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SPACE SHUTTLE LAUNCH VEHICLE PERFORMANCE TRAJECTORY, EXCHANGE RATIOS, AND DISPERSION ANALYSIS

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16. ABSTRACT

A baseline Space Shuttle performance trajectory for Mission 3A launched from WTR has been generated. Design constraints of maximum dynamic pressure, longitudinal acceleration, and delivered payload were satisfied. Payload exchange ratios are presented with explanation on use. Design envelopes of dynamic pressure, SRB staging point, aerodynamic heating and flight performance reserves are calculated and included.

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TABLE OF CONTENTS

DEFINITION OF ABBREVIATIONS

AOA	Abort-Once-Around
A_z	Azimuth
ET	External Tank
FPR	Flight Performance Reserve Propellants
fps	feet per second
g	gravity
in^2	square inches
Isp	Specific Impulse
lb	pounds
MECO	Orbital Main Engine Cutoff
n. mi.	Nautical Miles
OMS	Orbital Maneuvering System
Pl	Payload
RCS	Reaction Control System
RI/SD	Rockwell International/Space Division
RSS	Root Sum Squared
RTLS	Return To Launch Site
s	seconds
SRB	Solid Rocket Booster
SSLV	Space Shuttle Launch Vehicle
SSME(s)	Space Shuttle Main Engine(s)
WTR	Western Test Range
Δ	change from baseline
3-DOF	Three Degree Of Freedom
o	degrees of temperature
γ	flight path angle
V_R	Earth Relative Velocity
WT	Weight
$\dot{W}$	Weight Flow Rate

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SPACE SHUTTLE LAUNCH VEHICLE PERFORMANCE TRAJECTORY, EXCHANGE RATIOS, AND DISPERSION ANALYSIS

SUMMARY

A baseline Space Shuttle Trajectory for Mission 3A launched from WTR has been generated. Design constraints of maximum dynamic pressure, longitudinal acceleration, and delivered payload were satisfied. Payload exchange ratios for use in rapid tradeoff studies were generated and presented. A detailed dispersion analysis simulating vehicle parameters at their $\pm 3\sigma$ values was performed to define design envelopes of dynamic pressure, SRB staging point, aerodynamic stagnation point heating, and flight performance reserves. Optimum fuel bias quantity was calculated.

INTRODUCTION

The Space Shuttle Program has reached a phase where all major system elements have been contracted. Each contractor has evaluated the requirements and replied with a definition of operation of his particular element.

These data have been assembled to define a launch vehicle that will perform the mission requirements. A detailed evaluation and study of these data have been performed. This report contains the baseline vehicle definition, Mission 3A baseline performance trajectory, payload exchange ratios, dispersion analysis with design environment envelopes, and a definition of flight performance reserve propellants.

SECTION I

NOMINAL LAUNCH VEHICLE PARAMETERS AND BASELINE TRAJECTORY

A. Discussion

The Space Shuttle Launch Vehicle (SSLV) has been sized under Level I groundrules (Reference 1) for a flight labeled Mission 3A. This has been ascertained through various studies as the most payload critical mission defined in Reference 1. This mission is a single revolution payload delivery flight launched from Western Test Range (WTR) into a 50 X 100 n. mi. orbit inclined at 104^{o} with respect to the equatorial plane. The requirement of 'orbiter intact abort' sizes the propulsion system for an Abort-Once-Around (AOA) flight caused by Space Shuttle Main Engine (SSME) failure. The current abort requirement provides safe landing in the vicinity of the launch site following a SSME failure.

The Shuttle powered flight is divided into three phases, each of which requires a different response to an abort situation. The first phase is from liftoff through Solid Rocket Booster (SRB) burn-out and staging, and into the orbiter/ET flight. During this phase, if a failure causing an abort occurs, the SSLV executes a powered turn around maneuver, initiated after SRB staging,and flies back to the launch site. The latest time that this maneuver can be executed, and thus the terminal time of this first phase, is designated the last Return To Launch Site (RTLS), first AOA interface. Beyond this time the downrange energy is too great to be cancelled, and a second phase of flight is in effect. If a SSME failure occurs in this phase the SSLV is targeted to the AOA Main Engine Cutoff (MECO) conditions stated in Table I.1. Following MECO the Orbital Maneuvering System (OMS) is fired to place the orbiter on a conic from which safe entry and landing may occur. A third and final phase occurs when the powered flight nears the nominal targeting conditions of Table I.1. If a SSME failure occurs during this phase, the remaining orbiter engines are burned to the Nominal targeting conditions and a post MECO OMS burn is used to place the orbiter into the required 50 X 100 n. mi. orbit. The MECO target conditions are such that the ET is on an earth impacting conic required for safe ET disposal.

B. Description of Launch Vehicle

The SSLV has been sized by the prime contractor, Rockwell International/Space Division (RI/SD), and the component weight and mass data used for this study are contained in Reference 2 and displayed in Table I.2. A management requirement of 7000 pounds payload growth margin at the time when this sizing exercise was performed was implemented. A sketch of the launch vehicle is displayed in Figure I.1. The aerodynamic

data was obtained from Reference 3. The forebody axial force coeffi- vs Mach Number and base force vs altitude curves are displayed in Figures I.2 and I.3 respectively. The Solid Rocket Booster vacuum thrust and weight flow rate profiles produced by Thiokol Chemical Corporation and designated as TC-207-1, are displayed in Figure I.4. Values of vacuum thrust and specific impulse for the SSME, OMS, and aft firing RCS engines are presented in Table I.3.

The ascent trajectory for Mission 3A was simulated using the following groundrules:

1. Launch from WTR, latitude = 35^{o}, West Longitude = 120.5^{o}

2. Payload weight = 32,000 lbs. (exclusive of 7000 lb payload growth margin)

3. Orbit inclination = 104^{o}.

4. 1971 Vandenberg Reference Atmosphere simulated (Reference 4).

5. Maximum dynamic pressure on nominal trajectory ≤ 650 psf.

6. Vehicle erected on launch pad with tail fin pointing due south, $A_Z = 180^{o}$). Roll program ($)^{o}$/Sec) begar at 6 seconds flight until azimuth = 198.55^{o} as required for coplanar flight.

7. Booster open loop pitch attitude profile selected to maximize payload while limiting loads in region of maximum dynamic pressure.

8. Optimum guidance initiated at SRB staging and is in effect until MECO.

9. Thrust vector control supplied by SRB's from liftoff to beginning of thrust decay at which time orbiter engines assume control until cutoff.

10. Orbiter main engine throttle set at 109% from liftoff to AOA MECO or 100% from RTLS to Nominal MECO except for throttling as required to maintain longitudinal acceleration limit of 3g's.

11. Last RTLS time equals earliest AOA time (V_R = 8932 fps)

12. Trajectory shaped for earliest AOA (Table I.1 for targeting) with orbiter engine #1 failure. Nominal trajectory simulation started at RTLS/AOA point and targeted to nominal MECO target (Table I.1).

13. OMS propellant loading of 250 fps Δ V in excess of 50 X 100 n. mi. reference orbit and RCS loading of 100 fps on orbit translational Δ V respectively (Reference 1) are assumed.

14. OMS and aft firing RCS engines burned in parallel with orbiter main engines during AOA burn after engine failure. The duration is limited such that sufficient propellants are available to perform the post MECO maneuvers.

C. Trajectory Results

A sequence of events and resulting trajectory weight statement for both AOA and Nominal MECO conditions are contained in Table I.4.

Plots of dynamic pressure versus time and longitudinal acceleration versus time are displayed in Figures I.5, and I.6, respectively. A plot of stagnation point heating (Referenced to a one foot sphere) is displayed in Figure I.7.

Table I.5 is a definition of symbols of the trajectory tables. The detailed printout of the trajectory simulation from liftoff to AOA MECO is presented in Tables I.6 through I.13. Printout of the trajectory simulation from the RTLS/AOA point to Nominal MECO is presented in Tables I.14 through I.21.

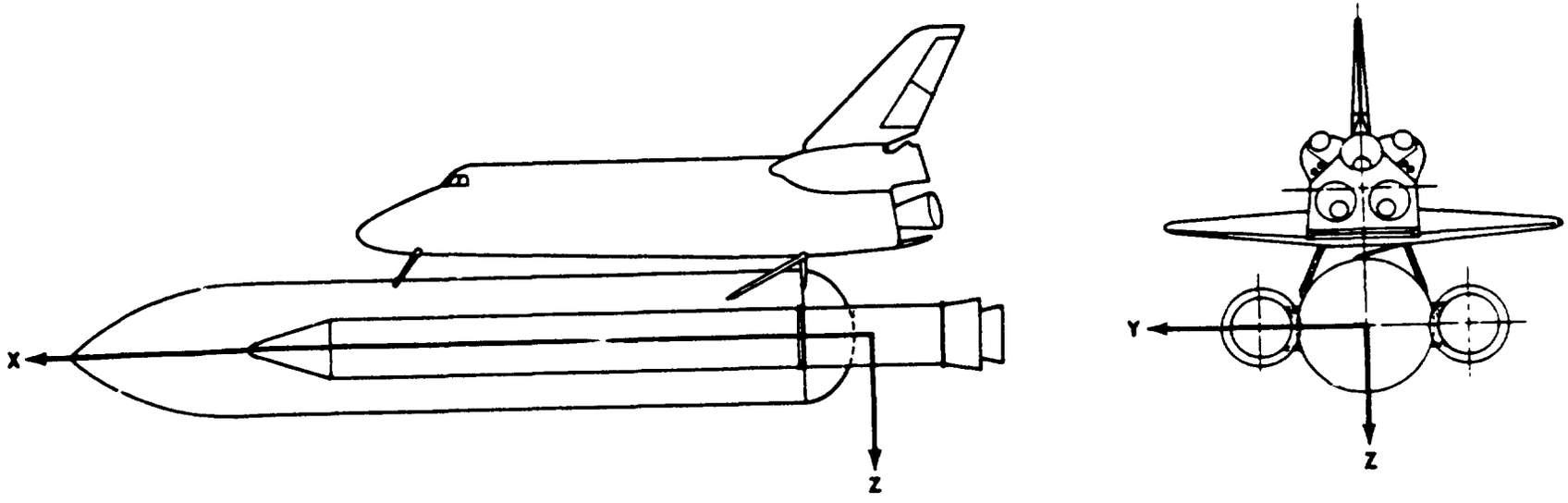

FIGURE 1-1 SHUTTLE LAUNCH VEHICLE AND BODY COORDINATE SYSTEM

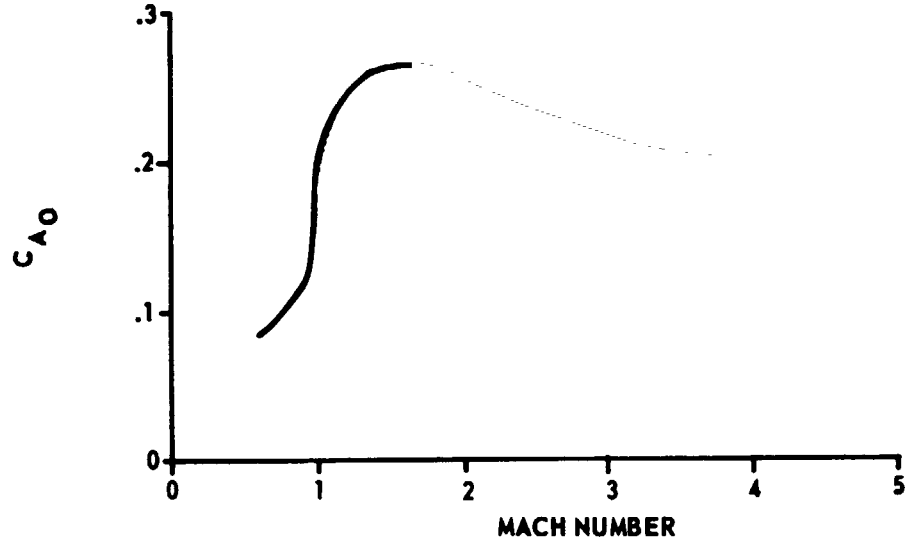

FIGURE I.2 FOREBODY AXIAL FORCE COEFFICIENT (C_{A_O}) VERSUS MACH NUMBER

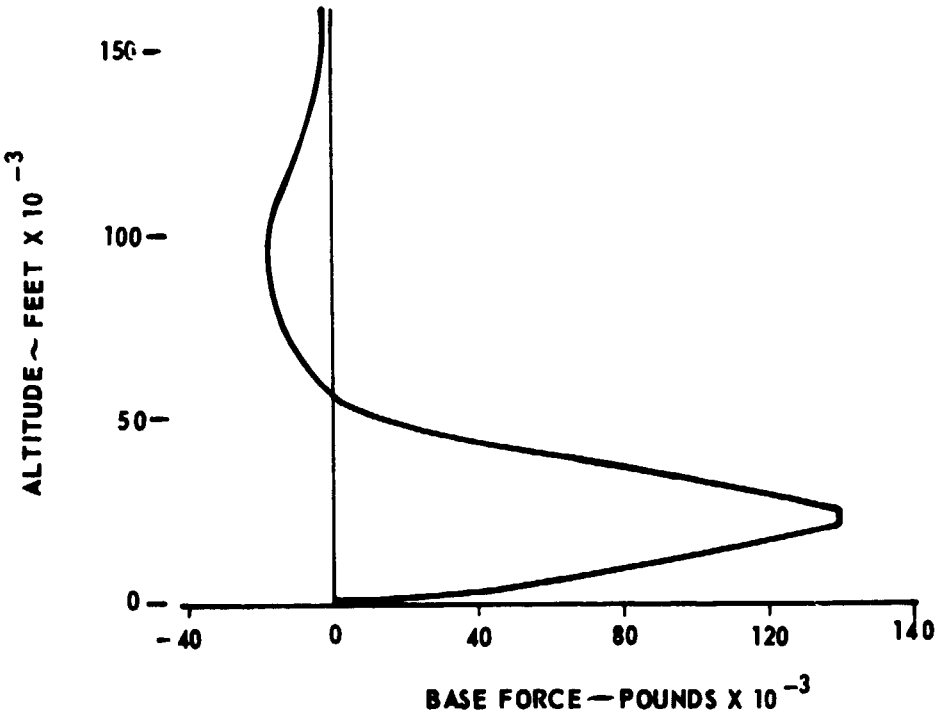

FIGURE I.3 ALTITUDE VERSUS POWER ON BASE FORCE

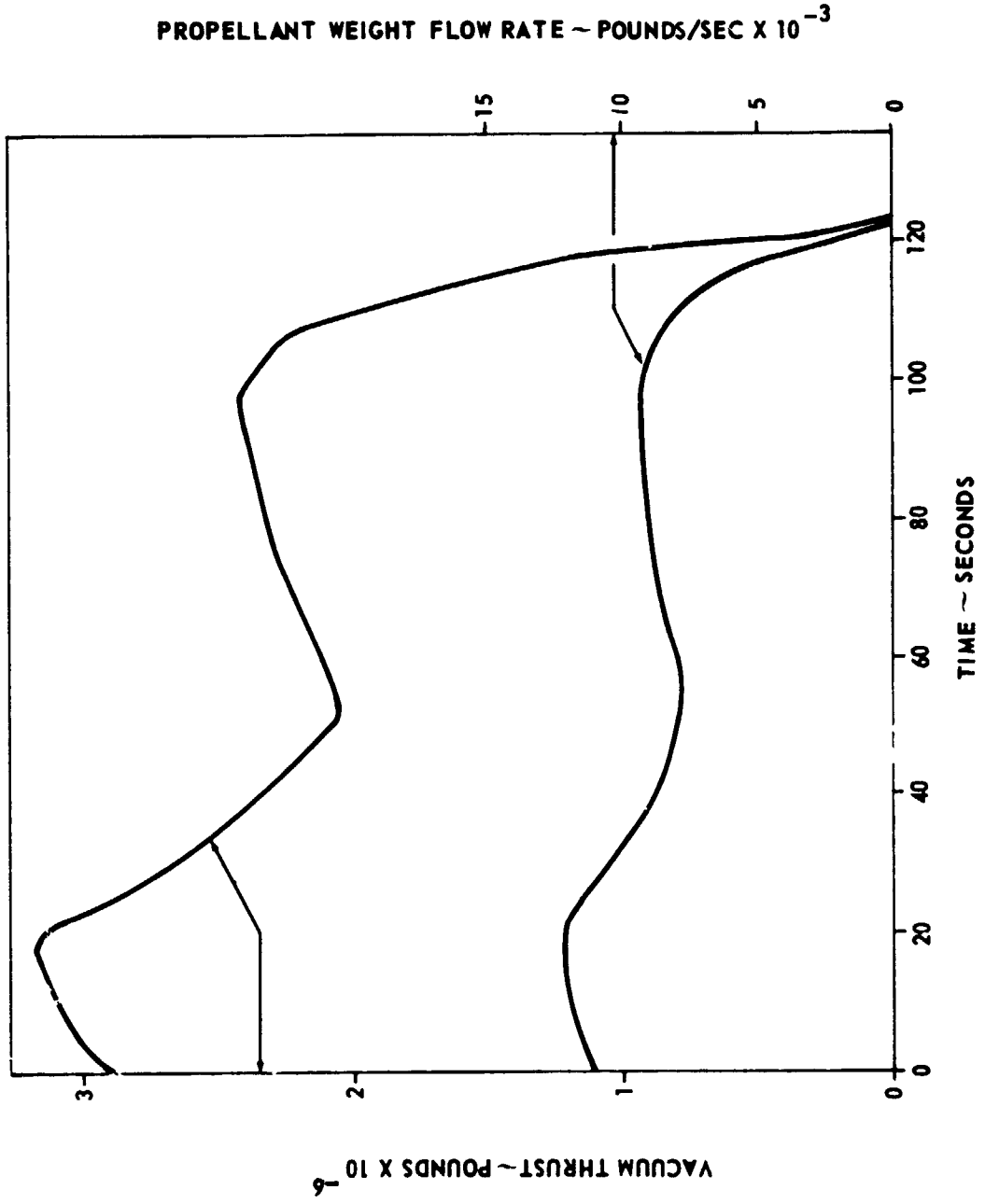

FIGURE 1.4 SRB VACUUM THRUST AND PROPELLANT WEIGHT FLOWRATE VERSUS TIME

TABLE I.1

MECO TARGETS - MISSION 3A

AOA Trajectory	
Altitude	= 55 n. mi. *
Inertial Velocity	= 25,317 fps
Inertial Flight Path Angle	= .75°
Inclination	= 104°
Nominal Trajectory	
Altitude	= 60 n. mi. *
Inertial Velocity	= 25,383 fps
Inertial Flight Path Angle	= .5°

* above equatorial radius

TABLE I.2

SHUTTLE COMPONENT WEIGHT AND CENTER OF GRAVITY DATA - MISSION 3A

Payload	32000 lb
Personnel	2636
Inert Wet Orbiter	156000
Usable RCS Propellant	3915
Usable OMS Propellant	12978
External Tank (WET)	75000
External Tank Propellant Capacity Incl FPR and Fuel Bias	1555338
SRB Inert Staging Weight	350380
SRB Propellants Incl Inerts	2202400
Gross Liftoff Weight at T/W = 1.5	4390647

	Weight lb	Center of Gravity XCG* (in)	ZCG* (in)
S	4400000	-448.0	-16.0
T	4368500	-449.2	-16.2
A	3615100	-454.1	-19.6
G	2957400	-415.8	-23.7
E	1911000	-279.4	-37.0
	1791600	-266.3	-39.8
1			
S	1428000	-122.0	-49.8
T	973400	-244.5	-72.0
A	601700	-412.9	-116.2
G	301300	-756.9	-235.6
E			
	YCG* = 0		
2			

* See Figure I.1

TABLE I.3

ORBITER LIQUID ENGINE PROPULSION PARAMETERS

I Space Shuttle Main Engine (3)

Vacuum Thrust at 100% Power Level	= 470000 lb
Vacuum Isp at 100% Power Level	= 455.2 s
at 109% Power Level	= 455.3 s
Exit Area	= 6471 in^2/Engine

Throttle range of 109% to 50% Nominal Power Level

II Orbital Maneuvering System (2)

Vacuum Thrust	= 6000 lb
Vacuum Isp	= 313.2 s

III Reaction Control System (4) (aft firing)

