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Type II

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Appendices to Volume I — Mission Description

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TABLE OF CONTENTS

	Page
Preface	i
Appendix A, Trejectory Computation Guidelines	A-1
Appendix B, Mission Weights	B-1
Appendix C, Engine Performance Parameters	C-1

LIST OF TABLES

B-1	Space Vehicle Weight Summary	B-4
B-2	Mission Phase Weight and Performance Summary - DRM	B-5
B-3	Mission Phase Weight and Performance Summary - Maximum Propellant Mission (MPM)	B-7
B-4	Mission Phase Weight and Performance Summary - Design Reference Mission with Consumables Expended (DRMCE)	B-9
B-5	CSM Consumables Summary for DRMCE Mission	B-11
B-6	LEM and Total Spacecraft Consumable Summary for DRMCE Mission	B-19

LIST OF ILLUSTRATIONS

		Page
A-1	Estimated Performance of LEM Descent Engine	A-6
C-1	Ascent Phase Engine Performance Parameters, S-1C	C-3
C-2	Ascent Phase Engine Performance Parameters, S-II	C-4
C-3	Ascent Phase Engine Performance Parameters, S-IVB	C-5
C-4	Translunar Injection Engine Performance Parameters	C-6
C-5	Lunar Orbit Insertion Engine Performance Parameters	C-7
C-6	Transfer Orbit Insertion Engine Performance Parameters	C-8
C-7	LEM Powered Descent Engine Performance Parameters	C-9
C-8	LEM Powered Ascent Engine Performance Parameters	C-10
C-9	First LEM Terminal Rendezvous Coast Phase Engine Parameters	C-11
C-10	Second Burn and Coast Phase of LEM Terminal Rendezvous Engine Performance Parameters	C-12
C-11	Third Burn and Coast Phase of LEM Terminal Rendezvous Engine Performance Parameters	C-13
C-12	Transearth Injection Engine Performance Parameters	C-14

PREFACE

To enhance the utility of this report, the "Classified" data which describe the Apollo Mission Planning Task Force (AMPTF) Design Reference Mission (DRM) have been placed in this volume. The additional guidelines which were used in the trajectory studies are listed in Appendix A. The weights data for the mission are presented in Appendix B, and the data related to engine performance are presented in Appendix C.

APPENDIX A

TRAJECTORY COMPUTATION GUIDELINES

APPENDIX A

TRAJECTORY COMPUTATION GUIDELINES

Section 2.3.3 in Volume I (Mission Description) of this document contains general trajectory ground rules. In order to define more completely the desired characteristics of the Design Reference Mission trajectory, additional guidelines were derived. These guidelines were provided to the MSC Mission Planning and Analysis Division for their use in performing the trajectory computations and are itemized herein:

- Phase 1.0 Preflight - None
- Phase 2.0 Earth Ascent - Earth liftoff weight shall be 6,000,000 pounds. Launch azimuth shall be such that it results in the largest Service Module propellant expenditure within the optimum 26 degree launch window for the selected launch date. A daylight launch is required.
- Phase 3.0 Earth Parking Orbit - Five S-IVB vents, expelling 550 pounds during each vent, and causing a 4 fps increase in velocity magnitude in the direction of motion per vent at 30 minute intervals, shall take place during earth orbit.
- Phase 4.0 Translunar Injection - Translunar injection shall be accomplished during the second earth parking orbit and establish a free-return, circumlunar trajectory having a 21 $\pm$15 nautical miles vacuum perigee altitude.
- Phase 5.0 Initial Coast Through S-IVB Jettison - Transposition and docking shall begin 15 minutes after the end of translunar injection. Thirty minutes later the S-IVB shall be jettisoned. After jettison of the S-IVB, the spacecraft gross weight shall be 86,600 pounds.
- Phase 6.0 S-IVB Jettison to Lunar Orbit Insertion - Three midcourse corrections totaling 300 fps delta V shall be assumed to occur during translunar flight (see note 4 below). A specific impulse of 313 seconds and thrust magnitude of 21,900 pounds shall be used for all SPS engine burns.

- Phase 7.0 Lunar Orbit Insertion - Lunar orbit insertion shall result in a near-circular orbit 80 ±5 nautical miles altitude above the selected landing site radius. The resultant parking orbit shall be such that the CSM will pass over the landing site during its third orbit and that the maximum out-of-plane condition of the landing site during the LEM lunar stay will be 0.5 degrees.
- Phase 8.0 Lunar Coast to LEM Separation - Two passes over the landing site are required prior to initiating the LEM Transfer Orbit Insertion (TOI) burn.
- Phase 9.0 CSM Solo Lunar Orbital Operations - None
- Phase 10.0 LEM Descent
  - Phase 10.1 LEM/CSM Separation - The LEM weight, prior to separation, shall be 29,870 pounds. A 5 fps delta V RCS burn shall be assumed for separation. The LEM RCS specific impulse for all burns shall be assumed to be 295 seconds.
  - Phase 10.2 Transfer Orbit Insertion - A 28-second low-thrust (1050 pounds) period using the LEM descent engine shall precede the high-thrust (10,500 pounds maximum) period of the TOI phase. The insertion maneuver shall place LEM into a Hohmann transfer descent orbit having a 50,000 foot pericynthion altitude. The GAEC-estimated nominal specific impulse versus thrust variation, as presented in Figure A-1 (from reference 10) shall be used for all LEM descent engine burns.
  - Phase 10.4 Powered Descent to Beginning of Visibility - The LEM powered descent phase from 50,000 feet altitude shall begin with a 28-second, low-thrust (1050 pounds) LEM descent engine burn period. The remainder of powered descent (up to the beginning of the visibility phase) shall be performed with a maximum thrust value of 10,500 pounds (the actual value required will be that which is called for by the guidance system). The beginning of the visibility phase shall occur at approximately 7 nautical miles slant range from the landing site.

- Phase 10.5 Beginning of Visibility to Hover - The look angle during this phase (the angle between the negative x-body axis of LEM and the line of sight to the landing site "aim point"*) shall average 35 degrees. The chosen "end point"* for the guidance system shall be 200 feet above the landing site and 1,000 feet uprange from the landing site "aim point"*. The corresponding inertial velocity vector at this "end point"* shall have a magnitude of 10 fps and a direction of 10 degrees below the landing site horizontal.

- Phase 10.6 Hover to Touchdown - Guidelines that shall be assumed for this phase are contained in reference 9.

- Phase 11.0 LEM Lunar Stay - The LEM lunar stay period shall be approximately 35 hours. The landing site shall lie within the region bounded by ±5 degrees selenographic latitude and ±45 degrees selenographic longitude. The altitude of the site shall be that corresponding to the current USAF Aeronautical Chart and Information Center (ACIC) lunar map information available on such a site. The lighting conditions at touchdown shall be within the 15 to 45 degree over-the-shoulder elevation angle, as required by ground rule 7.1 of reference 8. (This requirement was not met during the mission trajectory computation due to solar epheremis computational errors but this did not effect trajectory computational accuracy.)

- Phase 12.0 LEM Ascent -

  - Phase 12.1 Powered Ascent to Transfer Orbit Insertion - The LEM launch weight shall be 10,500 pounds. The launch time and guidance system end point conditions shall be optimized such that the burnout conditions yield a 35,000 foot pericynthion orbit with a 50,000 foot burnout altitude. A vertical thrusting period of 12 seconds, a thrust magnitude of 3,500 pounds, and a specific impulse of 306 seconds shall be used for the computation of the LEM ascent trajectory.

  - Phase 12.2 Coast to Terminal Rendezvous - A 50 fps delta V midcourse correction, using the LEM RCS, shall be assumed to result in a change in LEM weight during this phase (see note 4 below).

- - - - - - -

See Section 4 for definitions of "end point" and "aim point".

- Phase 12.3 Terminal Rendezvous - A three-burn LEM RCS rendezvous sequence shall be initiated when the LEM/CSM line-of-sight range attains a value of 5 nautical miles. A thrust value of 200 pounds shall be assumed (two jets) to provide the following range/range-rate schedule:

Range at Initiation of Thrusting (n. mi.)	G & N Scheduled Range Rate (fps)
5	-100
1.5	-20
0.25	-5

- Phase 12.4 Docking - A 25 fps delta V LEM RCS expenditure shall be assumed to be applied for docking.

- Phase 13.0 Lunar Orbit Coast to Transearth Injection - Prior to LEM jettison, a transfer weight of CSM of 590 pounds (510 pounds crew-plus-equipment and 80 pounds scientific equipment-plus-lunar samples) shall be assumed.

- Phase 14.0 Transearth Injection - Transearth injection shall be initiated after the 22nd pass of the CSM over the landing site (two orbits after rendezvous). The resultant transearth orbit shall satisfy the terminal inclination and entry range constraints as noted in phase 16.0 below and should have a transit time of less than 110 hours.

- Phase 15.0 Transearth Coast - A 300 fps midcourse correction delta V expenditure, assuming SPS thrusting, shall be assumed to change the CSM weight during this phase. Prior to entry, the SM shall be assumed to be jettisoned and result in a CM entry weight of 9,500 pounds.

- Phase 16.0 Entry - The equatorial inclination of the geocentric transearth plane shall not exceed 40° and no nominal cross-range meneuvering shall be accomplished. Although there is no earth landing lighting constraint for design purposes, the trajectory shall terminate in a daylight landing.

- Phase 17.0 Parachute Descent - Earth landing shall be assumed to take place within a 200 to 600 nautical mile radius east of one of the two primary landing areas (Hawaii or Pago Pago) as defined in reference 8 (21.367°N/157.967°W or 14.25°S/170.25°W). The beginning of the parachute descent shall be assumed to occur at a CM gross weight of 9,242 pounds.

- Phase 18.0 Post Landing Through Spacecraft Retrieval - The landing weight of the spacecraft shall be assumed to be 8,624 pounds.

GENERAL NOTES:

(1) The standard astrodynamic conversion factors and constants of reference 8 shall be used for the computation of the Design Reference Mission trajectory.

(2) No guidance, contingency or evaluation uncertainty delta V expenditure shall be expended during any of the powered flight phases of the mission

(3) Altitudes are measured above the earth spheroid described in reference 8 or lunar landing site radius.

(4) No effect on the orbit shall be assumed as a result of the midcourse correction application since it is to be assumed that no errors are made during powered phases.

(5) The weights used in the computation of the DRM trajectory are essentially based on CSM Block I design hardware which were in effect at the time of the trajectory computation.

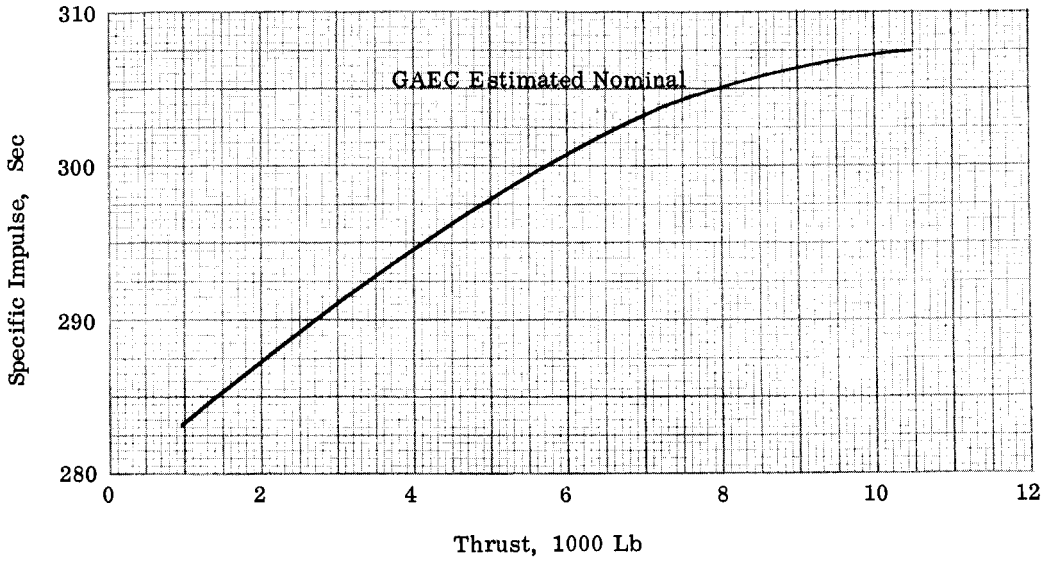

Figure A-1 Estimated Performance of LEM Descent Engine

APPENDIX B

MISSION WEIGHTS

APPENDIX B

MISSION WEIGHTS

The space vehicle weight breakdown by stage and the spacecraft weight by module is presented in Table B-1. These weights were used in the computation of the weight-time history of the Design Reference Mission (DRM) (Table B-2), the Maximum Propellant Mission (MPM) (Table B-3) and the trajectory upon which these missions are based. In addition, the other consumables that would have been expended during the DRM were computed and resulting modified DRM weight time history is presented in Table B-4 as the Design Reference Mission with Consumables Expended (DRMCE). The detailed breakdown of these consumables appears in Tables B-5 and B-6.

Table B-1 summarizes the weight breakdown for the space vehicle while on the launch pad and at lift-off. The 6,000,000 lb. lift-off weight is required on the basis of the combination of a 7,500,000 lb. effective sea-level thrust capability and a lift-off thrust-to-weight ratio of 1.25. A 90,000 lb. translunar injected S-IVB payload, composed of a 57,100 lb. CSM, a 29,500 lb. LEM, and a 3400 lb. adapter, formed the basis of the DRM weight reporting. These weights were the existing control weights of the spacecraft at the time the DRM trajectory was computed, as delineated in references 16 and 17. References 7 and 15 were used to define the launch vehicle weight breakdown and thrust buildup propellant expended prior to lift-off, respectively.

Table B-2 summarizes the weight, time, and engine performance (i.e. specific impulse, delta V and propellant used) for each phase of the DRM. The variable-thrust delta V and specific impulse values for the S-IC thrusting during the Earth Ascent (Phase 2.1.1), and for the LEM powered descent (Phases 10.4, 10.5 and 10.6), were computed by integrating the thrust-to-mass ratio vs. time which was available from the computed trajectory data. All other constant thrust specific impulse burn periods assumed specific impulse values as itemized in Table B-2 for each powered flight phase.

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The Maximum Propellant Mission (MPM) described in Table B-3 is characterized by the fact that all of the spacecraft budgeted delta V is assumed to be expended during each phase. This includes minimum-plus-flexibility, guidance, evaluation uncertainty, and contingency delta V allowances (e. g. LEM rescue) throughout the mission. The delta V's and corresponding engine burn times of the DRM were therefore changed for each powered phase as specified by the delta V budget tables in References 16 and 13. Coast time increments subsequent to spacecraft thrusting phases were adjusted in such a manner as to provide a mission trajectory that would approximate the DRM in time and space. Since the DRM trajectory was chosen in such a way as to be close to exercising the full delta V capability of the SM, the MPM requires relatively small additional delta V and propellant expenditure. The total propellant consumed during the MPM by the SM is 37,175 lb. and is within 75 lb. of the 37,100 lb. propellant loading budgeted for the 90,000 lb. spacecraft. The difference resulted from computational accuracies. If consumables other than propellant were taken into account, as discussed below, the propellant expended for the same expended delta V would be less than 37,000 lb.

The DRM with Consumables Expended Mission (DRMCE) of Table B-4 was constructed on the basis that the DRM timeline, which assumed no consumable expenditure other than translation propellant, would not be effected by expenditure of consumables. To construct the DRMCE, it was assumed for comparative purposes that both the CSM and LEM were loaded such that their lift-off weights would correspond with these of the DRM. Thus, any prelaunch consumable expenditures were considered to require loading CSM and LEM in excess of their lift-off weights. Table B-4 indicates that correspondingly less propellant is needed for the DRMCE mission as compared to the DRM; this amounts to 293 pounds for the CSM and 27 pounds for LEM.

Tables B-5 and B-6 present a detailed breakdown of the consumable expenditure requirements for CSM and LEM based on the DRM timeline. All consumable expenditures other than main engine or RCS translation propellant were considered in the preparation of these tables. Sub-totals for each phase were itemized and used for the computation of the DRMCE mission weight history of Table B-4. It will be noted in Table B-5, which was prepared by North American, that changes in consumables such as food are shown during thrusting as well as coasting phases. This results from the assumption that urine and feces are generated continuously, although they may be transferred intermittently. To maintain a horizontal balance of weight in Table B-5, it was therefore also assumed that food and biological water are consumed continuously.

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The Control weights for the spacecraft that are shown in Table B-1 and which were used in the above trajectory computations are currently being revised. Since these changes are not large, and the gravitational terms in the integrated trajectory computations are usually small, it is not expected that they would have a large effect on the trajectories shown in this report.

