	-61.774955	41.20
✓	✓		✓		Canary Island	27.742797	-15.598103	35.00
✓	✓		✓		Ascension Island	-7.974314	-14.392221	299.79
✓	✓		✓		Tananarive	-19.018056	47.304444	11.00
✓	✓		✓		Carnarvon	-24.897356	113.716067	64.00
✓	✓		✓		Hawaii	22.125267	-159.667619	1142.00
✓	✓		✓	Guaymas	27.958406	-110.720792	18.00	
✓	✓		✓	Corpus Christi ¹	27.655400	-97.380256	10.00	

NOTE: 1) All data are referenced to the Fischer Ellipsoid of 1960.
2) Station height unknown.

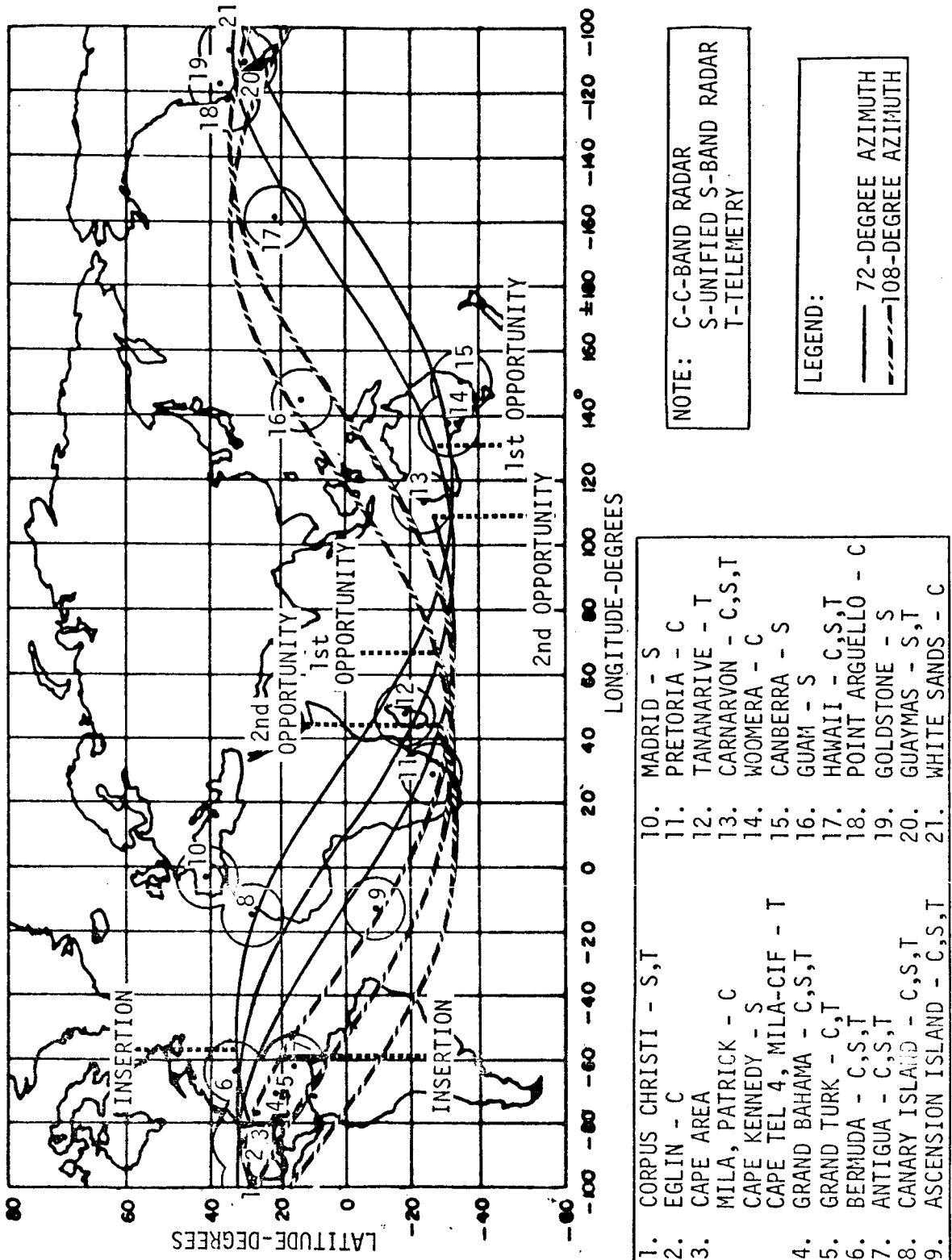


FIGURE 6-1. TRACKING AND TELEMETRY COVERAGE DURING THE INSERTION BOOST AND PARKING ORBIT

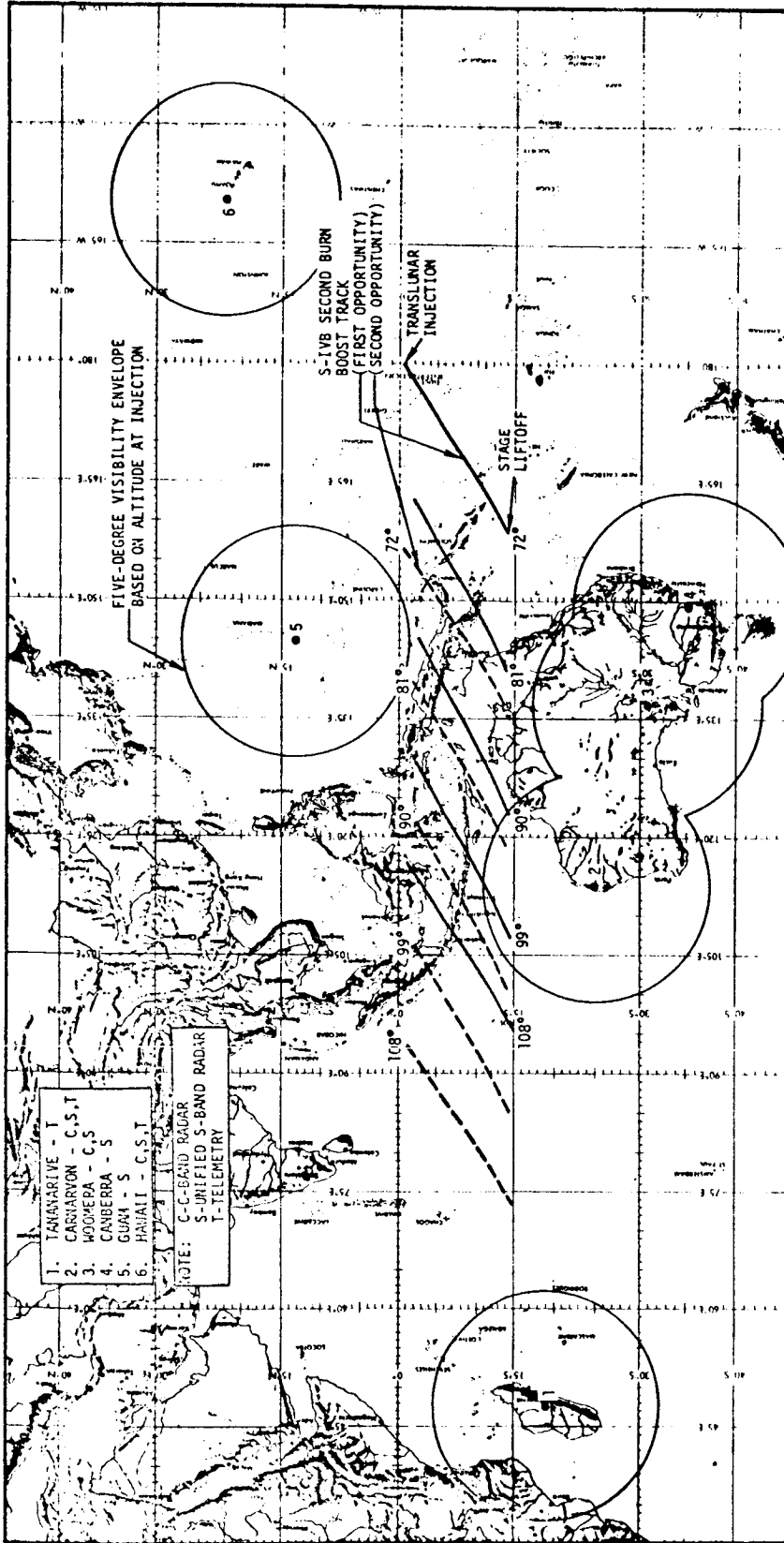


FIGURE 6-2. TRACKING AND TELEMETRY COVERAGE DURING THE TRANSLUNAR INJECTION BOOST (FEBRUARY 1)