Vacuum Thrust	= 875 lb
Vacuum Isp	= 289 s

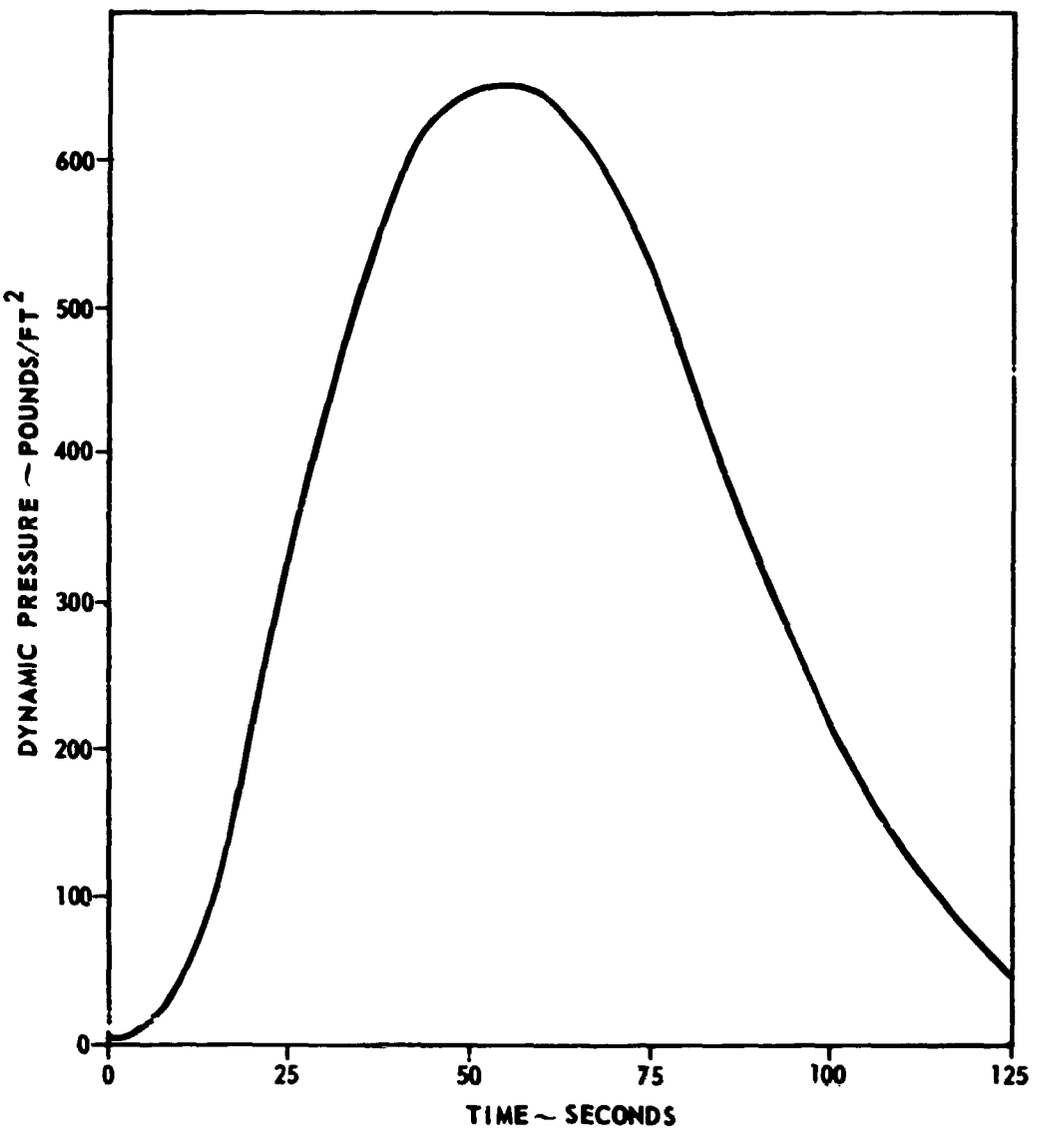

FIGURE 1.5 DYNAMIC PRESSURE VERSUS TIME

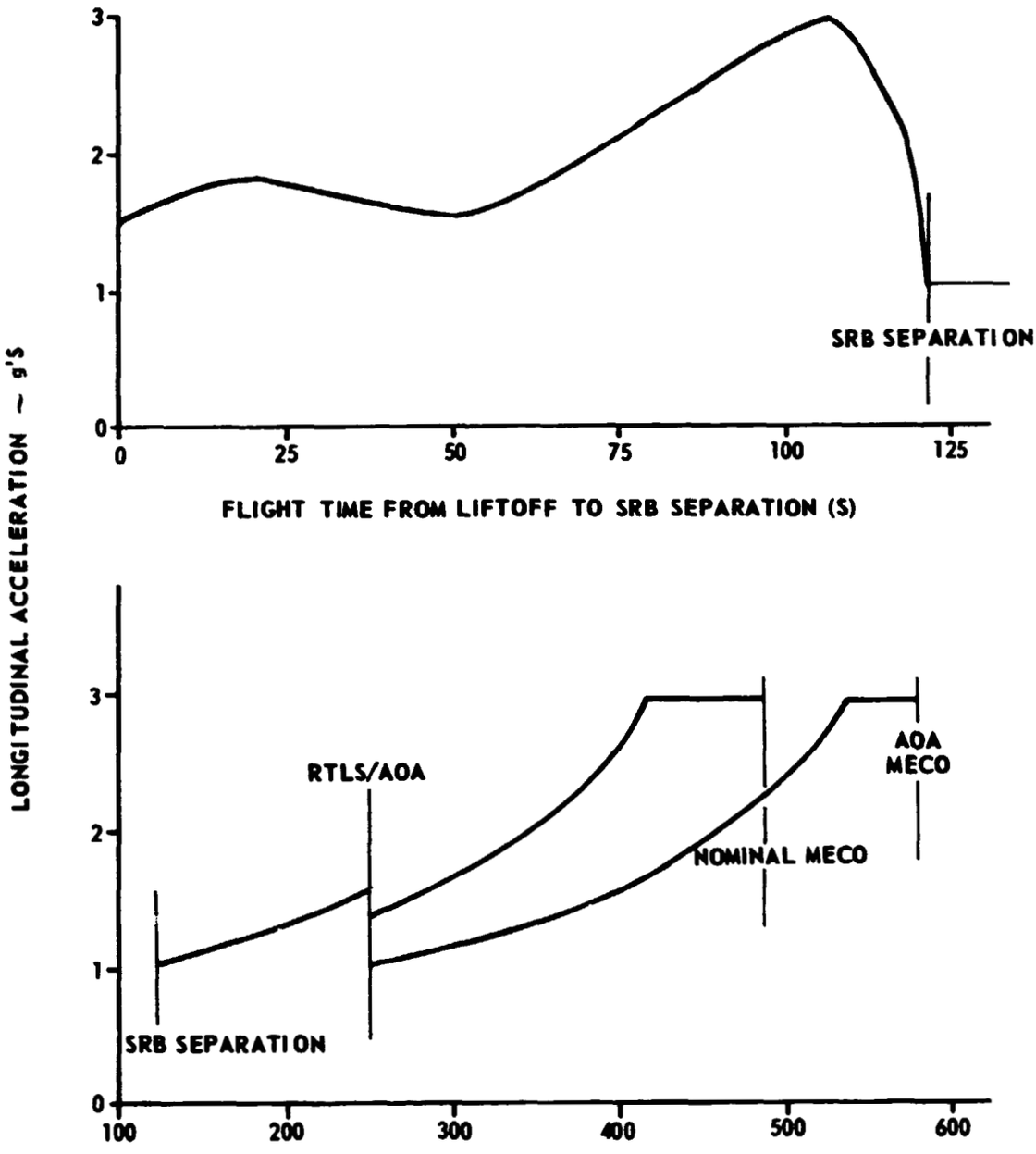

FIGURE 1.6 LONGITUDINAL ACCELERATION VERSUS FLIGHT TIME

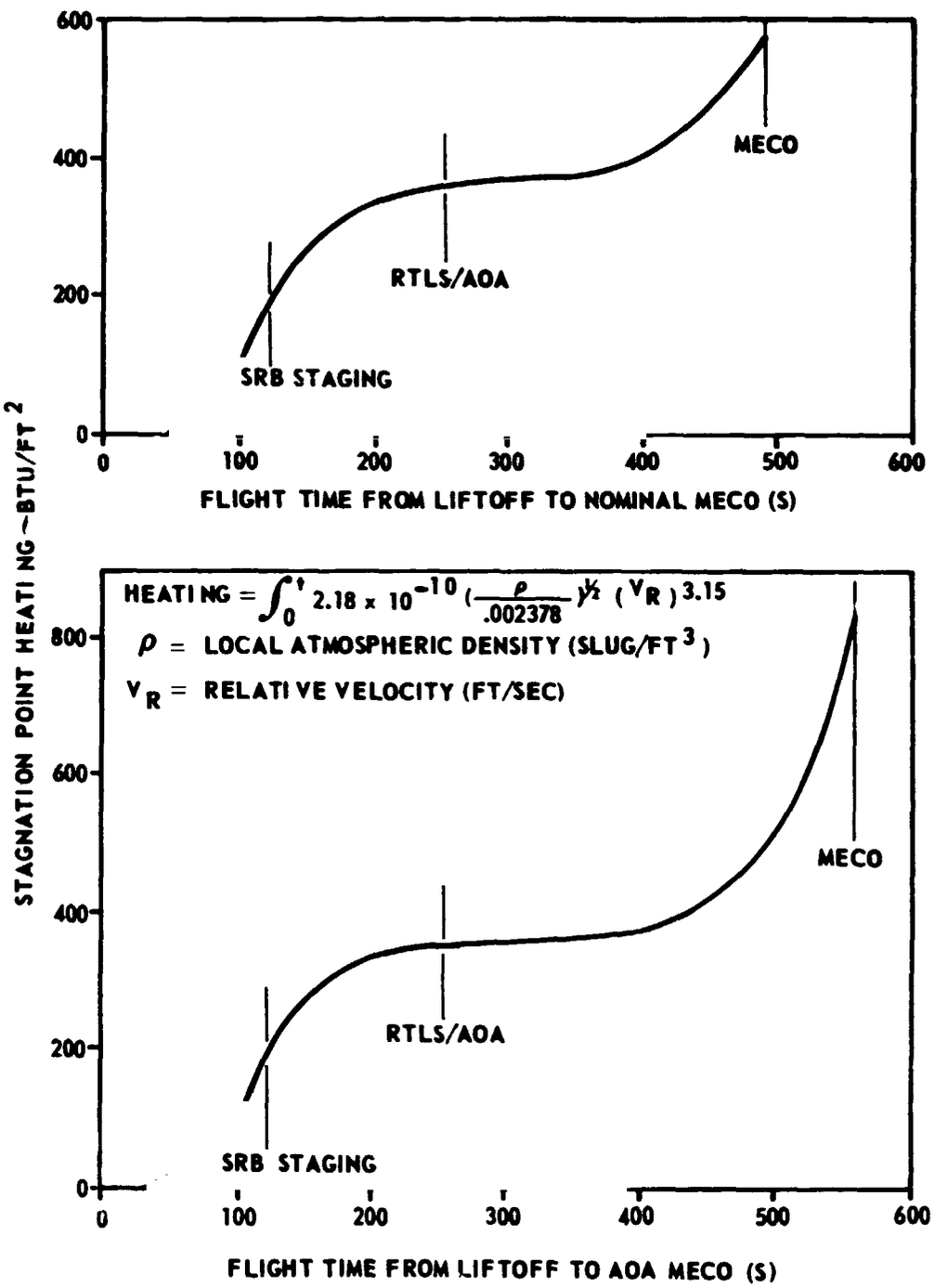

FIGURE 1.7 STAGNATION POINT HEATING VERSUS FLIGHT TIME

TABLE I.4

TIMED SEQUENCE OF EVENTS WITH CORRESPONDING WEIGHT HISTORY

AOA Trajectory

TIME (s)	EVENT	VEHICLE WT
0	Liftoff	4390647 lb
6	Initiate Tilt and Roll Attitude Program	4233432
7.86	Terminate Roll Maneuver	4183779
45.94	Mach Number = 1	3251833
54.49	Max Dynamic Pressure = 650 psf	3082478
107.50	Max SRB Longitudinal Acceleration	
	Orbiter Engines Assume Thrust Vector Control	1979738
121.42	SRB Staging	1778393
	Initiate Closed Loop Guidance	1428013
253.04	Common RTLS/AOA Point	
	Engine #1 Failed/Ignite OMS & RCS	983719
286.81	RCS Cutoff	905960
342.12	OMS Cutoff	779372
536.68	Max Longitudinal Acceleration - Throttle	341533
558.71	AOA MECO	295395
ET Propellants Consumed for AOA Trajectory		1538597

Nominal Mission

253.04	Common RTLS/AOA Point	983719
418.89	Max Longitudinal Acceleration - Throttle	470000
485.23	Nominal Mission MECO	303576
ET Propellants consumed for Nominal Trajectory		1534298

SA&I/EL24

DEFINITIONS AND SYMBOLS FOR TRAJECTORY TABLES

TABLE NO. I.5

SYMBOL	UNITS	DEFINITION
TIME	SECONDS	INSTANTANEOUS TIME FROM LIFTOFF
R	FEET	INSTANTANEOUS RADIUS FROM CENTER OF EARTH
VI	FT/SEC	INERTIAL VELOCITY
GAMMAI	DEGREES	INERTIAL FLIGHT PATH ANGLE
LAT-GD	DEGREES	GEODETIC LATITUDE
LONG	DEGREES	RELATIVE LONGITUDE
AZI	DEGREES	INERTIAL AZIMUTH (ANGULAR MEASUREMENT OF VI IN LOCAL HORIZONTAL PLANE)
ALT	FEET	INSTANTANEOUS ALTITUDE ABOVE REFERENCE ELLIPSOID
INC	DEGREES	INSTANTANEOUS INCLINATION
NODE	DEGREES	ANGULAR MEASUREMENT OF THE DESCENDING NODE FROM THE LAUNCH MERIDIAN
GAMMAR	DEGREES	RELATIVE FLIGHT PATH ANGLE
AZR	DEGREES	RELATIVE AZIMUTH ANGLE
MACH		MACH NUMBER

DEFINITIONS AND SYMBOLS FOR TRAJECTORY TABLES (Continued) TABLE NO. I.5

SYMBOL	UNITS	DEFINITION
Q	LB/FT**2	DYNAMIC PRESSURE
ALPHA	DEGREES	ANGLE OF ATTACK MEASURED IN VEHICLE PITCH PLANE
BETA	DEGREES	SIDESLIP ANGLE (LATERAL ANGLE OF ATTACK)
QALPHA	LB*DEG/FT**2	PRODUCT OF Q AND ALPHA
QBETA	LB*DEG/FT**2	PRODUCT OF Q AND BETA
THRUST	POUNDS	INSTANTANEOUS THRUST
WEIGHT	POUNDS	INSTANTANEOUS WEIGHT
AXIAL FORCE	POUNDS	AERODYNAMIC AXIAL FORCE
NORMAL FORCE	POUNDS	AERODYNAMIC NORMAL FORCE
SIDE FORCE	POUNDS	AERODYNAMIC SIDE FORCE
LONG ACC	G'S	LONGITUDINAL ACCELERATION
NORMAL ACC	G'S	NORMAL ACCELERATION
CHIR	DEGREES	INERTIAL ROLL ATTITUDE ANGLE
CHIP	DEGREES	INERTIAL PITCH ATTITUDE ANGLE
CHIY	DEGREES	INERTIAL YAW ATTITUDE ANGLE
DELRC	DEGREES	ROLL THRUST GIMBAL COMMAND

DEFINITION AND SYMBOLS FOR TRAJECTORY TABLES (Continued) TABLE NO. I.5

SYMBOL	UNITS	DEFINITION
DELPC	DEGREES	PITCH THRUST GIMBAL COMMAND
DELYC	DEGREES	YAW THRUST GIMBAL COMMAND
RANGE	NAUT MILES	RELATIVE SURFACE RANGE FROM INSTANTANEOUS LAUNCH POINT TO THE SUBVEHICLE POINT
RANGE ANGLE	DEGREES	RELATIVE RANGE ANGLE
IIP LAT	DEGREES	INSTANTANEOUS IMPACT POINT LATITUDE
IIP LONG	DEGREES	INSTANTANEOUS IMPACT POINT LONGITUDE
VCH	FT/SEC	CHARACTERISTIC VELOCITY
VIDEAL	FT/SEC	IDEAL VELOCITY
X	FEET	SHUTTLE COORDINATE SYSTEM NO 8 X POSITION
Y	FEET	SHUTTLE COORDINATE SYSTEM NO 8 Y POSITION
Z	FEET	SHUTTLE COORDINATE SYSTEM NO 8 Z POSITION
XDOT	FT/SEC	SHUTTLE COORDINATE SYSTEM NO 8 X VELOCITY
YDOT	FT/SEC	SHUTTLE COORDINATE SYSTEM NO 8 Y VELOCITY
ZDOT	FT/SEC	SHUTTLE COORDINATE SYSTEM NO 8 Z VELOCITY
XACC	FT/SEC**2	SHUTTLE COORDINATE SYSTEM NO 8 X ACCELERATION

DEFINITION AND SYMBOLS FOR TRAJECTORY TABLES (Continued) TABLE NO. I.5

SYMBOL	UNITS	DEFINITION
YACC	FT/SEC**2	SHUTTLE COORDINATE SYSTEM NO 8 Y ACCELERATION
ZACC	FT/SEC**2	SHUTTLE COORDINATE SYSTEM NO 8 Z ACCELERATION
HEAT	BTU/FT**2	STAGNATION POINT HEATING INDICATOR
HEAT RATE	BTU/FT**2/S	STAGNATION POINT HEATING RATE

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.6

	TIME SEC	R FT	VI FT/SEC	GAMMAI DEG	LAT-GD DEG	LONG DEG	AZI DEG
LIFT-OFF	.000	20902727.2	1251.343	.000	35.000	-120.500	90.000
	4.000	20902861.7	1253.215	3.159	35.000	-120.500	90.008
BEGIN ROLL	6.000	20903038.2	1255.882	4.912	35.000	-120.500	90.016
BEGIN TILT	6.000	20903038.2	1255.882	4.912	35.000	-120.500	90.016
END ROLL	7.855	20903272.2	1259.414	6.613	35.000	-120.500	90.051
	8.000	20903293.2	1259.718	6.749	35.000	-120.500	90.056
	12.000	20904057.0	1270.326	10.668	35.000	-120.500	90.380
	16.000	20905185.7	1286.184	14.896	35.000	-120.500	91.101
	17.500	20905710.0	1293.794	16.553	35.000	-120.500	91.491
	17.500	20905710.0	1293.794	16.553	35.000	-120.500	91.491
	20.000	20906712.5	1308.618	19.355	34.999	-120.500	92.298
	24.000	20908650.7	1335.816	23.564	34.999	-120.501	93.938
	28.000	20910974.2	1365.709	27.307	34.998	-120.501	95.946
	32.000	20913651.5	1397.128	30.570	34.996	-120.502	98.289
	36.000	20916651.0	1430.358	33.449	34.994	-120.503	100.995
	40.000	20919952.7	1466.005	36.000	34.991	-120.504	104.107
	44.000	20923536.5	1503.280	38.163	34.987	-120.505	107.599
MACH ONE	45.935	20925362.2	1521.281	39.038	34.985	-120.506	109.386
	48.000	20927371.7	1540.652	39.864	34.983	-120.507	111.342
	52.000	20931427.5	1579.211	41.169	34.978	-120.510	115.323
Q MAXIMUM	54.491	20934056.2	1605.870	41.836	34.974	-120.511	118.051
	55.500	20935143.7	1617.521	42.077	34.973	-120.512	119.213
	55.500	20935143.7	1617.521	42.077	34.973	-120.512	119.213
10 KMS.	55.891	20935568.2	1622.194	42.166	34.972	-120.512	119.672
	56.000	20935687.2	1623.514	42.191	34.972	-120.512	119.801
	60.000	20940154.2	1678.293	42.968	34.965	-120.515	124.810
	64.000	20944844.0	1746.919	43.466	34.956	-120.519	130.257
14 KMS.	67.160	20948718.2	1812.687	43.626	34.949	-120.522	134.771
	68.000	20949774.5	1832.070	43.631	34.947	-120.523	135.991
	70.000	20952335.2	1881.644	43.576	34.941	-120.525	138.911
	70.000	20952335.2	1881.644	43.576	34.941	-120.525	138.911
	72.000	20954963.0	1936.202	43.426	34.935	-120.528	141.831
	76.000	20960427.2	2060.980	42.849	34.922	-120.533	147.560

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO ADA MECO/ CASE 1

TABLE NO. I.6

	TIME SEC	R FT	VI FT/SEC	GAMMAI DEG	LAT-GD DEG	LONG DEG	AZI DEG
	80.000	20966180.0	2206.960	41.947	34.907	-120.539	152.966
	84.000	20972232.7	2375.206	40.793	34.890	-120.547	157.933
	88.000	20978598.2	2566.637	39.464	34.871	-120.555	162.410
	92.000	20985287.5	2781.835	38.029	34.849	-120.564	166.389
	96.000	20992312.2	3021.392	36.543	34.824	-120.575	169.896
	97.500	20995035.2	3117.606	35.983	34.814	-120.579	171.097
	97.500	20995035.2	3117.606	35.983	34.814	-120.579	171.097
	100.000	20999682.7	3283.805	35.059	34.796	-120.586	172.951
	104.000	21007400.2	3561.379	33.627	34.766	-120.599	175.549
	107.500	21014432.7	3814.931	32.430	34.736	-120.612	177.505
	107.500	21014432.7	3814.931	32.430	34.736	-120.612	177.505
	108.000	21015458.0	3851.583	32.262	34.732	-120.614	177.762
	112.000	21023826.0	4129.702	30.959	34.695	-120.629	179.545
	116.000	21032423.7	4376.907	29.729	34.654	-120.646	-179.074
	120.000	21041151.2	4562.665	28.595	34.612	-120.664	-178.113
	121.420	21044244.7	4591.878	28.228	34.596	-120.671	-177.938
SEPARATION	121.420	21044244.7	4591.878	28.228	34.596	-120.671	-177.938
BEGIN MINM	121.420	21044244.7	4591.878	28.228	34.596	-120.671	-177.938
	124.000	21049815.7	4637.672	27.576	34.567	-120.683	-177.658
	140.000	21082933.7	4956.180	23.718	34.379	-120.763	-176.030
	156.000	21113642.5	5328.153	20.275	34.172	-120.850	-174.602
	172.000	21142061.5	5748.886	17.279	33.946	-120.946	-173.356
	188.000	21168337.0	6216.208	14.712	33.698	-121.050	-172.266
	204.000	21192636.5	6729.157	12.537	33.428	-121.164	-171.308
	220.000	21215146.2	7287.760	10.716	33.134	-121.287	-170.464
	236.000	21236074.2	7892.982	9.210	32.815	-121.420	-169.716
	252.000	21255651.5	8547.037	7.976	32.470	-121.563	-169.052
	253.041	21256883.2	8591.555	7.900	32.446	-121.573	-169.011
INTERMEDIATE	253.041	21256883.2	8591.555	7.900	32.446	-121.573	-169.011
	268.000	21273135.0	9021.916	6.312	32.100	-121.716	-168.642
	284.000	21287430.0	9514.586	4.801	31.710	-121.876	-168.277
	286.811	21289621.0	9604.541	4.556	31.639	-121.905	-168.216
	286.811	21289621.0	9604.541	4.556	31.639	-121.905	-168.216

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.6

	TIME SEC	R FT	VI FT/SEC	GAMMAI DEG	LAT-GD DEG	LONG DEG	AZI DEG
	300.000	21298664.5	10038.853	3.480	31.298	-122.044	-167.943
	316.000	21306984.2	10596.517	2.338	30.863	-122.221	-167.636
	332.000	21312557.7	11189.003	1.364	30.404	-122.405	-167.354
	342.121	21314748.5	11582.430	.829	30.101	-122.526	-167.188
	342.121	21314748.5	11582.430	.629	30.101	-122.526	-167.188
	348.000	21315567.7	11815.074	.540	29.921	-122.598	-167.097
	364.000	21316186.0	12474.155	-.146	29.410	-122.800	-166.864
	380.000	21314628.7	13173.206	-.697	28.871	-123.011	-166.651
	396.000	21311148.0	13915.249	-1.120	28.303	-123.232	-166.456
	412.000	21306028.0	14704.013	-1.421	27.703	-123.463	-166.278
	428.000	21299591.0	15544.075	-1.608	27.069	-123.705	-166.117
	444.000	21292202.7	16441.045	-1.684	26.398	-123.957	-165.971
	460.000	21284283.5	17401.816	-1.652	25.689	-124.221	-165.839
	476.000	21276318.0	18434.950	-1.517	24.938	-124.497	-165.720
	492.000	21268867.2	19551.152	-1.279	24.142	-124.786	-165.613
	508.000	21262589.0	20764.002	-.939	23.298	-125.089	-165.518
	524.000	21258259.7	22091.020	-.496	22.399	-125.407	-165.432
BEGIN GLIMIT	536.683	21256820.2	23239.047	-.071	21.646	-125.671	-165.37[illegible]
	540.000	21256806.5	23551.814	.050	21.443	-125.741	-165.3[illegible]
	556.000	21259177.0	25060.908	.647	20.424	-126.092	-165.299
	558.712	21260010.2	25316.696	.751	20.245	-126.153	-165.291
INJECTION	558.712	21260010.2	25316.696	.751	20.245	-126.153	-165.291
	558.712	21260010.2	25316.696	.751	20.245	-126.153	-165.291

SA-1/LL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.7

	TIME SEC	ALT FT	INC DEG	NODE DEG	VR FT/SEC	GAMMAR DEG	AZR DEG
LIFT-OFF	.000	.00	34.819	90.000	.000	-2.179	88.001
	4.000	134.10	34.819	90.003	69.057	87.853	-166.980
BEGIN ROLL	6.000	310.45	34.819	89.998	107.533	89.813	-164.870
BEGIN TILT	6.000	310.45	34.819	89.998	107.533	89.813	-164.870
END ROLL	7.655	544.41	34.819	89.944	145.036	89.543	-162.867
	8.000	565.53	34.819	89.936	148.041	89.505	-162.319
	12.000	1329.15	34.821	89.385	235.330	87.850	-159.577
	16.000	2457.75	34.834	88.139	331.610	85.599	-159.858
	17.500	2981.87	34.847	87.462	370.204	84.675	-159.959
	17.500	2981.87	34.847	87.462	370.204	84.675	-159.959
	20.000	3984.16	34.885	86.062	436.885	83.077	-160.100
	24.000	5921.49	35.012	83.226	541.450	80.503	-160.253
	28.000	8243.71	35.258	79.777	640.593	77.972	-160.351
	32.000	10919.02	35.667	75.817	734.022	75.477	-160.419
	36.000	13916.07	36.298	71.354	824.566	72.969	-160.473
	40.000	17214.53	37.223	66.403	914.618	70.413	-160.520
	44.000	20794.13	38.496	61.118	1003.204	67.805	-160.560
MACH ONE	45.935	22617.66	39.236	58.532	1044.529	66.537	-160.577
	48.000	24624.5[illegible]	40.109	55.799	1087.831	65.200	-160.593
	52.000	28674.28	42.075	50.542	1170.991	62.593	-160.622
Q MAXIMUM	54.491	31298.74	43.552	47.177	1225.945	60.892	-160.640
	55.500	32384.49	44.211	45.799	1249.258	60.189	-160.647
	55.500	32384.49	44.211	45.799	1249.258	60.189	-160.647
10 KMS.	55.891	32808.33	44.476	45.264	1258.485	59.915	-160.650
	56.000	32927.06	44.550	45.115	1261.078	59.839	-160.651
	60.000	37385.92	47.598	39.605	1363.976	56.999	-160.677
	64.000	42066.23	51.182	34.212	1482.504	54.157	-160.699
14 KMS.	67.160	45931.87	54.326	30.150	1588.292	51.945	-160.714
	68.000	46985.64	55.198	29.109	1618.332	51.365	-160.718
	70.000	49539.97	57.320	26.703	1693.214	49.998	-160.726
	70.000	49539.97	57.320	26.703	1693.214	49.998	-160.726
	72.000	52160.95	59.487	24.410	1772.[illegible]	48.655	-160.733
	76.000	57610.41	63.846	20.196	1946	46.058	-160.745

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.7

	TIME SEC	ALT FT	INC DEG	NODE DEG	VR FT/SEC	GAMMAR DEG	AZR DEG
	80.000	63345.92	68.065	16.503	2138.841	43.607	-160.754
	84.000	69379.17	72.011	13.302	2350.2[illegible]	41.321	-160.761
	88.000	75722.46	75.612	10.541	2581.351	39.196	-160.766
	92.000	82386.44	78.840	8.162	2832.778	37.228	-160.769
	96.000	89382.82	81.701	6.111	3105.192	35.405	-160.772
	97.500	92094.43	82.684	5.416	3212.886	34.759	-1 .773
	97.500	92094.43	82.684	5.416	3212.886	34.759	-160.773
	100.000	96721.63	84.203	4.350	3397.074	33.729	-160.774
	104.000	104404.12	86.337	2.865	3700.471	32.207	-160.774
	107.500	111402.75	87.945	1.753	3973.994	30.985	-160.774
	107.500	111402.75	87.945	1.753	3973.994	30.985	-160.774
	108.000	112422.88	88.157	1.607	4013.310	30.816	-160.774
	112.000	120748.61	89.625	.596	4310.355	29.529	-160.772
	116.000	129300.11	90.763	-.186	4572.880	28.337	-160.768
	120.000	137979.14	91.556	-.730	4770.049	27.245	-160.760
	121.420	141054.72	91.701	-.830	4801.724	26.892	-160.755
SEPARATION	121.420	141054.72	91.701	-.830	4801.724	26.892	-160.755
BEGIN MINM	121.420	141054.72	91.701	-.830	4801.724	26.892	-160.755
	124.000	146592.97	91.933	-.989	4851.620	26.264	-160.746
	140.000	179496.65	93.283	-1.912	5194.179	22.569	-160.694
	156.000	209970.26	94.474	-2.723	5587.408	19.296	-160.657
	172.000	238132.53	95.520	-3.432	6026.631	16.460	-160.632
	188.000	264128.41	96.442	-4.054	6509.987	14.034	-160.617
	204.000	288124.23	97.260	-4.603	7036.869	11.981	-160.613
	220.000	310305.12	97.990	-5.089	7607.644	10.261	-160.618
	236.000	330877.79	98.646	-5.523	8223.568	8.836	-160.632
	252.000	350072.31	99.238	-5.911	8887.112	7.069	-160.654
	253.041	351278.02	99.275	-5.935	8932.215	7.597	-160.656
INTERMEDIATE	253.041	351278.02	99.275	-5.935	8932.215	7.597	-160.656
	268.000	367147.82	99.622	-6.160	9369.018	6.078	-160.678
	284.000	381015.49	99.972	-6.384	9867.871	4.629	-160.709
	286.811	383129.57	100.031	-6.422	9958.845	4.394	-160.715
	286.811	383129.57	100.031	-6.422	9958.845	4.394	-160.715

SA-I/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.7

	TIME SEC	ALT FT	INC DEG	NODE DEG	VR FT/SEC	GAMMAR DEG	AZR DEG
	300.000	391802.25	100.300	-6.592	10397.678	3.360	-160.747
	316.000	399653.49	100.610	-6.785	10960.338	2.261	-160.792
	332.000	404736.53	100.902	-6.964	11557.363	1.320	-160.844
	342.121	406605.58	101.079	-7.071	11953.457	.803	-160.879
	342.121	406605.58	101.079	-7.071	11953.457	.803	-160.879
	348.000	407233.65	101.178	-7.130	12187.571	.524	-160.901
	364.000	407316.50	101.437	-7.284	12850.437	-.142	-160.965
	380.000	405200.97	101.683	-7.427	13552.993	-.677	-161.034
	396.000	401137.86	101.918	-7.560	14298.303	-1.090	-161.109
	412.000	395411.37	102.141	-7.684	15090.131	-1.385	-161.189
	428.000	388343.02	102.354	-7.800	15933.081	-1.569	-161.275
	444.000	380298.62	102.558	-7.907	16832.787	-1.644	-161.366
	460.000	371697.92	102.753	-8.007	17796.162	-1.616	-161.461
	476.000	363025.24	102.940	-8.100	18831.785	-1.486	-161.562
	492.000	354842.02	103.120	-8.187	19950.373	-1.264	-161.668
	508.000	347806.28	103.293	-8.267	21165.518	-.921	-161.778
	524.000	342694.54	103.461	-8.342	22494.746	-.487	-161.893
BEGIN GLIMIT	536.683	340617.56	103.590	-8.397	23644.471	-.069	-161.987
	540.000	340434.86	103.623	-8.410	23957.672	.049	-162.013
	556.000	341977.67	103.769	-8.470	25468.727	.637	-162.133
	558.712	342669.11	103.793	-8.479	25724.828	.739	-162.154
INJECTION	558.712	342669.11	103.793	-8.479	25724.828	.739	-162.154
	558.712	342669.11	103.793	-8.479	25724.828	.739	-162.154