However, the new control weights may require that future revisions of the DRM be based on non-free return translunar trajectories with longer coast times. The longer translunar coast times will require less propellant expenditures at translunar injection and lunar orbit insertion.

Table 1

Space Vehicle Weight Summary

Stage/Module	Description	Weight - Lbs
S-IC	Lift-Off Weight (6,000,000 lb.) Minus Upper Stages	(4,718,066)
	Damp Weight*	353,068
	Propellant - Mainstage After Liftoff	4,262,576
	- Thrust Buildup	102,422
S-II	Lift-Off Weight (1,384,356 lb.) Minus Upper Stage	(1,024,108)
	Damp Weight	98,207
	S-II/S-IVB Interstage	9,450
	Launch Escape System (LES)	6,600
	Propellant	909,851
S-IVB	Lift-Off Weight (360,248 lb.) Minus Spacecraft	(270,248)
	Damp Weight	30,400
	Propellant - 1st Burn, Earth Orbit Insertion	79,296
	- Ullage Vents (5)	2,750
	- 2nd Burn, Translunar Injection	148,055
	- Reserves	9,747
Spacecraft	Lift-Off (86,600 lb.) Plus Adapter	(90,000)
CSM	Command & Service Module (57,100 lb.)	
CM	Command Module (incl. LEM Crew)**	9,500
SM	Service Module Damp Weight	10,500
	Propellant (SPS)	37,100
	Adapter	3,400
LEM	Lunar Excursion Module (29,500 lb.)	
	LEM Damp Weight (W/O Crew)	8,376
	Propellant - Descent	15,943
	- Ascent	5,181
	Space Vehicle at Ground Ignition - Total	(6,102,422)
	Minus: Thrust Buildup Propellant	- 102,422
	Space Vehicle at Lift-Off	(6,000,000)

* Damp Weight ≡ Inert Weight + Unused Propellant + Consumables, etc.

** LEM Crew (2) and Equipment = 450 lb. (translunar)
LEM Crew (2) Equipment and Lunar Samples = 590 lb. (transearth)

Table B-2

Mission Phase Weight and Performance Summary-DRM

PHASE NUMBER		CUMULATIVE WEIGHT (LB)	ELAPSED TIME (HR MIN SEC)	ELAPSED TIME (HR)	PHASE TIME (MIN)	ISP (SEC)	DELTA-V (FPS)	PROPELLANT USED (LB)
1.0	PREFLIGHT							
1.1	SPACEVEHICLE PRELAUNCH POSITIONING	529501.00	-487 46 13.1	-487.821				
					480.00	.00	.00	.00
1.2	PRELAUNCH CHECKOUT							
1.2.1	LAUNCH FACILITIES-SPACEVEHICLE INTERFACE	529501.00	-479 49 16.1	-479.821				
					1440.00	.00	.00	.00
1.2.2	SPACEVEHICLE CHECKOUT	529501.00	-455 49 16.1	-455.821				
					24469.26	.00	.00	.00
1.3	LAUNCH COUNTDOWN							
1.3.1	PRECOUNTDOWN (SPACECRAFT FUELING)	529501.00	-48 0 0.0	-48.000				
					2280.00	.00	.00	58224.00
1.3.2	TERMINAL COUNTDOWN (LAUNCHVEHICLE FUELING)	587725.00	-10 0 0.0	-10.000				
					599.90	.00	.00	5514627.00
1.3.3	IGNITION COMMAND	6102422.00	-0 0 5.0	-.002				
					.10	.00	.00	-102422.00
2.0	EARTH ASCENT (LIFT-OFF THRU EARTH ORBIT INSERT.)							
2.1	LIFT-OFF THRU S-IC JETTISON							
2.1.1	S-IC THRUSTING	6000000.00	0 0 0.0	.000				
					2.51	292.49	11663.22	4262575.00
2.1.2	JETTISON S-IC	1737424.10	0 2 30.6	.041				
					.06	.00	.00	.00
2.2	S-IC JETTISON(JET.LES+INTERSTAGE)THRU S-II JET.							
2.2.1	S-II THRUSTING	1384356.10	0 2 34.4	.042				
					.33	426.00	472.98	-46048.50
2.2.2	JETTISON LES + INTERSTAGE	1337407.60	0 2 54.4	.048				
					.00	.00	.00	.00
2.2.3	CONTINUE S-II THRUSTING	1321357.60	0 2 54.4	.048				
					6.12	426.00	14508.68	-862302.70
2.2.4	JETTISON S-II	458454.91	0 9 2.0	.150				
					.02	.00	.00	.00
2.3	S-II JETTISON THRU EARTH PARKING ORBIT INSERT. (S-IVB THRUSTING , FIRST BURN)	360247.91	0 9 3.5	.150				
					2.81	426.00	3407.45	-79205.75
3.0	EARTH PARKING ORBIT							
3.1	ORBIT INSERTION TO TLI DECISION							
3.1.1	INITIAL COAST TO VENT 1	280952.16	0 11 52.4	.197				
					30.00	.00	.00	.00
3.1.2	S-IVB VENT 1*	280952.16	0 41 52.4	.697				
					.00			-550.00
3.1.3	CONTINUE COAST TO VENT 2	280402.16	0 41 52.4	.697				
					30.00	.00	.00	.00
3.1.4	S-IVB VENT 2*	280402.16	1 11 52.4	1.197				
					.00			-550.00
3.1.5	CONTINUE COAST TO VENT 3	279852.16	1 11 52.4	1.197				
					30.00	.00	.00	.00
3.1.6	S-IVB VENT 3*	279852.16	1 41 52.4	1.697				
					.00			-550.00
3.1.7	CONTINUE COAST TO VENT 4	279302.16	1 41 52.4	1.697				
					30.00	.00	.00	.00
3.1.8	S-IVB VENT 4*	279302.16	2 11 52.4	2.197				
					.00			-550.00
3.1.9	CONTINUE COAST TO TLI DECISION	278752.16	2 11 52.4	2.197				
					14.52	.00	.00	.00
3.2	TLI DECISION TO S-IVB IGNITION							
3.2.1	BEGIN TLI PREPARATION	278752.16	2 26 24.0	2.440				
					15.47	.00	.00	.00
3.2.2	S-IVB VENT 5*	278752.16	2 41 52.4	2.697				
					.00			-550.00
3.2.3	CONTINUE TLI PREPARATION	278202.16	2 41 52.4	2.697				
					18.84	.00	.00	.00
4.0	TRANSLUNAR INJECTION(S-IVB THRUSTING,SECOND BURN)	278202.16	3 0 43.0	3.011				
					5.25	426.00	10412.32	-148055.11
5.0	INITIAL TRANSLUNAR COAST THRU S-IVB JETTISON							
5.1	INITIAL COAST TO TRANSPOSITION	130147.05	3 5 58.4	3.099				
					15.00	.00	.00	.00
5.2	TRANSPOSITION + DOCKING	130147.05	3 20 58.4	3.349				
					27.00	.00	.00	.00
5.3	COAST THRU S-IVB JETTISON	130147.05	3 47 58.4	3.799				
					3.00	.00	.00	.00
6.0	S-IVB JETTISON TO LUNAR ORBIT INSERTION							
6.1	COAST THRU FIRST MCC							
6.1.1	COAST TO FIRST MCC	86600.00	3 50 58.4	3.849				
					75.00	.00	.00	.00
6.1.2	FIRST MIDCOURSE CORRECTION	86600.00	5 5 58.4	5.029				
					.30	313.00	150.00	-1280.35
6.2	COAST THRU SECOND MCC							
6.2.1	COAST TO SECOND MCC	85319.65	5 6 16.4	5.104				
					3023.72	.00	.00	.00
6.2.2	SECOND MIDCOURSE CORRECTION	85319.65	55 30 00.0	55.500				
					.20	313.00	100.00	-843.03
6.3	COAST THRU THIRD MCC							
6.3.1	COAST TO THIRD MCC	84476.61	55 30 12.0	55.503				
					464.87	.00	.00	.00
6.3.2	THIRD MIDCOURSE CORRECTION	84476.61	63 15 4.2	63.251				
					.10	313.00	50.00	-418.39
6.4	PREPARATION FOR LUNAR ORBIT INSERTION	84058.22	63 15 10.2	63.252				
					59.00	.00	.00	.00
7.0	LUNAR ORBIT INSERTION	84058.22	64 15 4.2	64.251				
					5.86	313.00	3400.31	-24620.09
8.0	LUNAR ORBIT COAST TO LEM SEPARATION							
8.1	LUNAR ORBIT COAST	59437.22	64 20 56.1	64.348				
					86.06	.00	.00	.00
8.2	PREPARATION FOR LEM SEPARATION	59437.22	65 47 0.0	65.783				
					137.23	.00	.00	.00

*Results in 4 fps Velocity Magnitude Increase in the Flight Direction

[redacted]

Table B-2 (Cont'd.)

PHASE NUMBER		CUMULATIVE WEIGHT (LB)	ELAPSED TIME (H) (M) (S)	ELAPSED TIME (HR)	PHASE TIME (MIN)	ISP (SEC)	DELTA-V (F/S)	PROPELLANT USED (LB)
9.0	CSM SOLO LUNAR ORBITAL OPERATIONS							
9.1	LEM CSM SEPARATION	59437.22	68 4 14.3	68.070	20.00	.00	.00	.00
9.2	LUNAR ORBIT COAST (TO PHASE 13.0)	29567.22	68 24 14.3	68.403	2240.03	.00	.00	.00
10.0	LEM SEPARATION AND DESCENT							
10.1	LEM/CSM SEPARATION + PREPARATION FOR DESCENT							
10.1.1	LEM CSM SEPARATION	29870.00	68 4 14.3	68.070	6.83	295.00	5.00	-15.73
10.1.2	PREPARATION FOR DESCENT	29854.26	68 11 4.3	68.184	13.16	.00	.00	.00
10.2	TRANSFER ORBIT INSERTION	29854.26	68 24 14.3	68.403	.56	299.36	101.25	-312.18
10.3	COAST TO INITIATION OF POWERED DESCENT	29542.08	68 24 48.4	68.413	58.07	.00	.00	.00
10.4	POWERED DESCENT TO BEGINNING OF VISIBILITY	29542.08	69 22 52.8	69.381	6.50	306.56	5004.60	-11755.70
10.5	BEGINNING OF VISIBILITY TO HOVER	17786.37	69 25 22.8	69.480	1.92	296.70	1050.37	-1853.19
10.6	HOVER TO TOUCHDOWN	15933.17	69 31 18.3	69.521	1.08	289.12	336.23	-565.62
11.0	LEM LUNAR STAY							
11.1	POST LANDING CHECKOUT	15367.55	69 32 23.2	69.539	14.66	.00	.00	.00
11.2	LUNAR EXPLORATION	15367.55	69 47 3.0	69.784	2008.25	.00	.00	.00
11.3	PRELAUNCH PREPARATION	15367.55	103 15 18.0	103.255	61.79	.00	.00	.00
10.6	HOVER TO TOUCHDOWN	15933.17	69 31 18.3	69.521	1.12	289.42	355.73	-597.20
11.0	LEM LUNAR STAY							
11.1	POST LANDING CHECKOUT	15335.97	69 32 25.7	69.540	14.66	.00	.00	.00
11.2	LUNAR EXPLORATION	15335.97	69 47 5.5	69.784	2008.20	.00	.00	.00
11.3	PRELAUNCH PREPARATION	15335.97	103 15 18.0	103.255	61.79	.00	.00	.00
12.0	LEM ASCENT							
12.1	POWERED ASCENT THRU TRANSFER ORBIT INSERTION	10500.00	104 17 5.7	104.284	7.05	306.00	6081.61	-4838.69
12.2	COAST TO TERMINAL RENDEZVOUS							
12.2.1	COASTING LUNAR ASCENT TO FIRST MCC	5661.30	104 24 8.9	104.402	9.00	.00	.00	.00
12.2.2	FIRST MIDCOURSE CORRECTION	5661.30	104 33 8.9	104.552	.48	295.00	34.00	-20.24
12.2.3	COAST TO SECOND MCC	5641.06	104 33 37.7	104.560	13.52	.00	.00	.00
12.2.4	SECOND MIDCOURSE CORRECTION	5641.06	104 47 8.9	104.785	.15	295.00	11.00	-6.53
12.2.5	COAST TO THIRD MCC	5634.53	104 47 18.2	104.788	9.84	.00	.00	.00
12.2.6	THIRD MIDCOURSE CORRECTION	5634.53	104 57 8.9	104.952	.07	295.00	5.00	-2.96
12.2.7	COAST TO TERMINAL RENDEZVOUS	5631.56	104 57 13.2	104.953	13.78	.00	.00	.00
12.3	TERMINAL RENDEZVOUS							
12.3.1	FIRST THRUSTING AT 5 N.MI LOS RANGE	5631.56	105 11 0.2	105.183	.00	.00	.00	.00
12.3.2	COAST TO SECOND THRUSTING	5631.56	105 11 0.2	105.183	4.22	.00	.00	.00
12.3.3	SECOND THRUSTING AT 1.5 N.MI. LOS RANGE	5631.56	105 15 13.4	105.253	1.34	295.00	92.84	-54.81
12.3.4	COAST TO THIRD THRUSTING	5576.74	105 16 34.3	105.276	2.57	.00	.00	.00
12.3.5	THIRD THRUSTING AT 0.25 N.MI. LOS RANGE	5576.74	105 19 8.9	105.319	.12	295.00	8.59	-5.05
12.4	DOCKING							
12.4.1	BEGIN DOCK	5571.69	105 19 16.4	105.321	15.00	295.00	25.00	-14.65
12.4.2	HARD DOCK	5557.03	105 34 16.4	105.571	10.00	.00	.00	.00
13.0	LUNAR ORBIT COAST TO TEI							
13.1	COAST TO LEM JETTISON	35124.26	105 44 16.4	105.737	30.00	.00	.00	.00
13.2	JETTISON LEM	35124.26	106 14 16.4	106.237	1.30	.00	.00	.00
13.3	PREPARATION FOR TEI	30157.22	106 15 34.4	106.259	172.64	.00	.00	.00
14.0	TRANSEARTH INJECTION	30157.22	109 8 13.3	109.137	1.71	313.00	2747.08	-7201.01
15.0	TRANSEARTH COAST							
15.1	COAST THRU FIRST MCC							
15.1.1	COAST TO FIRST MCC	22055.31	109 9 56.2	109.165	1200.00	.00	.00	.00
15.1.2	FIRST MIDCOURSE CORRECTION	22055.31	129 9 56.2	129.165	.08	313.00	150.00	-339.38
15.2	COAST THRU SECOND MCC							
15.2.1	COAST TO SECOND MCC	22615.92	129 10 1.1	129.166	2609.21	.00	.00	.00
15.2.2	SECOND MIDCOURSE CORRECTION	22615.92	174 9 56.2	174.165	.05	313.00	100.00	-223.46
15.3	COAST THRU THIRD MCC							
15.3.1	COAST TO THIRD MCC	22392.46	174 9 59.4	174.166	1385.57	.00	.00	.00
15.3.2	THIRD MIDCOURSE CORRECTION	22392.46	197 15 33.8	197.259	.02	313.00	50.00	-110.90
15.4	THIRD MCC THRU SM JETTISON							
15.4.1	COAST TO SM JETTISON	22281.55	197 15 35.4	197.259	44.97	.00	.00	.00
15.4.2	JETTISON SM	22281.55	198 0 33.8	198.009	.00	.00	.00	.00
15.5	SM JETTISON TO ENTRY	9500.00	198 0 33.8	198.009	15.00	.00	.00	.00
16.0	ENTRY	9500.00	198 15 33.8	198.259	10.46	.00	.00	.00
17.0	PARACHUTE DESCENT(DROGUE DEPLOY TO TOUCHDOWN)	9242.00	198 26 1.4	198.433	7.10	.00	.00	.00
18.0	POST LANDING THRU SPACECRAFT RETRIEVAL	9024.00	198 33 7.6	198.552				

*Underline Values Differ From Manual Hover-To-Touchdown.