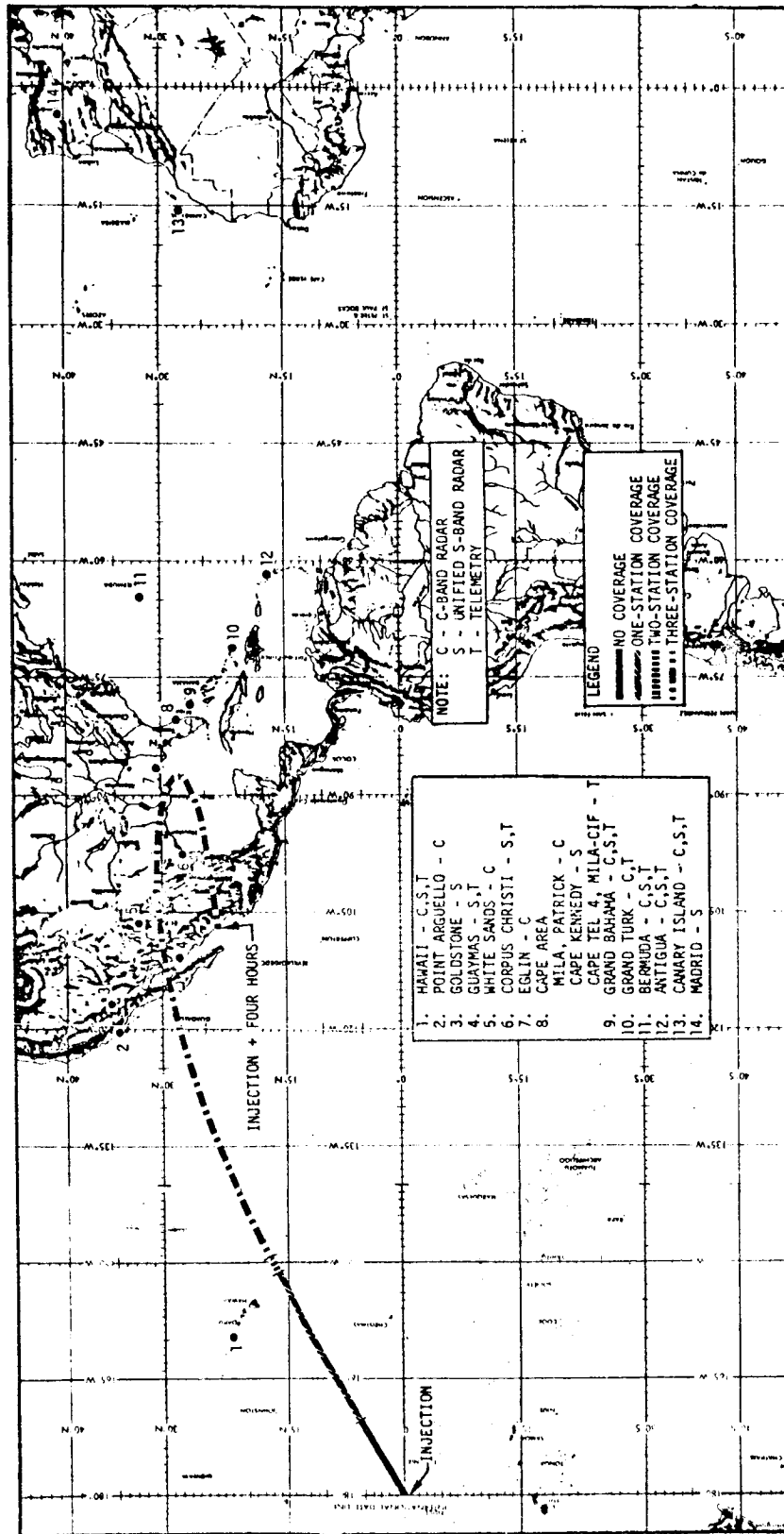


FIGURE 6-3. TRACKING AND TELEMETRY COVERAGE DURING THE FIRST FOUR HOURS OF TRANSLUNAR COAST (FEBRUARY 1, 72-DEGREES LAUNCH AZIMUTH, FIRST OPPORTUNITY)