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.8

	TIME SEC	MACH	Q LB/FT**2	ALPHA DEG	BETA DEG	QALPHA LB*DEG/FT**2	QBETA LB*DEG/FT**2
LIFT-OFF	.000	.000	.000	.000	.000	.000	.000
	4.000	.062	5.690	2.509	-.019	14.276	-.110
BEGIN ROLL	6.000	.096	13.706	2.469	-.028	33.844	-.384
BEGIN TILT	6.000	.096	13.706	2.469	-.028	33.844	-.384
END ROLL	7.855	.130	24.716	2.903	.094	71.746	2.334
	8.000	.133	25.730	2.932	.091	75.441	2.345
	12.000	.211	63.209	3.245	.027	205.137	1.720
	16.000	.297	120.554	3.183	-.010	383.766	-1.218
	17.500	.332	147.544	3.142	-.02	463.556	-3.044
	17.500	.332	147.544	3.142	-.021	463.556	-3.044
	20.000	.392	198.592	3.064	-.035	608.389	-7.031
	24.000	.488	286.203	2.854	-.054	816.780	-15.591
	26.000	.581	372.056	2.611	-.070	971.407	-26.077
	32.000	.671	449.432	2.382	-.083	1070.402	-37.481
	36.000	.762	516.606	2.195	-.095	1134.015	-48.896
	40.000	.856	573.342	2.046	-.104	1172.864	-59.698
	44.000	.953	615.851	1.890	-.112	1163.975	-69.189
MACH ONE	45.935	1.000	629.726	1.792	-.116	1128.270	-73.069
	48.000	1.051	640.021	1.727	-.120	1105.591	-76.563
	52.000	1.154	648.515	1.709	-.126	1108.444	-81.474
Q MAXIMUM	54.491	1.224	649.711	1.743	-.129	1132.165	-83.915
	55.500	1.254	649.383	1.764	-.131	1145.347	-84.779
	55.500	1.254	649.383	1.764	-.131	1145.347	-84.779
30 KMS.	55.891	1.266	649.071	1.773	-.131	1150.789	-85.086
	56.000	1.269	648.960	1.776	-.131	1152.391	-85.168
	60.000	1.398	639.765	1.857	-.136	1187.958	-87.322
	64.000	1.536	617.292	1.846	-.142	1139.255	-87.486
19 KMS.	67.160	1.655	594.334	1.846	-.146	1096.974	-86.735
	68.000	1.689	587.736	1.847	-.147	1085.509	-86.437
	70.000	1.773	571.235	1.853	-.150	1058.647	-85.560
	70.000	1.773	571.235	1.853	-.150	1058.647	-85.560
	72.000	1.862	553.519	1.858	-.153	1028.483	-84.425
	76.000	2.044	509.450	1.829	-.158	931.694	-80.564

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.8

	TIME SEC	MACH	Q LB/FT**2	ALPHA DEG	BETA DEG	QALPHA LB-DEG/FT**2	QBETA LB-DEG/FT**2
	80.000	2.233	458.534	1.742	-.164	798.610	-75.202
	84.000	2.433	407.533	1.636	-.170	666.629	-69.276
	88.000	2.651	356.210	1.518	-.176	540.781	-62.724
	92.000	2.890	310.041	1.404	-.182	435.413	-56.511
	96.000	3.149	266.520	1.315	-.188	350.600	-50.219
	97.500	3.248	250.424	1.251	-.191	313.328	-47.758
	97.500	3.248	250.424	1.251	-.191	313.328	-47.758
	100.000	3.411	224.231	1.104	-.195	247.650	-43.636
	104.000	3.676	184.964	.845	-.201	156.359	-37.208
	107.500	3.910	154.197	.725	-.207	111.756	-31.945
	107.500	3.910	154.197	.725	-.207	111.756	-31.945
	108.000	3.944	149.978	.722	-.208	108.276	-31.208
	112.000	4.184	118.531	.793	-.217	94.029	-25.673
	116.000	4.378	90.993	.848	-.227	77.127	-20.666
	120.000	4.499	68.471	.696	-.241	47.647	-16.496
	121.420	4.506	60.795	.487	-.248	29.603	-15.061
SEPARATION	121.420	4.506	60.795	1.536	-.248	93.379	-15.061
BEGIN MINH	121.420	4.506	60.795	1.536	-.248	93.379	-15.061
	124.000	4.619	48.783	1.317	-.260	64.237	-12.707
	140.000	4.836	16.089	-.325	-.337	-5.227	-5.418
	156.000	5.490	6.051	-2.322	-.407	-14.053	-2.463
	172.000	6.284	2.227	-4.068	-.471	-9.059	-1.048
	188.000	7.239	.789	-5.474	-.528	-4.320	-.416
	204.000	7.960	.252	-6.544	-.579	-1.647	-.146
	220.000	8.296	.081	-7.305	-.624	-.589	-.050
	23 .000	8.538	.031	-7.792	-.664	-.241	-.021
	252.000	8.664	.014	-7.331	-.700	-.101	-.010
	253.041	8.680	.013	-7.099	-.702	-.094	-.009
INTERMEDIATE	253.041	8.680	.013	-7.099	-.702	-.094	-.009
	268.000	8.539	.007	-6.642	-.748	-.045	-.005
	284.000	8.390	.004	-7.288	-.793	-.030	-.003
	286.811	8.396	.004	-7.385	-.801	-.028	-.003
	286.811	8.396	.004	-7.385	-.801	-.028	-.003

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.8

	TIME SEC	MACH	Q LB/FT**2	ALPHA DEG	BETA DEG	QALPHA LB-DEG/FT**2	QBETA LB-DEG/FT**2
	300.000	8.418	.003	-7.774	-.834	-.024	-.003
	316.000	8.396	.002	-8.110	-.871	-.020	-.002
	332.000	8.499	.002	-8.309	-.904	-.018	-.002
	342.121	8.671	.002	-8.368	-.924	-.018	-.002
	342.121	8.671	.002	-8.368	-.924	-.018	-.002
	348.000	8.803	.002	-8.385	-.934	-.019	-.002
	364.000	9.276	.002	-8.353	-.961	-.021	-.002
	380.000	9.932	.003	-8.217	-.985	-.025	-.003
	396.000	10.820	.004	-7.985	-1.006	-.031	-.004
	412.000	11.944	.005	-7.666	-1.024	-.042	-.006
	428.000	13.132	.008	-7.279	-1.038	-.059	-.008
	444.000	14.354	.012	-6.834	-1.050	-.084	-.013
	460.000	15.799	.020	-6.333	-1.059	-.126	-.021
	476.000	17.557	.033	-5.778	-1.065	-.192	-.035
	492.000	19.196	.056	-5.166	-1.068	-.289	-.060
	508.000	20.759	.087	-4.491	-1.068	-.390	-.093
	524.000	22.410	.124	-3.747	-1.064	-.465	-.132
BEGIN GLIMIT	536.683	23.717	.152	-3.098	-1.058	-.471	-.161
	540.000	24.046	.157	-2.922	-1.057	-.460	-.166
	556.000	25.432	.165	-2.044	-1.050	-.337	-.173
	558.712	25.630	.163	-1.894	-1.049	-.308	-.171
INJECTION	558.712	25.630	.163	-1.894	-1.049	-.308	-.171
	558.712	25.630	.163	-1.894	-1.049	-.308	-.171

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.9

	TIME SEC	THRUST LBS	WEIGHT LBS	AXIAL FORCE LBS	NORMAL FORCE LBS	SIDE FORCE LBS	LONG ACC G'S	NORMAL ACC G'S
LIFT-OFF	.000	6617381.3	4390646.9	.0	-.0	.0	1.5006	.0744
	4.000	6788809.5	4286742.5	2462.1	534.1	11.8	1.5764	.0744
BEGIN ROLL	6.000	6854833.7	4233431.8	5814.5	1205.5	41.5	1.6111	.0745
BEGIN TILT	6.000	6854833.7	4233431.8	5814.5	1205.5	41.5	1.6111	.0745
END ROLL	7.855	6901844.7	4183779.3	10342.8	3775.9	-251.8	1.6404	.0741
	8.000	6905595.6	4179898.1	10756.1	4043.0	-253.0	1.6427	.0741
	12.000	7013792.8	4072454.5	25868.3	12892.7	-186.6	1.7068	.0724
	16.000	7130965.4	3963207.2	48623.8	23471.7	131.4	1.7797	.0703
	17.500	7177182.2	3922089.0	59268.5	27810.5	328.4	1.8074	.0693
	17.500	7177182.2	3922089.0	59268.5	27810.5	328.4	1.8074	.0693
	20.000	7138259.6	3853285.7	79503.1	35108.2	758.4	1.8243	.0681
	24.000	6795422.8	3747914.6	116235.5	41626.5	1681.7	1.7742	.0690
	28.000	6464642.4	3646803.3	149901.6	39081.1	2807.1	1.7233	.0723
	32.000	6157851.9	3551652.4	194277.0	52429.2	4124.9	1.6705	.0753
	36.000	5998622.1	3462608.4	246870.4	81236.1	5555.7	1.6521	.0763
	40.000	5839113.0	3373564.3	290150.4	116414.0	6971.8	1.6353	.0755
	44.000	5678188.7	3291030.1	401816.6	109904.5	8380.2	1.5934	.0757
MACH ONE	45.935	5599470.5	3251832.7	469540.6	88400.4	9047.4	1.5676	.0791
	48.000	5514613.2	3209985.9	507897.5	85064.8	9748.7	1.5495	.0808
	52.000	5422795.3	3130429.0	552542.2	132482.2	10557.5	1.5450	.0825
Q MAXIMUM	54.491	5441683.1	3082478.0	551068.6	162681.9	10743.8	1.5756	.0742
	55.500	5448831.9	3063074.9	548009.3	168810.3	10819.4	1.5889	.0730
	55.500	5448831.9	3063074.9	548009.3	168810.3	10819.4	1.5889	.0730
10 KMS.	55.891	5461593.6	3055409.7	546503.1	170579.6	10844.8	1.5975	.0727
	56.000	5465144.1	3053276.1	546061.2	171039.4	10851.4	1.6000	.0726
	60.000	5593125.7	2974885.1	530835.8	176760.7	10947.1	1.6902	.0712
	64.000	5715858.4	2896494.1	498911.6	160832.8	10786.5	1.7893	.0751
14 KMS.	67.160	5809197.8	2833214.7	459499.6	146102.4	10569.4	1.8761	.0784
	66.000	5833486.5	2816119.1	447631.8	141838.5	10500.6	1.9004	.0793
	70.000	5890436.9	2775147.0	420761.7	131306.9	10317.4	1.9586	.0815
	70.000	5890436.9	2775147.0	420761.7	131306.9	10317.4	1.9586	.0815
	72.000	5946183.9	2734175.0	393994.7	119883.0	10101.7	2.0182	.0839
	76.000	6030705.7	2651132.4	341992.9	93022.2	9473.7	2.1328	.0908

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.9

	TIME SEC	THRUST LBS	WEIGHT LBS	AXIAL FORCE LBS	NORMAL FORCE LBS	SIDE FORCE LBS	LONG ACC G'S	NORMAL ACC G'S
	80.000	6096873.8	2567430.5	290693.7	62584.2	8668.9	2.2481	.0998
	84.000	6159572.9	2482914.7	242150.1	34519.0	7811.6	2.3694	.1085
	88.000	6219609.8	2396984.6	201065.0	10804.4	6900.5	2.4964	.1161
	92.000	6277248.6	2310888.5	166617.2	-7878.3	6045.9	2.6292	.1222
	96.000	6331832.2	2224349.9	135935.2	-18415.8	5235.8	2.7697	.1269
	97.500	6348483.4	2191547.5	125141.5	-21583.2	4936.2	2.8237	.1289
	97.500	6348483.4	2191547.5	125141.5	-21583.2	4936.2	2.8237	.1289
	100.000	6260194.4	2137497.3	109434.0	-26043.5	4449.9	2.8611	.1337
	104.000	6118112.3	2052435.2	87368.1	-29477.5	3716.5	2.9212	.1407
	107.500	5957623.7	1979737.6	71243.4	-27379.7	3137.0	2.9555	.1451
	107.500	5957623.7	1979737.6	71243.4	-27379.7	3137.0	2.9630	.1401
	108.000	5865353.5	1969741.1	69249.8	-26751.9	3057.4	2.9320	.1417
	112.000	5125607.4	1895649.4	55043.2	-20763.5	2471.6	2.6619	.1554
	116.000	4386915.1	1832543.8	43501.4	-15630.1	1962.3	2.3543	.1709
	120.000	2509132.5	1786299.2	33094.0	-12780.5	1553.3	1.3613	.2125
	121.420	1735336.3	1778393.4	29284.5	-12653.9	1417.4	.9301	.2300
SEPARATION	121.420	1536324.2	1428013.4	27858.9	-322.2	1314.1	1.0282	.2445
BEGIN MINH	121.420	1536324.2	1428013.4	27858.9	-322.2	1314.1	1.0282	.2445
	124.000	1536439.4	1419304.4	22083.7	-1004.0	1107.1	1.0387	.2464
	140.000	1536767.3	1365295.3	5346.7	-2260.1	456.8	1.0926	.2558
	156.000	1536861.4	1311286.2	249.4	-1621.7	203.9	1.1419	.2643
	172.000	1536889.2	1257277.1	-1474.6	-836.5	87.3	1.1928	.2732
	188.000	1536897.1	1203268.0	-2136.5	-365.0	34.7	1.2474	.2828
	204.000	1536899.2	1149258.9	-2384.0	-133.1	12.1	1.3068	.2934
	220.000	1536899.8	1095249.8	-2456.1	-46.2	4.2	1.3720	.3048
	236.000	1536899.9	1041240.7	-2475.4	-18.4	1.7	1.4439	.3173
	252.000	1536900.0	987231.6	-2484.8	-7.7	.8	1.5237	.3308
	253.041	1536900.0	983719.0	-2485.2	-7.1	.8	1.5292	.3318
INTERMEDIATE	253.041	1040100.0	983658.0	14.7	-7.1	.8	1.0332	.2245
	268.000	1040100.0	949239.3	9.7	-3.4	.4	1.0711	.2309
	284.000	1040100.0	912426.4	7.2	-2.2	.3	1.1148	.2381
	286.811	1040100.0	905959.8	6.9	-2.1	.3	1.1228	.2394
	286.811	1036600.0	905959.8	6.9	-2.1	.3	1.1190	.2386

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.9

	TIME SEC	THRUST LBS	WEIGHT LBS	AXIAL FORCE LBS	NORMAL FORCE LBS	SIDE FORCE LBS	LONG ACC G'S	NORMAL ACC G'S
	300.000	1036600.0	876773.3	6.1	-1.7	.2	1.1580	.2449
	316.000	1036600.0	839154.2	5.5	-1.4	.2	1.2091	.2531
	332.000	1036600.0	802535.1	5.4	-1.3	.2	1.2643	.2619
	342.121	1036600.0	779372.2	5.5	-1.3	.2	1.3028	.2678
	342.121	1024600.0	779372.2	5.5	-1.3	.2	1.2877	.2647
	348.000	1024600.0	766141.3	5.7	-1.3	.2	1.3102	.2681
	364.000	1024600.0	730135.2	6.4	-1.4	.2	1.3765	.2780
	380.000	1024600.0	694129.1	7.7	-1.7	.2	1.4476	.2888
	396.000	1024600.0	658123.0	9.7	-2.1	.3	1.5276	.3005
	412.000	1024600.0	622117.0	13.0	-2.9	.5	1.6169	.3132
	428.000	1024600.0	586110.9	18.1	-4.2	.7	1.7173	.3269
	444.000	1024600.0	550104.8	25.3	-6.0	1.1	1.8309	.3415
	460.000	1024600.0	514098.8	37.3	-9.3	1.8	1.9604	.3574
	476.000	1024600.0	478092.7	56.2	-14.6	3.0	2.1099	.3750
	492.000	1024600.0	442086.6	84.9	-22.7	5.0	2.2836	.3950
	508.000	1024600.0	406080.6	121.4	-32.0	7.7	2.4879	.4185
	524.000	1024600.0	370074.5	164.5	-40.4	11.0	2.7319	.4470
BEGIN GLIMIT	536.683	1024600.0	341533.3	198.1	-43.5	13.4	2.9616	.4749
	540.000	1002449.9	334150.0	205.6	-43.3	13.9	2.9619	.4727
	556.000	902161.1	300720.4	224.7	-36.1	14.4	2.9632	.4639
	558.712	886185.7	295395.2	224.8	-34.0	14.2	2.9634	.4627
INJECTION	558.712	.0	295395.2	224.8	-34.0	14.2	2.9634	.4627
	558.712	.0	295395.1	.0	.0	.0	.0000	.0000

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/

CASE 1

TABLE NO. I.10

	TIME SEC	CHIR DEG	CHIP DEG	CHIY DEG	DELRC DEG	DELPC DEG	DELYC DEG
LIFT-OFF	.000	-161.471	-2.690	-.902	.000	-.681	.000
	4.000	-161.492	-2.686	-.900	.000	-.586	-.000
BEGIN ROLL	6.000	-161.492	-2.684	-.899	.000	-.542	-.000
BEGIN TILT	6.000	-161.492	-2.684	-.899	.000	-.542	-.000
END ROLL	7.855	-180.000	-3.522	-.000	.000	-.506	.000
	8.000	180.000	-3.590	.000	.000	-.503	.000
	12.000	180.000	-5.553	.000	.000	-.422	.000
	16.000	180.000	-7.737	.000	.000	-.333	-.000
	17.500	180.000	-8.617	.000	.000	-.297	-.000
	17.500	180.000	-8.617	.000	.000	-.297	-.000
	20.000	180.000	-10.135	.000	.000	-.262	-.001
	24.000	180.000	-12.495	.000	.000	-.270	-.002
	28.000	180.000	-14.780	.000	.000	-.269	-.003
	32.000	180.000	-17.043	.000	.000	-.444	-.005
	36.000	180.000	-19.362	.000	.000	-.722	-.008
	40.000	180.000	-21.768	.000	.000	-1.025	-.011
	44.000	180.000	-24.220	.000	.000	-.850	-.014
MACH ONE	45.935	180.000	-25.389	.000	.000	-.658	-.015
	48.000	180.000	-26.662	.000	.000	-.987	-.014
	52.000	180.000	-29.252	.000	.000	-1.256	-.013
Q MAXIMUM	54.491	180.000	-30.987	.000	.000	-1.232	-.012
	55.500	180.000	-31.712	.000	.000	-1.236	-.013
	55.500	180.000	-31.712	.000	.000	-1.236	-.013
10 KMS.	55.891	180.000	-31.995	.000	.000	-1.231	-.013
	56.000	180.000	-32.074	.000	.000	-1.230	-.013
	60.000	180.000	-34.999	.000	.000	-1.096	-.014
	64.000	180.000	-37.834	.000	.000	-.894	-.015
14 KMS.	67.160	180.000	-40.050	.000	.000	-.715	-.016
	68.000	180.000	-40.633	.000	.000	-.666	-.017
	70.000	180.000	-42.010	.000	.000	-.545	-.018
	70.000	180.000	-42.010	.000	.000	-.545	-.018
	72.000	180.000	-43.362	.000	.000	-.423	-.018
	76.000	180.000	-45.938	.000	.000	-.199	-.018

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.10

	TIME SEC	CMIR DEG	CMIP DEG	CMIY DEG	DELRC DEG	DELPC DEG	DELYC DEG
	80.000	180.000	-48.312	.000	.000	.007	-.016
	84.000	180.000	-50.508	.000	.000	.202	-.014
	88.000	180.000	-52.531	.000	.000	.391	-.012
	92.000	180.000	-54.404	.000	.000	.568	-.011
	96.000	180.000	-56.159	.000	.000	.693	-.010
	97.500	180.000	-56.751	.000	.000	.728	-.009
	97.500	180.000	-56.751	.000	.000	.728	-.009
	100.000	180.000	-57.649	.000	.000	.757	-.009
	104.000	180.000	-58.941	.000	.000	.789	-.008
	107.500	180.000	-60.069	.000	.000	.813	-.007
	107.500	180.000	-60.069	.000	.000	-9.373	-.027
	108.000	180.000	-60.239	.000	.000	-9.463	-.026
	112.000	180.000	-61.632	.000	.000	-10.271	-.022
	116.000	180.000	-62.917	.000	.000	-11.168	-.018
	120.000	180.000	-63.897	.000	.000	-13.814	-.015
	121.420	180.000	-64.056	.000	.000	-14.954	-.014
SEPARATION	121.420	180.000	-65.105	.000	.000	-13.124	-.017
BEGIN MINH	121.420	180.000	-65.105	.000	.000	-13.124	-.017
	124.000	180.000	-65.541	.000	.000	-13.117	-.014
	140.000	180.000	-67.774	.000	.000	-13.052	-.006
	156.000	180.000	-69.250	.000	.000	-12.973	-.002
	172.000	180.000	-70.561	.000	.000	-12.883	-.001
	188.000	180.000	-71.825	.000	.000	-12.780	-.000
	204.000	180.000	-73.075	.000	.000	-12.667	-.000
	220.000	180.000	-74.325	.000	.000	-12.544	-.000
	236.000	180.000	-75.580	.000	.000	-12.412	-.000
	252.000	180.000	-77.554	.000	.000	-12.273	-.000
	253.041	180.000	-77.882	.000	.000	-12.260	-.000
INTERMEDIATE	253.041	180.000	-77.882	.000	.000	-12.260	-.000
	268.000	180.000	-80.207	.000	.000	-12.164	-.000
	284.000	180.000	-81.402	.000	.000	-12.056	-.000
	286.811	180.000	-81.613	.000	.000	-12.036	-.000
	286.811	180.000	-81.613	.000	.000	-12.036	-.000

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/

CASE 1

TABLE NO. I.10

	TIME SEC	CHIR DEG	CHIP DEG	CHIY DEG	DELRC DEG	DELPC DEG	DELYC DEG
	300.000	180.000	-82.602	.000	.000	-11.942	-.000
	316.000	180.000	-83.805	.000	.000	-11.823	-.000
	332.000	180.000	-85.011	.000	.000	-11.697	-.000
	342.121	180.000	-85.777	.000	.000	-11.614	-.000
	342.121	180.000	-85.777	.000	.000	-11.614	-.000
	348.000	180.000	-86.223	.000	.000	-11.566	-.000
	364.000	180.000	-87.439	.000	.000	-11.428	.000
	380.000	180.000	-88.660	.000	.000	-11.282	.000
	396.000	180.000	-89.884	.000	.000	-11.127	.000
	412.000	180.000	-91.110	.000	.000	-10.963	.000
	428.000	180.000	-92.329	.000	.000	-10.777	.000
	444.000	180.000	-93.536	.000	.000	-10.564	.000
	460.000	180.000	-94.734	.000	.000	-10.329	.000
	476.000	180.000	-95.927	.000	.000	-10.076	.000
	492.000	180.000	-97.124	.000	.000	-9.811	.000
	508.000	180.000	-98.333	.000	.000	-9.545	.000
	524.000	180.000	-99.565	.000	.000	-9.290	.000
BEGIN GLIMIT	536.683	180.000	-100.570	.000	.000	-9.106	.000
	540.000	180.000	-100.836	.000	.000	-9.063	.000
	556.000	180.000	-102.174	.000	.000	-8.892	.000
	558.712	180.000	-102.405	.000	.000	-8.870	.001
INJECTION	558.712	180.000	-102.405	.000	.000	-8.870	.001
	558.712	180.000	-102.405	.000	.000	.000	.000

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/

CASE 1

TABLE NO. I.11

	TIME SEC	RANGE NM	RANGE ANGLE DEG	IIP LAT DEG	IIP LONG DEG	VCH FT/SEC	VIDEAL FT/SEC
LIFT-OFF	.000	.0	.0	34.8	-120.5	.000	.000
	4.000	.0	.0	34.8	-120.5	197.658	221.360
BEGIN ROLL	6.000	.0	.0	34.8	-120.5	300.479	336.184
BEGIN TILT	6.000	.0	.0	34.8	-120.5	300.479	336.184
END ROLL	7.855	.0	.0	34.8	-120.5	397.718	444.613
	8.000	.0	.0	34.8	-120.5	405.395	453.167
	12.000	.0	.0	34.8	-120.5	621.780	693.750
	16.000	.0	.1	34.8	-120.5	847.596	943.621
	17.500	.0	.1	34.8	-120.5	934.890	1039.840
	17.500	.0	.1	34.8	-120.5	934.890	1039.840
	20.000	.0	.1	34.8	-120.5	1082.891	1202.538
	24.000	.1	.1	34.8	-120.5	1317.964	1460.472
	28.000	.2	.1	34.8	-120.5	1547.966	1712.265
	32.000	.3	.1	34.8	-120.5	1772.495	1957.254
	36.000	.4	.1	34.8	-120.5	1994.738	2198.419
	40.000	.6	.1	34.8	-120.5	2216.813	2437.750
	44.000	.8	.1	34.8	-120.5	2438.478	2674.957
MACH ONE	45.935	.9	.2	34.7	-120.5	2545.361	2788.757
	48.000	1.1	.2	34.7	-120.5	2659.223	2909.555
	52.000	1.4	.2	34.7	-120.6	2879.526	3141.961
Q MAXIMUM	54.491	1.6	.2	34.7	-120.6	3019.169	3288.317
	55.500	1.7	.2	34.7	-120.6	3076.501	3348.197
	55.500	1.7	.2	34.7	-120.6	3076.501	3348.197
10 KMS.	55.691	1.8	.2	34.7	-120.6	3098.860	3371.517
	56.000	1.8	.2	34.7	-120.6	3105.103	3378.025
	60.000	2.2	.2	34.6	-120.6	3340.371	3622.289
	64.000	2.8	.2	34.6	-120.6	3587.378	3876.953
14 KMS.	67.160	3.3	.2	34.5	-120.6	3791.116	4085.907
	68.000	3.4	.2	34.5	-120.6	3846.598	4142.663
	70.000	3.7	.2	34.5	-120.6	3981.001	4279.928
	70.000	3.7	.2	34.5	-120.6	3981.001	4279.928
	72.000	4.1	.2	34.4	-120.7	4118.705	4420.268
	76.000	4.9	.2	34.4	-120.7	4404.002	4710.235