[redacted]

Table B-3 Mission Phase Weight & Performance Summary - Maximum Propellant Mission (MPM)

PHASE NUMBER		CUMULATIVE WEIGHT (LB)	ELAPSED TIME (H) (M) (S)	ELAPSED TIME (HR)	PHASE TIME (MIN)	ISP (SEC)	DELTA-V (FPS)	PROPELLANT USED (LB)
1.0	PREFLIGHT							
1.1	SPACEVEHICLE PRELAUNCH POSITIONING	529501.00	-487 49 16.1	-487.821				
					480.00	.00	.00	.00
1.2	PRELAUNCH CHECKOUT							
1.2.1	LAUNCH FACILITIES-SPACEVEHICLE INTERFACE	529501.00	-479 49 16.1	-479.821				
					1440.00	.00	.00	.00
1.2.2	SPACEVEHICLE CHECKOUT	529501.00	-455 49 16.1	-455.821				
					24469.26	.00	.00	.00
1.3	LAUNCH COUNTDOWN							
1.3.1	PRECOUNTDOWN (SPACECRAFT FUELING)	529501.00	-48 0 0.0	-48.000				
					2200.00	.00	.00	58224.00
1.3.2	TERMINAL COUNTDOWN (LAUNCHVEHICLE FUELING)	587725.00	-10 0 0.0	-10.000				
					599.90	.00	.00	5514627.00
1.3.3	IGNITION COMMAND	6102422.00	-0 0 5.9	-.002				
					.10	.00	.00	-102422.00
2.0	EARTH ASCENT (LIFT-OFF THRU EARTH ORBIT INSERT.)							
2.1	LIFT-OFF THRU S-IC JETTISON							
2.1.1	S-IC THRUSTING	6000000.00	0 0 0.0	.000				
					2.51	292.40	11663.22	-4262575.00
2.1.2	JETTISON S-IC	1737424.10	0 2 30.6	.041				
					.05	.00	.00	.00
2.2	S-IC JETTISON(JET.LES+INTERSTAGE)THRU S-II JET.							
2.2.1	S-II THRUSTING	1384356.10	0 2 34.4	.042				
					.33	426.00	472.88	-46048.50
2.2.2	JETTISON LES + INTERSTAGE	1337407.60	0 2 54.4	.048				
					.00	.00	.00	.00
2.2.3	CONTINUE S-II THRUSTING	1321357.60	0 2 54.4	.048				
					6.12	426.00	14508.68	-862302.70
2.2.4	JETTISON S-II	458454.91	0 9 2.0	.150				
					.02	.00	.00	.00
2.3	S-II JETTISON THRU EARTH PARKING ORBIT INSERT. (S-IVB THRUSTING , FIRST BURN)	300247.91	0 9 3.5	.150				
					2.81	426.00	3407.45	-77205.75
3.0	EARTH PARKING ORBIT							
3.1	ORBIT INSERTION TO TLI DECISION							
3.1.1	INITIAL COAST TO VENT 1	280352.16	0 11 52.4	.197				
					30.00	.00	.00	.00
3.1.2	S-IVB VENT 1*	280352.16	0 41 52.4	.697				
					.00			-550.00
3.1.3	CONTINUE COAST TO VENT 2	280402.16	0 41 52.4	.697				
					30.00	.00	.00	.00
3.1.4	S-IVB VENT 2*	280402.16	1 11 52.4	1.197				
					.00			-550.00
3.1.5	CONTINUE COAST TO VENT 3	279852.16	1 11 52.4	1.197				
					30.00	.00	.00	.00
3.1.6	S-IVB VENT 3*	279852.16	1 41 52.4	1.697				
					.00			-550.00
3.1.7	CONTINUE COAST TO VENT 4	279302.16	1 41 52.4	1.697				
					30.00	.00	.00	.00
3.1.8	S-IVB VENT 4*	279302.16	2 11 52.4	2.197				
					.00			-550.00
3.1.9	CONTINUE COAST TO TLI DECISION	278752.16	2 11 52.4	2.197				
					14.52	.00	.00	.00
3.2	TLI DECISION TO S-IVB IGNITION							
3.2.1	BEGIN TLI PREPARATION	278752.16	2 26 24.0	2.440				
					15.47	.00	.00	.00
3.2.2	S-IVB VENT 5*	278752.16	2 41 52.4	2.697				
					.00			-550.00
3.2.3	CONTINUE TLI PREPARATION	278202.16	2 41 52.4	2.697				
					18.84	.00	.00	.00
4.0	TRANSLUNAR INJECTION(S-IVB THRUSTING,SECOND BURN)	278202.16	3 0 43.0	3.011				
					5.25	426.00	10412.32	-148055.11
5.0	INITIAL TRANSLUNAR COAST THRU S-IVB JETTISON							
5.1	INITIAL COAST TO TRANSPOSITION	130147.05	3 5 58.4	3.099				
					15.00	.00	.00	.00
5.2	TRANSPOSITION + DOCKING	130147.05	3 20 58.4	3.349				
					27.00	.00	.00	.00
5.3	COAST THRU S-IVB JETTISON	130147.05	3 47 58.4	3.799				
					3.00	.00	.00	.00
6.0	S-IVB JETTISON TO LUNAR ORBIT INSERTION							
6.1	COAST THRU FIRST MCC							
6.1.1	COAST TO FIRST MCC	86600.00	3 50 58.4	3.849				
					75.00	.00	.00	.00
6.1.2	FIRST MIDCOURSE CORRECTION	86600.00	5 5 58.4	5.099				
					.30	313.00	150.00	-1280.35
6.2	COAST THRU SECOND MCC							
6.2.1	COAST TO SECOND MCC	85319.65	5 6 16.4	5.104				
					3023.72	.00	.00	.00
6.2.2	SECOND MIDCOURSE CORRECTION	85319.65	55 30 00.0	55.500				
					.20	313.00	100.00	-843.03
6.3	COAST THRU THIRD MCC							
6.3.1	COAST TO THIRD MCC	84476.61	55 30 12.0	55.503				
					464.87	.00	.00	.00
6.3.2	THIRD MIDCOURSE CORRECTION	84476.61	63 15 4.2	63.251				
					10	313.00	50.00	-418.39
6.4	PREPARATION FOR LUNAR ORBIT INSERTION	84058.22	63 15 10.2	63.252				
					59.90	.00	.00	.00
7.0	LUNAR ORBIT INSERTION	84058.22	64 15 4.2	64.251				
					5.97	313.00	3570.00	-25080.44
8.0	LUNAR ORBIT COAST TO LEM SEPARATION							
8.1	LUNAR ORBIT COAST	58968.77	64 21 2.8	64.350				
					85.55	.00	.00	.00
8.2	PREPARATION FOR LEM SEPARATION	58968.77	65 47 0.0	65.783				
					137.23	.00	.00	.00

*Results In 4fps Velocity Magnitude Increase In The Flight Direction

[redacted]

Table B-3 (Cont.)

PHASE NUMBER		CUMULATIVE WEIGHT (LB)	ELAPSED TIME (H) (M) (S)	ELAPSED TIME (HR)	PHASE TIME (MIN)	ISP (SEC)	DELTA-V (F/S)	PROPELLANT USED (LB)
9.0	CSM SOLO LUNAR ORBITAL OPERATIONS							
9.1	LEM/CSM SEPARATION	58968.77	68 4 14.3	68.070	20.00	.00	.00	.00
9.2	LUNAR ORBIT COAST (TO PHASE 13.0) (LEM RESCUE)	29098.77	68 24 14.3	68.403	2240.03	313.00	455.00	-1285.47
10.0	LEM SEPARATION AND DESCENT							
10.1	LEM/CSM SEPARATION + PREPARATION FOR DESCENT							
10.1.1	LEM/CSM SEPARATION	29870.00	68 4 14.3	68.070	6.83	295.00	5.00	-15.73
10.1.2	PREPARATION FOR DESCENT	29854.26	68 11 4.3	68.184	13.16	.00	.00	.00
10.2	TRANSFER ORBIT INSERTION	29854.26	68 24 14.3	68.403	.56	299.36	100.00	-308.35
10.3	COAST TO INITIATION OF POWERED DESCENT	29545.91	68 24 48.3	68.413	58.07	.00	.00	.00
10.4	POWERED DESCENT TO BEGINNING OF VISIBILITY	29545.91	69 22 52.8	69.381	6.50	306.56	5014.60	-11775.26
10.5	BEGINNING OF VISIBILITY TO HOVER	17770.65	69 29 22.8	69.489	2.03	296.83	1115.39	-1958.82
10.6	HOVER TO TOUCHDOWN	15811.83	69 31 25.1	69.523	3.62	288.68	1150.00	-1841.36
11.0	LEM LUNAR STAY							
11.1	POST LANDING CHECKOUT	13970.47	69 35 2.7	69.584	14.66	.00	.00	.00
11.2	LUNAR EXPLORATION	13970.47	69 49 42.5	69.829	2005.59	.00	.00	.00
11.3	PRELAUNCH PREPARATION	13970.47	103 15 18.0	103.255	61.79	.00	.00	.00
12.0	LEM ASCENT							
12.1	POWERED ASCENT THRU TRANSFER ORBIT INSERTION	10500.00	104 17 5.9	104.284	7.29	306.00	6373.00	-5003.79
12.2	COAST TO TERMINAL RENDEZVOUS							
12.2.1	COASTING LUNAR ASCENT TO FIRST MCC	5496.20	104 24 23.4	104.406	8.75	.00	.00	.00
12.2.2	FIRST MIDCOURSE CORRECTION	5496.20	104 33 8.9	104.552	.48	295.00	34.00	-19.65
12.2.3	COAST TO SECOND MCC	5476.55	104 33 37.7	104.560	13.52	.00	.00	.00
12.2.4	SECOND MIDCOURSE CORRECTION	5476.55	104 47 8.9	104.785	.15	295.00	11.00	-6.34
12.2.5	COAST TO THIRD MCC	5470.21	104 47 18.2	104.788	9.84	.00	.00	.00
12.2.6	THIRD MIDCOURSE CORRECTION	5470.21	104 57 8.9	104.952	.07	295.00	5.00	-2.88
12.2.7	COAST TO TERMINAL RENDEZVOUS	5467.33	104 57 13.2	104.953	13.78	.00	.00	.00
12.3	TERMINAL RENDEZVOUS							
12.3.1	FIRST THRUSTING AT 5 N.MI LOS RANGE	5467.33	105 11 0.2	105.183	.93	295.00	66.00	-37.88
12.3.2	COAST TO SECOND THRUSTING	5429.44	105 11 56.1	105.198	3.28	.00	.00	.00
12.3.3	SECOND THRUSTING AT 1.5 N.MI. LOS RANGE	5429.44	105 15 13.4	105.253	1.56	295.00	112.00	-63.69
12.3.4	COAST TO THIRD THRUSTING	5365.75	105 16 47.3	105.279	2.36	.00	.00	.00
12.3.5	THIRD THRUSTING AT 0.25 N.MI. LOS RANGE	5365.75	105 19 8.9	105.319	.27	295.00	20.00	-11.29
12.4	DOCKING							
12.4.1	BEGIN DOCK	5354.45	105 19 25.6	105.323	14.84	295.00	25.00	-14.08
12.4.2	HARD DOCK	5340.37	105 34 16.4	105.571	10.00	.00	.00	.00
13.0	LUNAR ORBIT COAST TO TEI							
13.1	COAST TO LEM JETTISON	33153.67	105 44 16.4	105.737	30.00	.00	.00	.00
13.2	JETTISON LEM	33153.67	106 14 16.4	106.237	1.30	.00	.00	.00
13.3	PREPARATION FOR TEI	28403.30	106 15 34.4	106.259	172.64	.00	.00	.00
14.0	TRANSEARTH INJECTION	28403.30	109 8 13.3	109.137	1.82	313.00	3160.00	-7649.76
15.0	TRANSEARTH COAST							
15.1	COAST THRU FIRST MCC							
15.1.1	COAST TO FIRST MCC	20753.54	109 10 2.6	109.167	1199.89	.00	.00	.00
15.1.2	FIRST MIDCOURSE CORRECTION	20753.54	129 9 56.2	129.165	.08	313.00	150.00	-306.83
15.2	COAST THRU SECOND MCC							
15.2.1	COAST TO SECOND MCC	20446.70	129 10 1.1	129.166	2699.91	.00	.00	.00
15.2.2	SECOND MIDCOURSE CORRECTION	20446.70	174 9 56.2	174.165	.05	313.00	100.00	-202.03
15.3	COAST THRU THIRD MCC							
15.3.1	COAST TO THIRD MCC	20244.67	174 9 59.4	174.166	1385.57	.00	.00	.00
15.3.2	THIRD MIDCOURSE CORRECTION	20244.67	197 15 33.8	197.259	.02	313.00	50.00	-100.26
15.4	THIRD MCC THRU SM JETTISON							
15.4.1	COAST TO SM JETTISON	20144.41	197 15 35.4	197.259	44.97	.00	.00	.00
15.4.2	JETTISON SM	20144.41	198 0 33.8	198.009	.00	.00	.00	.00
15.5	SM JETTISON TO ENTRY	9500.00	198 0 33.8	198.009	15.00	.00	.00	.00
16.0	ENTRY	9500.00	198 15 33.8	198.259	10.46	.00	.00	.00
17.0	PARACHUTE DESCENT(DROGUE DEPLOY TO TOUCHDOWN)	9242.00	198 26 1.4	198.433	7.10	.00	.00	.00
18.0	POST LANDING THRU SPACECRAFT RETRIEVAL	8624.00	198 33 7.6	198.552				

[redacted]

Table B-4 Mission Phase Weight & Performance Summary - Design Reference Mission with Consumables Expended (DRMCE)

PHASE NUMBER		CUMULATIVE WEIGHT (LB)	ELAPSED TIME (H) (M) (S)	ELAPSED TIME (HR)	PHASE TIME (MIN)	ISP (SEC)	DELTA-V (F/S)	PROPELLANT USED (LB)
1.0	PREFLIGHT							
1.1	SPACEVEHICLE PRELAUNCH POSITIONING	529507.53	-487 49 16.1	-487.821	480.00	.00	.00	.00
1.2	PRELAUNCH CHECKOUT							
1.2.1	LAUNCH FACILITIES-SPACEVEHICLE INTERFACE	529507.53	-479 49 16.1	-479.821	1440.00	.00	.00	.00
1.2.2	SPACEVEHICLE CHECKOUT	529507.53	-455 49 16.1	-455.821	24469.26	.00	.00	.00
1.3	LAUNCH COUNTDOWN							
1.3.1	PRECOUNTDOWN (SPACECRAFT FUELING)	529507.53	-48 0 0.0	-48.000	2280.00	.00	.00	58224.00
1.3.2	TERMINAL COUNTDOWN (LAUNCHVEHICLE FUELING)	587731.53	-10 0 0.0	-10.000	599.90	.00	.00	5514697.00
1.3.3	IGNITION COMMAND	6102422.00	-0 0 5.9	-.002	.10	.00	.00	-102422.00
2.0	EARTH ASCENT (LIFT-OFF THRU EARTH ORBIT INSERT.)							
2.1	LIFT-OFF THRU S-IC JETTISON							
2.1.1	S-IC THRUSTING	6000000.00	0 0 0.0	.000	2.51	292.49	11663.22	-4262575.20
2.1.2	JETTISON S-IC	1737424.00	0 2 30.6	.041	.06	.00	.00	.00
2.2	S-IC JETTISON(JET.LES+INTERSTAGE)THRU S-II JET.							
2.2.1	S-II THRUSTING	1384356.00	0 2 34.4	.042	.33	426.00	472.88	-46948.57
2.2.2	JETTISON LES + INTERSTAGE	1337407.30	0 2 54.4	.048	.00	.00	.00	.00
2.2.3	CONTINUE S-II THRUSTING	1321357.30	0 2 54.4	.048	6.12	426.00	14508.68	-862901.52
2.2.4	JETTISON S-II	458453.62	0 9 2.0	.150	.02	.00	.00	.00
2.3	S-II JETTISON THRU EARTH PARKING ORBIT INSERT. (S-IVB THRUSTING , FIRST BURN)	360246.62	0 9 3.5	.150	2.81	426.00	3407.45	-79295.33
3.0	EARTH PARKING ORBIT							
3.1	ORBIT INSERTION TO TLI DECISION							
3.1.1	INITIAL COAST TO VENT 1	280950.28	0 11 52.4	.197	30.00	.00	.00	.00
3.1.2	S-IVB VENT 1*	280948.52	0 41 52.4	.697	.00			-550.00
3.1.3	CONTINUE COAST TO VENT 2	280398.52	0 41 52.4	.697	30.00	.00	.00	.00
3.1.4	S-IVB VENT 2*	280396.78	1 11 52.4	1.197	.00			-550.00
3.1.5	CONTINUE COAST TO VENT 3	279846.78	1 11 52.4	1.197	30.00	.00	.00	.00
3.1.6	S-IVB VENT 3*	279845.02	1 41 52.4	1.697	.00			-550.00
3.1.7	CONTINUE COAST TO VENT 4	279295.02	1 41 52.4	1.697	30.00	.00	.00	.00
3.1.8	S-IVB VENT 4*	279293.28	2 11 52.4	2.197	.00			-550.00
3.1.9	CONTINUE COAST TO TLI DECISION	278743.28	2 11 52.4	2.197	14.52	.00	.00	.00
3.2	TLI DECISION TO S-IVB IGNITION							
3.2.1	BEGIN TLI PREPARATION	278742.42	2 26 24.0	2.440	15.47	.00	.00	.00
3.2.2	S-IVB VENT 5*	278741.53	2 41 52.4	2.697	.00			-550.00
3.2.3	CONTINUE TLI PREPARATION	278191.53	2 41 52.4	2.697	18.84	.00	.00	.00
4.0	TRANSLUNAR INJECTION(S-IVB THRUSTING,SECOND BURN)	278190.44	3 0 43.0	3.011	5.25	426.00	10412.32	-148048.84
5.0	INITIAL TRANSLUNAR COAST THRU S-IVB JETTISON							
5.1	INITIAL COAST TO TRANSPOSITION	130141.51	3 5 58.4	3.099	15.00	.00	.00	.00
5.2	TRANSPOSITION + DOCKING	130141.25	3 20 58.4	3.349	27.00	.00	.00	.00
5.3	COAST THRU S-IVB JETTISON	130091.97	3 47 58.4	3.799	3.00	.00	.00	.00
6.0	S-IVB JETTISON TO LUNAR ORBIT INSERTION							
6.1	COAST THRU FIRST MCC							
6.1.1	COAST TO FIRST MCC	86516.15	3 50 58.4	3.849	75.00	.00	.00	.00
6.1.2	FIRST MIDCOURSE CORRECTION	86436.75	5 5 58.4	5.029	.30	313.00	150.00	-1277.88
6.2	COAST THRU SECOND MCC							
6.2.1	COAST TO SECOND MCC	85152.72	5 6 16.4	5.104	3023.72	.00	.00	.00
6.2.2	SECOND MIDCOURSE CORRECTION	84968.39	55 30 00.0	55.500	.20	313.00	100.00	-839.50
6.3	COAST THRU THIRD MCC							
6.3.1	COAST TO THIRD MCC	84122.73	55 30 12.0	55.503	464.87	.00	.00	.00
6.3.2	THIRD MIDCOURSE CORRECTION	84033.34	63 15 4.2	63.251	.10	313.00	50.00	-420.21
6.4	PREPARATION FOR LUNAR ORBIT INSERTION	83606.96	63 15 10.2	63.252	59.90	.00	.00	.00
7.0	LUNAR ORBIT INSERTION	83584.51	64 15 4.2	64.251	5.86	313.00	3400.31	-24480.88
8.0	LUNAR ORBIT COAST TO LEM SEPARATION							
8.1	LUNAR ORBIT COAST	59095.51	64 20 56.1	64.348	86.06	.00	.00	.00
8.2	PREPARATION FOR LEM SEPARATION	59084.76	65 47 0.0	65.783	137.23	.00	.00	.00