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.11

	TIME SEC	RANGE NM	RANGE ANGLE DEG	IIP LAT DEG	IIP LONG DEG	VCH FT/SEC	VIDEAL FT/SEC
	80.000	5.9	.3	34.3	-120.7	4701.875	5012.109
	84.000	7.0	.3	34.2	-120.8	5012.889	5326.604
	88.000	8.2	.3	34.0	-120.8	5337.960	5664.757
	92.000	9.6	.3	33.9	-120.9	5678.083	5997.678
	96.000	11.2	.3	33.7	-121.0	6034.302	6356.496
	97.500	11.8	.3	33.6	-121.0	6172.219	6496.349
	97.500	11.8	.3	33.6	-121.0	6172.219	6496.349
	100.000	12.9	.3	33.5	-121.1	6405.396	6730.045
	104.000	14.9	.4	33.3	-121.1	6783.857	7110.854
	107.500	16.7	.4	33.1	-121.2	7119.955	7448.948
	107.50	16.7	.4	33.1	-121.2	7119.955	7448.948
	108.000	17.0	.4	33.1	-121.2	7167.987	7497.147
	112.000	19.4	.4	32.8	-121.3	7532.920	7863.453
	116.000	21.9	.4	32.6	-121.4	7860.278	8192.269
	120.000	24.6	.5	32.4	-121.5	8119.776	8453.301
	121.420	25.6	.5	32.4	-121.5	8173.438	8507.330
SEPARATION	121.420	25.6	.5	32.4	-121.5	8173.438	8507.330
BEGIN MINM	121.420	25.6	.5	32.4	-121.5	8173.438	8507.330
	124.000	27.4	.5	32.3	-121.5	8263.020	8596.942
	140.000	39.4	.7	31.9	-121.7	8831.243	9165.261
	156.000	52.5	.9	31.5	-121.9	9422.474	9756.522
	172.000	66.9	1.1	31.0	-122.1	10038.598	10372.654
	188.000	82.6	1.3	30.4	-122.3	10681.785	11015.894
	204.000	99.8	1.6	29.8	-122.6	11354.516	11688.576
	220.000	118.4	1.9	29.2	-122.8	12059.636	12393.696
	236.000	138.7	2.2	28.5	-123.1	12800.420	13134.481
	252.000	160.6	2.5	27.7	-123.4	13580.671	13914.731
	253.041	162.1	2.5	27.7	-123.4	13632.885	13966.945
INTERMEDIATE	253.041	162.1	2.5	27.7	-123.4	13632.885	13966.945
	268.000	184.1	2.9	27.2	-123.6	14150.923	14484.983
	284.000	208.8	3.3	26.6	-123.8	14726.210	15060.270
	286.811	213.3	3.4	26.5	-123.9	14829.658	15163.718
	286.811	213.3	3.4	26.5	-123.9	14829.658	15163.718

SA+1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AGA MECO/ CASE 1

TABLE NO. I.11

	TIME SEC	RANGE NM	RANGE ANGLE DEG	IIP LAT DEG	IIP LONG DEG	VCM FT/SEC	VIDEAL FT/SEC
	300.000	235.0	3.7	26.0	-124.1	15323.480	15657.540
	316.000	262.5	4.1	25.4	-124.3	15945.904	16279.964
	332.000	291.6	4.6	24.7	-124.5	16596.104	16930.164
	342.121	310.8	4.9	24.3	-124.7	17022.882	17356.942
	342.121	310.8	4.9	24.3	-124.7	17022.882	17356.942
	348.000	322.2	5.1	24.0	-124.8	17273.701	17607.761
	364.000	354.6	5.6	23.3	-125.1	17978.851	18312.911
	380.000	388.7	6.2	22.5	-125.3	18719.668	19053.728
	396.000	424.6	6.7	21.7	-125.6	19499.955	19834.015
	412.000	462.6	7.4	20.8	-126.0	20324.155	20658.215
	428.000	502.6	8.0	19.8	-126.3	21197.511	21531.572
	444.000	545.0	8.7	18.6	-126.7	22126.258	22460.318
	460.000	589.7	9.4	17.3	-127.1	23117.891	23451.951
	476.000	637.1	10.2	15.8	-127.6	24181.556	24515.616
	492.000	687.2	11.0	13.8	-128.3	25328.544	25662.604
	508.000	740.4	11.9	11.1	-129.2	26573.027	26907.087
	524.000	797.0	12.8	6.9	-130.5	27933.133	28267.193
BEGIN GLIMIT	536.683	844.3	13.6	.9	-132.3	29108.837	29442.898
	540.000	857.1	13.8	-1.6	-133.1	29429.018	29763.078
	556.000	921.1	14.8	-35.8	-145.0	30973.370	31307.430
	558.712	932.4	15.0	-59.0	-160.4	31235.093	1569.154
INJECTION	558.712	932.4	15.0	-59.0	-160.4	31235.093	31569.154
	558.712	932.4	15.0	-59.0	-160.4	31235.093	31569.154

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.12

	TIME SEC	X FT	Y FT	Z FT	XDOT FT/SEC	YDOT FT/SEC	ZDOT FT/SEC
LIFT-OFF	.000	20902623.5	-20962.5	62469.2	.000	-1186.331	-398.092
	4.000	20902757.7	-25708.0	60877.4	68.757	-1186.374	-397.916
BEGIN ROLL	6.000	20902933.2	-28080.8	60081.8	107.082	-1186.415	-397.737
BEGIN TILT	6.000	20902933.2	-28080.8	60081.8	107.082	-1186.415	-397.737
END ROLL	7.855	20903166.2	-30281.7	59344.5	144.440	-1186.471	-396.925
	8.000	20903187.2	-30453.7	59287.0	147.433	-1186.466	-396.801
	12.000	20903947.7	-35199.3	57712.1	234.243	-1186.319	-389.238
	16.000	20905072.2	-39944.2	56185.1	329.369	-1186.149	-372.608
	17.500	20905594.5	-41723.4	55632.7	367.209	-1186.080	-363.693
	17.500	20905594.5	-41723.4	55632.7	367.209	-1186.080	-363.693
	20.000	20906593.5	-44688.5	54745.5	432.071	-1185.963	-345.379
	24.000	20908524.2	-49431.9	53434.6	532.018	-1185.773	-308.713
	26.000	20910839.0	-54174.7	52285.7	624.124	-1185.587	-264.601
	32.000	20913505.7	-58916.6	51326.3	707.759	-1185.413	-214.101
	36.000	20916493.0	-63658.0	50582.1	785.194	-1185.258	-156.760
	40.000	20919781.2	-68398.7	50082.5	858.042	-1185.123	-91.752
	44.000	20923349.5	-73139.0	49857.8	924.782	-1185.011	-19.519
MACH ONE	45.935	20925167.0	-75431.5	49855.6	953.862	-1184.965	17.329
	48.000	20927167.5	-77878.9	49932.8	982.973	-1184.926	57.667
	52.000	20931204.2	-82618.4	50325.9	1034.558	-1184.874	140.255
Q MAXIMUM	54.491	20933820.0	-85569.7	50745.5	1065.807	-1184.844	197.529
	55.500	20934902.0	-86765.4	50957.2	1078.509	-1184.831	222.185
	55.500	20934902.0	-86765.4	50957.2	1078.509	-1184.831	222.185
10 KMS.	55.591	20935324.7	-87228.9	51046.0	1083.461	-1184.826	231.975
	56.000	20935442.7	-87357.8	51071.4	1084.846	-1184.825	234.726
	60.000	20939887.0	-92097.0	52223.4	1137.854	-1184.764	343.932
	64.000	20944551.2	-96[illegible].9	53844.0	1195.081	-1184.678	469.090
14 KMS.	67.160	20948403.5	-100[illegible].4	55498.7	1243.454	-1184.587	580.008
	68.000	20949453.5	-101[illegible].4	55999.0	1256.785	-1184.559	611.386
	70.000	20951999.2	-103[illegible]	57299.0	1289.300	-1184.485	689.408
	70.000	20951999.2	-103[illegible]	57299.0	1289.300	-1184.485	689.408
	72.000	20954611.0	-106312.3	58759.8	1322.816	-1184.401	772.159
	76.000	20960040.7	-111049.6	62201.8	1392.539	-1184.199	951.916

SA-1/EL-24

MISSION-SA/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.12

	TIME SEC	X FT	Y FT	Z FT	XDOT FT/SEC	YDOT FT/SEC	ZDOT FT/SEC
	80.000	20965755.2	-115785.9	66399.5	1465.066	-1183.949	1150.010
	84.000	20971765.0	-120521.1	71426.6	1540.368	-1183.649	1366.693
	88.000	20978081.7	-125255.0	77358.7	1618.408	-1183.294	1602.559
	92.000	20984715.7	-129987.4	84273.4	1699.041	-1182.881	1858.133
	96.000	20991677.2	-134718.0	92251.0	1782.097	-1182.408	2134.210
	97.500	20994374.2	-136491.4	95533.7	1813.893	-1182.216	2243.128
	97.500	20994374.2	-136491.4	95533.7	1813.893	-1182.216	2243.128
	100.000	20998975.2	-139446.5	101373.4	1866.769	-1181.677	2429.345
	104.000	21006608.7	-144172.9	111700.9	1949.668	-1181.287	2736.198
	107.500	21013556.7	-148306.4	121760.2	2020.140	-1180.724	3013.075
	107.500	21013556.7	-148306.4	121760.2	2020.140	-1180.724	3013.075
	108.000	21014569.2	-148896.8	123276.7	2029.766	-1180.639	3053.004
	112.000	21022824.5	-153617.9	136107.8	2094.151	-1179.924	3358.086
	116.000	21031292.2	-158336.1	150102.4	2135.820	-1179.157	3633.893
	120.000	21039872.0	-163051.1	165111.8	2144.511	-1178.339	3851.039
	121.420	21042908.5	-164724.1	170611.9	2131.257	-1178.038	3892.983
SEPARATION	121.420	21042908.5	-164724.1	170611.9	2131.257	-1178.038	3892.983
BEGIN MINH	121.420	21042908.5	-164724.1	170611.9	2131.257	-1178.038	3892.983
	124.000	21048371.2	-167762.7	180744.4	2103.605	-1177.476	3961.868
	140.000	21080653.2	-186572.4	247679.6	1931.538	-1173.630	4410.836
	156.000	21110187.7	-205316.1	322056.1	1760.644	-1169.254	4891.032
	172.000	21137007.7	-223986.0	404344.7	1592.353	-1164.405	5399.839
	188.000	21161158.5	-242574.7	495008.1	1426.986	-1159.109	5938.133
	204.000	21182687.0	-261075.2	594532.5	1264.552	-1153.381	6507.855
	220.000	21201639.2	-279480.6	703440.6	1104.920	-1147.229	7111.573
	236.000	21218058.2	-297784.3	822300.6	947.876	-1140.660	7752.392
	252.000	21231982.7	-315979.5	951735.0	792.315	-1133.678	8434.385
	253.041	21232801.7	-317159.0	960535.7	781.630	-1133.213	8480.548
INTERMEDIATE	253.041	21232801.7	-317159.0	960535.7	781.630	-1133.213	8480.548
	268.000	21242525.0	-334059.8	1090782.4	516.776	-1126.287	8936.408
	284.000	21248496.0	-352018.5	1237810.3	229.071	-1118.490	9445.838
	286.811	21249068.5	-355160.2	1264487.6	178.199	-1117.078	9537.693
	286.811	21249068.5	-355160.2	1264487.6	178.199	-1117.078	9537.693

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO. I.12

	TIME SEC	X FT	Y FT	Z FT	XDOT FT/SEC	YDOT FT/SEC	ZDOT FT/SEC
	300.000	21249833.5	-369849.3	1393163.6	-62.619	-1110.286	9977.070
	316.000	21246470.2	-387545.5	1557209.4	-358.532	-1101.676	10532.993
	332.000	21238334.7	-405100.8	1730363.7	-659.282	-1092.662	11115.990
	342.121	21230687.2	-416129.4	1844796.0	-852.380	-1086.751	11499.788
	342.121	21230687.2	-416129.4	1844796.0	-852.380	-1086.751	11499.788
	348.000	21225340.7	-422508.5	1913069.6	-966.481	-1083.243	11725.548
	364.000	21207365.0	-439762.4	2105723.5	-1281.648	-1073.420	12361.622
	380.000	21184287.2	-456855.8	2308823.5	-1604.439	-1063.193	13031.836
	396.000	21155976.2	-473782.4	2522942.7	-1935.996	-1052.563	13739.657
	412.000	21122281.7	-490535.7	2748714.7	-2277.623	-1041.531	14489.156
	428.000	21083030.7	-507109.3	2986843.6	-2630.835	-1030.097	15285.152
	444.000	21038023.7	-523496.7	3238119.0	-2997.415	-1018.263	16133.400
	460.000	20987030.7	-539691.5	3503427.8	-3379.470	-1006.031	17040.941
	476.000	20929784.7	-555687.6	3783785.7	-3779.547	-993.406	18015.980
	492.000	20865972.7	-571478.4	4080355.9	-4200.748	-980.391	19069.350
	508.000	20795227.7	-587058.0	4394492.2	-4646.938	-966.994	20214.220
	524.000	20717111.7	-602420.3	4727788.9	-5123.019	-953.225	21467.631
BEGIN GLIMIT	536.683	20649609.2	-614439.3	5006847.0	-5525.797	-942.054	22552.858
	540.000	20631098.0	-617559.3	5082149.2	-5635.280	-939.095	22848.407
	556.000	20536574.7	-632469.4	5459092.5	-6186.469	-924.613	24267.711
	558.712	20519668.5	-634973.2	5525220.2	-6283.656	-922.125	24507.151
INJECTION	558.712	20519668.5	-634973.2	5525220.2	-6283.656	-922.125	24507.151
	558.712	20519668.5	-634973.2	5525220.2	-6283.656	-922.125	24507.151

SA-1/EL-24

MISSION-3A/MCR-500/LIFTOFF TO AOA MECO/

CASE 1

TABLE NO. I.13

	TIME SEC	XACC FT/SEC**2	YACC FT/SEC**2	ZACC FT/SEC**2	HEAT BTU/FT**2	HEAT RATE BTU/FT**2-S
LIFT-OFF	.000	16.1224	.0167	-.0497	.0	.0
	4.000	18.5588	-.0125	.0613	.0	.0
BEGIN ROLL	6.000	19.6730	-.0256	.1120	.0	.0
BEGIN TILT	6.000	19.6730	-.0256	.1120	.0	.0
END ROLL	7.855	20.6072	.0328	.8178	.0	.0
	8.000	20.6806	.0331	.8860	.0	.0
	12.000	22.7339	.0399	2.9577	.0	.0
	16.000	24.8334	.0449	5.4285	.1	.0
	17.500	25.6209	.0462	6.4700	.1	.0
	17.500	25.6209	.0462	6.4700	.1	.0
	20.000	25.9592	.0474	8.1323	.2	.0
	24.000	24.0121	.0473	10.1466	.4	.1
	28.000	22.0128	.0453	11.8635	.8	.1
	32.000	19.9122	.0414	13.4026	1.5	.2
	36.000	18.7861	.0363	15.2759	2.4	.3
	40.000	17.5989	.0310	17.2264	3.6	.4
	44.000	15.6001	.0251	18.7807	5.2	.4
MACH ONE	45.935	14.5082	.0217	19.2954	6.1	.5
	48.000	13.6921	.0164	19.7875	7.2	.5
	52.000	12.5379	.0117	21.9449	9.6	.6
Q MAXIMUM	54.491	12.5659	.0125	24.0222	11.2	.7
	55.500	12.6057	.0130	24.8410	12.0	.7
	55.500	12.6057	.0130	24.8410	12.0	.7
10 KMS.	55.891	12.7138	.0132	25.2181	12.2	.7
	56.000	12.7438	.0133	25.3236	12.3	.7
	60.000	13.7580	.0178	29.2800	15.6	.9
	64.000	14.8623	.0254	33.3668	19.4	1.0
14 KMS.	67.160	15.7529	.0324	36.8718	22.9	1.2
	68.000	15.9887	.0344	37.8413	23.9	1.2
	70.000	16.5127	.0395	40.1848	26.4	1.3
	70.000	16.5127	.0395	40.1848	26.4	1.3
	72.000	17.0047	.0447	42.5750	29.2	1.4
	76.000	17.7808	.0564	47.2301	35.4	1.7

SA=1/EL=24

MISSION=3A/MCR=600/LIFTOFF TO AOA MECO/

CASE 1

TABLE NO.I.13

	TIME SEC	XACC FT/SEC**2	YACC FT/SEC**2	ZACC FT/SEC**2	HEAT BTU/FT**2	HEAT RATE BTU/FT**2-S
	80.000	18.4789	.0687	51.8238	42.7	2.0
	84.000	19.1711	.0814	56.5452	51.1	2.3
	88.000	19.8393	.0960	61.4048	60.8	2.6
	92.000	20.4693	.1107	66.4146	71.8	2.9
	96.000	21.0746	.1254	71.6481	84.3	3.3
	97.500	21.3440	.1310	73.6038	89.4	3.5
	97.500	21.3440	.1310	73.6038	89.4	3.5
	100.000	20.9720	.1402	76.3552	98.4	3.7
	104.000	20.4712	.1547	78.0523	113.9	4.0
	107.500	19.6165	.1669	79.9402	128.5	4.3
	107.500	19.5957	.1702	80.2274	128.5	4.3
	108.000	18.9102	.1719	79.4860	130.6	4.3
	112.000	13.2429	.1853	72.8220	148.3	4.5
	116.000	7.5596	.1983	64.7558	166.3	4.5
	120.000	-6.3852	.2102	36.1172	183.8	4.2
	121.420	-12.0385	.2144	23.4574	189.7	4.1
SEPARATION	121.420	-10.7232	.2141	26.4841	189.7	4.1
BEGIN MINH	121.420	-10.7232	.2141	26.4841	189.7	4.1
	124.000	-10.7162	.2214	26.9112	199.7	3.7
	140.000	-10.7514	.2579	29.1003	247.9	2.5
	156.000	-10.6051	.2886	30.9063	281.5	1.8
	172.000	-10.4276	.3172	32.7056	305.6	1.3
	188.000	-10.2430	.3446	.6016	322.7	.9
	204.000	-10.0627	.3713	.6404	334.4	.6
	220.000	-9.8935	.3976	38.8566	342.2	.4
	236.000	-9.7397	.4235	41.2841	347.7	.3
	252.000	-10.1704	.4492	44.2252	351.8	.2
	253.041	-10.3609	.4508	44.4982	352.0	.2
INTERMEDIATE	253.041	-17.0840	.4508	29.6204	352.0	.2
	268.000	-17.6883	.4747	31.1424	355.0	.2
	284.000	-18.0812	.5001	32.5530	357.7	.2
	286.811	-18.1191	.5045	32.8116	358.1	.2
	286.811	-18.1025	.5045	32.6951	358.1	.2

SA•1/EL=24

MISSION=3A/MCR=500/LIFTOFF TO AOA MECO/ CASE 1

TABLE NO• I.13

	TIME SEC	XACC FT/SEC••2	YACC FT/SEC••2	ZACC FT/SEC••2	HEAT BTU/FT••2	HEAT RATE BTU/FT••2-S
	300•000	-18•3591	•5254	33•9434	360•1	•2
	316•000	-18•6377	•5508	35•5684	362•5	•2
	332•000	-18•9644	•5760	37•3306	365•0	•2
	342•121	-19•1986	•5920	38•5253	366•7	•2
	342•121	-19•3338	•5920	38•0487	366•7	•2
	348•000	-19•4814	•6013	38•7521	367•7	•2
	364•000	-19•9251	•6266	40•7881	370•9	•2
	380•000	-20•4357	•6518	43•0246	374•7	•3
	396•000	-21•0224	•6770	45•4953	379•5	•3
	412•000	-21•6967	•7021	48•2420	385•7	•5
	428•000	-22•4731	•7271	51•3166	394•2	•6
	444•000	-23•3707	•7521	54•7854	405•9	•9
	460•000	-24•4126	•7768	58•7327	422•3	1•2
	476•000	-25•6291	•8013	63•2686	446•2	1•8
	492•000	-27•0611	•8254	68•5396	481•2	2•6
	508•000	-28•7638	•8490	74•7450	531•6	3•7
	524•000	-30•8126	•8720	82•1619	601•6	5•1
BEGIN GLIMIT	536•683	-32•7568	•8897	89•1594	673•3	6•2
	540•000	-33•4512	•8942	89•0328	694•5	6•5
	556•000	-35•6419	•9159	88•3647	808•6	7•6
	558•712	-36•0407	•9195	88•2425	829•5	7•7
INJECTION	558•712	-36•0407	•9195	88•2425	829•5	7•7
	558•712	-30•0973	•9219	-8•0726	829•5	7•7

SA-I/SL-24

MISSION-3A/MCR-5LC/AOA/RTLS POINT TO NOM MECO

CASE 1

TABLE NO. I.14

	TIME SEC	R FT	VI FT/SEC	GAMMAI DEG	LAT-CD DEG	LONG DEG	AZI DEG
IGNITION	253.041	21250882.7	8591.555	7.000	32.446	-121.573	-169.011
BEGIN MINH	253.041	21256382.7	8591.555	7.000	32.446	-121.573	-169.011
	269.000	21273375.0	9273.717	5.882	32.072	-121.728	-168.448
	285.000	21287306.7	10012.652	4.195	31.656	-121.904	-167.948
	301.000	21297427.7	10868.851	2.780	31.227	-122.072	-167.507
	317.000	21304169.0	11665.734	1.638	30.755	-122.262	-167.116
	333.000	21308097.5	12588.139	.733	30.245	-122.466	-166.770
	349.000	21309434.7	13582.568	.243	29.696	-122.683	-166.463
	365.000	21308557.5	14657.557	-.450	29.104	-122.914	-166.191
	381.000	21305915.2	15824.223	-.759	28.465	-123.161	-165.951
	397.000	21302050.7	17097.089	-.894	27.770	-123.424	-165.739
	413.000	21297620.0	18495.318	-.963	27.032	-123.704	-165.553
BEGIN CLIMIT	418.898	21296001.5	19046.275	-.811	26.743	-123.812	-165.490
	429.000	21293409.5	20011.215	-.589	26.227	-124.003	-165.395
	445.000	21290116.5	21539.185	-.428	25.358	-124.321	-165.278
	461.000	21289365.7	23067.906	-.117	24.425	-124.658	-165.197
	477.000	21288861.7	24596.624	.273	23.429	-125.011	-165.145
	485.231	21290246.0	25382.783	.500	22.891	-125.200	-165.127
INJECTION	485.231	21290246.0	25382.783	.500	22.891	-125.200	-165.127
	485.231	21290246.0	25382.783	.500	22.891	-125.200	-165.127

SA-I/EL-24

MISSION-3A/MCR-5CO/AOA/RTLS POINT TO NOM MECO

CASE 1

TABLE NO. I.15

	TIME SEC	ALT FT	INC DEG	NODE DEG	VR FT/SEC	GAMMAR DEG	AZR DEG
IGNITION	253.041	351277.61	99.275	-5.935	8932.215	7.597	-160.656
BEGIN MINH	253.041	351277.61	99.275	-5.935	8932.215	7.597	-160.656
	269.000	367857.30	99.789	-6.268	9623.028	5.668	-160.702
	285.000	380844.49	100.255	-6.567	10359.414	4.041	-160.759
	301.000	390369.45	100.679	-6.835	11172.082	2.690	-160.823
	317.000	396720.63	101.067	-7.077	12034.647	1.538	-160.894
	333.000	400106.69	101.423	-7.295	12962.103	.712	-160.974
	349.000	400964.12	101.752	-7.492	13961.074	.041	-161.060
	365.000	399369.50	102.057	-7.672	15040.194	-.438	-161.154
	381.000	396070.62	102.341	-7.836	16210.660	-.741	-161.255
	397.000	391508.00	102.607	-7.985	17487.053	-.874	-161.364
	413.000	386355.77	102.858	-8.122	18888.588	-.945	-161.480
BEGIN CLIMIT	418.888	384453.30	102.947	-8.169	19440.714	-.795	-161.524
	429.000	381353.27	103.091	-8.245	20407.556	-.676	-161.602
	445.000	377216.90	103.292	-8.347	21938.231	-.430	-161.729
	461.000	374598.79	103.467	-8.433	23469.750	-.115	-161.855
	477.000	374195.25	103.621	-8.505	25000.223	.269	-161.984
	485.231	375106.30	103.692	-8.538	25787.411	.492	-162.051
INJECTION	485.231	375106.30	103.692	-8.538	25787.411	.492	-162.051
	485.231	375106.30	103.692	-8.538	25787.411	.492	-162.051

SA-I/IL-24

MISSION-3A/MCR-500/ACA/RTLS POINT TO NOM MECO CASE 1

TABLE NO. I.16

	TIME SEC	MACH	Q LB/FT**2	ALPHA DEG	BETA DEG	QALPHA LB-DEG/FT**2	QBETA LB-DEG/FT**2
IGNITION	253.041	8.680	.013	4.455	-.702	.059	-.009
BEGIN MINH	253.041	8.680	.013	4.455	-.702	.059	-.009
	269.000	8.734	.007	3.262	-.774	.023	-.005
	285.000	8.823	.005	2.336	-.761	.011	-.003
	301.000	9.115	.004	1.648	-.784	.006	-.003
	317.000	9.435	.003	1.168	-.803	.004	-.003
	333.000	9.892	.003	.871	-.818	.003	-.003
	349.000	10.589	.004	.734	-.830	.003	-.003
	365.000	11.547	.005	.739	-.838	.003	-.004
	381.000	12.770	.006	.869	-.844	.005	-.005
	397.000	14.182	.009	1.110	-.846	.010	-.007
	413.000	15.710	.012	1.450	-.845	.018	-.010
BEGIN CLIMIT	418.888	16.301	.014	1.598	-.844	.022	-.012
	429.000	17.329	.017	1.864	-.842	.032	-.015
	445.000	18.951	.024	2.297	-.842	.054	-.020
	461.000	20.529	.030	2.744	-.843	.084	-.026
	477.000	21.902	.035	3.200	-.847	.113	-.030
	485.231	22.492	.036	3.447	-.849	.124	-.030
INJECTION	485.231	22.492	.036	3.447	-.849	.124	-.030
	485.231	22.492	.036	3.447	-.849	.124	-.030

SA-I/SL-24

MISSION-SA/MCR-SCC/ASA/RTLS POINT TO NOM MECO

CASE 1

TABLE NO. I.17

	TIME SEC	THRUST LBS	WEIGHT LBS	AXIAL FORCE LBS	NORMAL FORCE LBS	SIDE FORCE LBS	LONG ACC G*S	NORMAL ACC G*S
IGNITION	253.041	1410000.0	983719.0	-2495.2	2.3	.8	1.3980	.3272
BEGIN MINH	253.041	1410000.0	983719.0	-2495.2	2.3	.8	1.3980	.3272
	269.000	1410000.0	934234.1	-2489.8	.8	.4	1.4725	.3424
	285.000	1410000.0	884723.4	-2491.6	.3	.3	1.5555	.3593
	301.000	1410000.0	835162.9	-2492.4	.1	.2	1.6484	.3779
	317.000	1410000.0	785602.2	-2492.5	.0	.2	1.7531	.3988
	333.000	1410000.0	736041.5	-2491.9	-.0	.2	1.8719	.4223
	349.000	1410000.0	686480.9	-2490.6	-.0	.2	2.0079	.4490
	365.000	1410000.0	636920.3	-2488.4	-.0	.3	2.1651	.4795
	381.000	1410000.0	587359.6	-2484.6	-.0	.4	2.3489	.5150
	397.000	1410000.0	537799.0	-2479.2	.1	.6	2.5667	.5565
	413.000	1410000.0	488238.4	-2471.6	.4	.9	2.8287	.6061
BEGIN GLIMIT	418.888	1410000.0	470000.0	-2468.2	.5	1.0	2.9390	.6269
	429.000	1319132.5	439710.8	-2461.4	.9	1.2	2.9404	.6221
	445.000	1137163.9	395721.3	-2448.8	1.8	1.7	2.9425	.6148
	461.000	1068383.9	356128.0	-2425.1	3.2	2.1	2.9446	.6079
	477.000	961483.7	320494.6	-2423.3	4.7	2.5	2.9467	.6012
	485.231	910728.9	303576.3	-2420.6	5.4	2.5	2.9478	.5979
INJECTION	485.231	1410000.0	303576.3	-2420.6	5.4	2.5	2.9478	.5979
	485.231	1410000.0	303576.3	-2420.6	5.4	2.5	4.6594	.9257

SA-I/IL-24

MISSION-3A/MCR-500/AOA/RTLS POINT TO NOM MECO CASE 1

TABLE NO. I.18

	TIME SEC	CHIR DEG	CHIP DEG	CHIY DEG	DELRC DEG	DELPC DEG	DELYC DEG
IGNITION	253.041	180.000	-89.436	.000	.000	-13.197	-.000
BEGIN MINH	253.041	180.000	-89.436	.000	.000	-13.197	-.000
	269.000	180.000	-90.550	.000	.000	-13.115	-.000
	285.000	180.000	-91.661	.000	.000	-13.028	-.000
	301.000	180.000	-92.767	.000	.000	-12.938	-.000
	317.000	180.000	-93.869	.000	.000	-12.938	-.000
	333.000	180.000	-94.967	.000	.000	-12.735	-.000
	349.000	180.000	-96.061	.000	.000	-12.626	-.000
	365.000	180.000	-97.151	.000	.000	-12.510	-.000
	381.000	180.000	-98.236	.000	.000	-12.387	-.000
	397.000	180.000	-99.316	.000	.000	-12.256	-.000
	413.000	180.000	-100.391	.000	.000	-12.115	-.000
BEGIN GLIMIT	418.888	180.000	-100.785	.000	.000	-12.061	-.000
	429.000	180.000	-101.462	.000	.000	-11.968	-.000
	445.000	180.000	-102.542	.000	.000	-11.826	-.000
	461.000	180.000	-103.634	.000	.000	-11.690	-.000
	477.000	180.000	-104.737	.000	.000	-11.561	-.000
	485.231	180.000	-105.308	.000	.000	-11.497	.000
INJECTION	485.231	180.000	-105.308	.000	.000	-11.497	.000
	485.231	180.000	-105.308	.000	.000	-11.497	.000

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MISSION-3A/MCR-500/AOA/RTLS POINT TO NOM MECO CASE 1

TABLE NO.I.19

	TIME SEC	RANGE NM	RANGE ANGLE DEG	IIP LAT DEG	IIP LONG DEG	VCH FT/SEC	VIDEAL FT/SEC
IGNITION	253.041	162.1	2.5	27.7	-123.4	.000	.000
BEGIN MINH	253.041	162.1	2.5	27.7	-123.4	.000	.000
	269.000	185.9	2.9	27.0	-123.7	755.123	755.123
	285.000	211.6	3.3	26.3	-123.9	1553.388	1553.388
	301.000	239.4	3.8	25.6	-124.2	2397.683	2397.683
	317.000	269.4	4.2	24.7	-124.5	3293.645	3293.645
	333.000	301.6	4.9	23.8	-124.8	4248.010	4248.010
	349.000	336.4	5.3	22.9	-125.2	5268.927	5268.927
	365.000	373.8	5.9	21.7	-125.6	6366.380	6366.380
	381.000	414.2	6.6	20.4	-126.0	7552.778	7552.778
	397.000	457.7	7.3	18.9	-126.6	8843.823	8843.823
	413.000	504.7	8.0	18.9	-127.2	10259.776	10259.776
BEGIN GLIMIT	418.389	522.9	8.3	15.0	-127.5	10917.349	10917.349
	429.000	555.5	8.9	14.1	-128.1	11793.377	11793.377
	445.000	610.2	9.8	12.2	-129.4	13337.729	13337.729
	461.000	669.0	10.7	7.6	-131.4	14882.080	14882.080
	477.000	731.7	11.7	-14.2	-136.9	16426.431	16426.431
	485.231	765.5	12.3	-62.8	-164.8	17220.873	17220.873
INJECTION	485.231	765.5	12.3	-62.8	-164.8	17220.873	17220.873
	485.231	765.5	12.3	-62.8	-164.8	17220.873	17220.873

SA-I/SL-24

MISSION-3A/MCR-5CO/A0A/RTLS POINT TO NOM MECO CASE 1

TABLE NO. I.20

	TIME SEC	X FT	Y FT	Z FT	XDOT FT/SEC	YDOT FT/SEC	ZDOT FT/SEC
IGNITION	253.041	21232801.5	-317159.0	960535.7	781.630	-1133.210	8480.549
BEGIN MINH	253.041	21232801.5	317159.0	960535.7	781.630	-1133.210	8480.549
	269.000	21242694.7	331185.8	1101520.5	457.247	-1125.812	9193.764
	285.000	21247369.2	-353136.8	1254607.8	125.099	-1117.998	9949.240
	301.000	21246688.7	-370959.3	1420135.7	-212.324	-1109.757	10749.634
	317.000	21240531.2	-388646.8	1598960.5	-559.937	-1101.113	11600.198
	333.000	21229755.2	-406192.9	1791643.1	-914.878	-1092.073	12507.263
	349.000	21211196.0	-423591.0	1999439.0	-1232.012	-1082.620	13478.521
	365.000	21187661.7	-440834.6	2223340.3	-1662.112	-1072.761	14523.448
	381.000	21157327.2	-457917.2	2464643.8	-2057.466	-1062.495	15653.381
	397.000	21121726.5	-474832.3	2724803.0	-2470.926	-1051.824	16884.865
	413.000	21078741.7	-491573.4	3005593.6	-2906.128	-1040.750	18235.900
BEGIN GLIMIT	418.888	21061142.0	-497689.1	3114529.0	-3072.662	-1036.573	18768.188
	429.000	21029587.2	-508134.1	3309020.0	-3369.302	-1029.274	19638.823
	445.000	20970785.7	-524508.0	3635943.8	-3862.205	-1017.403	21165.651
	461.000	20904826.5	-540698.9	3986277.8	-4398.013	-1005.141	22624.396
	477.000	20830200.2	-556670.5	4359876.9	-4945.542	-992.497	24073.855
	485.231	20788270.0	-564812.1	4561075.2	-5244.611	-985.345	24815.476
INJECTION	485.231	20788270.0	-564812.1	4561075.2	-5244.611	-985.845	24815.476
	485.231	20788270.0	-564812.1	4561075.2	-5244.611	-985.845	24815.476

SA+I/EL-24

MISSION-?A/MCR-5CO/AOA/RTLS POINT TO NOM MECO

CASE 1

TABLE NO. I.21

	TIME SEC	XACC FT/SEC**2	YACC FT/SEC**2	ZACC FT/SEC**2	HEAT BTU/FT**2	HEAT RATE BTU/FT**2-S
IGNITION	253.041	-20.1556	.4508	43.5078	.0	.0
BEGIN MINH	253.041	-20.1556	.4508	43.5078	.0	.0
	269.000	-20.5046	.4763	45.9097	3.3	.2
	285.000	-20.9130	.5017	48.5709	6.3	.2
	301.000	-21.3981	.5272	51.5326	9.3	.2
	317.000	-21.9399	.5526	54.8536	12.6	.2
	333.000	-22.5815	.5781	58.6092	16.3	.3
	349.000	-23.3296	.6035	62.8962	20.8	.3
	365.000	-24.2065	.6289	67.8421	26.6	.4
	381.000	-25.2427	.6543	73.6175	34.2	.6
	397.000	-26.4779	.6796	80.4567	44.8	.8
	413.000	-27.9720	.7047	88.6093	59.7	1.1
BEGIN GLIMIT	418.388	-28.6030	.7139	92.1586	66.6	1.2
	429.000	-29.8080	.7296	91.9032	80.6	1.5
	445.000	-31.8673	.7542	91.4367	109.5	2.1
	461.000	-33.8562	.7784	90.8939	148.3	2.7
	477.000	-35.8316	.8021	90.2761	197.4	3.4
	485.231	-36.8380	.8141	89.9297	226.5	3.7
INJECTION	485.231	-36.8387	.8141	89.9237	226.5	3.7
	485.231	-40.3562	.8141	142.7270	226.5	3.7

SECTION II

EXCHANGE RATIOS

A. Discussion

After a baseline launch vehicle system is defined, there are design variations that occur during detailed development phases. These variations may be advantageous or disadvantageous. The effects of these variations on delivered performance must be continuously analyzed. This can be done by performing a trajectory simulation with the changes evaluated. A more cost effective method is the use of exchange ratios, sometimes called payload partials whose primary purpose is to provide a quick and economical assessment of design variations on the payload delivery capability in the region near the baseline. Exchange ratios are used by multiplying a change of a baseline parameter by its corresponding exchange ratio to define the performance change at MECO. Combining these data with similar cost analyses data, trade studies may be performed to define the minimum cost impact required to recover performance capability lost due to design changes. A secondary use is to increase the baseline capability using the same methodology. The final test of any proposed change is the trajectory simulation containing all the proposed changes. This will define the new baseline payload capability and then the exchange ratios may be used during the next design cycle.

As stated in Section I the 3A Mission is the design reference (payload critical) mission. The exchange ratios contained herein are generated to describe the effects of a 'planned change' in the baseline system as compared to the random occurrence of unknown variations about the baseline as discussed in Section III. Exchange ratios are generated by changing each system parameter individually and simulating a maximum payload trajectory through the RTLS/AOA point of V_R = 8932 fps to the AOA and Nominal MECO conditions specified on Table I.1. This is done by optimizing the tilt over maneuver and closed loop guidance while limiting ET propellant consumption to maximum loaded value.

A change in the weight at AOA MECO provides a similar change in the gross payload (cargo bay plus consumables) weight. The case of Nominal MECO is not the same. At this point the change in MECO weight represents a change in gross payload from the AOA condition and a change in the ET propellant residuals. The residual increase or decrease is dependent upon whether the Nominal MECO exchange ratio is greater or less than at AOA MECO.

Historically, exchange ratios have been assumed and used as linear values. This is generally valid in small regions about the baseline; but for some cases, the design parameters of max q and accelerations are violated and must be constrained. The method for constraining max q in this analysis is reducing the initial tilt-over (lofting) prior to max q which causes the vehicle to exit the dense atmosphere quicker. This results in a non-optimum trajectory and a resulting payload improvement less for a given system change than the non-constrained results. Detailed SSME throttling prior to max q was not investigated.

A rule of thumb for use of exchange ratios is that the unconstrained ratios are used when payload is degraded or when recovering payload lost due to design refinements and the constrained curves are used when trying to increase the baseline performance.

B. Description of Results

A summary of linearized exchange ratios for both AOA MECO and Nominal MECO is shown in Table II.1. The exchange ratios for each deviation are shown in terms of Δ gross payload per unit parameter change at AOA MECO. At Nominal MECO the exchange ratio is labeled as Δ MECO weight per unit change and includes the change in AOA gross payload and ET residuals.

Figures II.1 through II.17 display Δ weight for both AOA and Nominal MECO conditions for unconstrained trajectory results. Figures II.1, 6, 7 8, 9, 10, 12 and 17 include the effects at AOA MECO when the trajectory must be reshaped to meet the dynamic pressure design constraint. These constrained curves emphasize that the exchange ratios must be used correctly in order to obtain valid results.

A method of recovering the performance losses due to meeting the constraints is by reoptimizing the trajectory portion past the time of max q to SRB staging. The system parameter chosen for this illustration is SSME thrust variation. Figure II.17 shows weight losses for a 30000 pound increase of vacuum thrust per engine of about 1000 pounds for the constrained q case as compared to 6400 pounds gain for the unconstrained q case. By optimizing the flight path profile after max q has been passed, a net gain of 3100 pounds weight can be attained as shown on Figure II.18. This example stresses that linear exchange ratios are valid only when used for small deviations about the baseline. In order to increase the baseline performance, it is more realistic to perform detailed analysis than to use the exchange ratios where design constraints are violated.

MISSION 3A

TABLE II.1 EXCHANGE RATIOS*

PARAMETER VARIED	@ AOA MECO $\frac{\Delta \text{ PAYLOAD}}{\Delta \text{ PARAMETER}}$	@ NOMINAL MECO $\frac{\Delta \text{ MECO WEIGHT}}{\Delta \text{ PARAMETER}}$ **
FOREBODY DRAG (C_{A_0})	- 84 lb/%	- 94 lb/%
BASE DRAG	- 20 lb/%	- 28 lb/%
SRB SEPARATION DELAY	-185 lb/s	-200 lb/s
SRB VACUUM ISP (CONSTANT THRUST)	300 lb/s	330 lb/s
SRB VACUUM ISP (CONSTANT $\dot{W}$)	810 lb/s	880 lb/s
SRM VACUUM THRUST (CONSTANT ISP)	664 lb/%	720 lb/%
SRM VACUUM THRUST (CONSTANT $\dot{W}$)	2,120 lb/%	2,300 lb/%
SRB INERT WEIGHT	-.093 lb/lb	- .1 lb/lb
SRB PROPELLANT CAPACITY	.024 lb/lb	.025 lb/lb
SRB PROPELLANT TEMPERATURE	90 lb/deg F	100 lb/deg F
LAST RTLS - RELATIVE VELOCITY	3.3 lb/fps	1.2 lb/fps
ET PROPELLANT CAPACITY (NO ET INERT WT CHANGE)	.061 lb/lb	-
ET PROPELLANT CAPACITY (ET INERT WT CHANGE)	.015 lb/lb	-
SSME VACUUM ISP (CONSTANT THRUST)	1,090 lb/s	865 lb/s
SSME VACUUM ISP (CONSTANT $\dot{W}$)	1,360 lb/s	1,100 lb/s
SSME VACUUM THRUST (CONSTANT $\dot{W}$)	.4 lb/lb	.43 lb/lb
SSME VACUUM THRUST (CONSTANT ISP)	.08 lb/lb	.07 lb/lb