* Results In 4fps Velocity Magnitude Increase In The Flight Direction

[redacted]

Table B-4 (Cont.)

PHASE NUMBER		CUMULATIVE WEIGHT (LB)	ELAPSED TIME (H) (M) (S)	ELAPSED TIME (HR)	PHASE TIME (MIN)	ISP (SEC)	DELTA-V (F/S)	PROPELLANT USED (LB)
9.0	CSM SOLO LUNAR ORBITAL OPERATIONS							
9.1	LEM/CSM SEPARATION	59038.00	68 4 14.3	68.070	20.00	.00	.00	.00
9.2 *	LUNAR ORBIT COAST (TO PHASE 13.0)	29171.80	68 24 14.3	68.403	2240.03	.00	.00	.00
10.0	LEM SEPARATION AND DESCENT							
10.1	LEM/CSM SEPARATION + PREPARATION FOR DESCENT							
10.1.1	LEM/CSM SEPARATION	29864.54	68 4 14.3	68.070	6.83	295.00	5.00	-15.67
10.1.2	PREPARATION FOR DESCENT	29842.75	68 11 4.3	68.184	13.16	.00	.00	.00
10.2	TRANSFER ORBIT INSERTION	29828.17	68 24 14.3	68.403	.56	299.36	101.25	-311.91
10.3	COAST TO INITIATION OF POWERED DESCENT	29516.13	68 24 48.4	68.413	58.07	.00	.00	.00
10.4	POWERED DESCENT TO BEGINNING OF VISIBILITY	29494.64	69 22 52.8	69.381	6.50	306.56	5004.60	-11735.40
10.5	BEGINNING OF VISIBILITY TO HOVER	17753.12	69 29 22.8	69.489	1.92	296.70	1050.37	-1849.70
10.6	HOVER TO TOUCHDOWN	15903.02	69 31 18.3	69.521	1.08	289.12	336.23	-564.38
11.0	LEM LUNAR STAY							
11.1	POST LANDING CHECKOUT	15330.44	69 32 23.2	69.539	14.66	.00	.00	.00
11.2	LUNAR EXPLORATION	15327.58	69 47 3.0	69.784	2008.25	.00	.00	.00
11.3	PRELAUNCH PREPARATION	15030.44	103 15 18.0	103.255	61.79	.00	.00	.00
12.0	LEM ASCENT							
12.1	POWERED ASCENT THRU TRANSFER ORBIT INSERTION	10500.00	104 17 5.9	104.284	7.05	306.00	6081.61	-4837.88
12.2	COAST TO TERMINAL RENDEZVOUS							
12.2.1	COASTING LUNAR ASCENT TO FIRST MCC	5659.21	104 24 8.9	104.402	9.00	.00	.00	.00
12.2.2	FIRST MIDCOURSE CORRECTION	5655.54	104 33 8.9	104.552	.48	295.00	34.00	-20.22
12.2.3	COAST TO SECOND MCC	5634.95	104 33 37.7	104.560	13.52	.00	.00	.00
12.2.4	SECOND MIDCOURSE CORRECTION	5630.57	104 47 8.9	104.785	.15	295.00	11.00	-6.52
12.2.5	COAST TO THIRD MCC	5623.93	104 47 18.2	104.788	9.84	.00	.00	.00
12.2.6	THIRD MIDCOURSE CORRECTION	5620.29	104 57 8.9	104.952	.07	295.00	5.00	-2.96
12.2.7	COAST TO TERMINAL RENDEZVOUS	5617.27	104 57 13.2	104.953	13.78	.00	.00	.00
12.3	TERMINAL RENDEZVOUS							
12.3.1	FIRST THRUSTING AT 5 N.MI LOS RANGE	5613.84	105 11 0.2	105.183	.00	.00	.00	.00
12.3.2	COAST TO SECOND THRUSTING	5613.84	105 11 0.2	105.183	4.22	.00	.00	.00
12.3.3	SECOND THRUSTING AT 1.5 N.MI. LOS RANGE	5611.30	105 15 13.4	105.253	1.34	295.00	92.84	-54.61
12.3.4	COAST TO THIRD THRUSTING	5555.80	105 16 34.3	105.276	2.57	.00	.00	.00
12.3.5	THIRD THRUSTING AT 0.25 N.MI. LOS RANGE	5553.57	105 19 8.9	105.319	.12	295.00	8.59	-5.02
12.4	DOCKING							
12.4.1	BEGIN DOCK	5548.45	105 19 16.4	105.321	15.00	295.00	25.00	-14.50
12.4.2	HARD DOCK	5520.02	105 34 16.4	105.571	10.00	.00	.00	.00
13.0	LUNAR ORBIT COAST TO TEI							
13.1	COAST TO LEM JETTISON	34566.25	105 44 16.4	105.737	30.00	.00	.00	.00
13.2	JETTISON LEM	34563.61	106 14 16.4	106.237	1.30	.00	.00	.00
13.3	PREPARATION FOR TEI	29633.61	106 15 34.4	106.259	172.64	.00	.00	.00
14.0	TRANSEARTH INJECTION	29603.99	109 8 13.3	109.137	1.71	313.00	2747.98	-7069.45
15.0	TRANSEARTH COAST							
15.1	COAST THRU FIRST MCC							
15.1.1	COAST TO FIRST MCC	22532.21	109 9 56.2	109.165	1200.00	.00	.00	.00
15.1.2	FIRST MIDCOURSE CORRECTION	22480.66	129 9 56.2	129.165	.08	313.00	150.00	-332.36
15.2	COAST THRU SECOND MCC							
15.2.1	COAST TO SECOND MCC	22147.68	129 10 1.1	129.166	2699.91	.00	.00	.00
15.2.2	SECOND MIDCOURSE CORRECTION	22041.25	174 9 56.2	174.165	.05	313.00	100.00	-217.78
15.3	COAST THRU THIRD MCC							
15.3.1	COAST TO THIRD MCC	21822.84	174 9 59.4	174.166	1385.57	.00	.00	.00
15.3.2	THIRD MIDCOURSE CORRECTION	21750.60	197 15 33.8	197.259	.02	313.00	50.00	-107.72
15.4	THIRD MCC THRU SM JETTISON							
15.4.1	COAST TO SM JETTISON	21642.25	197 15 35.4	197.259	44.97	.00	.00	.00
15.4.2	JETTISON SM	21614.59	198 0 33.8	198.009	.00	.00	.00	.00
15.5	SM JETTISON TO ENTRY	9500.00	198 0 33.8	198.009	15.00	.00	.00	.00
16.0	ENTRY	9499.77	198 15 33.8	198.259	10.46	.00	.00	.00
17.0	PARACHUTE DESCENT(DROGUE DEPLOY TO TOUCHDOWN)	9240.60	198 26 1.4	198.433	7.10	.00	.00	.00
18.0	POST LANDING THRU SPACECRAFT RETRIEVAL	9621.15	198 33 7.6	198.552				

[redacted]

Table B-5

CSM Consumables Summary for DRMCE Mission

Phase Number	Description	Mission Time (hr)	Phase Time (min)	WATER Production (lb)	WATER Potable Consumed (lb)	WATER Waste Collection (lb)	WATER Dumped Cooling Potable (lb)	WATER Dumped Cooling Waste (lb)	Hydrogen Depletion (lb)	Oxygen Depletion (lb)	CO_2 Accumulation (lb)	RCS (Non-ΔV) Propellant (lb)	Food Consumed (lb)	Feces Production (lb)	Urine Production (lb)	Urine Dumped (lb)	CSM Sub-Total Per Phase (lb)
1.1	Spacevehicle Prelaunch Positioning	-487.821															
			480.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.2	Prelaunch Checkout	-479.821															
			25902.26	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.3.1	Precountdown (Spacecraft Fueling)	- 48.000															
			2280.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.3.2	Terminal Countdown (Launch Vehicle Fueling)	- 10.000															
			599.90	6.400	-3.725	2.850	0	0	-.720	-7.125	.725	0	0	.175	1.025	0	-.395
1.3.3	Ignition Command	- .002															
			.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.1.1	S-IC Thrusting	.000															
			2.51	.082	- .061	.047	-.832	0	-.009	- .091	.012	0	-.007	.003	.016	0	-.840
2.1.2	Jettison S-IC	.041															
			.06	.002	- .001	.001	-.020	0	0	- .002	0	0	0	0	0	0	-.020
2.2.1	S-II Thrusting	.042															
			.33	.012	- .009	.007	-.122	0	-.001	- .013	.001	0	-.001	0	.003	0	-.123
2.2.2	Jettison LES & Interstage	.048															
			.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.2.3	Continue S-II Thrusting	.048															
			6.12	.203	- .151	.116	-2.071	0	-.023	- .227	.030	0	-.017	.007	.042	0	-2.091
2.2.4	Jettison S-II	.150															
			.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.3	S-II Jettison Thru Earth Park. Orbit Insert.	.150															
			2.81	.093	- .070	.054	-.955	0	-.010	- .105	.014	0	-.008	.003	.019	0	-.965
3.1.1	Initial Coast to Vent 1	.197															
			30.00	.975	- .745	.570	-.074	-1.116	-.110	-1.103	.145	0	-.085	.035	.205	0	-1.303
3.1.2	S-IVB Vent 1	.697															
			.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.1.3	Continue Coast to Vent 2	.697															
			30.00	.975	- .745	.570	-.074	-1.116	-.110	-1.103	.145	0	-.085	.035	.205	0	-1.303
3.1.4	S-IVB Vent 2	1.197															
			.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table B-5 (Cont'd.)

Phase Number	Description	Mission Time (hr)	Phase Time (min)	WATER Production (lb)	WATER Potable Consumed (lb)	WATER Waste Collection (lb)	WATER Dumped Cooling Potable (lb)	WATER Dumped Cooling Waste (lb)	Hydrogen Depletion (lb)	Oxygen Depletion (lb)	CO_2 Accumulation (lb)	RCS (Non-ΔV) Propellant (lb)	Food Consumed (lb)	Feces Production (lb)	Urine Production (lb)	Urine Dumped (lb)	CSM Sub-Total Per Phase (lb)
3.1.5	Continue Coast to Vent 3	1.197															
			30.00	.975	-.745	.570	-.074	-1.116	-.110	-1.103	.145	0	-.085	.035	.205	0	-1.303
3.1.6	S-IVB Vent 3	1.697															
			.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.1.7	Continue Coast to Vent 4	1.697															
			30.00	.975	-.745	.570	-.074	-1.116	-.110	-1.103	.145	0	-.085	.035	.205	0	-1.303
3.1.8	S-IVB Vent 4	2.197															
			.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.1.9	Continue Coast to TLI Decision	2.197															
			14.52	.474	-.362	.277	-.036	-.542	-.053	-.535	.070	0	-.041	.017	.100	0	-.631
3.2.1	Begin TLI Preparation	2.440															
			15.47	.501	-.383	.293	-.038	-.574	-.057	-.566	.075	0	-.044	.018	.105	0	-.670
3.2.2	S-IVB Vent 5	2.697															
			.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.2.3	Continue TLI Preparation	2.697															
			18.84	.614	-.469	.359	-.046	-.704	-.069	-.694	.091	0	-.054	.022	.129	0	-.821
4.0	Translunar Injection (S-IVB, 2nd Burn)	3.011															
			5.25	.171	-.130	.099	0	0	-.019	-.190	.025	0	-.015	.006	.036	0	-.017
5.1	Initial Coast to Transposition	3.099															
			15.00	.493	-.372	.285	0	0	-.055	-.546	.073	0	-.042	.018	.102	0	-.044
5.2	Transposition & Docking	3.349															
			27.00	.608	-1.122	.360	0	0	-.067	-.802	.123	-48.120	-.077	.031	.184	0	-48.882
5.3	Coast Thru S-IVB Jettison	3.799															
			3.00	.067	-.124	.040	0	0	-.007	-.089	.014	-20.000	-.008	.004	.021	0	-20.082
6.1.1	Coast to First MCC	3.849															
			75.00	1.687	-3.116	1.000	0	0	-.188	-2.228	.343	-76.170	-.211	.087	.512	0	-78.284
6.1.2	First Midcourse Correction	5.099															
			.30	.007	-.005	.003	0	0	-.001	-.008	.001	-6.150	-.001	0	.002	0	-6.152
6.2.1	Coast to Second MCC	5.104															
			3023.73	73.111	-55.782	37.369	0	0	-8.123	-89.788	14.623	-103.590	-9.207	3.741	22.205	-23.395	-138.836

Table B-5 (Cont'd.)