* LINEARITY ASSUMED OVER SMALL VARIATIONS

** REPRESENTS Δ PAYLOAD + Δ ET PROPELLANT RESERVE AT MECO

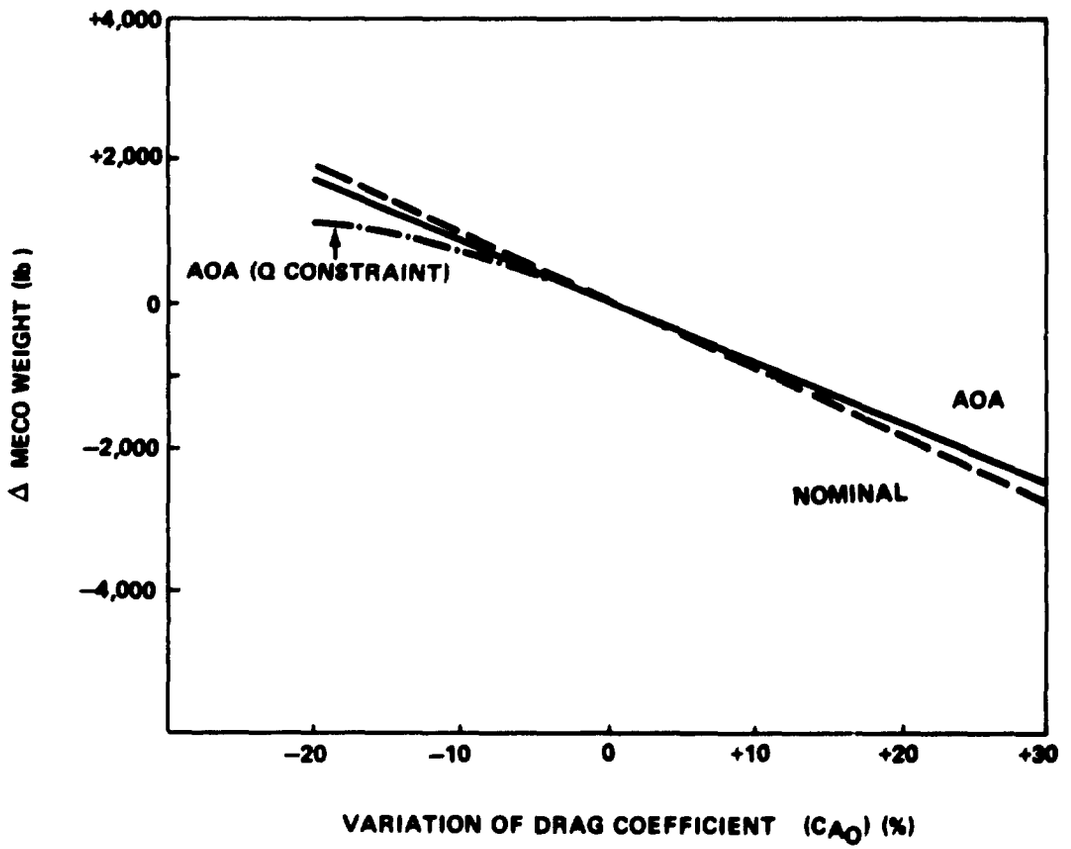

FIGURE II. 1 MECO WEIGHT VARIATION WITH VARIATION OF FOREBODY AXIAL FORCE COEFFICIENT C_{A_0}

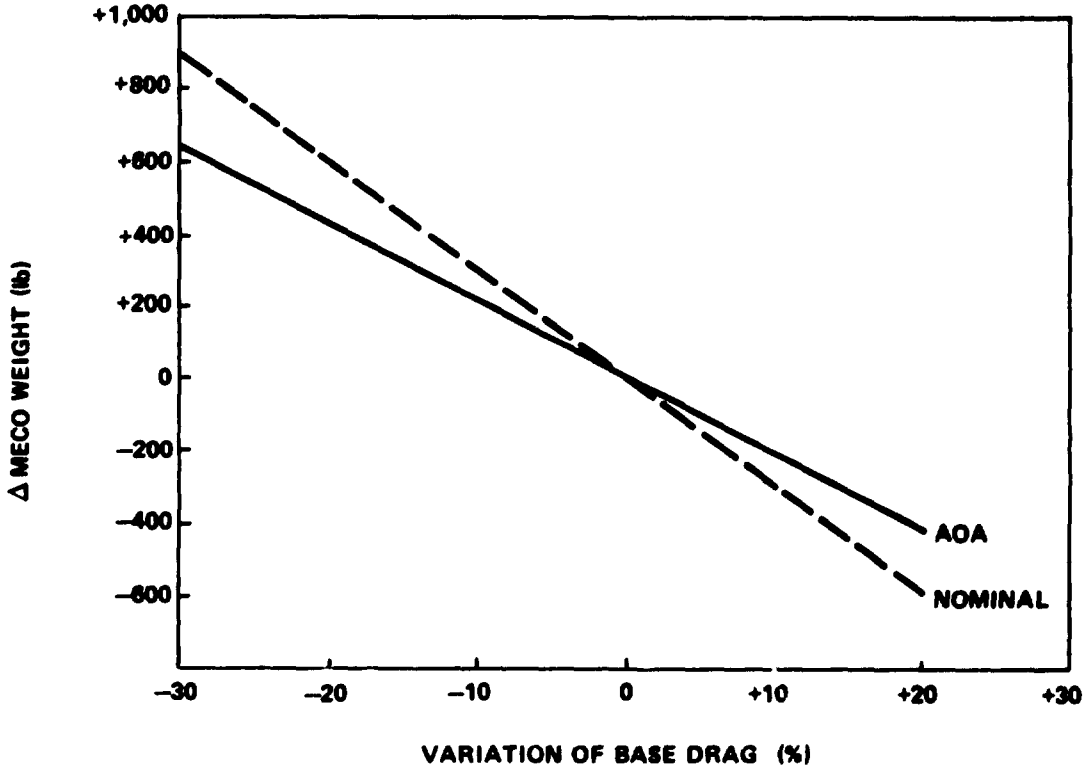

FIGURE II. 2 MECO WEIGHT VARIATION WITH VARATION OF THE BASE DRAG

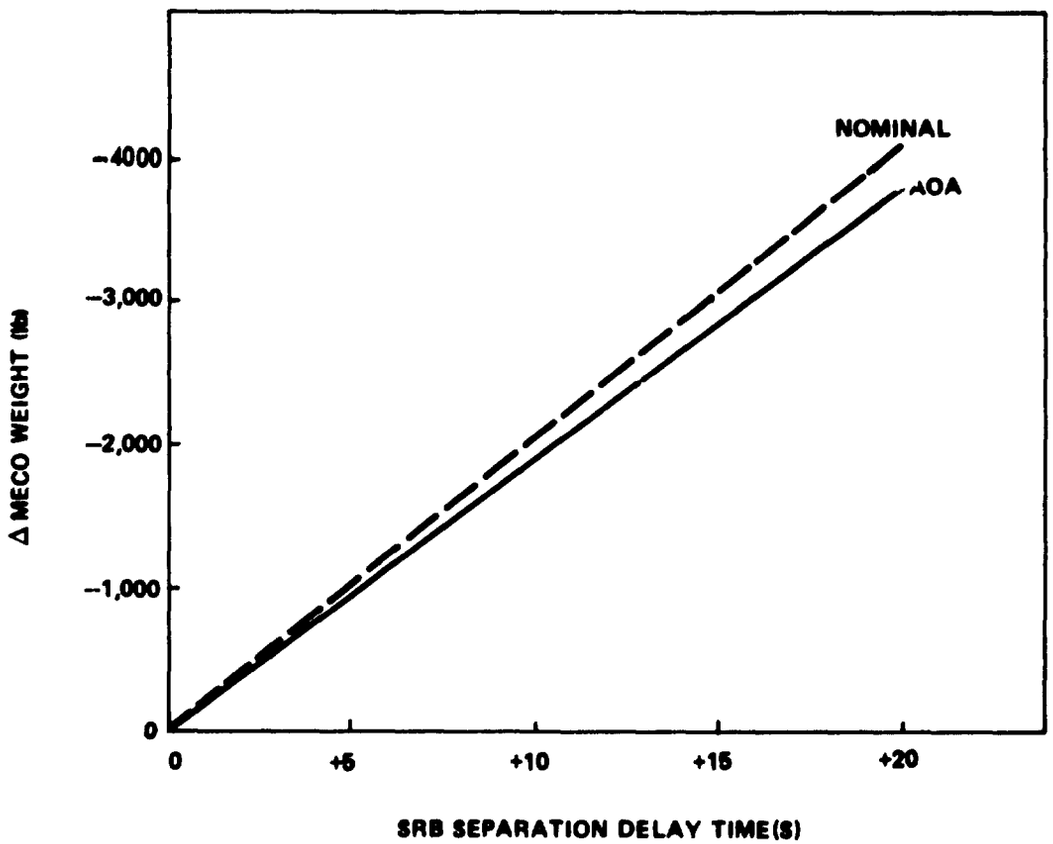

FIGURE II. 3 MECO WEIGHT VARIATION WITH VARIATION OF SRB SEPARATION DELAY TIME WITH NO THRUST

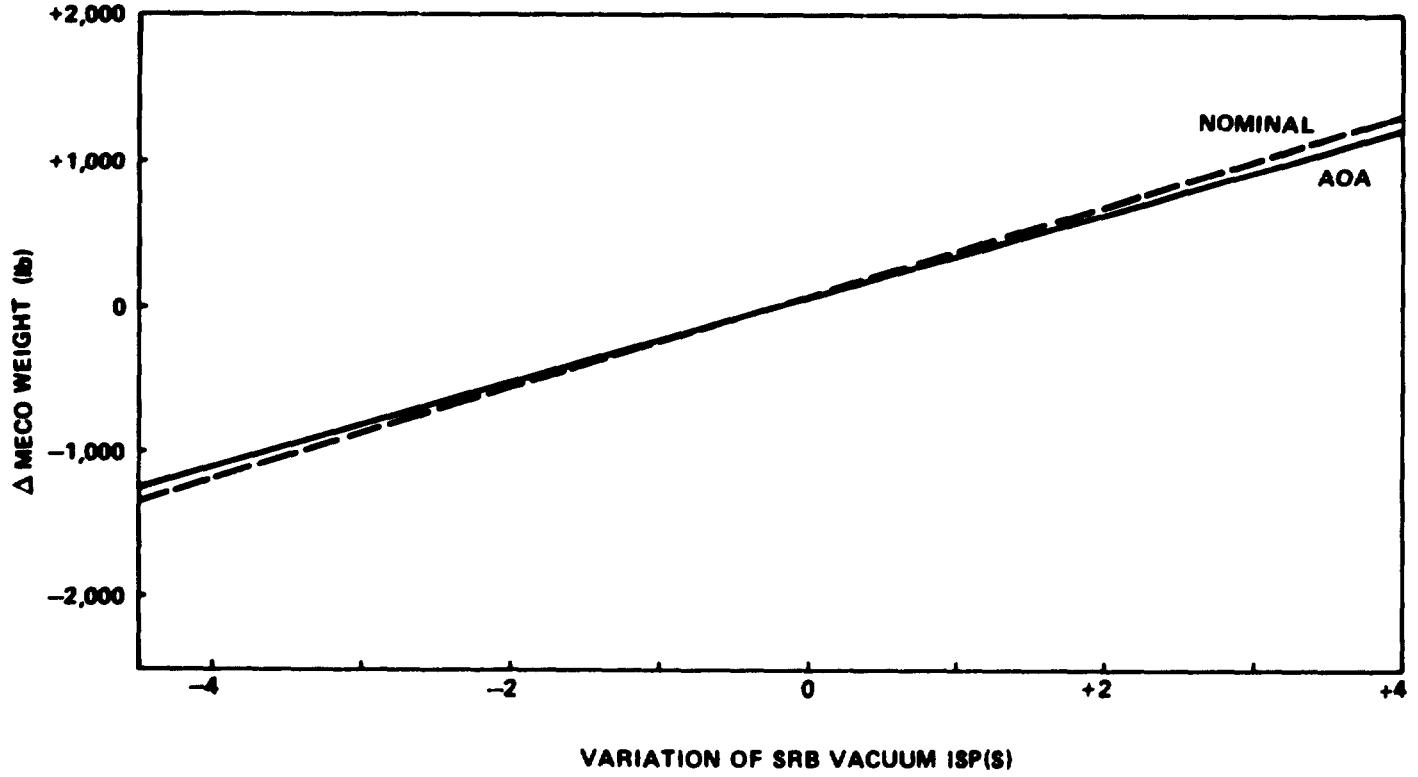

FIGURE II. 4 MECO WEIGHT VARIATION WITH VARIATION OF SRB VACUUM ISP WITH CONSTANT SRB VACUUM THRUST TRACE

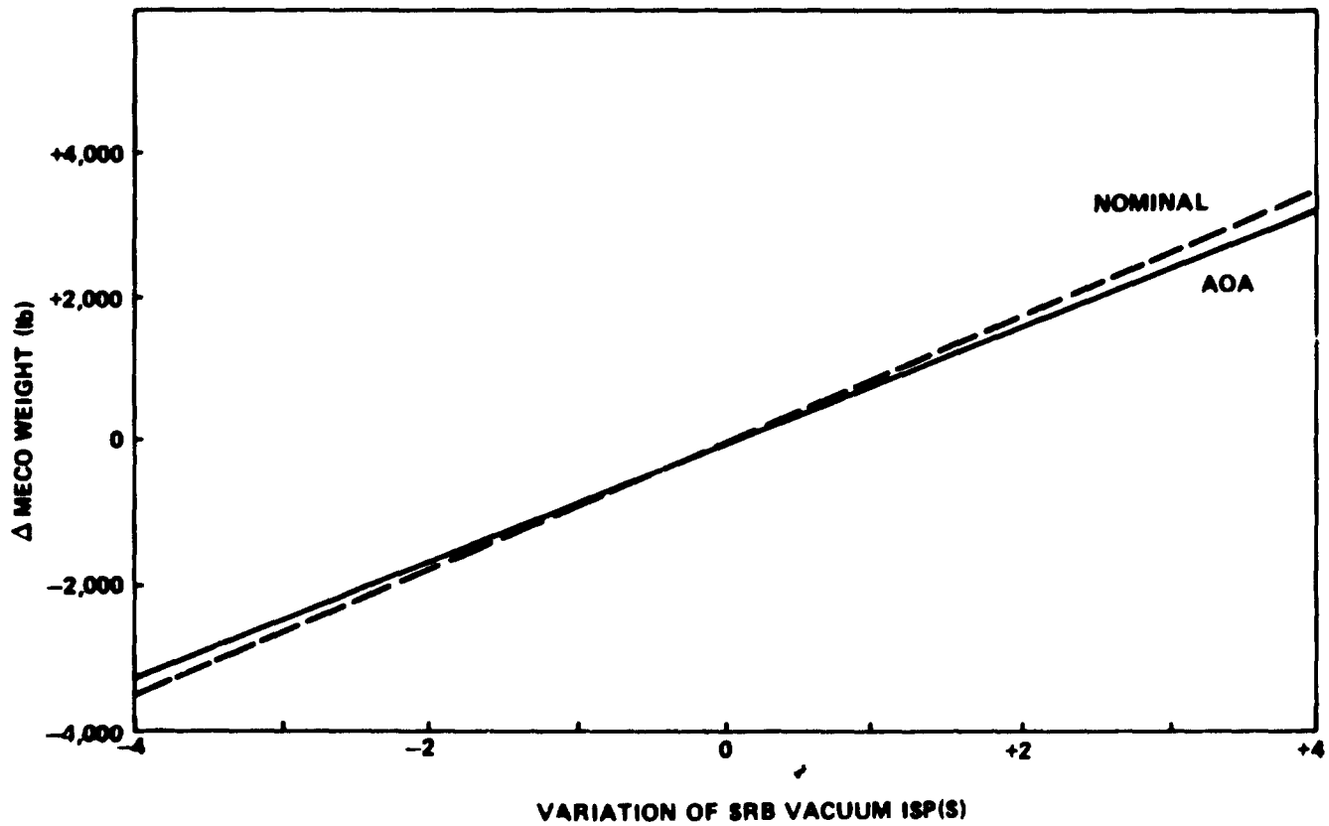

FIGURE II. 5 MECO WEIGHT VARIATION WITH VARIATION OF SRB VACUUM ISP WITH CONSTANT SRB PROPELLANT LOADING

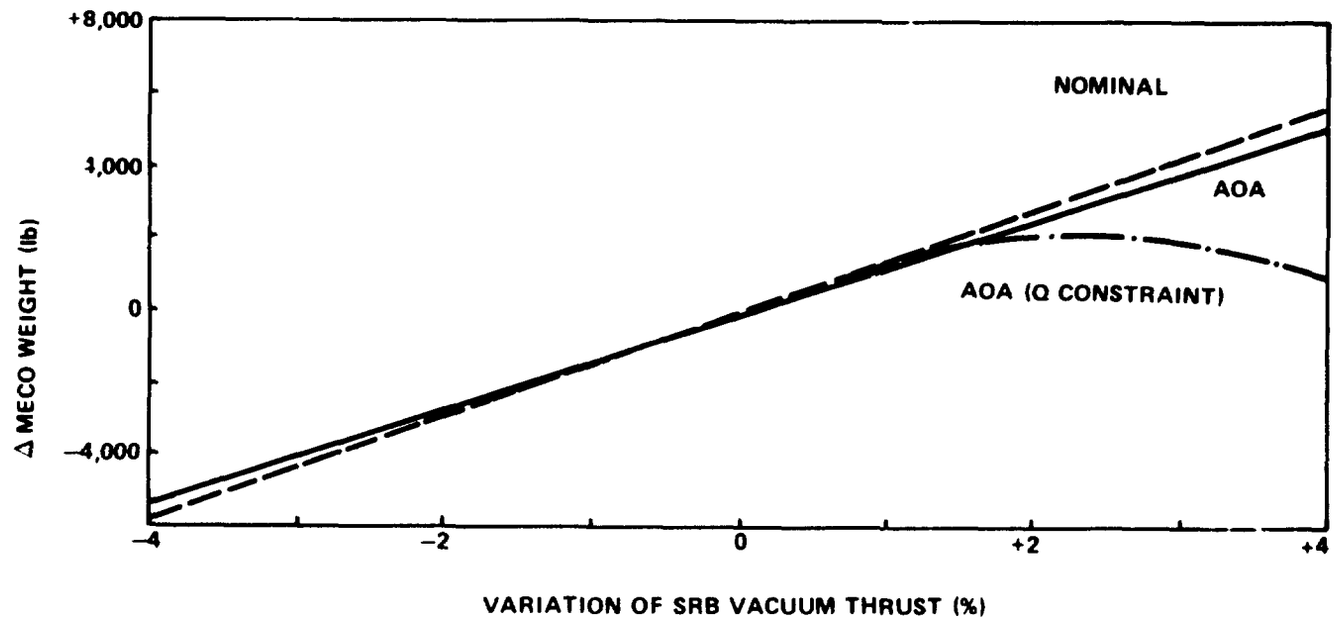

FIGURE II. 6 MECO WEIGHT VARIATION WITH VARIATION OF SRB VACUUM THRUST WITH CONSTANT VACUUM ISP

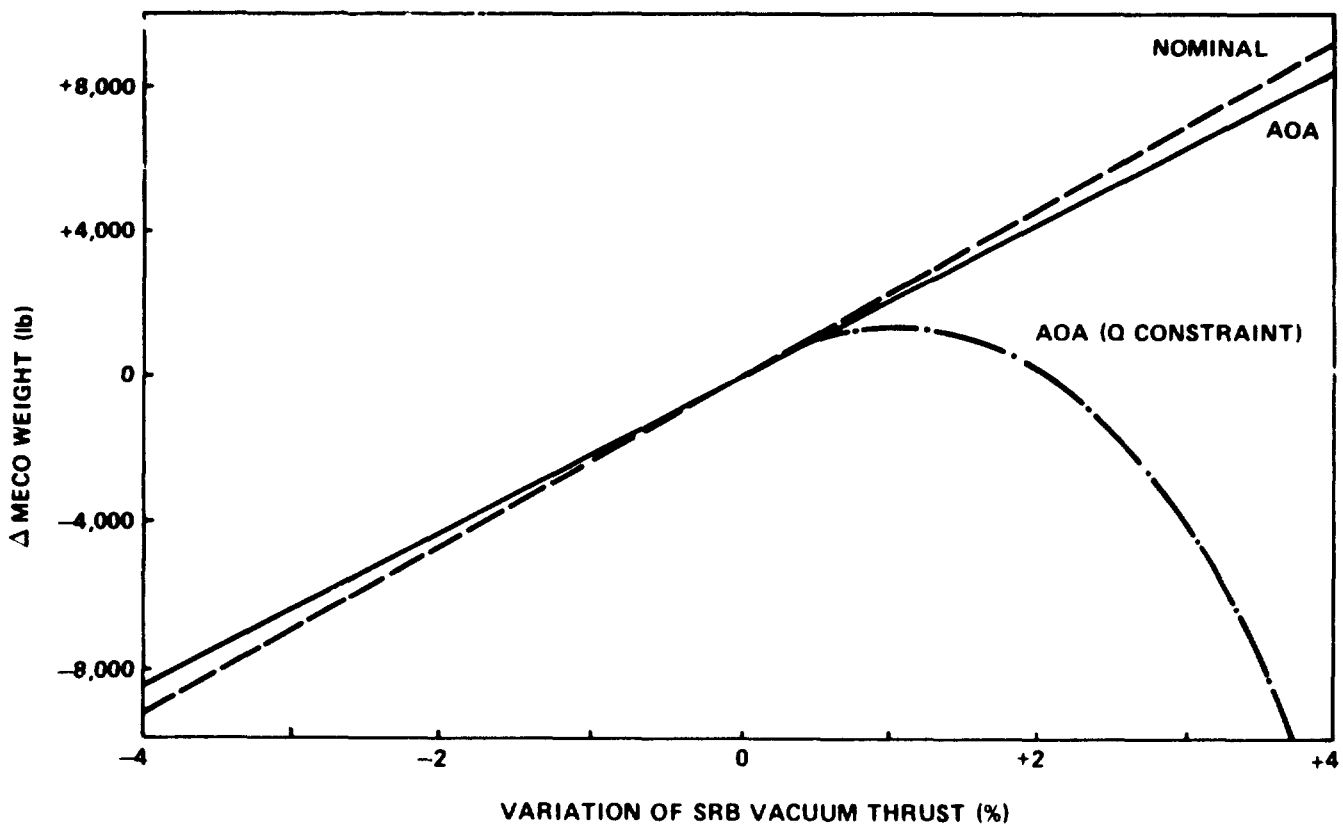

FIGURE II. 7 MECO WEIGHT VARIATION WITH VARIATION OF SRB VACUUM THRUST WITH CONSTANT SRB PROPELLANT LOADING

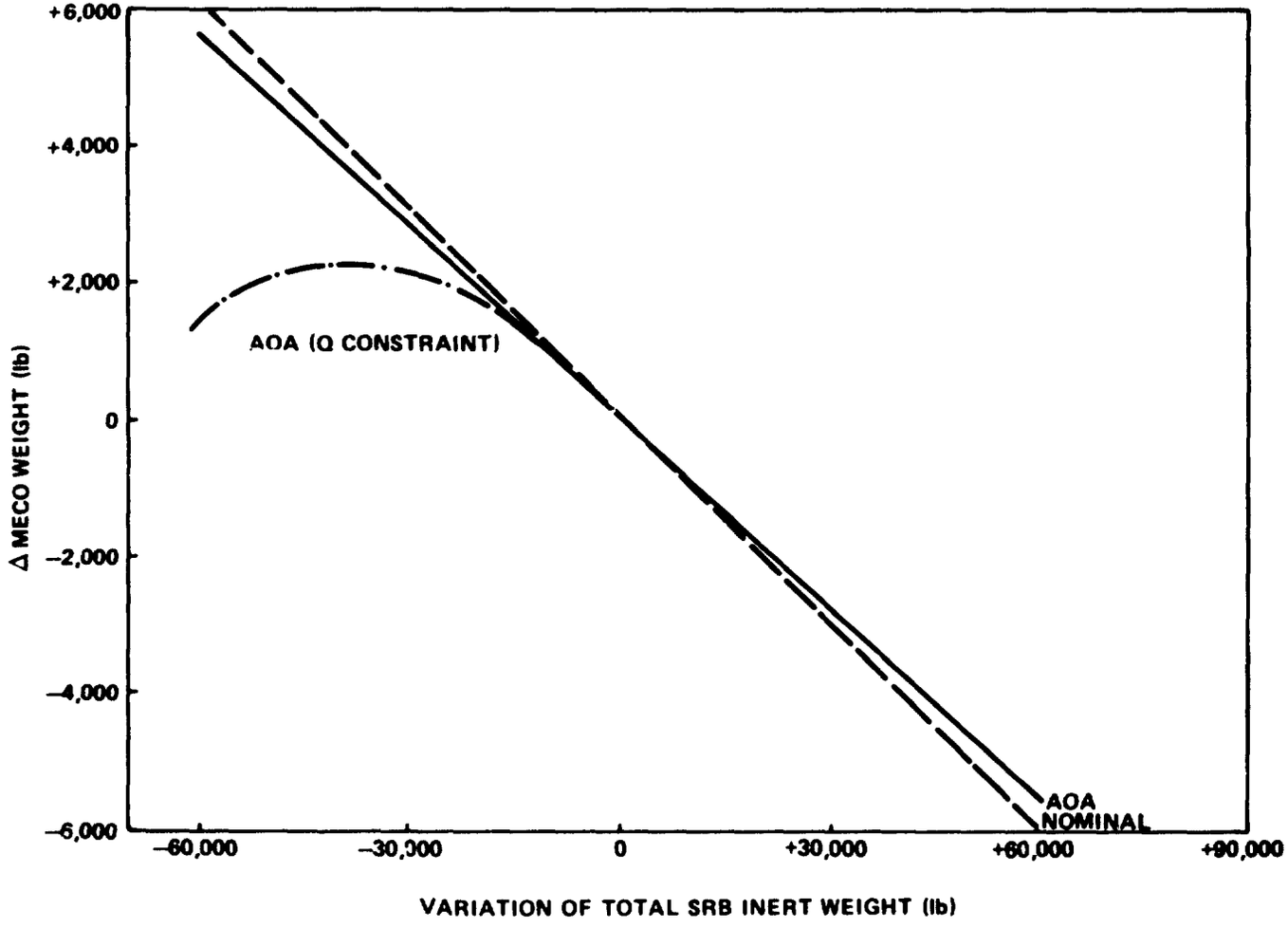

FIGURE II. 8 MECO WEIGHT VARIATION WITH VARIATION OF TOTAL SRB INERT WEIGHT

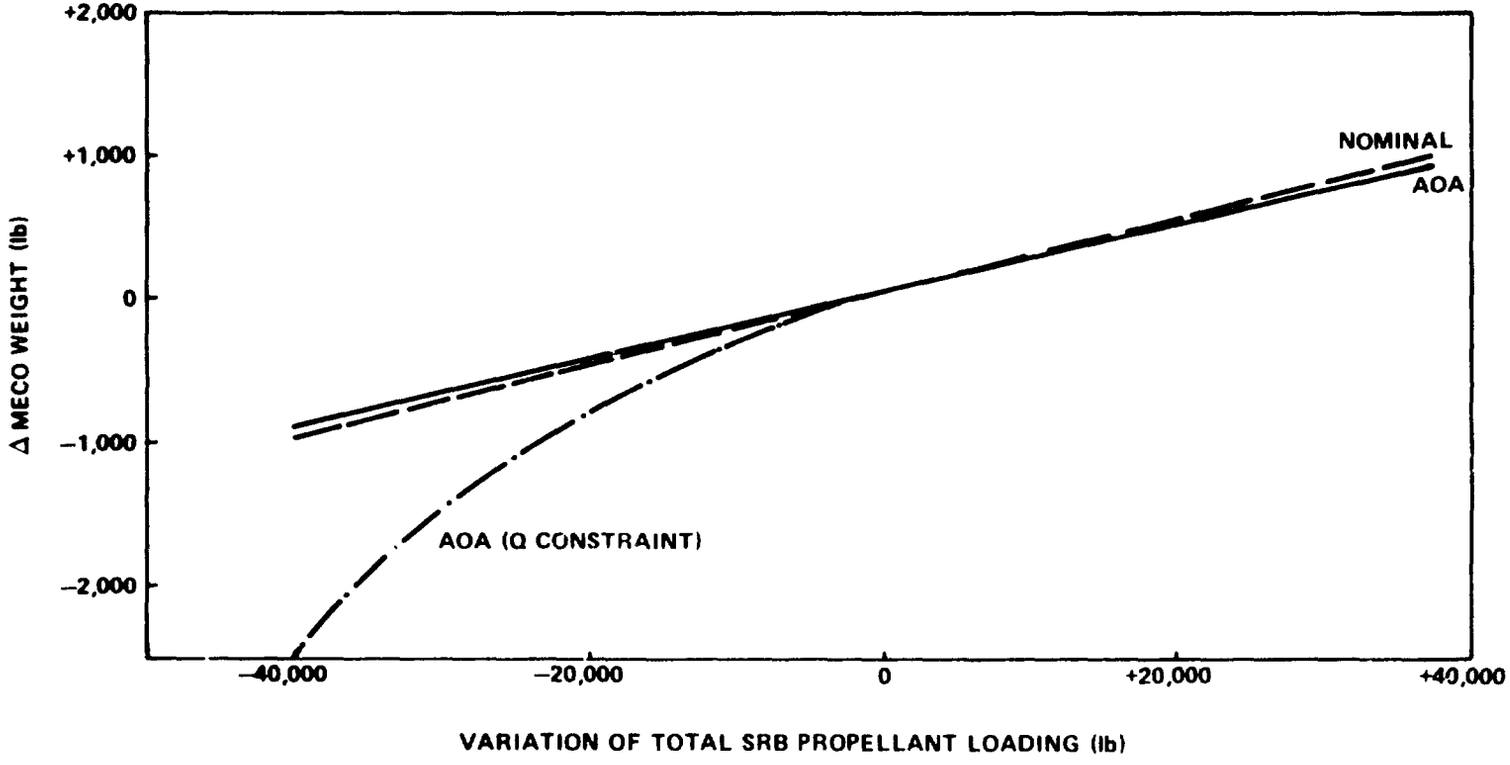

FIGURE II. 9 MECO WEIGHT VARIATION WITH VARIATION OF SRB TOTAL PROPELLANT LOADING

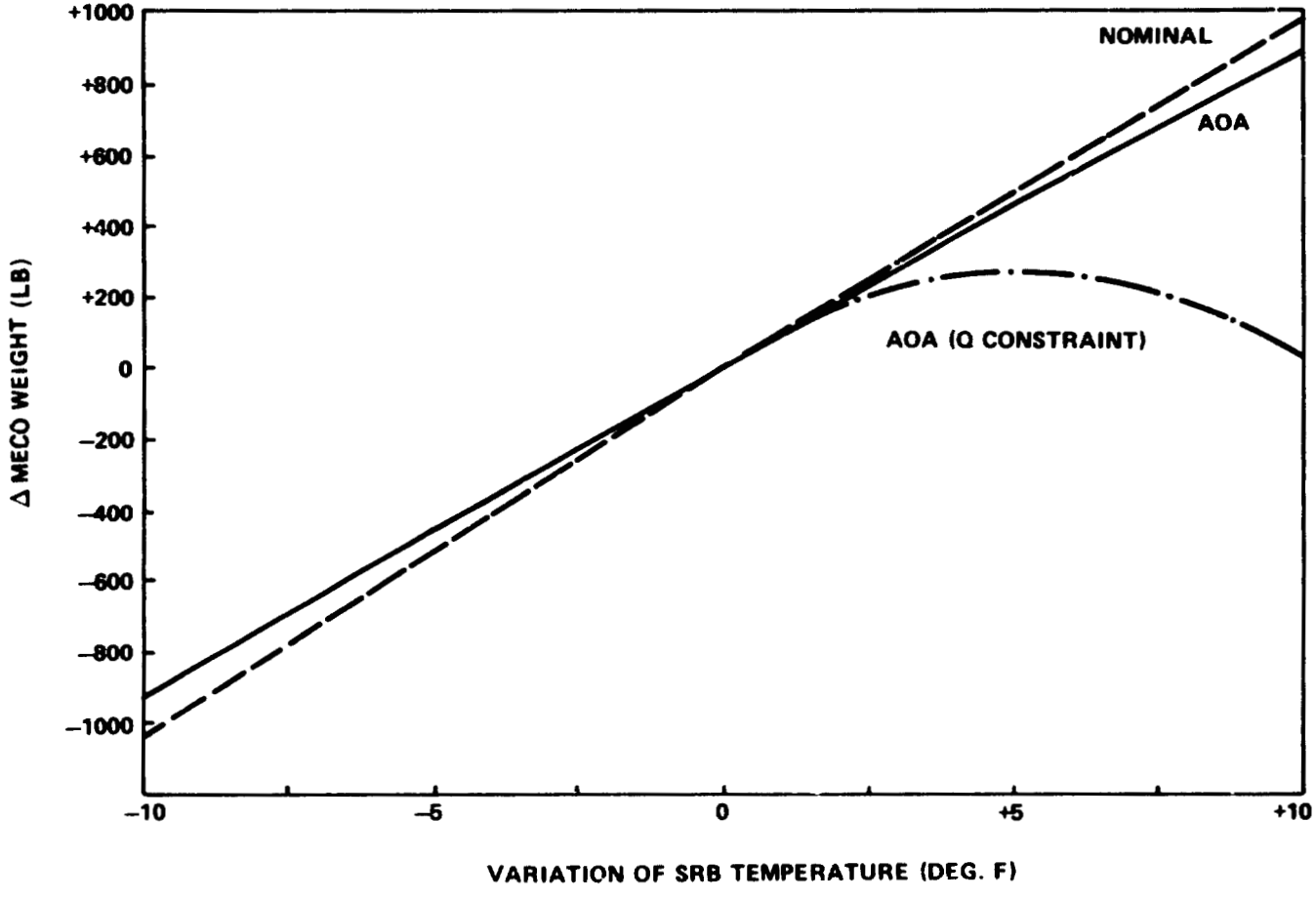

FIGURE II. 10 MECO WEIGHT VARIATION WITH VARIATION OF SRB PROPELLANT TEMPERATURE

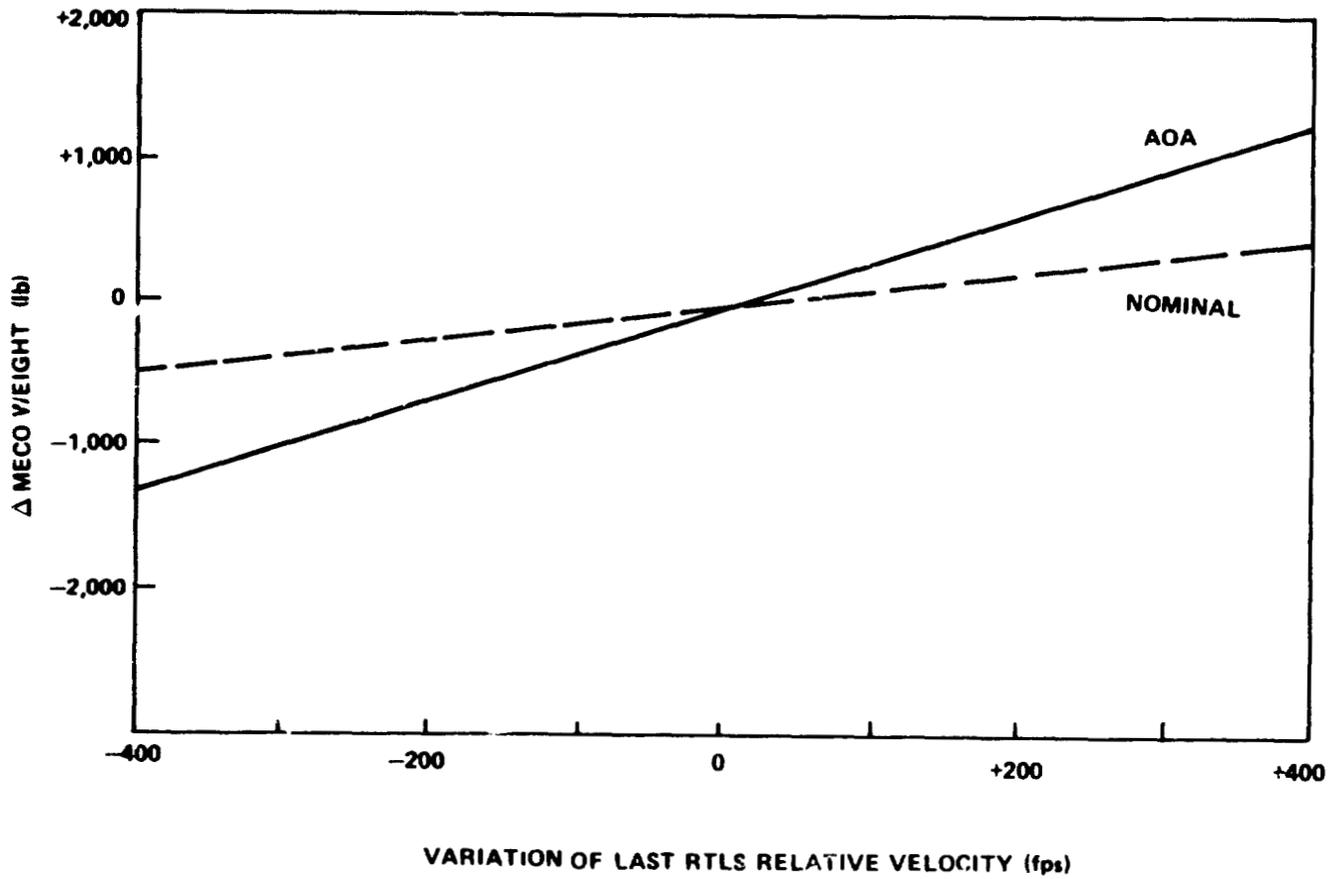

FIGURE II. 11 MECO WEIGHT VARIATION WITH VARIATION OF RELATIVE VELOCITY AT LAST RTLS POINT

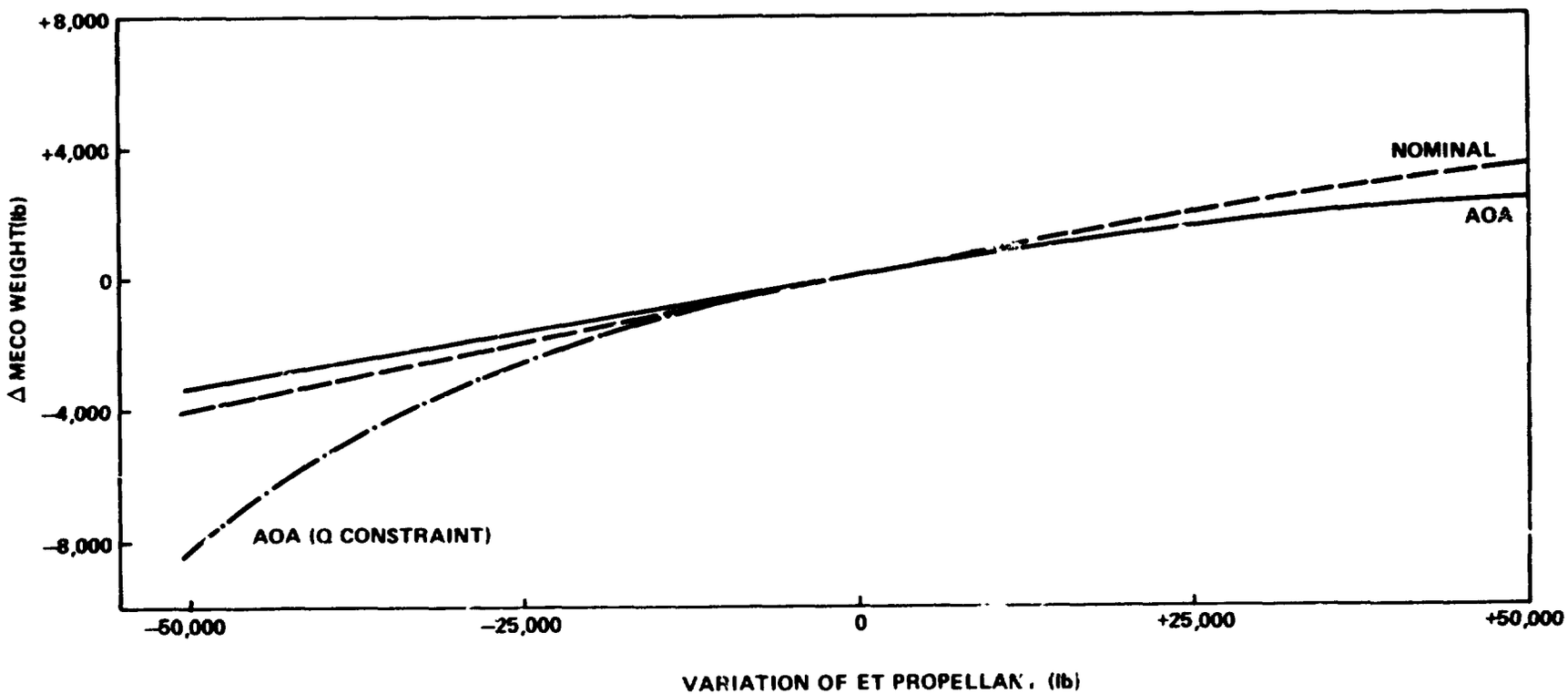

FIGURE II. 12 MECO WEIGHT VARIATION WITH VARIATION OF ET PROPELLANT AND CONSTANT ET INERT WEIGHT

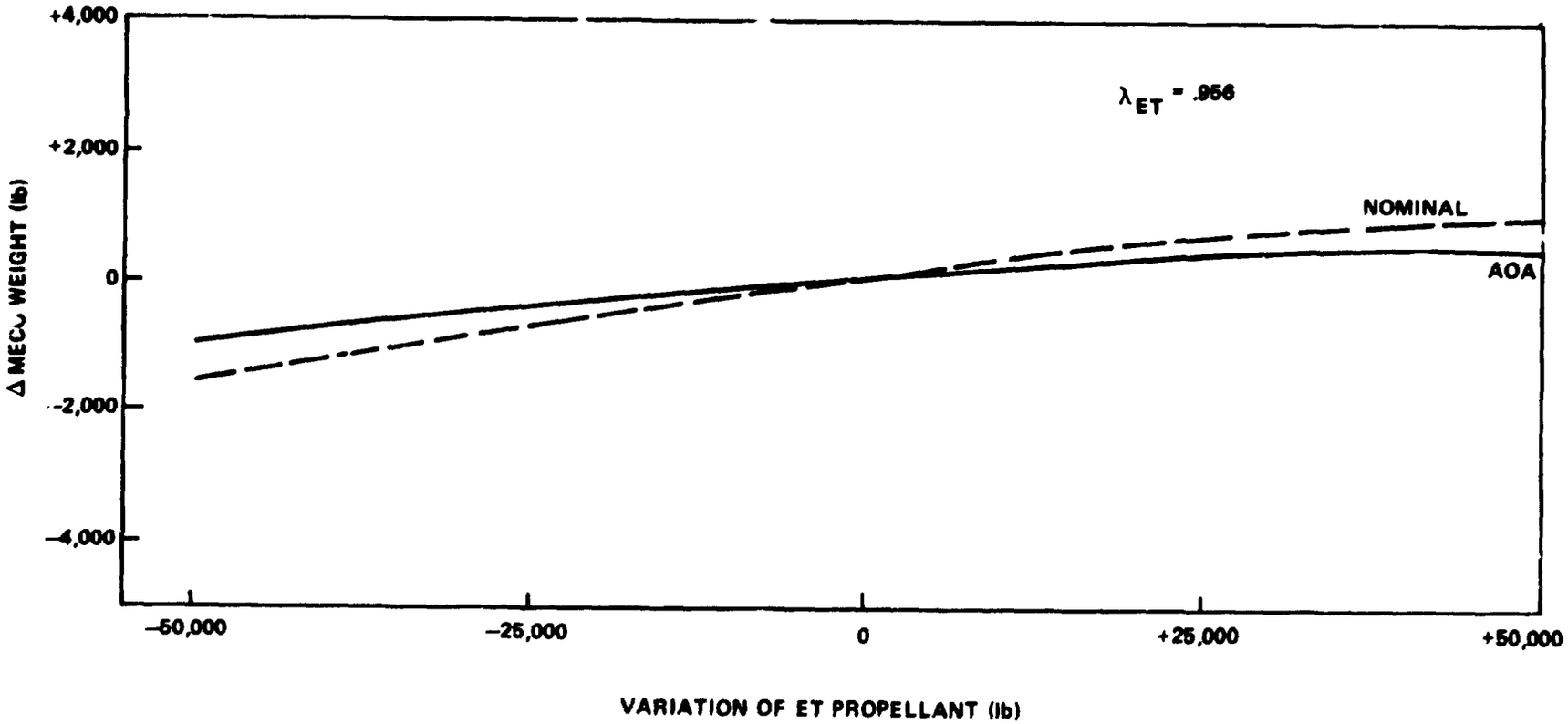

FIGURE 11.13 MECO WEIGHT VARIATION WITH VARIATION OF ET PROPELLANT AND ET INERT WEIGHT WITH CONSTANT ET MASS FRACTION

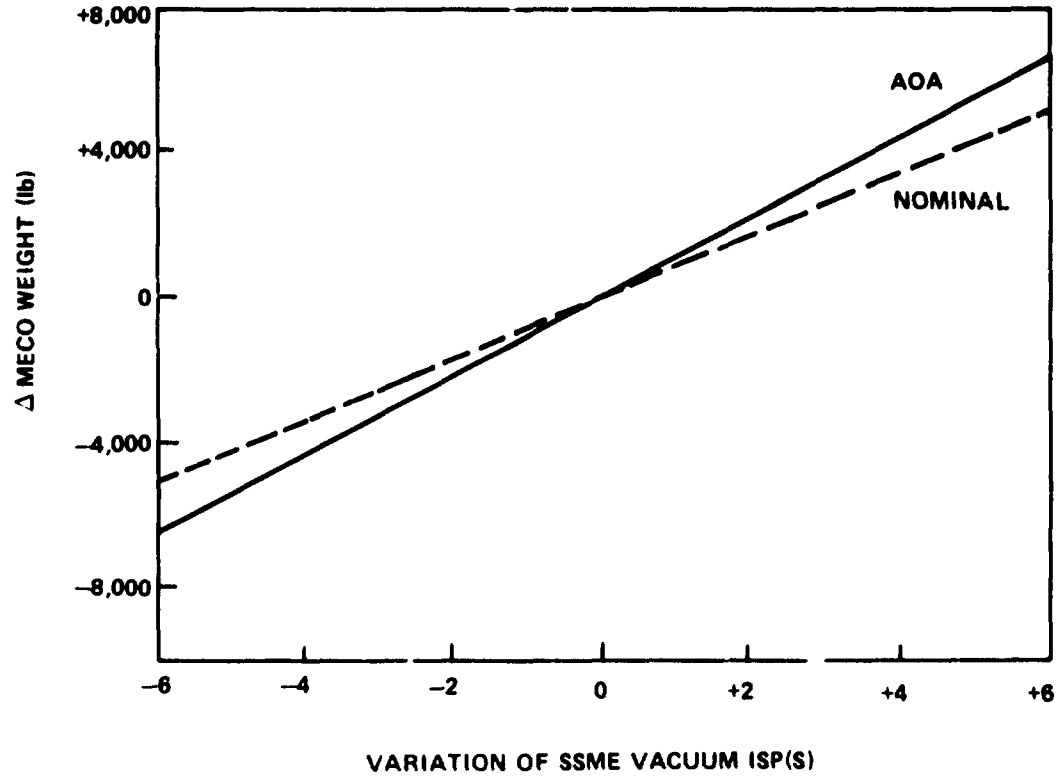

FIGURE 11.14 MECO WEIGHT VARIATION WITH VARIATION OF SSME VACUUM ISP WITH CONSTANT SSME VACUUM THRUST

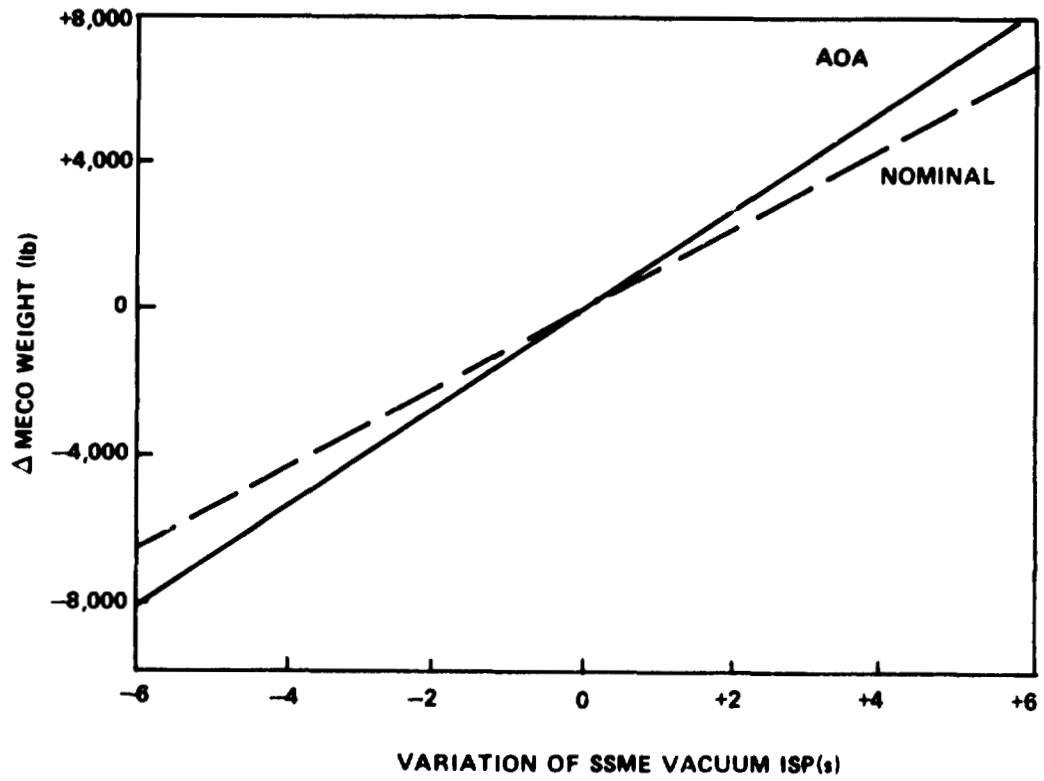

FIGURE II. 15 MECO WEIGHT VARIATION WITH VARIATION OF SSME VACUUM ISP WITH CONSTANT SSME FLOW RATE

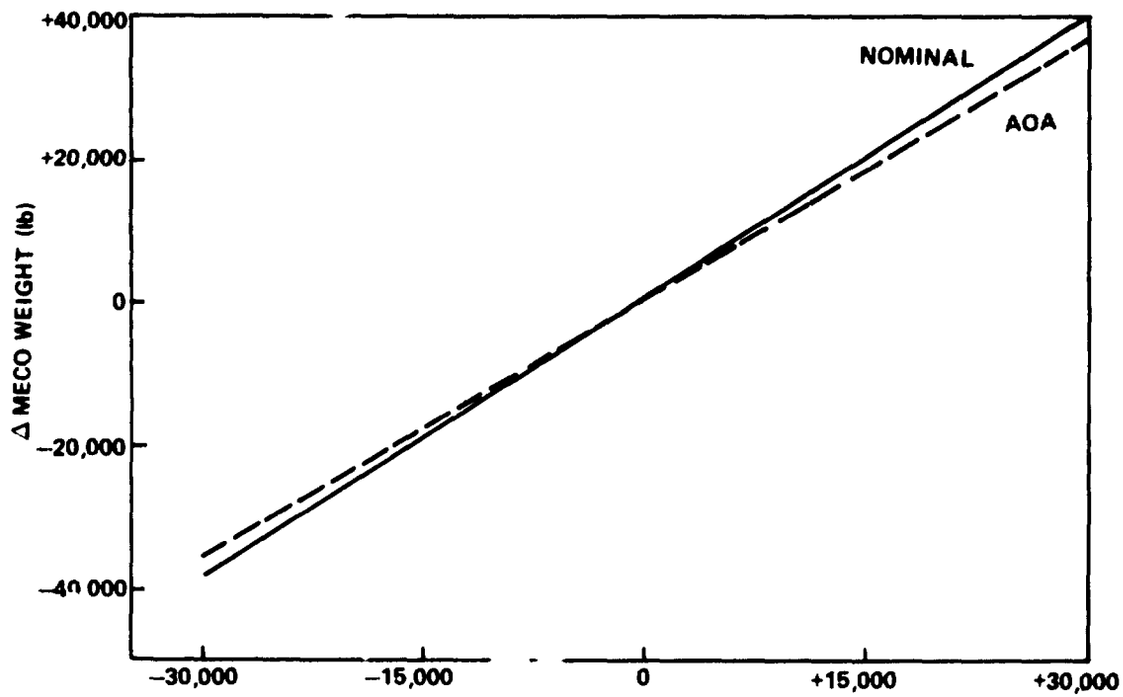

FIGURE II. 16 MECO WEIGHT VARIATION WITH VARIATION OF SSME VACUUM THRUST WITH CONSTANT PROPELLANT FLOW RATE

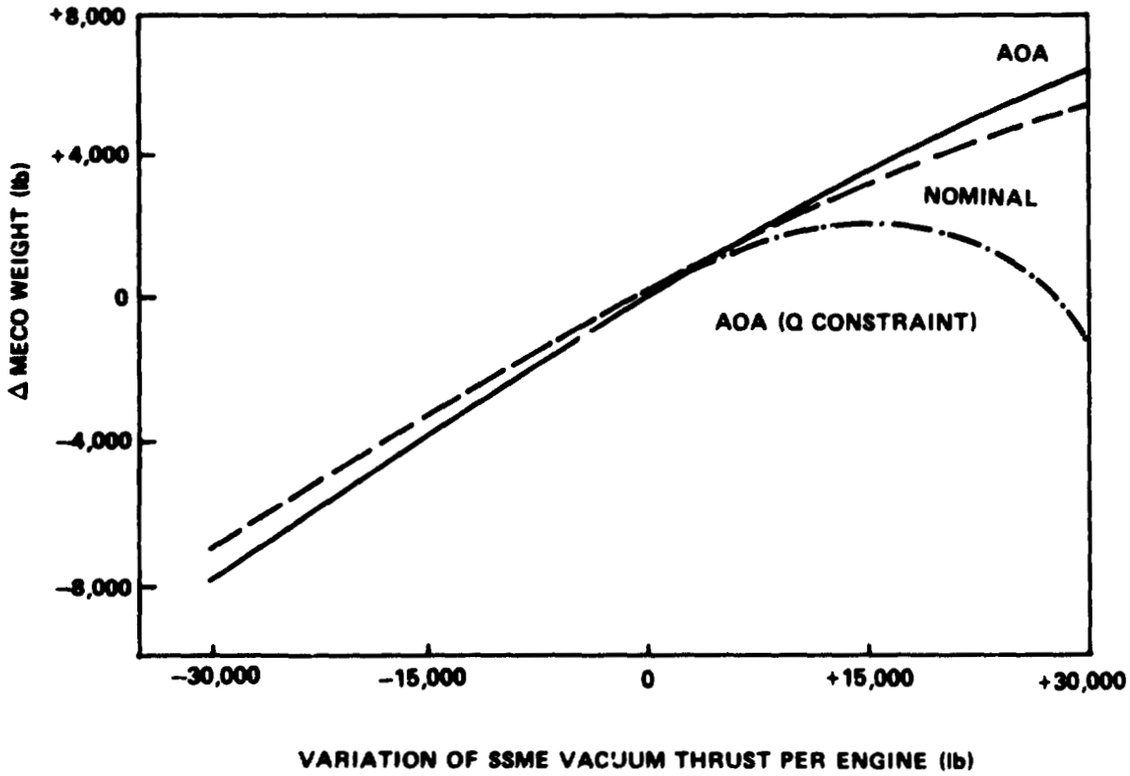

FIGURE 11. 17 MECO WEIGHT VARIATION WITH VARIATION OF SSME VACUUM THRUST WITH CONSTANT VACUUM ISP

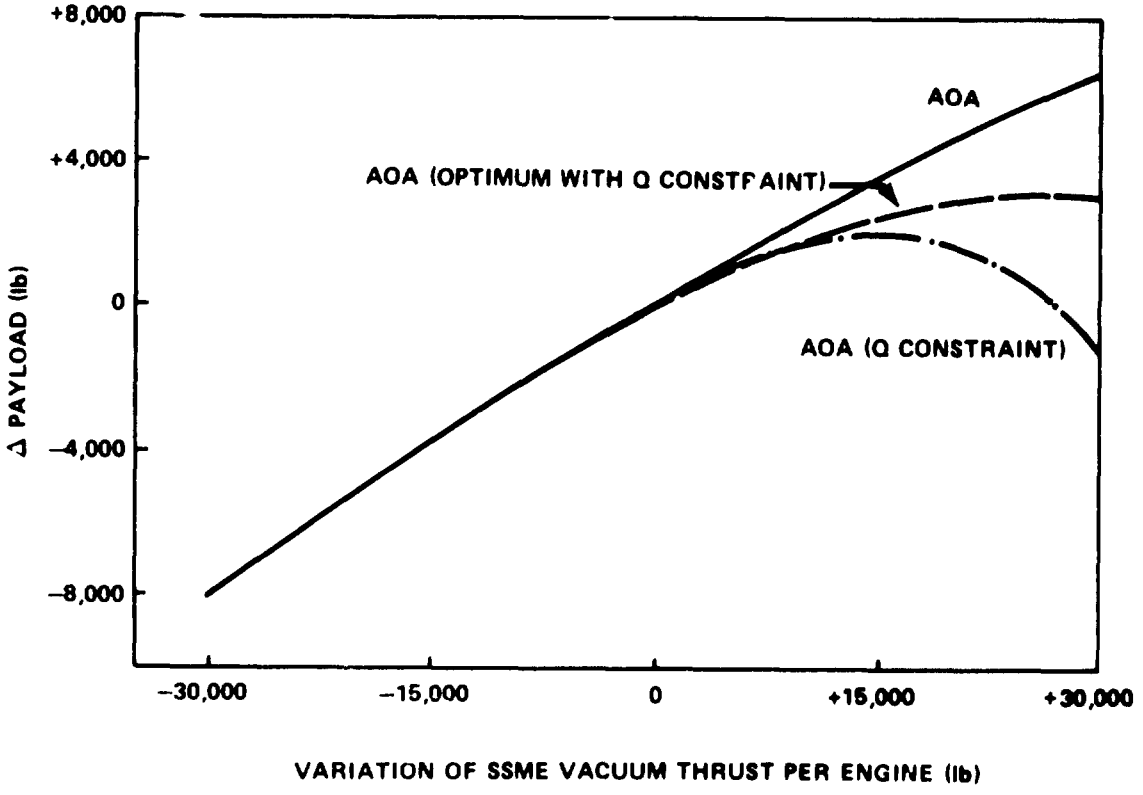

FIGURE II. 18 EFFECT OF OPTIMIZATION OF BOOST FLIGHT ON PAYLOAD VARIATIONS FOR VARIATIONS OF SSME VACUUM THRUST WITH CONSTANT VACUUM ISP

SECTION III

DESIGN ENVIRONMENT AND FLIGHT PERFORMANCE RESERVES

A. Discussion

The purpose of this section is to develop a set of ascent trajectory induced design environments and flight performance reserve (FPR) propellant requirements using the same techniques as previously used on the Saturn class of launch vehicles. Every vehicle is initially designed to some nominal set of parameters and conditions at a given safety factor. It is assumed that each parameter is independent, normally distributed, and exhibits a known extreme tolerance defined as a 3 σ deviation. This says that for 99.74% of the time a given item will operate within its $\pm$ 3 σ limits. This uncertainty is accounted for by providing design envelopes of key trajectory characteristics which the vehicle is predicted to stay within 99.74% of the time. The propellant variations at MECO (FPR) are analyzed to assure attainment of MECO 99.87% of the time. Therefore, each parameter may be investigated at its extreme tolerance and the deviated trajectory results combined by the root-sum-squared method. This is the technique used for the results presented in this section.