Phase Number	Description	Mission Time (hr)	Phase Time (min)	WATER Production (lb)	WATER Potable Consumed (lb)	WATER Waste Collection (lb)	WATER Dumped Cooling Potable (lb)	WATER Dumped Cooling Waste (lb)	Hydrogen Depletion (lb)	Oxygen Depletion (lb)	CO_2 Accumulation (lb)	RCS (Non-ΔV) Propellant (lb)	Food Consumed (lb)	Feces Production (lb)	Urine Production (lb)	Urine Dumped (lb)	CSM Sub-Total Per Phase (lb)
6.2.2	Second Midcourse Correction	55.500															
			.20	.004	- .003	.002	0	0	-.001	-.005	.001	-6.150	-.001	0	.001	- .001	- 6.153
6.3.1	Coast to Third MCC	55.503															
			464.87	5.387	-4.110	2.753	0	0	-1.198	-6.563	1.077	-78.530	-.678	.280	1.636	-2.459	-82.405
6.3.2	Third Midcourse Correction	63.251															
			.16	.003	- .002	.002	0	0	-.001	-.004	0	-6.150	0	0	.001	- .001	-6.152
6.4	Preparation for Lunar Orbit Insert.	63.253															
			59.83	1.343	-1.025	1.135	0	0	-.374	-1.939	.269	-21.240	-.169	.070	.408	0	-21.522
7.0	Lunar Orbit Insertion	64.251															
			5.86	.187	-.145	.111	0	-.141	-.018	-.191	.028	-7.900	-.016	.007	.040	0	-8.038
8.1	Lunar Orbit Coast	64.348															
			86.06	2.766	-2.138	1.635	0	-2.080	-.273	-2.819	.416	-7.420	-.244	.100	.588	0	-9.469
8.2	Preparation for LEM Separation	65.783															
			137.23	3.883	-3.410	2.608	0	-3.318	-.435	-4.183	.313	-11.830	-.138	.160	.439	-2.320	-18.231
9.1	LEM/CSM Separation	68.070															
			20.00	.564	-.172	.130	-.379	-.020	-.066	-.601	.034	-1.140	-.021	.008	.047	-.047	-1.663
9.2	Lunar Orbit Coast	68.404															
			2240.03	63.468	-19.313	14.683	-42.604	-2.195	-7.485	-67.615	3.857	-64.980	-2.311	.859	5.334	-5.319	-123.621
13.1	Coast to LEM Jettison	105.737															
			30.00	.852	- .259	.197	-.572	-.030	-.101	-.907	.052	-1.140	-.031	.035	.072	-.072	-1.904
13.2	Jettison LEM	106.237															
			1.30	.036	- .031	.024	-.030	-.014	-.004	-.036	.006	- 2.600	-.004	.001	.009	-.011	-2.654
13.3	Preparation for TEI	106.259															
			172.64	4.892	-4.289	3.281	-4.173	-1.920	-.568	-4.884	.835	-22.240	-.489	.202	1.180	-1.450	-29.623
14.0	Transearth Injection	109.137															
			1.71	.039	-.029	.019	-.004	-.019	-.004	-.047	.008	-2.280	-.005	.002	.011	-.011	-2.320
15.1.1	Coast to First MCC	109.165															
			1200.00	27.645	-20.600	13.800	-2.796	-13.800	-3.400	-33.600	5.400	-22.990	-3.434	1.400	8.200	-7.370	-51.545
15.1.2	First Midcourse Correction	129.165															
			.08	.001	-.001	.001	0	-.001	0	-.002	0	-.620	0	0	0	0	-.622
15.2.1	Coast to Second MCC	129.166															
			2699.91	61.649	-46.349	31.049	-15.300	-31.049	-7.150	-75.423	12.150	-32.710	-7.650	3.150	18.450	-17.220	-106.403

Table B-5 (Cont'd.)

Phase Number	Description	Mission Time (hr)	Phase Time (min)	WATER Production (lb)	WATER Potable Consumed (lb)	WATER Waste Collection (lb)	WATER Dumped Cooling Potable (lb)	WATER Dumped Cooling Waste (lb)	Hydrogen Depletion (lb)	Oxygen Depletion (lb)	CO_2 Accumulation (lb)	RCS (Non-ΔV) Propellant (lb)	Food Consumed (lb)	Feces Production (lb)	Urine Production (lb)	Urine Dumped (lb)	CSM Sub-Total Per Phase (lb)
15.2.2	Second Midcourse Correction	174.165															
			.05	.001	-.001	.001	0	-.001	0	-.002	0	-.620	0	0	0	0	-.622
15.3.1	Coast to Third MCC	174.166															
			1385.57	31.638	-23.786	15.933	-7.852	-15.933	-3.864	-38.749	6.235	-33.210	-3.926	1.617	9.469	-9.840	-72.268
15.3.2	Third Midcourse Correction	197.259															
			.02	.001	-.001	.001	0	-.001	0	-.002	0	-.620	0	0	0	0	-.622
15.4.1	Coast to SM Jettison	197.259															
			44.97	1.026	-.771	.517	-.255	-.517	-.112	-1.255	.202	-26.730	-.127	.052	.307	0	-27.663
15.4.2	Jettison SM	198.009															
			.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.5	SM Jettison to Entry	198.009															
			15.00	0	-.373	.285	0	-.285	0	0	.073	-50.000	-.043	.018	.103	0	-50.222
16.0	Entry (400,000 Alt. to Drogue Chute Deploy.)	198.259															
			10.46	0	-.267	.204	0	-.204	0	0	.050	-85.000	-.030	.013	.074	-1.016	-86.176
17.0	Parachute Descent	198.433															
			7.10	0	-.328	.251	0	-.251	0	0	.061	-135.000	-.038	.015	.090	-1.248	-136.448
18.0	Post Landing Thru Spacecraft Retrieval	198.552															
	TOTALS			293.810	-196.265	134.062	-78.381	-78.063	-34.896	-346.248	47.867	-875.130	-29.428	12.261	71.780	-71.780	-1150.411

Table B-6

LEM and Total Spacecraft Consumable Summary for DRMCE Mission

PHASE NUMBER	DESCRIPTION	MISSION TIME (HR.)	PHASE TIME (MIN.)	EPS HYDROGEN DEPLETION (LB)	EPS OXYGEN DEPLETION (LB)	ECS OXYGEN DEPLETION (LB)	ECS WATER CONSUMED (LB)	RCS (NON-ΔV) PROPELLANT (LB)	LEM SUB-TOTAL PER PHASE (LB)	LEM & CSM TOTAL PER PHASE (LB)
1.1	Space Vehicle Prelaunch Positioning	-487.821								
			480.00	0	0	0	0	0	0	0
1.2	Prelaunch Checkout	-479.821								
			25,902.26	0	0	0	0	0	0	0
1.3.1	Precountdown (Spacecraft Fueling)	-48.000								
			2,280.00	0	0	0	0	0	0	0
1.3.2	Terminal Countdown (Launch Vehicle Fueling)	-10.000								
			599.90	-2.013	-4.125	0	0	0	-6.138	-6.533
1.3.3	Ignition Command	-.002								
			.10	0	0	0	0	0	0	0
2.1.1	S-IC Thrusting (Earth Ascent)	.000								
			2.51	-.006	-.011	-.001	-.020	0	-.038	-.878
2.1.2	Jettison S-IC	.041								
			.06	0	0	0	0	0	0	-.020
2.2.1	S-II Thrusting	.042								
			.33	-.001	-.001	0	-.003	0	-.005	-.128
2.2.2	Jettison LES & Interstage	.048								
			.00	0	0	0	0	0	0	0
2.2.3	Continue S-II Thrusting	.048								
			6.12	-.014	-.027	-.002	-.048	0	0.091	-2.182
2.2.4	Jettison S-II	.150								
			.02	0	0	0	0	0	0	0
2.3	S-II Jettison Thru Earth Parking Orbit Insertion	.150								
			2.81	-.009	-.012	-.001	-.022	0	-.044	-1.009
3.1.1	Initial Coast To Vent 1 (Earth Parking Orbit)	.197								
			30.00	-.069	-.147	-.008	-.233	0	-.457	-1.760
3.1.2	S-IV B Vent 1	.697								
			.00	0	0	0	0	0	0	0

Table B-6 (Cont'd.)

PHASE NUMBER	DESCRIPTION	MISSION TIME (HR.)	PHASE TIME (MIN.)	EPS HYDROGEN DEPLETION (LB)	EPS OXYGEN DEPLETION (LB)	ECS OXYGEN DEPLETION (LB)	ECS WATER CONSUMED (LB)	RCS (NON-U) PROPELLANT (LB)	LEM SUB-TOTAL PER PHASE (LB)	LEM & CSM TOTAL PER PHASE (LB)
3.1.3	Continue Coast to Vent 2	.697								
			30.00	-.069	-.129	-.008	-.233	0	-.439	-1.742
3.1.4	S-IV B Vent 2	1.197								
			.00	0	0	0	0	0	0	0
3.1.5	Continue Coast to Vent 3	1.197								
			30.00	-.071	-.147	-.008	-.233	0	-.459	-1.762
3.1.6	S-IV B Vent 3	1.697								
			.00	0	0	0	0	0	0	0
3.1.7	Continue Coast To Vent 4	1.697								
			30.00	-.069	-.129	-.008	-.233	0	-.439	-1.742
3.1.8	S-IV B Vent 4	2.197								
			.00	0	0	0	0	0	0	0
3.1.9	Continue Coast to TLI Decision	2.197								
			14.52	-.037	-.082	-.004	-.113	0	-.236	-.867
3.2.1	Begin TLI Preparation	2.440								
			15.47	-.035	-.065	-.004	-.120	0	-.224	-.894
3.2.2	S-IV B Vent 5	2.697								
			.00	0	0	0	0	0	0	0
3.2.3	Continue TLI Preparation	2.697								
			18.84	-.043	-.081	-.005	-.147	0	-.276	-1.097
4.0	Translunar Injection (S-IV B Thrusting, Second Burn)	3.011								
			5.25	-.013	-.022	-.001	-.041	0	-.077	-.094
5.1	Initial Coast to Transposition	3.099								
			15.00	-.035	-.065	-.004	-.117	0	-.221	-.265
5.2	Transposition & Docking	3.349								
			27.00	-.061	-.121	-.007	-.210	0	-.399	-49.281
5.3	Coast Thru S-IV B Jettison	3.799								
			3.00	-.007	-.013	-.001	-.023	0	-.044	-20.126
6.1.1	Coast to First MCC	3.849								
			75.00	-.171	-.336	-.018	-.584	0	-1.109	-79.393

PHASE NUMBER		MISSION TIME (HR.)	PHASE TIME (MIN.)	EPS HYDROGEN DEPLETION (LB)	EPS OXYGEN DEPLETION (LB)	ECS OXYGEN DEPLETION (LB)	ECS WATER CONSUMED (LB)	RCS (NON-U) PROPELLANT (LB)	LEM SUB-TOTAL PER PHASE (LB)	LEM & CSM TOTAL PER PHASE (LB)
6.1.2	First Midcourse Correction	5.099								
			.30	-.001	-.001	0	-.002	0	-.004	-6.156
6.2.1	Coast to Second MCC	5.104								
			3023.73	-7.292	-13.924	-.764	-23.519	0	-45.499	-184.335
6.2.2	Second Midcourse Correction	55.500								
			.20	0	0	0	-.002	0	-.002	-6.155
6.3.1	Coast to Third MCC	55.503								
			464.87	-1.121	-2.141	-.118	-3.615	0	-6.995	-89.400
6.3.2	Third Midcourse Correction	63.251								
			.16	0	0	0	-.001	0	-.001	-6.153
6.4	Preparation for Lunar Orbit Insertion	63.253								
			59.83	-.155	-.295	-.015	-.465	0	-.930	-22.452
7.0	Lunar Orbit Insertion	64.251								
			5.86	-.012	-.021	-.001	-.046	0	-.080	-8.118
8.1	Lunar Orbit Coast	64.348								
			86.06	-.208	-.389	-.022	-.670	0	-1.289	-10.758
8.2	Preparation For LEM Separation	65.783								
			137.23	-2.397	-4.205	-1.631	-16.200	-4.10	-28.533	-46.764
9.1	LEM/CSM Separation (CSM Solo Lunar Orbital Operations)	68.070								
			20.00							-1.663
9.2	Lunar Orbit Coast (To Phase 13.0)	68.403								
			2240.03							-123.621
10.1.1	LEM/CSM Separation (LEM Solo Lunar Operations)	68.070								
			6.83	-.164	-.213	-.048	-.741	-4.940	-6.106	-6.106
10.1.2	Preparation For Descent	68.148								
			13.16	-.152	-.167	-.093	-1.664	-12.500	-14.576	-14.576
10.2	Transfer Orbit Insertion	68.404								
			.56	-.014	-.019	-.022	-.069	-.010	-.134	-.134

[redacted]

[redacted]

Table B-6 (Cont'd)

PHASE NUMBER		MISSION TIME (HR.)	PHASE TIME (MIN.)	EPS HYDROGEN DEPLETION (LB)	EPS OXYGEN DEPLETION (LB)	ECS OXYGEN DEPLETION (LB)	ECS WATER CONSUMED (LB)	RCS (NON-U) PROPELLANT (LB)	LEM SUB-TOTAL PER PHASE (LB)	LEM & CSM TOTAL PER PHASE (LB)
10.3	Coast to Initiation of Powered Descent	68.413								
			58.07	-1.514	-1.852	-.412	-7.442	-10.269	-21.489	-21.489
10.4	Powered Descent To Beginning of Visibility	69.381								
			6.50	-.176	-.231	-.046	-.861	-4.800	-6.114	-6.114
10.5	Beginning of Visibility to Hover	69.489								
			1.92	-.053	-.066	-.014	-.258	0	-.391	-.391
10.6	Hover to Touchdown	69.521								
			1.08	-.030	-.037	-.008	-.143	-7.980	-8.198	-8.198
11.1	Post Landing Checkout (LEM Lunar Stay)	69.539								
			14.66	-.394	-.450	-.105	-1.915	0	-2.864	-2.864
11.2	Lunar Exploration	69.784								
			2008.25	-25.049	-33.928	-74.492	-163.698	0	-297.167	-297.167
11.3	Prelaunch Preparation	103.255								
			61.79	-1.155	-1.789	-.374	-8.309	-4.100	-15.727	-15.727
12.1	Powered Ascent Thru Transfer Orbit Insertion	104.285								
			7.05	-.151	-.218	-.051	-.963	-1.520	-2.903	-2.903
12.2.1	Coasting Lunar Ascent to First MCC	104.402								
			9.00	-.203	-.291	-.057	-1.209	-1.910	-3.670	-3.670
12.2.2	First Midcourse Correction	104.552								
			.48	-.011	-.016	-.003	-.056	-2.79	-.365	-.365
12.2.3	Coast to Second MCC	104.560								
			13.52	-.320	-.441	-.085	-1.497	-2.034	-4.377	-4.377
12.2.4	Second Midcourse Correction	104.785								
			.15	-.004	-.005	-.001	-.021	-.090	-.121	-.121
12.2.5	Coast to Third MCC	104.788								
			9.84	-.241	-.321	-.062	-1.083	-1.935	-3.642	-3.642
12.2.6	Third Midcourse Correction	104.952								
			.07	-.002	-.003	0	-.006	-.042	-.053	-.053
12.2.7	Coast to Terminal Rendezvous	104.953								
			13.78	-.348	-.452	-.087	-.507	-2.045	-3.439	-3.439

PHASE NUMBER		MISSION TIME (HR.)	PHASE TIME (MIN.)	EPS HYDROGEN DEPLETION (LB)	EPS OXYGEN DEPLETION (LB)	ECS OXYGEN DEPLETION (LB)	ECS WATER CONSUMED (LB)	RCS (NON-U) PROPELLANT (LB)	LEM SUB-TOTAL PER PHASE (LB)	LEM & CSM TOTAL PER PHASE (LB)
12.3.1	First Thrusting at 5 n. mi. LOS Range (Terminal Rendezvous)	105.183								
			.00	0	0	0	0	0	0	0
12.3.2	Coast to Second Thrusting	105.183								
			4.22	-.109	-.143	-.026	-.476	-1.778	-2.532	-2.532
12.3.3	Second Thrusting at 1.5 n. mi. LOS Range	105.253								
			1.34	-.010	-.011	-.009	-.071	-.791	-.892	-.892
12.3.4	Coast to Third Thrusting	105.276								
			2.57	-.089	-.115	-.016	-.253	-1.750	-2.223	-2.223
12.3.5	Third Thrusting at 0.25 n. mi LOS Range	105.319								
			.12	-.003	-.005	0	-.014	-.074	-.096	-.096
12.4.1	Begin Dock	105.321								
			15.00	-.400	-.505	-.100	-2.068	-10.850	-13.923	-13.923
12.4.2	Hard Dock	105.571								
			10.00	-.278	-.209	-.067	-1.399	0	-1.953	-1.953
13.1	Coast to LEM Jettison (Lunar Orbit Coast)	105.737								
			30.00	-.484	-.252	0	0	0	-.736	-2.640
13.2	Jettison LEM	106.237								
			1.30							-2.654
13.3	Preparation For TEI	106.259								
			172.64							-29.623
14.0	Transearth Injection	109.137								
			1.71							-2.320
15.1.1	Coast to First MCC (Transearth Coast)	109.165								
			1200.00							-51.545
15.1.2	First Midcourse Correction	129.165								
			.08							-.622
15.2.1	Coast to Second MCC	129.166								
			2699.91							-106.403
15.2.2	Second Midcourse Correction	174.165								
			.05							-.622

Table B-6 (Cont'd.)

PHASE NUMBER		MISSION TIME (HR.)	PHASE TIME (MIN.)	EPS HYDROGEN DEPLETION (LB)	EPS OXYGEN DEPLETION (LB)	ECS OXYGEN DEPLETION (LB)	ECS WATER CONSUMED (LB)	RCS (NON-U) PROPELLANT (LB)	LEM SUB-TOTAL PER PHASE (LB)	LEM & CSM TOTAL PER PHASE (LB)
15.3.1	Coast to Third MCC	174.166								
			1385.57							-72.268
15.3.2	Third Midcourse Correction	197.259								
			.02							-.622
15.4.1	Coast to SM Jettison	197.259								
			44.97							-27.663
15.4.2	Jettison SM	198.009								
			.00							0
15.5	SM Jettison to Entry	198.009								
			15.00							-50.222
16.0	Entry	198.259								
			10.46							-86.176
17.0	Parachute Descent (Drogue Deploy, to Touchdown)	198.433								
			7.10							-136.448
18.0	Post Landing thru Spacecraft Retrieval	198.552								
TOTALS				-45.263	-68.228	-78.809	-241.623	-73.797	-507.720	-1658.131

APPENDIX C

ENGINE PERFORMANCE PARAMETERS

APPENDIX C

ENGINE PERFORMANCE PARAMETERS

Figures C-1 through C-12 present the engine performance parameter time histories for each powered flight phase of the DRM. Included are the time variation of delta V, thrust, fuel remaining, and thrust/weight ratio.

During the S-IC burn (Figure C-1) the thrust increases from 7.5×10^6 to 8.63×10^6 due to the increase in exhaust gas velocity with increasing altitude. Near the end of the burn (4.5 seconds-to-go), the thrust tailoff was approximated for the trajectory computation by reducing the thrust to a constant value of 6.9×10^6 lbs. The thrust/weight ratio varies from 1.25 at lift-off to 4.7 prior to the tailoff.

Figures C-2 and C-3 present the S-II and S-IVB engine performance parameters and illustrate their constant 1.0×10^6 lb and 200,000 lb. thrust levels, respectively. The corresponding maximum thrust/weight ratios for the S-II and S-IVB are 2.02 and 0.71. Figures C-4 and C-5 present the translunar injection and lunar orbit insertion S-IVB second burn SPS engine performance data. The S-IVB thrust magnitude during TLI is 200,000 lb. and the maximum thrust/weight ratio is 1.53. During lunar orbit insertion the SPS provided a thrust magnitude of 21,900 lbs. which results in a peak thrust/weight ratio of 2.23 at the end of the burn period.

During transfer orbit insertion (Figure C-6), the LEM descent engine burns for 28 seconds at the 1050 lb. thrust level, followed by 6.1 seconds at the 10,500 lb. maximum level. The resulting thrust/weight ratio for the first sub-phase is approximately 0.2. During the latter sub-phase the thrust/weight ratio attains a value of 2.17 at the end of the burn.

The 28-second low thrust period (1050 lbs) is again employed at the beginning of LEM powered descent (Figure C-7). A maximum thrust period at 10,500 lbs. of 37 seconds then follows; a gradual thrust decay to 9400 pounds is then called for by the guidance system until the beginning of the visibility sub-phase. A sudden thrust reduction, followed by a gradual thrust decay from 4900 lbs. to 4700 lbs. then takes place until the

pitchover to the hover point. The pitchover demands a double step-down thrust schedule: the first at a constant thrust/weight ratio of 1.5 (4000 lb thrust) until the 200 foot altitude level is reached, and the second level at a thrust/weight ratio such that the vertical component is 1.0 (2700-2800 lb thrust) to provide constant altitude flight during the remainder of the pitchover. The remainder of the powered descent to touchdown requires a thrust and thrust/weight excursion of 1150 to 4100 lb. and 0.45 to 1.6, respectively, depending upon the touchdown procedure followed. The maximum descent stage thrust/weight ratio of 3.2 occurs at the beginning of the visibility phase.

A 3500 lb. constant thrust and a peak thrust/weight ratio value of 3.7 are indicated in Figure C-8 for the LEM powered ascent phase.

Figure C-9, -10 and -11 present the LEM terminal rendezvous RCS performance requirements. No thrusting is required for the first scheduled burn at the 5 n. mi. LEM/CSM line-of-sight range due to the existing closing rate value of less than 100 ft/sec. During the second and third burns two 100 lb. thrusters are assumed to be used. The thrust/weight ratio during this phase is almost constant at 0.036.

Figure C-12 presents the SPS engine performance parameters during transearth injection. The 21,900 lb. thrust level provided the maximum CSM thrust/weight ratio for the mission of 5.8 at the end of the burn period.