The trajectories to AOA and Nominal conditions of Section I produce the baseline characteristics for this dispersion analysis. The analysis was performed by curve fitting the booster attitude tilt profile from liftoff to SRB staging versus relative velocity and reloading this into the trajectory simulator (Reference 6). This open loop attitude profile was held constant for all dispersion runs except for the boost steering error dispersion. The closed loop guidance was initiated at SRB staging, flying the same type profile as described in Section I. Each system component parameter was deviated from its baseline value by the amount listed in Table III.1 and a trajectory simulated. All deviated trajectories assumed orbiter engine #1 failure at a relative velocity of 8932 fps to define the last RTLS/first AOA interface. AOA and Nominal targeting trajectories were simulated from this point. The RTLS trajectories were not simulated. The following list of trajectory characteristics are investigated:

- Maximum dynamic pressure
- Maximum longitudinal acceleration during SRB burn
- SRB staging state vector and dynamic pressure

- o RTLS/AOA point vector deviations and ET propellant consumed from liftoff (V_R held constant at 8932 fps)
- o Stagnation point heating
- o ET propellants consumed from liftoff to AOA MECO
- o ET propellants consumed from liftoff to Nominal MECO
- o Vehicle subpoint range from liftoff to AOA MECO and Nominal MECO

Extreme (maximum and minimum) envelopes which are possible to occur during a flight are generated for each trajectory characteristic.

Table III.1 lists the dispersion sources and the 3 σ extreme values of each parameter. The atmospheric variations are listed as Hot day and Cold day correlated atmospheric models and are found in Reference 4. The wind data used are from Reference 4. The aerodynamic coefficient parameters were obtained from Reference 3. Contributions due to guidance, control, and navigation systems were not analyzed due to lack of complete definition and simulator limitations. These will be analyzed at a later time when preflight analyses are performed.

B. Induced Design Environments

As each dispersion trajectory was computed, the deviated values of trajectory characteristics to be investigated were calculated. These were then root-sum-squared to define the maximum deviation envelopes about the baseline. This was done by evaluating all the plus and minus deltas separately.

Figure III.1 displays the envelope of dynamic pressure the launch vehicle may encounter in the region about nominal time of maximum q from the baseline trajectory. It is observed the maximum value could reach 727 psf at 55 seconds flight time. The major contributions are SRB Web Action Time (52%) and Headwind (44%). Figure III.2 displays the stagnation point heating envelope for the AOA and Nominal missions. The major contributors to the maximum heating envelope are + SSME thrust (24%), - SRB WAT (9%), + boost steering error (10%), Hot day atmosphere deviation (37%), and SRM misalignment (17%). It should be noted the heating at AOA MECO is 143% that at Nominal MECO for the undispersed cases. It can also be noted that the maximum heating at Nominal MECO is only 82% of the minimum heating at AOA MECO. The detailed design of ET thermal protection should be performed on the AOA trajectory. The safety factor required will define what degree of heating to use. Table III.2 lists the deviation in state vector and dynamic pressure at SRB staging.