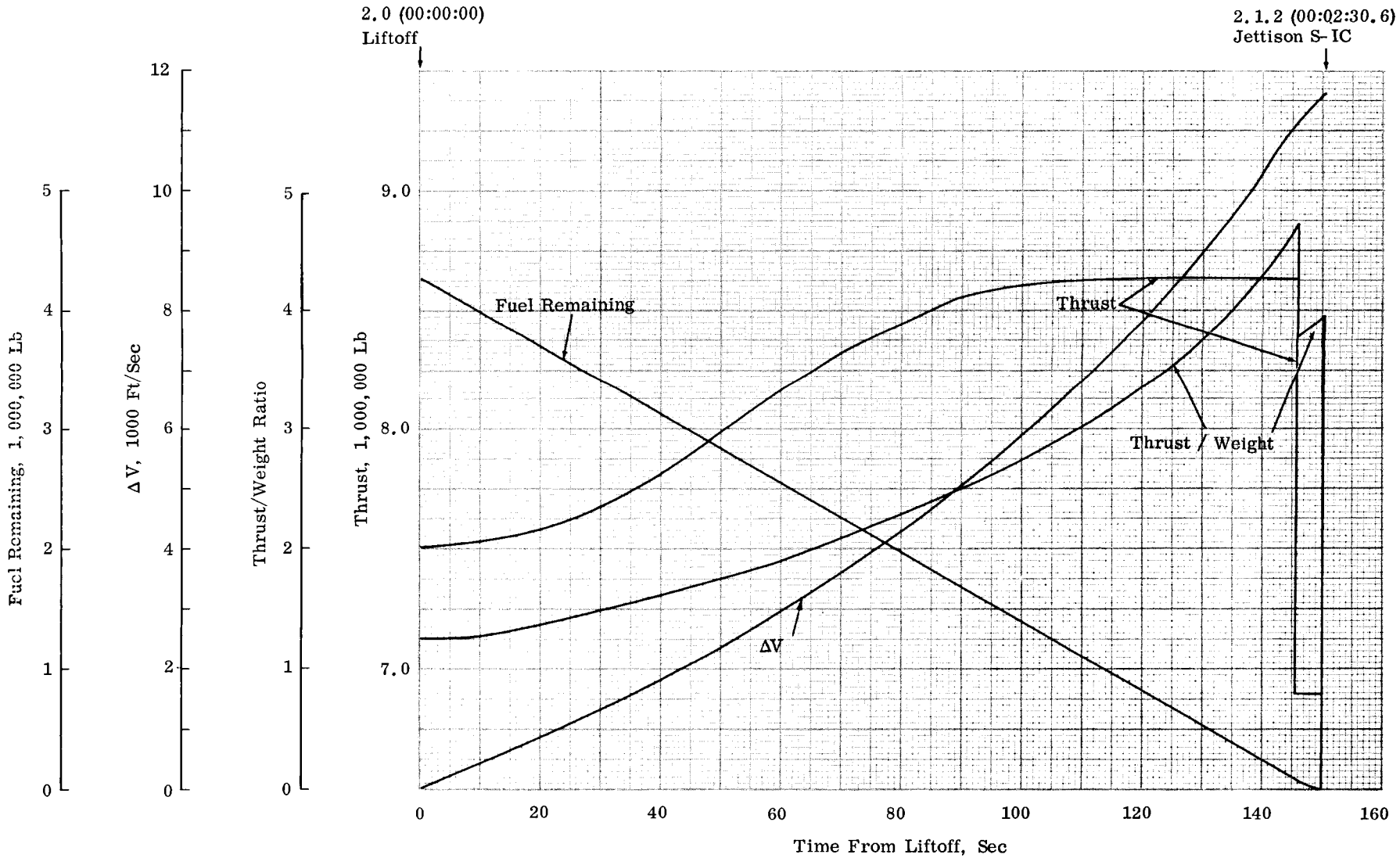

Figure C-1 Ascent Phase Engine Performance Parameters S-IC

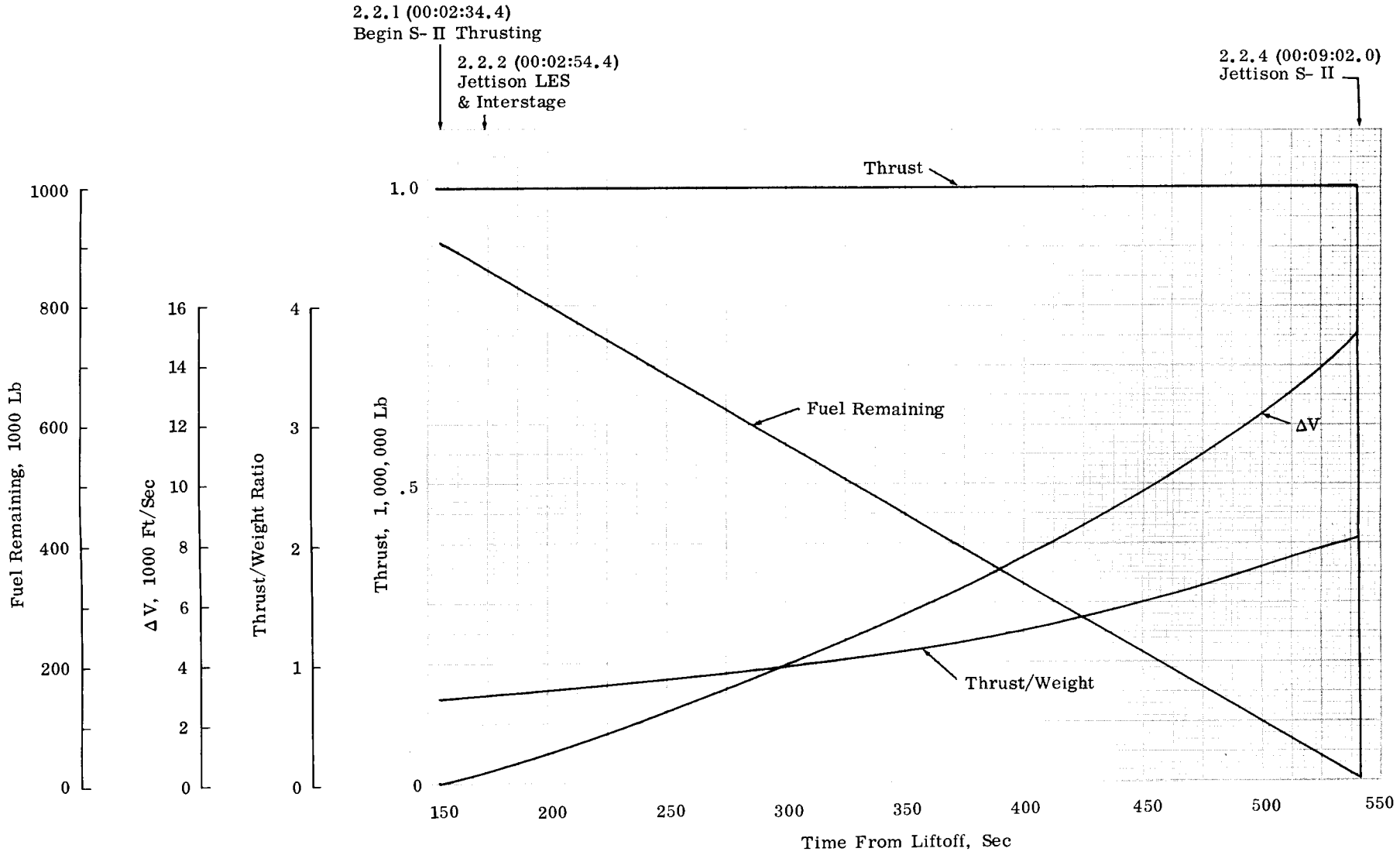

Figure C-2 Ascent Phase Engine Performance Parameters S-II

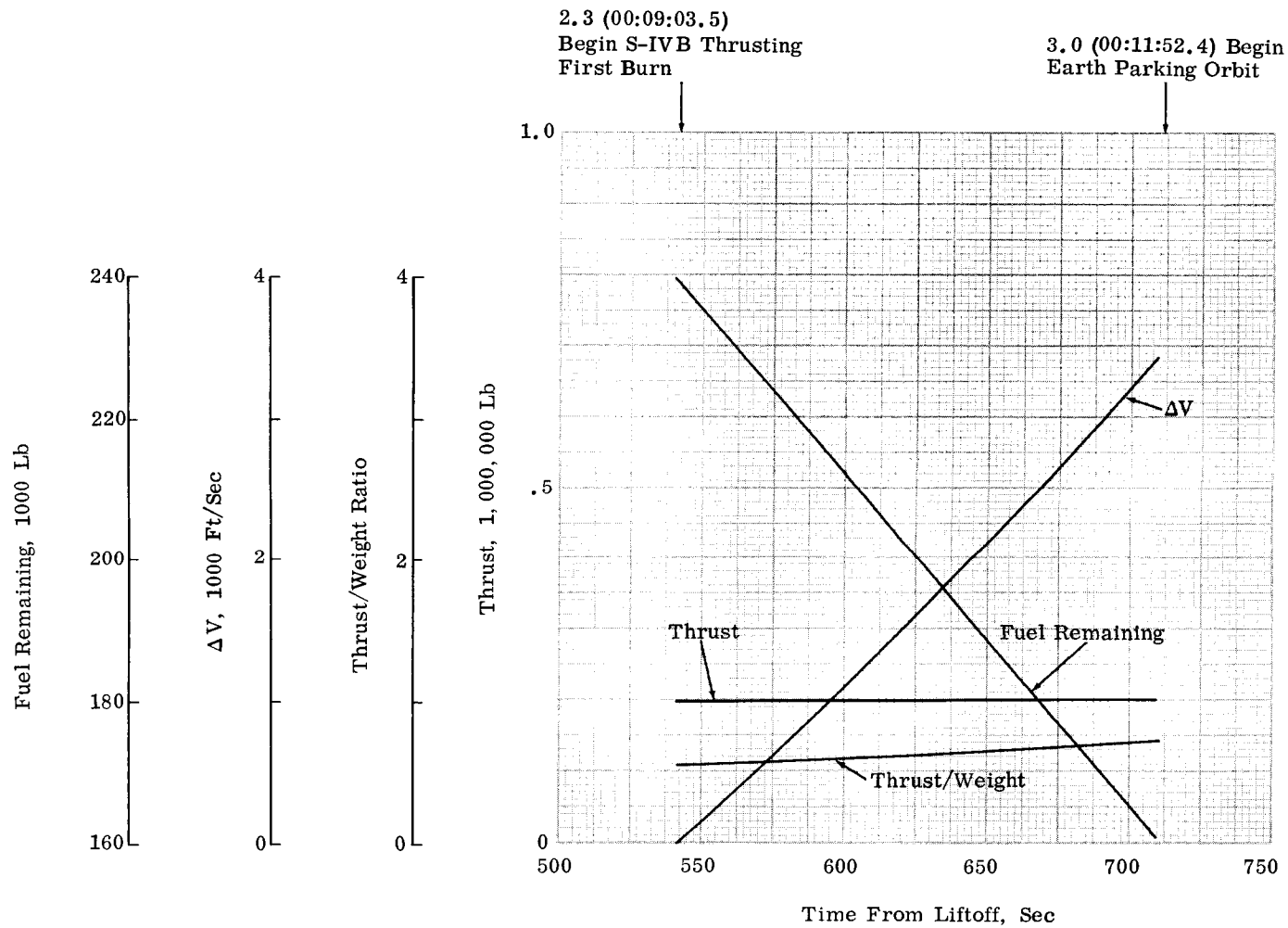

Figure C-3 Ascent Phase Engine Performance Parameters S-IVB

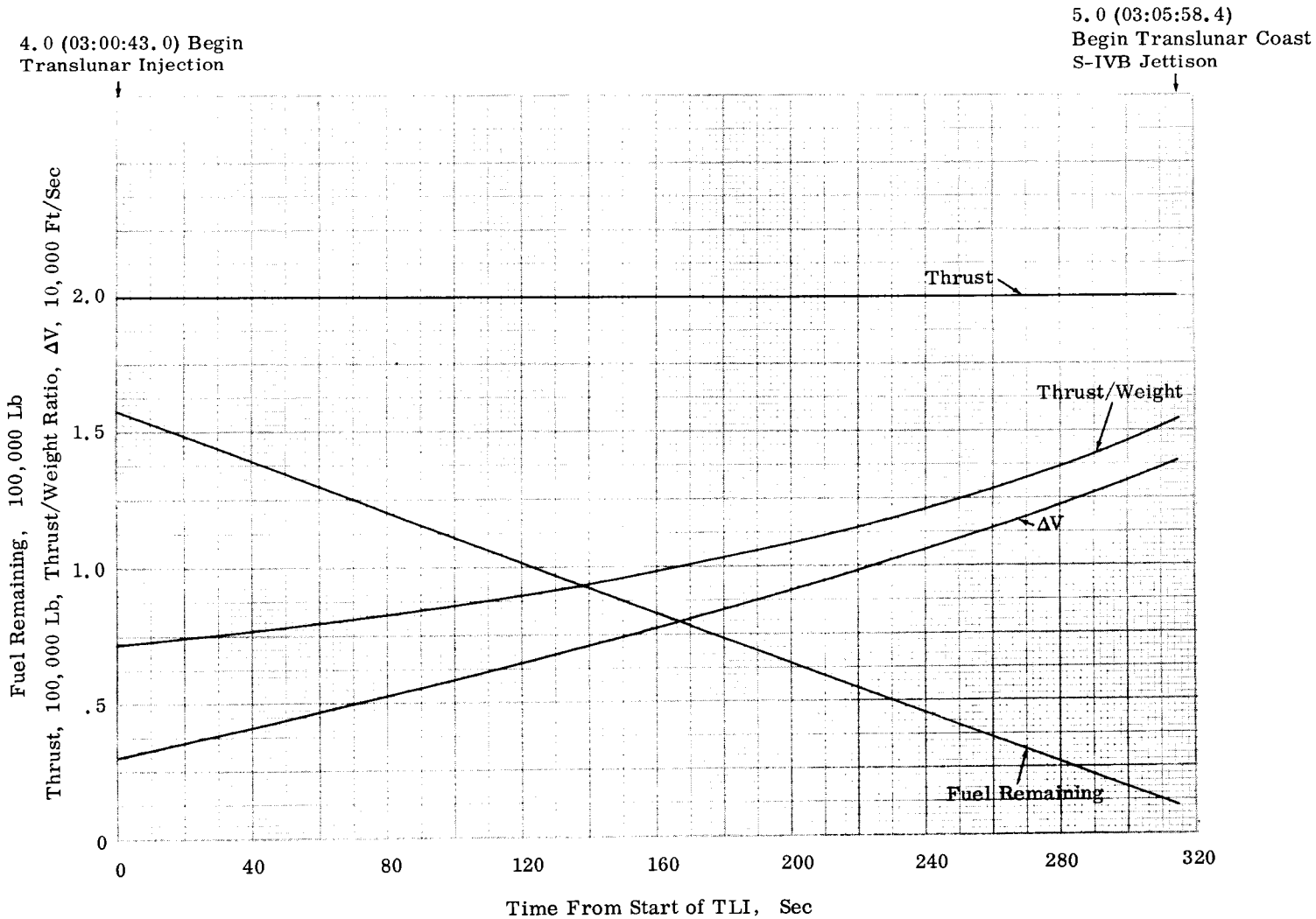

Figure C-4 Translunar Injection Engine Performance Parameters

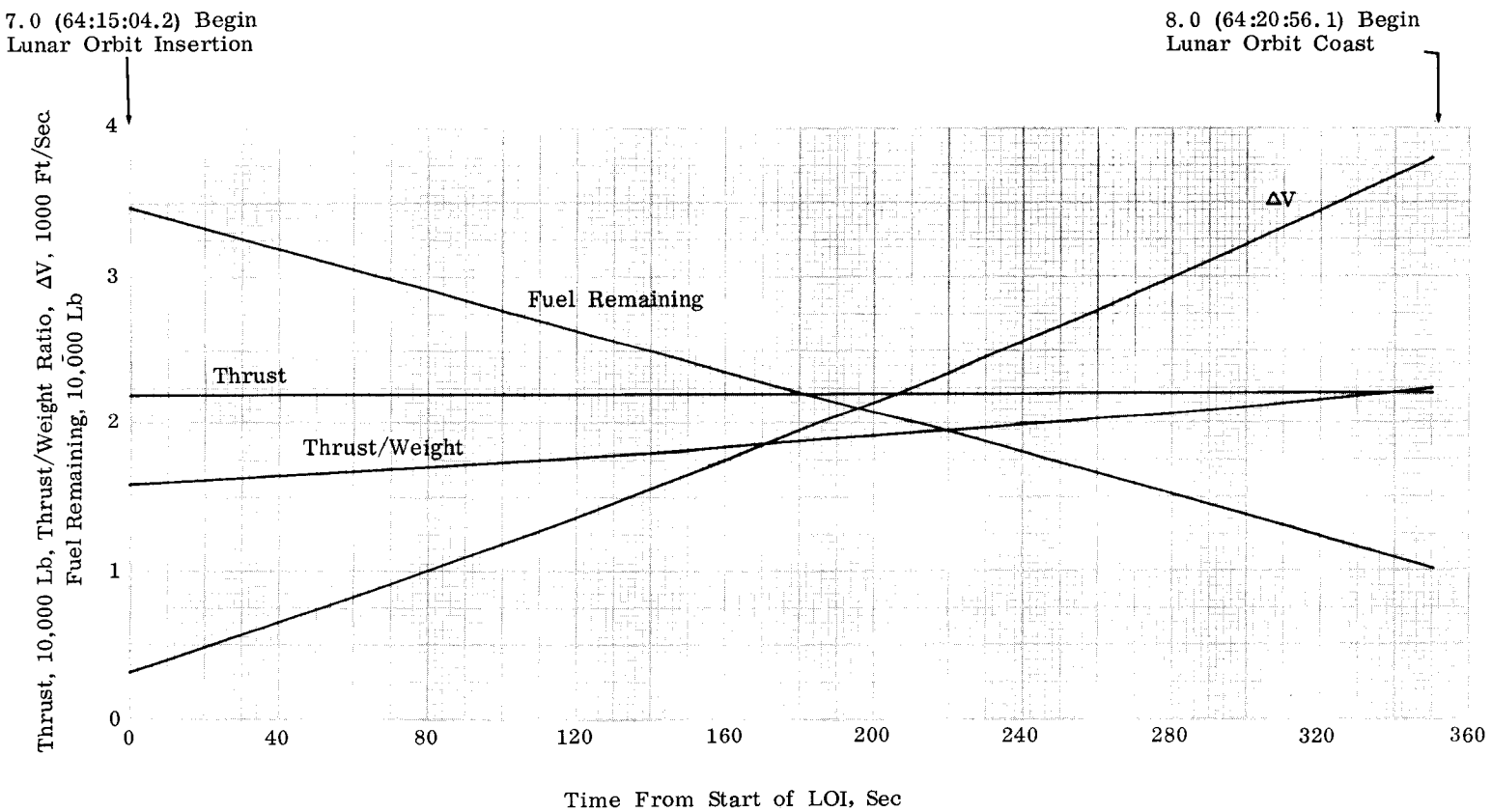

Figure C-5 Lunar Orbit Insertion Engine Performance Parameters

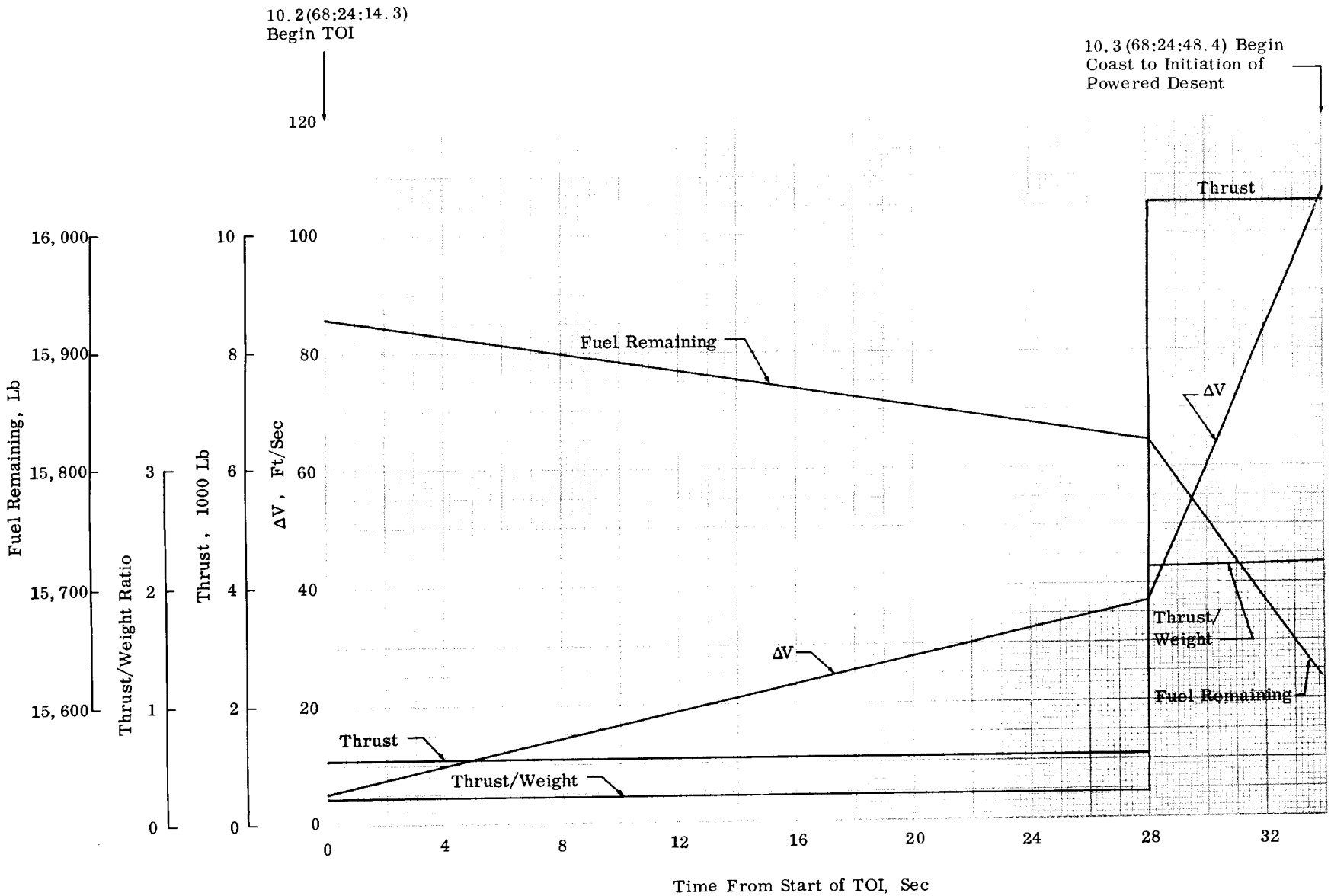

Figure C-6 Transfer Orbit Insertion Engine Performance Parameters

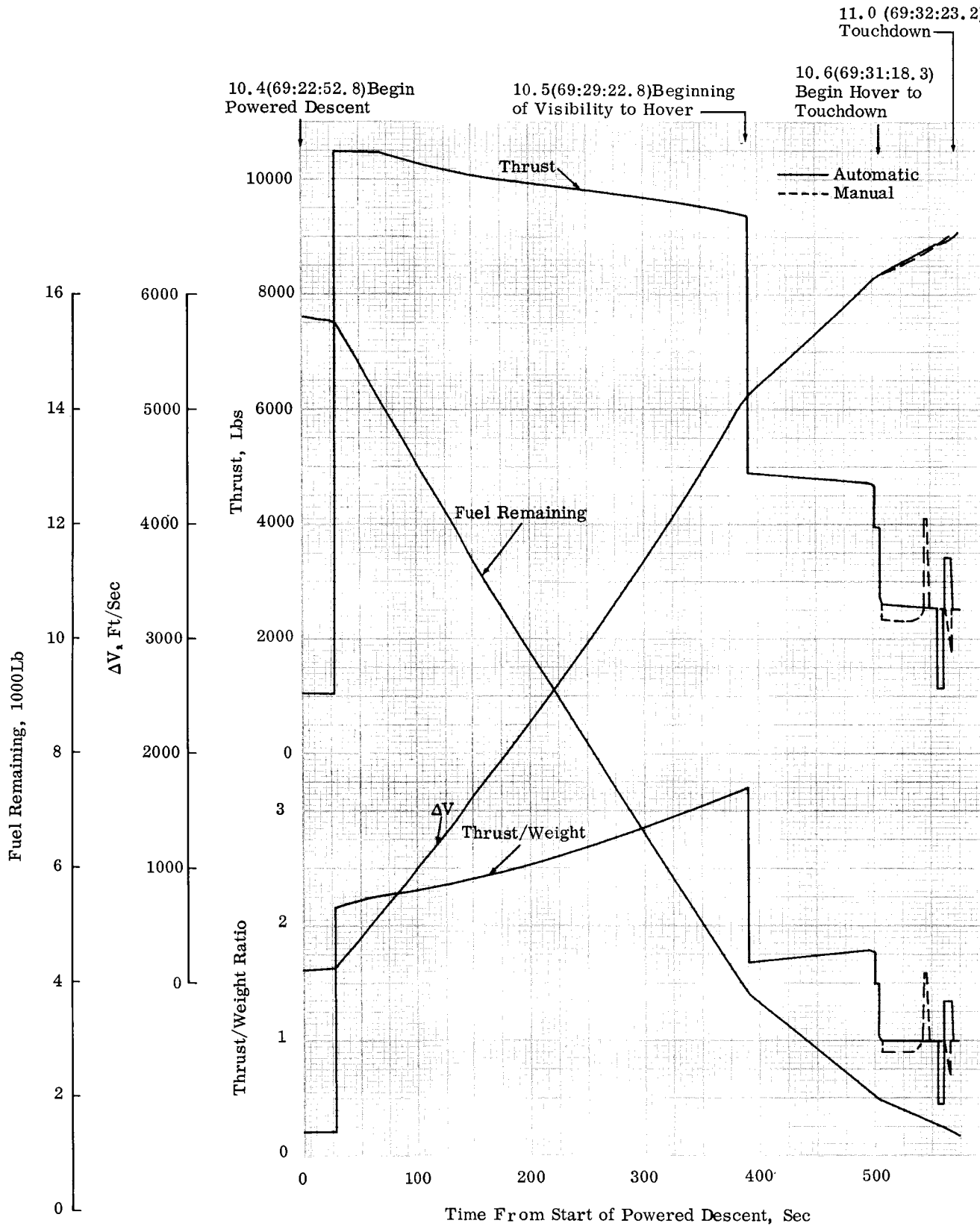