The deviation of maximum longitudinal acceleration experienced during SRB burn is included in Table III.2.

The RTLS/AOA point was assumed to be constant at a relative velocity of 8932 fps. Table III.3 displays the deviation in state vector and consumed ET propellant at that velocity. Currently, the on-board logic to determine this interface has not been determined. More analyses are required to define which parameter will be used to define this interface in the flight computer. Some candidates other than V_R are time or characteristic velocity. Table III.4 summarizes the deviations of MECO time and surface range from the launch site at both AOA and Nominal MECO. The launch vehicle was targeted to the conditions of Table I.1 for all cases simulated.

C. Flight Performance Reserves

In order to guarantee that the MECO targets may be attained for 99.87% of the time, an extra amount of usable mainstage propellants must be carried. These are known as Flight Performance Reserves (FPR). They are calculated by root-sum-squaring the positive (those above baseline) mainstage ET propellants expended from liftoff to MECO. Table III.5 lists the contributions to FPR for each dispersion source at AOA MECO and Nominal MECO. These contributions are at baseline SSME mixture ratio of 6:1. The mixture ratio uncertainty effects of the SSME and ET loading were combined statistically while optimizing the fuel bias quantity using the technique as defined in reference 5.

The FPR required for this mission is 6471 pounds at AOA MECO and 6661 pounds at Nominal MECO including fuel bias. The optimum fuel bias is 1150 pounds. The cause for the Nominal MECO FPR being greater than the AOA MECO FPR is that the trajectory is shaped for the AOA condition and the Nominal is 'branched' at the RTLS/AOA point.

The RSS of the negative quantities of ET propellants consumed yield the negative FPR or excess residuals at MECO. These result from over-performing launch vehicle parameters and are jettisoned with the ET. The negative FPR including fuel bias could be as great as 6366 pounds at AOA MECO or 6266 pounds at Nominal MECO.

When generating performance trajectories, an estimate of FPR is desired. This has been historically done by converting the FPR from a detailed analysis such as this to a percentage of the characteristic velocity from liftoff to MECO. The results of this analysis yield an equivalent ΔV of .0085 V_{char} at AOA MECO and .0087 V_{char} at Nominal MECO not including the fuel bias. The fuel bias is summed with normal residuals and is not recalculated for performance quotations.

TABLE III.1

DISPERSION SOURCE	3 σ VALUES
SRB Web Action Time *	± 4.71%
SRB Vacuum Specific Impulse *	± .5%
SRB Propellant Loading *	± .21%
SRB Staging Weight *	± .85%
SRB Staging Time	± .5 s
SRB Misalignment	± .5°
SSME Vacuum Thrust	± 6000 lb/Eng
SSME Vacuum Specific Impulse	± 2.3 s/Eng
SSME Misalignment	± .5°
SSME Mixture Ratio	± 1%/Eng
Orbiter & ET Inert Weight	± .81%
ET Propellant Loading	± .48%
Booster Steering Program	± .5°
Vehicle Center of Gravity	± 2 inches
Atmospheric	Hot/Cold day
Winds	Head/Tail Right/Left
Base Force	Reference 3
Aerodynamic Coefficients	Reference 3

NOTE: Orbiter Main Engine Variations Combined by
Stage Variation = N (Dispersion/Eng)/$\sqrt{N}$

Where N is number of engines operating i.e.
N = 3 for Nominal, N = 2 for Abort

* Combined Stage Variation

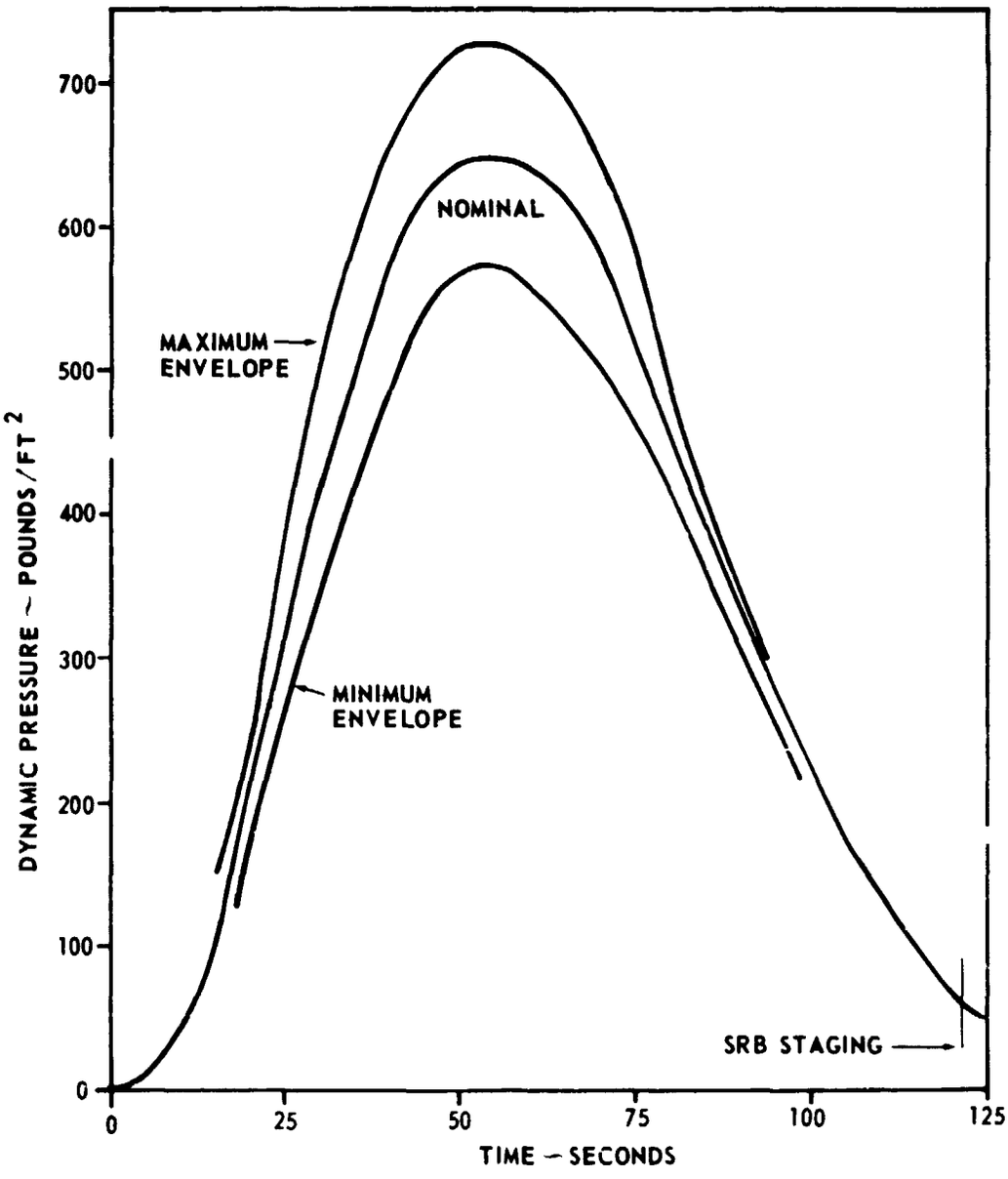

FIGURE III.1 DYNAMIC PRESSURE ENVELOPE VERSUS TIME

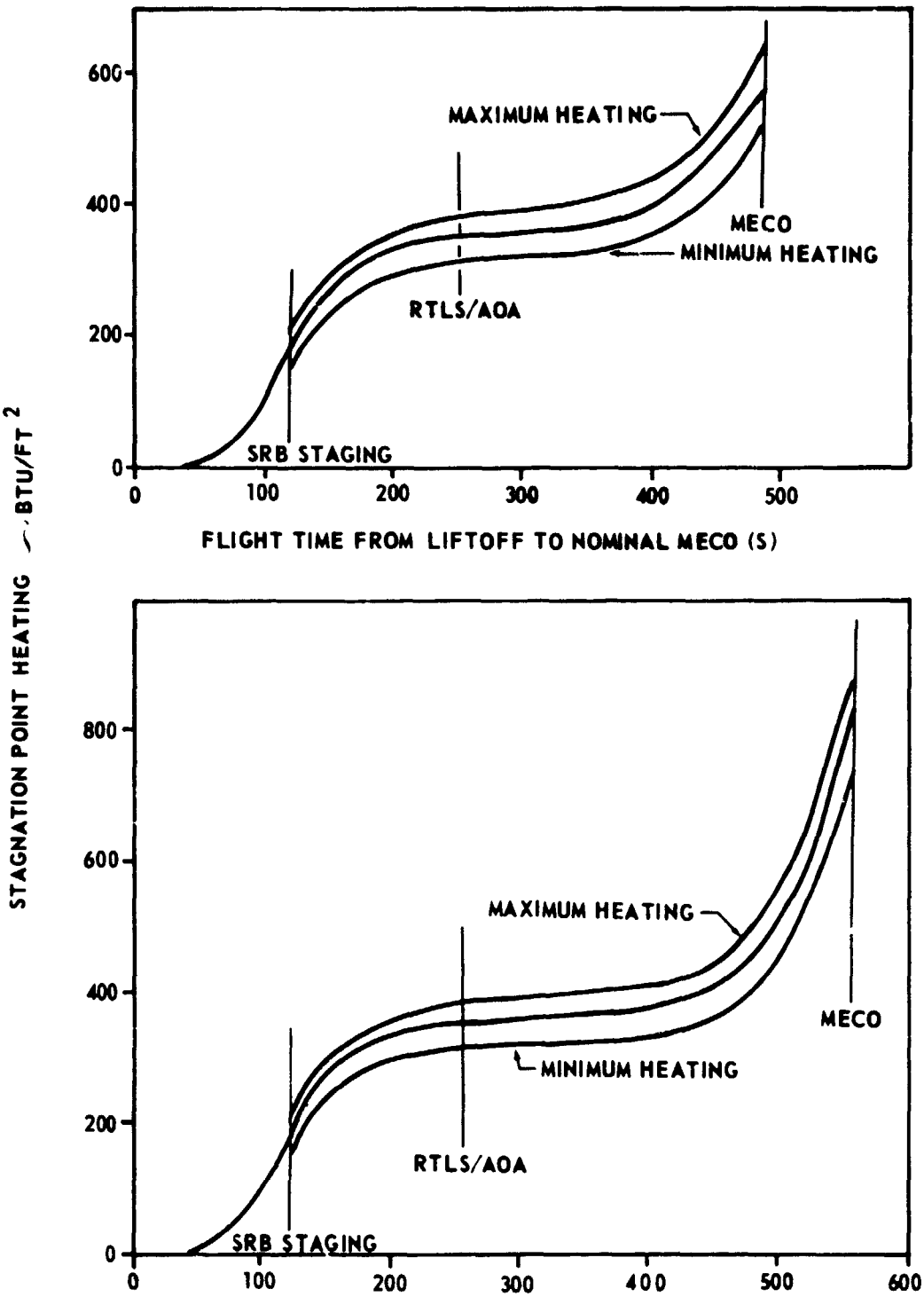

FIGURE III.2 STAGNATION POINT HEATING ENVELOPE VERSUS FLIGHT TIME

TABLE III.2 STATE VECTOR DEVIATIONS AT SRB STAGING

DISPERSION		Δ Range n. mi.	ΔV_I fps	Δ γ deg	Δ Alt feet	Δ Dynamic Pressure psf	Δ Max Acc.* g's
SRB Web Action Time	+	.49	-24.247	- .12	3481	- 9.1	- .07
	-	-.39	19.246	.15	-3825	11.42	.08
SRB Vacuum Specific Impulse	+	.32	38.425	- .16	807	- 1.09	.01
	-	-.33	-38.481	.15	- 810	1.12	- .01
SRB Propellant Load	+	.09	10.226	- .04	180	- .2	.01
	-	-.08	-10.377	.04	- 180	.2	0
SRB Staging Weight	+	-.06	- 9.911	.02	- 184	.2	0
	-	.07	9.813	- .03	184	- .2	.01
SRB Staging Time	+	.36	7.283	- .13	1083	- 2.6	0
	-	-.34	- 8.579	.12	-1079	2.7	0
SRB Misalignment	+	-.46	-19.062	.86	1755	- 5.	0
	-	.44	16.263	- .85	-1811	5.5	.01
SSME Vacuum Thrust	+	.15	21.145	- .04	456	- .6	.01
	-	-.14	- 21.217	.03	- 453	.6	- .01
SSME Vacuum Specific Impulse	+	-.01	- 2.244	.0	- 26	.02	0
	-	.02	2.254	- .01	33	- .02	0
SSME Misalignment	+	-.18	- 11.266	.32	453	- 1.5	0
	-	.07	6 519	- .25	- 295	1.	0

* Maximum Acceleration is that noted prior to cutoff. Time = 107.5 Sec.

TABLE III.2 (Continued)

DISPERSION		Δ Range n. mi.	ΔV fps	Δ γ deg	Δ Alt feet	Δ Dynamic Pressure psf	Δ Max Acc.* g's
Orbiter & ET Inert Weight	+	- .04	- 6.841	.02	-125	.2	0
	-	.05	6.752	- .02	128	- .2	.01
ET Propellant Loading	+	- .17	-24.413	.06	-456	.6	-.01
	-	.18	24.505	- .07	459	- .6	.01
Booster Steering Program	+	.40	16.115	- .70	-1493	4.6	0
	-	- .39	-16.237	.70	1469	-4.1	.01
Vehicle Center of Gravity	+	- .03	- 1.703	.09	157	- .5	0
	-	.04	1.385	- .07	- 141	.4	0
Hot Day		- .04	- 7.260	0	- 177	3.1	0
Cold Day		.17	23.704	- .05	568	-8.	.01
Head Wind		- .5[illegible]	-31.158	.14	295	-1.6	0
Tail Wind		.6[illegible]	31.184	- .22	- 404	1.9	0
Right Cross Wind		.04	-29.99[illegible]	.17	- 171	.4	0
Left Cross Wind		.01	9.902	- .08	- 13	.05	0
Base Force	+	- .15	-14.649	.07	- 312	- .4	0
	-	.15	14.370	- .08	308	- [illegible]	0
C_{A_o}	+	- .14	17.382	.05	- 318	.3	0
	-	.14	16.381	- .06	305	- .3	0

* Maximum Acceleration is that noted prior to cutoff. Time ≈ 107.5 Sec.

TABLE III.2 (Continued)

DISPERSION		Δ Range n. mi.	ΔVI fps	Δ γ deg	Δ Alt feet	Δ Dynamic Pressure psf	Δ Max Acc.* g's
C_{N_o}	+	.08	2.687	- .08	- 262	.8	0
	-	- .07	- 2.193	.08	262	- .8	0
C_{N_α}	+	.03	.758	- .03	79	.2	0
	-	- .02	- 1.033	.03	105	- .3	0
C_{M_o}	+	- .01	.213	- .01	- 16	.1	0
	-	0	- .220	0	20	- .1	0
C_{M_α}	+	.02	.522	- .02	- 46	.1	0
	-	- .01	- .548	.01	49	- .1	0
C_{L_β}	+	0	0	0	49	0	0
	-	0	.226	.02	16	- .1	0
C_{N_β}	+	0	.246	.02	16	- .1	0
	-	0	.020	0	49	0	0
C_{Y_β}	+	0	- .022	0	49	0	0
	-	0	.203	.02	16	- .1	0
RSS	(+)	1.16	76.906	1.21	4539	14.4	.09
RSS	(-)	-1.18	-81.347	- 1.19	-4801	-13.4	- .07
Baseline		25.62	4591.878	28.23	141,054	60.8	2.96

* Maximum Acceleration is that noted prior to cutoff. Time ≈ 107.5 Sec.

TABLE III.3 RELATIVE STATE VECTOR AND ET PROPELLANT DEVIATIONS AT RTLS/AOA DEFINED AT CONSTANT V_R = 8932 FT/SEC

DISPERSION		Δ TIME seconds	Δ γ deg	Δ ALTITUDE feet	Δ ET PROPELLANT pounds
SRB Web Action	+	3.671	- .066	- 1509	12393
Time	-	- 3.422	.101	2060	- 11551
SRB Vacuum Specific	+	- .870	.151	1506	- 2937
Impulse	-	1.056	- .058	- 289	3564
SRB Propellant Load	+	- .197	.057	604	- 667
	-	.297	- .009	72	1002
SRB Staging	+	.287	- .008	3	969
Weight	-	- .189	.060	224	- 605
SRB Staging	+	.123	.040	173	415
Time	-	.006	.001	21	14
SRB Misalignment	+	.430	- .029	1717	1452
	-	- .212	.064	- 1513	- 716
SSME	+	- 2.094	.101	- 340	- 1343
Vacuum Thrust	-	2.250	- .053	564	1772
SSME	+	.400	.035	278	- 1140
Vacuum Specific Impulse	-	- .300	.011	- 67	1484
SSME	+	.287	- .016	599	968
Misalignment	-	- .072	.050	- 275	- 243
Orbiter & ET	+	.481	- .003	142	1623
Inert Weight	-	- .372	.054	84	- 1256

TABLE III.3 (Continued)

DISPERSION		Δ TIME seconds	Δ γ deg	Δ ALTITUDE feet	Δ ET PROPELLANT pounds
ET Propellant	+	1.602	- .077	215	5405
Load	-	1.488	.126	- 3	- 4975
Booster [illegible]ering	+	- .241	.063	- 1219	- 814
Program	-	.371	- .021	1413	1253
Vehicle Center	+	.086	.022	285	289
of Gravity	-	.029	.030	- 17	97
Hot Day		.260	- .003	19	877
Cold Day		- .565	.114	409	- 1906
Head Wind		.812	- .058	183	741
Tail Wind		- .644	.137	1	- 2173
Right Cross Wind		.137	.019	40	462
Left Cross Wind		.045	.026	97	153
Base Force	+	.463	- .037	- [illegible]	1563
	-	- .362	.083	222	- 1224
C_{A_o}	+	.463	- .034	- 51	1563
	-	- .334	.082	267	- 1128
C_{N_o}	+	- .007	.031	- 70	- 25
	-	.107	.016	277	362
C_{N_γ}	+	.041	.029	62	136
	-	.073	.023	209	246

TABLE III.3 (Continued)

DISPERSION		Δ TIME seconds	Δ γ deg	Δ ALTITUDE feet	Δ ET PROPELLANT pounds
C_{M_o}	+	.041	.022	85	136
	-	.053	.025	126	198
C_{M_α}	+	.035	.023	66	117
	-	.065	.024	146	218
C_{L_β}	+	.054	.026	115	182
	-	.058	.026	151	196
C_{N_β}	+	.058	.026	151	197
	-	.050	.026	115	182
C_{Y_β}	+	.054	.026	115	183
	-	.058	.026	151	196
RSS	(+)	+ 4.942	+ .366	+ 3655	+14969
RSS	(-)	- 4.522	- .155	- 2518	-13587
Baseline		253.041	7.597	351278	854156

TABLE III.4 DEVIATION IN MECO TIME AND RANGE FROM LAUNCH SITE FOR AOA AND NOMINAL TRAJECTORIES

DISPERSION		AOA Δ MECO TIME seconds	AOA Δ RANGE n. mi.	NOMINAL Δ MECO TIME seconds	NOMINAL Δ RANGE n. mi.
SRB Web Action Time	+	- .118	- 10.59	1.527	- 6.40
	-	.094	10.07	- 1.418	6.16
SRB Vacuum Specific Impulse	+	- .076	1.91	- .413	.91
	-	- .018	- 2.28	.445	- 1.08
SRB Propellant Load	+	- .038	- .43	- .105	.20
	-	- .014	- .64	.121	- .30
SRB Staging Weight	+	- .013	- .60	.118	- .27
	-	- .044	.37	- .099	.17
SRB Staging Time	+	- .046	- .24	.031	- .10
	-	- .004	- .01	- .002	- .01
SRB Misalignment	+	- .122	- 1.67	.094	- 1.25
	-	.073	1.23	- .024	1.06
SSME Vacuum Thrust	+	- 4.231	- 6.65	- 3.141	- 4.03
	-	4.246	6.52	3.217	3.99
SSME Vacuum Specific Impulse	+	1.181	2.45	.741	1.16
	-	- 1.234	- 2.65	- .727	- 1.26
SSME Misalignment	+	- .048	- .86	.089	- .56
	-	- .010	.30	- .030	.23

TABLE III.4 (Continued)

DISPERSION		AOA Δ MECO TIME seconds	AOA Δ RANGE n. mi.	NOMINAL Δ MECO TIME seconds	NOMINAL Δ RANGE n. mi.
Orbiter & ET	+	.603	.65	.550	.50
Inert Weight	-	.660	- .87	- .531	- .60
ET Propellant	+	2.263	2.65	1.969	1.96
Load	-	- 2.315	- 2.88	- 1.946	- 2.06
Booster Steering	+	.055	1.16	- .052	.94
Program	-	- .104	- 1.42	.084	- 1.05
Vehicle Center	+	- .039	- .26	.014	- .16
of Gravity	-	- .020	.00	.005	.04
Hot Day		- .014	- .53	.105	- .22
Cold Day		- .068	1.16	- .276	.52
Head Wind		- .023	- 2.09	.332	- 1.18
Tail Wind		- .051	1.82	- .295	1.10
Right Cross Wind		.041	0	.109	.17
Left Cross Wind		- .047	- .17	.013	.12
Base Force	+	- .003	- .98	.324	- .11
	-	- .048	.76	- .305	.01
C_{A_o}	+	- .003	- 1.	.198	- .47
	-	- .052	.73	- .170	.35
C_{N_o}	+	- .016	.11	- .008	.11
	-	- .036	- .33	.025	- .21

TABLE III.4 (Continued)

DISPERSION		AOA Δ MECO TIME seconds	AOA Δ RANGE n. mi.	NOMINAL Δ MECO TIME seconds	NOMINAL Δ RANGE n. mi.
C_{N_α}	+	- .026	- .06	.005	- .01
	-	- .034	- .20	.012	- .11
C_{M_o}	+	- .023	- .08	.004	- .04
	-	- .029	- .13	.010	- .06
C_{M_α}	+	- .022	- .06	.003	- .02
	-	- .030	- .16	.012	- .08
C_{L_β}	+	- .028	- .11	.009	- .05
	-	- .031	- .13	.009	- .07
C_{N_β}	+	- .031	- .13	.009	- .07
	-	- .028	- .11	.009	- .05
C_{Y_β}	+	- .028	- .11	.009	- .05
	-	- .031	- .13	.009	- .07
RSS	(+)	+ 5.000	+ 13.04	+4.235	+ 7.99
RSS	(-)	- 4.986	- 13.82	-4.118	- 8.34
Baseline		558.712	932.37	485.231	765.46

TABLE III.5 FLIGHT PERFORMANCE RESERVE CONTRIBUTION

DISPERSION		@ AOA MECO Δ ET Propellants Consumed lb	@ NOMINAL MECO Δ ET Propellants Consumed lb
SRB Web Action	+	3327	3690
Time	-	- 3160	- 3468
SRB Vacuum Specific	+	- 933	- 987
Impulse	-	995	1082
SRB Propellant	+	- 262	- 250
Load	-	266	289
SRB Staging	+	259	289
Weight	-	- 256	- 231
SRB Staging	+	36	86
Time	-	0	- 6
SRB Misalignment	+	184	268
	-	- 60	- 86
SSME	+	- 785	- 532
Vacuum Thrust	-	811	610
SSME	+	- 1586	- 1381
Vacuum Specific Impulse	-	1589	1489
SSME	+	189	227
Misalignment	-	- 85	26

TABLE III.5 (Continued)

DISPERSION		@ AOA MECO Δ ET Propellants Consumed lb	@ NOMINAL MECO Δ ET Propellants Comsumed lb
Orbiter & ET Inert Weight	+	1923	1919
	-	- 1919	- 1853
ET Propellant Loading	+	- 446	- 564
	-	456	628
Booster Steering Program	+	- 123	- 151
	-	163	237
Vehicle Center of Gravity	+	11	46
	-	- 8	16
Hot Day		227	260
Cold Day		- 683	- 656
Head Wind		749	806
Tail Wind		- 723	- 706
Right Cross Wind		218	345
Left Cross Wind		- 43	- 15
Base Force	+	448	733
	-	- 442	- 680
C_{A_o}	+	- 448	481
	-	- 422	- 400

TABLE III.5 (Continued)

DISPERSION		@ AOA MECO Δ ET Propellants Consumed lb	@ NOMINAL MECO Δ ET Propellants Consumed lb
C_{N_o}	+	- 34	- 22
	-	38	73
C_{N_α}	+	- 6	20
	-	9	40
C_{M_o}	+	- 2	13
	-	5	34
C_{M_α}	+	- 5	9
	-	9	38
C_{L_β}	+	1	29
	-	0	30
C_{N_β}	+	1	31
	-	2	29
C_{Y_β}	+	2	30
	-	0	30
RSS	(+)	4522	4838
RSS	(-)	-4417	-4543
Orbiter Mixture Ratio Effects (SSME and ET Loading)		Dependent on amount of fuel bias	
FPR Total Including Optimum fuel bias of 1150 lb		6471	6661

CONCLUSION

The described launch vehicle has been evaluated and displays the capability to deliver the required performance to the design reference mission. The exchange ratios will enable management and design engineers to quickly evaluate performance effects of any proposed system changes in a rapid economic manner.

The design envelopes calculated shows that the maximum dynamic pressure encountered on ascent may exceed the design requirement of 650 psf by 77 psf mainly due to overperforming SRB and a headwind. The maximum ascent heating occurs on the abort-once-around mission and is considerably greater (43% on an undispersed trajectory) than that from a nominal flight. The flight performance reserves calculated have been converted to an equivalent percentage of characteristic velocity of .85% at AOA MECO and .87% at Nominal MECO. A statistical calculation of fuel bias resulted in an optimum requirement of 1150 pounds.

RECOMMENDATION

It is recommended that these data be utilized in conjunction with corresponding data generated by the system contractor, Rockwell International/Space Division, and Johnson Space Center for design of the Space Shuttle.

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APPROVAL

SPACE SHUTTLE LAUNCH VEHICLE PERFORMANCE TRAJECTORY, EXCHANGE RATIOS, AND DISPERSION ANALYSIS

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The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.

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