Figure C-7 LEM Powered Descent Engine Performance Parameters

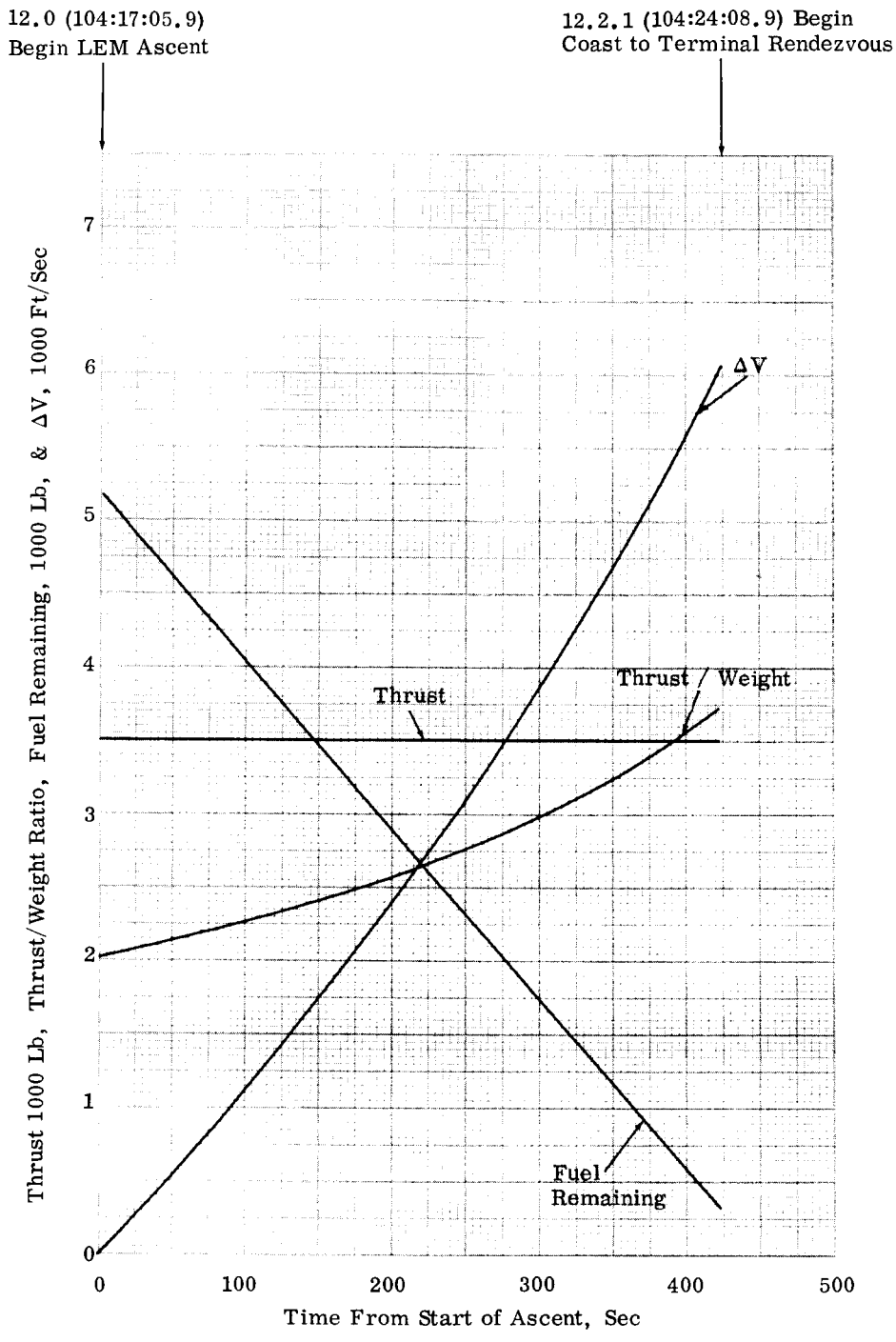

Figure C-8 LEM Powered Ascent Engine Performance Parameters

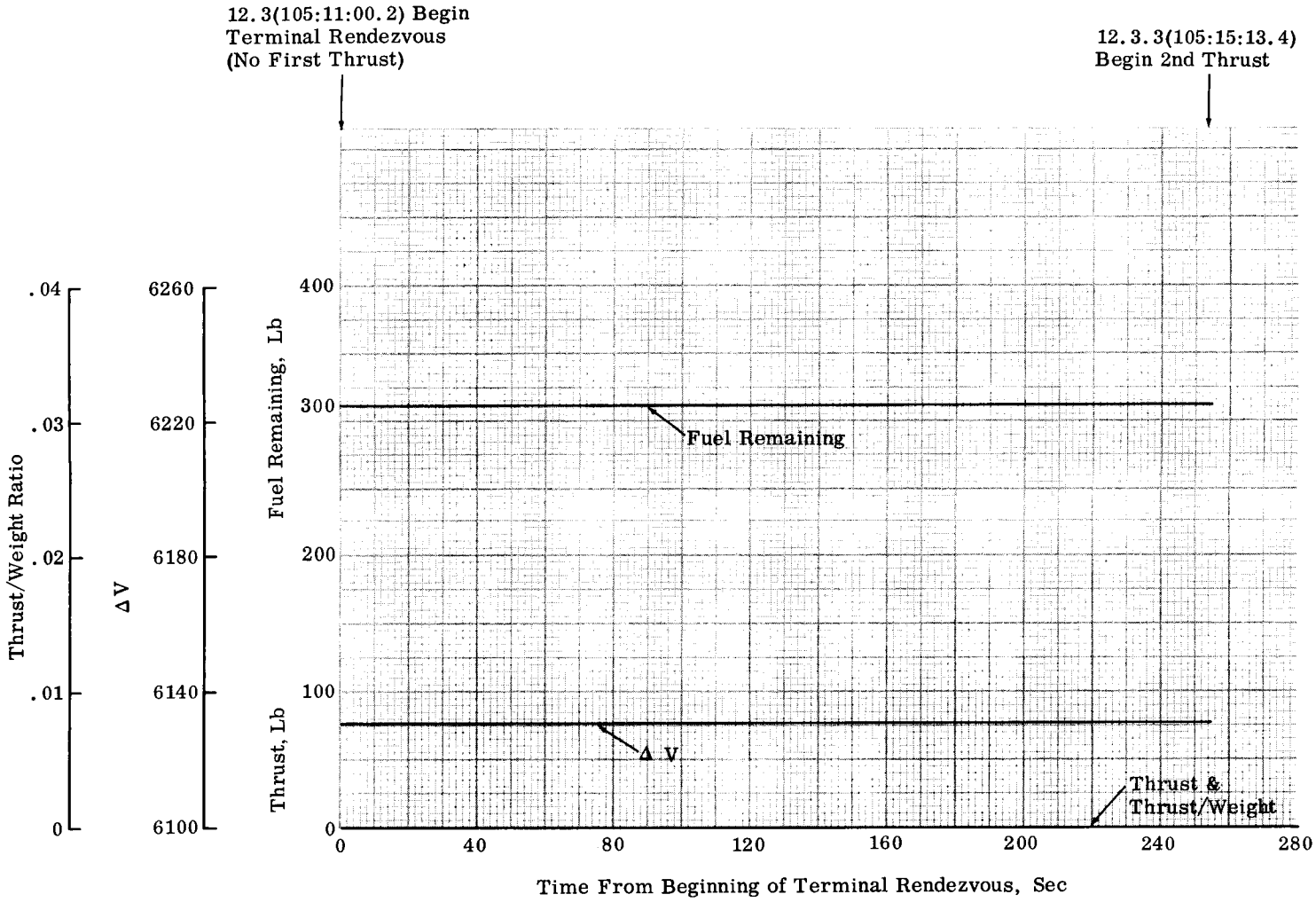

Figure C-9 First LEM Terminal Rendezvous Coast Phase Engine Parameters

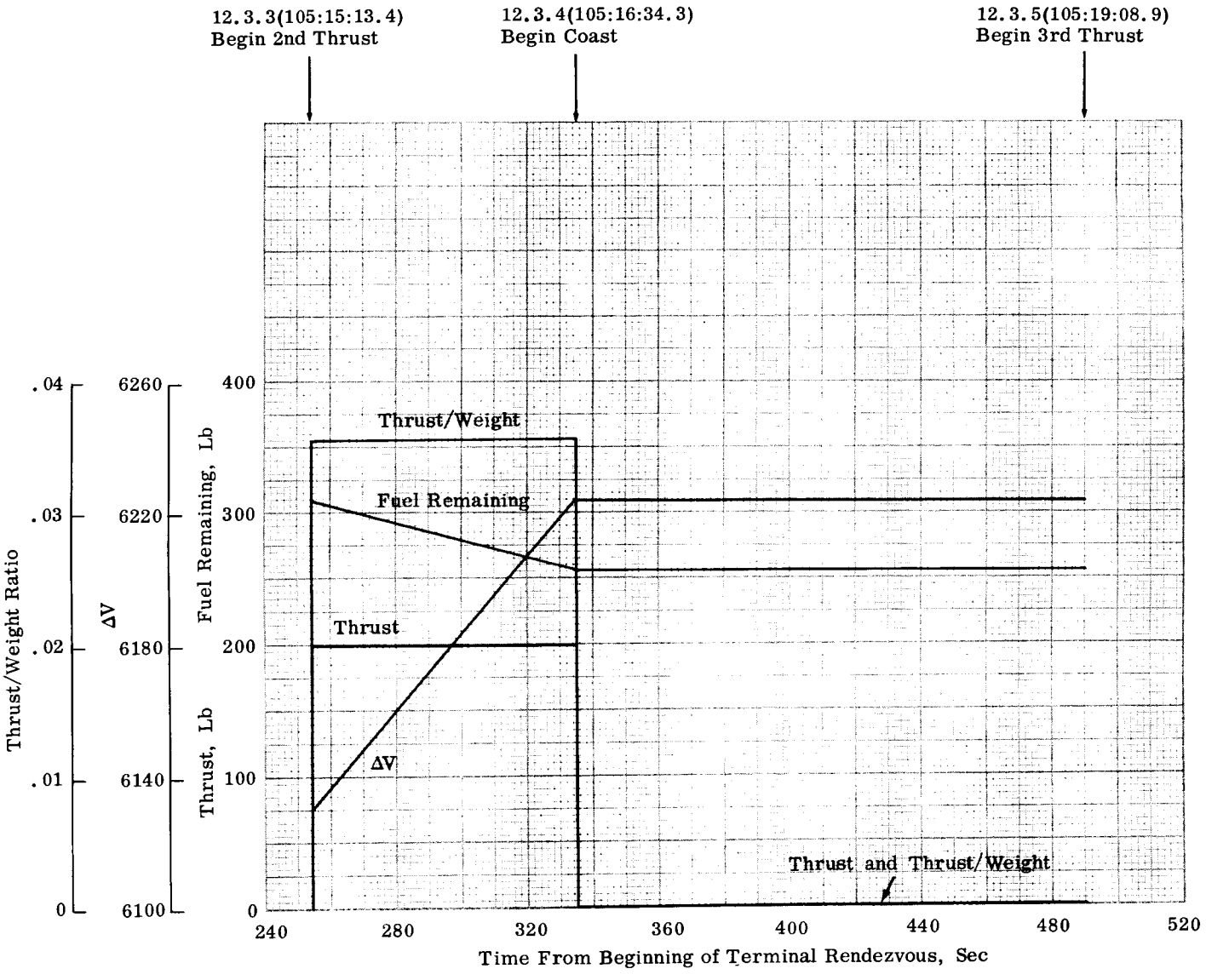

Figure C-10 Second Burn and Coast Phase of LEM Terminal Rendezvous Engine Performance Parameters

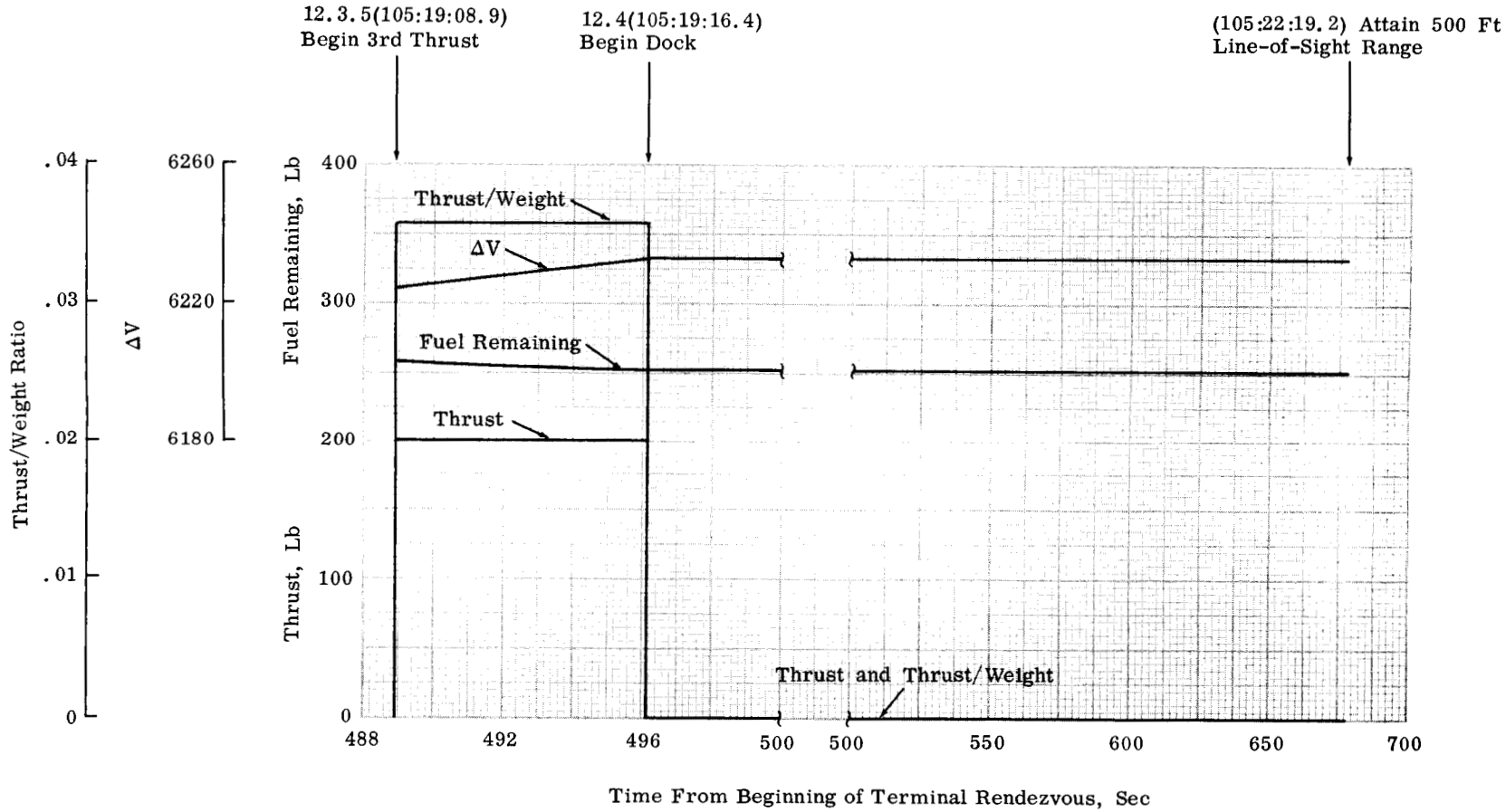

Figure C-11 Third Burn and Coast Phase of LEM Terminal Rendezvous Engine Performance Parameters

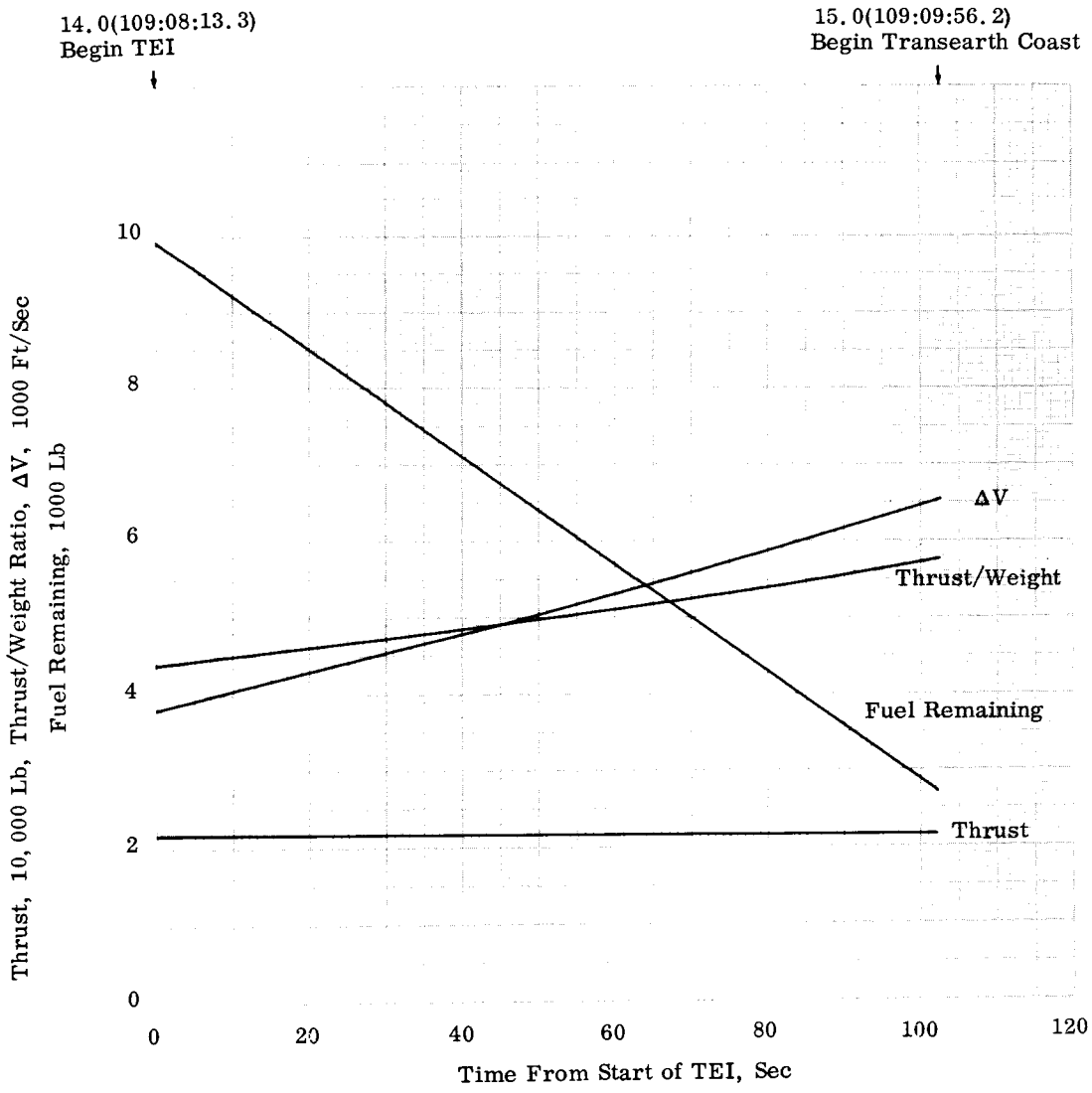

Figure C-12 Transearth Injection Engine Performance Parameters